NOTICE

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Bibliography of Lewis Research Center Technical Publications Announced in 1980

May 1981
PREFACE

In 1980, Lewis' 1020 research authors published 427 technical publications which were announced to and reached the worldwide scientific community. This number was our typical output even though, once again, we had a slight decrease in staff. In recent years, the trend in Lewis publishing has been that each year the number of technical presentations given at seminars, society symposia, and Lewis-hosted conferences has surpassed the record set the previous year. Lewis authors publish approximately 61 percent of their research contributions in outside publications and the rest as NASA research reports. Lewis authors primarily use society proceedings, seminar presentations, and journal and transactions articles to describe their work.

In 1980 the production of 307 contractor-authored research reports was higher than the previous year's output of 294. In addition, 38 patent applications were filed, and 17 patents were issued, fewer numbers than in recent years.

In 1980, the annual award for Best Lewis Publication was presented to J. Anthony Powell, Anthony J. Strazisar, and Richard G. Seasholtz for their paper "Efficient Laser Anemometer for Intra-Rotor Flow Mapping in Turbomachinery," which describes several innovative features of this anemometer. The paper was presented at the Joint Fluids Engineering Gas Turbine Conference and Products Show, New Orleans, Louisiana, March 10-13, 1980. A description is given in abstract A80-36140 (p. 111) in this bibliography.

Also in 1980, the American Society of Lubrication Engineers presented the "Captain Alfred E. Hunt Memorial Award" for the best paper appearing in one of its publications to L. D. Wedeven. This paper, coauthored with Professor Cristino Cusano, a summer faculty fellow from the University of Illinois, entitled "Elastohydrodynamic Film Thickness Measurements of Artificially Produced Nonsmooth Surfaces," is described in abstract A80-14720 (p. 102).

All the publications in this collection were announced in the 1980 issues of STAR (Scientific and Technical Aerospace Reports) and IAA (International Aerospace Abstracts).

The arrangement of the material is by NASA subject category, as noted in the Contents. The Lewis-authored items are listed first, followed by the contractor items. Within each of these groups is listed report literature, in N-number sequence, followed by the journal and conference presentations, in A-number sequence.

The various indexes will help locate specific publications by subject, author, contractor organization, contract number, and report number.

George Mandel
Chief, Management Services Division
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AERONAUTICS (GENERAL)</td>
<td>1</td>
</tr>
<tr>
<td>AERODYNAMICS</td>
<td>2</td>
</tr>
<tr>
<td>AIR TRANSPORTATION AND SAFETY</td>
<td>8</td>
</tr>
<tr>
<td>AIRCRAFT COMMUNICATIONS AND NAVIGATION</td>
<td>9</td>
</tr>
<tr>
<td>AIRCRAFT DESIGN, TESTING AND PERFORMANCE</td>
<td>10</td>
</tr>
<tr>
<td>AIRCRAFT INSTRUMENTATION</td>
<td>11</td>
</tr>
<tr>
<td>AIRCRAFT PROPULSION AND POWER</td>
<td>12</td>
</tr>
<tr>
<td>AIRCRAFT STABILITY AND CONTROL</td>
<td>46</td>
</tr>
<tr>
<td>RESEARCH AND SUPPORT FACILITIES (AIR)</td>
<td>47</td>
</tr>
<tr>
<td>ASTRONAUTICS (GENERAL)</td>
<td>48</td>
</tr>
<tr>
<td>GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)</td>
<td>49</td>
</tr>
<tr>
<td>LAUNCH VEHICLES AND SPACE VEHICLES</td>
<td>50</td>
</tr>
<tr>
<td>SPACE TRANSPORTATION</td>
<td>51</td>
</tr>
<tr>
<td>SPACECRAFT COMMUNICATIONS, COMMAND AND TRACKING</td>
<td>52</td>
</tr>
<tr>
<td>SPACECRAFT DESIGN, TESTING AND PERFORMANCE</td>
<td>53</td>
</tr>
<tr>
<td>SPACECRAFT PROPULSION AND POWER</td>
<td>56</td>
</tr>
<tr>
<td>CHEMISTRY AND MATERIALS (GENERAL)</td>
<td>66</td>
</tr>
<tr>
<td>COMPOSITE MATERIALS</td>
<td>67</td>
</tr>
<tr>
<td>INORGANIC AND PHYSICAL CHEMISTRY</td>
<td>74</td>
</tr>
<tr>
<td>METALLIC MATERIALS</td>
<td>76</td>
</tr>
<tr>
<td>NONMETALLIC MATERIALS</td>
<td>85</td>
</tr>
<tr>
<td>PROPELLANTS AND FUELS</td>
<td>93</td>
</tr>
<tr>
<td>ENGINEERING (GENERAL)</td>
<td>96</td>
</tr>
<tr>
<td>ELECTRONICS AND ELECTRICAL ENGINEERING</td>
<td>97</td>
</tr>
<tr>
<td>FLUID MECHANICS AND HEAT TRANSFER</td>
<td>101</td>
</tr>
<tr>
<td>INSTRUMENTATION AND PHOTOGRAPHY</td>
<td>110</td>
</tr>
<tr>
<td>LASERS AND MASERS</td>
<td>113</td>
</tr>
<tr>
<td>MECHANICAL ENGINEERING</td>
<td>114</td>
</tr>
<tr>
<td>QUALITY ASSURANCE AND RELIABILITY</td>
<td>130</td>
</tr>
<tr>
<td>STRUCTURAL MECHANICS</td>
<td>132</td>
</tr>
<tr>
<td>GEOSCIENCES (GENERAL)</td>
<td>135</td>
</tr>
<tr>
<td>EARTH RESOURCES</td>
<td>136</td>
</tr>
<tr>
<td>ENERGY PRODUCTION AND CONVERSION</td>
<td>137</td>
</tr>
<tr>
<td>ENVIRONMENT POLLUTION</td>
<td>157</td>
</tr>
<tr>
<td>METEOROLOGY AND CLIMATOLOGY</td>
<td>159</td>
</tr>
<tr>
<td>LIFE SCIENCES (GENERAL)</td>
<td>160</td>
</tr>
<tr>
<td>AEROSPACE MEDICINE</td>
<td>161</td>
</tr>
<tr>
<td>COMPUTER OPERATIONS AND HARDWARE</td>
<td>162</td>
</tr>
<tr>
<td>COMPUTER PROGRAMMING AND SOFTWARE</td>
<td>163</td>
</tr>
<tr>
<td>STATISTICS AND PROBABILITY</td>
<td>164</td>
</tr>
<tr>
<td>SYSTEMS ANALYSIS</td>
<td>165</td>
</tr>
<tr>
<td>THEORETICAL MATHEMATICS</td>
<td>166</td>
</tr>
<tr>
<td>ACOUSTICS</td>
<td>167</td>
</tr>
<tr>
<td>ATOMIC AND MOLECULAR PHYSICS</td>
<td>174</td>
</tr>
<tr>
<td>Category</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Plasma Physics</td>
<td>175</td>
</tr>
<tr>
<td>Solid-State Physics</td>
<td>178</td>
</tr>
<tr>
<td>Thermodynamics and Statistical Physics</td>
<td>180</td>
</tr>
<tr>
<td>Administration and Management</td>
<td>181</td>
</tr>
<tr>
<td>Economics and Cost Analysis</td>
<td>182</td>
</tr>
<tr>
<td>Urban Technology and Transportation</td>
<td>183</td>
</tr>
<tr>
<td>Subject Index (Keywords)</td>
<td>A-1</td>
</tr>
<tr>
<td>Personal Author Index (Includes Lewis and Contractor Authors)</td>
<td>B-1</td>
</tr>
<tr>
<td>Corporate Source Index (Contractor Organizations)</td>
<td>C-1</td>
</tr>
<tr>
<td>Contract Number Index</td>
<td>D-1</td>
</tr>
<tr>
<td>Report/Accession Number Index (Includes Patents)</td>
<td>E-1</td>
</tr>
</tbody>
</table>
The computational techniques are described which are utilized at Lewis Research Center to determine the optimum propulsion systems for future aircraft applications and to identify system tradeoffs and technology requirements. Cycle performance, and engine weight can be calculated along with costs and installation effects as opposed to fuel consumption alone. Almost any conceivable turbine engine cycle can be studied. These computer codes are: NNEP, WATE, LIFCYC, INSTAL, and POD DRG. Examples are given to illustrate how these computer techniques can be applied to analyze and optimize propulsion system fuel consumption, weight and cost for representative types of aircraft and missions.

F.O.S.
02 AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

For related information see also 34 Fluid Mechanics and Heat Transfer.

N80-10128# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. COAXIAL SUPERSONIC EJECTOR NOZZLES Allan R. Bishop. In NASA Ames Res. Center Workshop on Thrust Augmenting Ejectors Sep 1979 p 385-396 refs (For primary document see N80-10107 01-02)

The nozzles described exhibit a flow field which is supersonic except for the initial flow region, and the secondary mass flow is typically about five percent of the primary core flow. The features to improve the accuracy of the performance calculations are discussed. A special calculation is made to get as realistic a sonic line as possible for this geometry, using an analysis developed by Brown. The mixing between the secondary and core flows is treated to account for entrainment of the secondary flow into core. Both of these phenomena directly affect the pressure distribution on the shroud and therefore, the thrust that the nozzle produces. The importance of using a realistic sonic line and a mixing analysis is stressed. M.M.M.


The effects of low aspect ratio blading on aerodynamic performance were examined. Four individual transonic compressor stages, representative of the inlet stage of an advanced high pressure ratio core compressor, are discussed. The flow phenomena for the four stages are investigated. Comparisons of blade element parameters are presented for the two different aspect ratio configurations. Blade loading levels are compared for the near stall conditions and comparisons are made of loss and diffusion factors over the operating range of incidence angles.

A.W.H.


A laser anemometer system employing a efficient data acquisition technique was used to make measurements upstream, within, and downstream of the compressor rotor. A fluorescent dye technique allowed measurements within endwall boundary layers. Adjustable laser beam orientation minimized shadowed regions and enabled radial velocity measurements outside of the blade row. The flow phenomena investigated include flow variations from passage to passage, the rotor shock system, three-dimensional flows in the blade wake, and the development of the outer endwall boundary layer. Laser anemometer measurements are compared to a numerical solution of the streamfunction equations and to measurements made with conventional instrumentation.

Author

N80-14061# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio MODIFICATION OF AXIAL COMPRESSOR STREAMLINE PROGRAM FOR ANALYSIS OF ENGINE TEST DATA Jeffrey G. Williams. Nov. 1979 49 p refs (NASA-TM-79312; E-268) Avail: NTIS HC A03/MF A01 CSCL 01A

An existing axial compressor streamline analysis computer program to allow input of measured radial pressure and temperature profiles obtained from engine or cascade data is described. The proposed modifications increase the input flexibility and are accomplished without changing the computer program's input format.

A.R.H.


Three advanced analyses for predicting aircraft propeller performance at high subsonic speeds are described. Two of these analyses use a lifting line representation for the propeller blades and vortex filaments for the blade wakes but differ in the details of the solution. The third analysis is a finite difference solution of the unsteady, three dimensional Euler equations for the flow between adjacent blades. Analysis results are compared to data for a high speed propeller having eight swept blades integrally designed with the spinner and nacelle.

Author

N80-17030# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio PREDICTION METHOD FOR TWO-DIMENSIONAL AERODYNAMIC LOSSES OF COOLED VANES USING INTEGRAL BOUNDARY-LAYER PARAMETERS Louis J. Goldman and Raymond E. Augler. Feb. 1980 43 p refs (NASA-TP-1623; E-076) Avail: NTIS HC A03/MF A01 CSCL 01A

A generalized analysis to predict the two-dimensional aerodynamic losses of film-cooled vanes by using integral boundary-layer parameters is presented. Heat-transfer and trailing-edge injection effects are included in the method. An approximate solution of the generalized equations is also included to show more clearly the effect of the different boundary-layer and cooling parameters on the losses. The analytical predictions agree well with the experimental results, indicating that available boundary-layer calculations for cooled vanes are of sufficient accuracy to use in the prediction method.

Author


Four high speed propeller models were designed and tested in an 8x6 foot wind tunnel in order to evaluate the potential of advanced propeller technology. Results from these tests show that the combination of: increased blade number, aerodynamically integrated propeller/nacelles, reduced blade thickness, spinner area ruling, and blade sweep are important in achieving high propeller efficiency at the high cruise speeds.

R.E.S.

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Explicitly an artificial viscosity in a conservative form. In addition, solved iteratively by using successive line overrelaxation. The dependent form of the actual FPE. The governing equation was discretized by using type-dependent, rotated finite differencing, providing a boundary-fitted, nonuniform computational mesh. The mesh was generated by using a sequence of conforming mapping, nonorthogonal coordinate stretching, and local, isoparametric, bilinear mapping functions. The discretized form of the FPE was solved iteratively by using successive line overrelaxation. The possible isotropic shocks were correctly captured by adding explicitly an artificial viscosity term. In addition, a three-level consecutive, mesh refinement feature makes CAS213a reliable and fast algorithm for the analysis of transonic, two-dimensional cascade flows. 

A computer program is presented which numerically solves an exact, full potential-equation (FPE) model for the steady, irrotational, homentropic and homogenetic flow of a compressible, homocompositional, inviscid fluid through two-dimensional planar cascades of airfoils was derived, together with its appropriate boundary conditions. A computer program, CAS213a, was developed that numerically solves an artificially time-dependent form of the actual FPE. The governing equation was discretized by using type-dependent, rotated finite differencing and the finite area technique. The flow field was discretized by providing a boundary-fitted, nonuniform computational mesh. The mesh was generated by using a sequence of conforming mapping, nonorthogonal coordinate stretching, and local, isoparametric, bilinear mapping functions. The discretized form of the FPE was solved iteratively by using successive line overrelaxation. The possible isotropic shocks were correctly captured by adding explicitly an artificial viscosity term. In addition, a three-level consecutive, mesh refinement feature makes CAS213a reliable and fast algorithm for the analysis of transonic, two-dimensional cascade flows.

A numerical procedure for the efficient simulation of steady inviscid flow is described and its utility demonstrated. Application of the surrogate equation technique allows the formulation of a stable, fully conservative, type dependent finite difference equations for use in obtaining numerical solutions to systems of first order partial differential equations, such as the steady state Euler equations or their various approximations. Computational results are presented for the full Euler equations and for the transonic disturbance equations. For the latter case, a computational efficiency greater than that obtained by means of the standard perturbation potential approach is indicated. E.D.K.

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A three-dimensional, viscous computer code was used to calculate the mixing downstream of a typical turbomix mixer geometry. Experimental data were obtained using pressure and temperature rakes at the lobe and nozzle exit stations. Secondary flow velocities were also obtained. These data were used to validate the computer results. An assessment was also made to determine the relative importance of turbulence in the mixing phenomenon as compared with the streamwise vorticity set up by the secondary flows. The observations suggest that the generation of streamwise vorticity appears to play a significant role in determining the temperature distribution at the nozzle exit plane.

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A three-dimensional, fully viscous computer analysis, which retains the viscous nature of the Navier-Stokes equations, was evaluated to determine its usefulness in the design of supersonic inlets. This procedure takes advantage of physical approximations to limit the high computer time and storage associated with the Navier-Stokes solutions. Computed results are presented for a Mach 3 supersonic inlet with bleed and a Mach 7.4 hypersonic inlet. Good agreement was obtained between theory and data for both inlets. Results of a mesh sensitivity study are also shown.


A comparison between numerical and experimental results is presented for the flowfield within a transonic axial-flow compressor rotor. The rotor was tested at design speed and a wide open throttle discharge condition. The relative tip Mach number was 1.4. A laser anemometer system was used to measure velocity and flow angle upstream, within, and downstream of the rotor. A holographic interferometer was used to visualize the rotor wakes and shock structure. The computational procedure solves the full three-dimensional Euler equations using a time-marching technique. Shock location and shape determined from the two optical systems are compared. Calculated relative Mach number and flow angle contours, shock locations, and shock strength are compared to values measured with the laser anemometer.
A80-38904 * #

Measurements of surface static pressures, flow total pressure loss, and exit air angle were obtained for two linear cascades to establish the effects of endwall profiling. Testing was conducted at an isentropic exit Mach number of 0.85. One cascade was fabricated with planar endwalls while the other had one planar and one profiled endwall. Both cascades utilized the same high pressure turbine inlet guide vane section. It was found that in terms of full passage loss the profiled endwall cascade has the superior performance. The secondary loss results obtained are reasonably well predicted by correlations developed from incompressible flow testing of similar configurations. Inviscid flow and boundary layer calculations are compared with the test data, and overall, the agreement is found to be good. Use of the results for design purposes is briefly discussed. (Author)

A80-41203 * #

Zero-length, slotted-lip inlet performance and associated fan blade stresses were determined during model tests using a 20-inch diameter fan simulator in the NASA-LERC B- by 15-foot low-speed wind tunnel. The model configuration variables consisted of inlet contraction ratio, slot width, circumferential extent of slot fillers, and length of a constant area section between the inlet throat and fan face. Inlet configurations having contraction ratios of 1.2 and 1.3 satisfied all critical low-speed inlet operating requirements for a fixed horizontal nacelle and tilt-nacelle type subsonic V/STOL aircraft, respectively. Relative to a conventional axisymmetric tilt-nacelle inlet, the zero-length, slotted-lip inlet has a 27-percent smaller inlet lip contraction ratio, an 83-percent shorter total length, and a 5-percent smaller maximum cowl diameter. (Author)

A80-42145 * #

Neutrally buoyant helium-filled bubbles were observed as they followed the streamlines in a horseshoe vortex system around the vane leading edge in a large-scale, two-dimensional, turbine stator cascade. Bubbles were introduced into the endwall boundary layer through a slot upstream of the vane leading edge. The paths of the bubbles were recorded photographically as streaklines on 16-mm movie film. Individual frames from the film have been selected, and overlaid to show the details of the horseshoe vortex around the leading edge. The transport of the vortex across the passage near the leading edge is clearly seen when compared to the streaks formed by bubbles carried in the main stream. Limiting streamlines on the endwall surface were traced by the flow of oil drops. (Author)

A80-44862 * #

The turbulence downstream of a rapid contraction is calculated for the case when the turbulence scale can have the same magnitude as the mean-flow spatial scale. The approach used is based on the formulation of Goldstein (1978) for turbulence downstream of a contraction, with the added assumptions of a parallel mean flow at downstream infinity and turbulence calculated far enough downstream so that the nonuniformity of the mean flow field has decayed, and by treating the inverse contraction ratio as a small parameter. Consideration is given to the large-contraction ratio and classical rapid-distortion theory limits, and to results at an arbitrary contraction ratio. It is shown that the amplification effect of the contraction is reduced when the spatial scale of the turbulence increases, with the upstream turbulence actually suppressed for a contraction ratio less than five and a turbulence spatial scale greater than three times the transverse dimensions of the downstream channel. A. L. W.

A80-44956 * #


A panel method is used to calculate incompressible flow about arbitrary three-dimensional inlets with or without centerbodies for four fundamental flow conditions: unit onset flows parallel to each of the coordinate axes plus static operation. The computing time is scarcely longer than for a single solution. A linear superposition of these solutions quite rigorously gives incompressible flow about the inlet for any angle of attack, angle of yaw, and mass flow rate. Compressibility is accounted for by applying a well-proven correction to the incompressible flow. Since the computing times for the combination and the compressibility correction are small, flows at a large number of inlet operating conditions are obtained rather cheaply. Geometric input is aided by an automatic generating program. A number of graphical output features are provided to aid the user, including surface streamline tracing and automatic generation of curves of curvatures of constant pressure, Mach number, and flow inclination.

A80-17985 * #

Turbulent flow within turbomachines having arbitrary blade geometries is examined. Effects of turbulence are modeled using two equations, one expressing the development of the turbulence kinetic energy and the other its dissipation rate. To account for complicated blade geometries, the flow equations are formulated in terms of a nonorthogonal boundary fitted coordinate system. The analysis is applied to a radial inflow turbine. The solution obtained indicates the severity of the complex interaction mechanism that occurs between the different flow regimes (i.e., boundary layers, recirculating eddies, separation zones, etc.). Comparison with nonviscous flow solutions tend to justify strongly the inadequacy of using the latter with standard boundary layer techniques to obtain viscous flow details within turbomachine rotors. Capabilities and limitations of the present method of analysis are discussed.

N80-24262* General Dynamics/Fort Worth, Tex.
EXPERIMENTAL INVESTIGATION OF A 0.15 SCALE MODEL OF A CONFORMAL VARIABLE-RAMP INLET FOR THE F-18 AIRPLANE Final Report
A 0.15 scale model of a proposed conformal variable-ramp inlet for the Multifoil Fighter was tested from Mach 0.8 to 2.2 at a wide range of angles of attack and sideslip. Inlet ramp angle was varied to optimize ramp angle to a function of engine airflow, Mach number, angle of attack, and angle of sideslip. Several inlet configuration options were investigated to study their effects on inlet operation and to establish the final inlet configuration. These variations were cowl sidewall cutback, cowl lip bluntness, boundary layer bleed, and first-ramp leading edge shape. Diagnostic and engine face instrumentation were used to evaluate inlet operation at various inlet stations and at the inlet/engine interface. Pressure recovery and stability of the inlet were satisfactory for the proposed application. On the basis of an engine study and the worst-case instantaneous disturbance patterns, no inlet/engine compatibility problems are expected for normal operations. Author

CALCULATION OF WATER DROP TRAJECTORIES TO AND ABOUT ARBITRARY THREE-DIMENSIONAL BODIES IN POTENTIAL AIRFLOW Final Report
Hiller G. Norment Washington NASA Aug 1980 83 p refs (Contract NASA-21999) (NASA-CR-3291) Avail. NTIS HC A05/MF A01 CSCL 20D Calculations can be performed for any atmospheric conditions and for all water drop sizes, from the smallest cloud droplet to large raindrops. Any subsonic, external, non-lifting flow can be accommodated, but not through, inlet also can be simulated. Experimental water drop drag relations are used in the water drop equations of motion and effects of gravity settling are included. Seven codes are described: (1) a code used to debug and plot body surface description data, (2) a code that processes the body surface data to yield the potential flow field, (3) a code that computes flow velocities at arrays of points in space, (4) a code that computes water drop trajectories from an array of points in space, (5) a code that computes water drop trajectories and fluxes to arbitrary target points, (6) a code that computes water drop trajectories tangent to the body, and (7) a code that produces stereo pair plots which include both the body and trajectories. Code descriptions include operating instructions, card inputs and printouts for example problems, and listing of the FORTRAN codes. Accuracy of the calculations is discussed, and trajectory calculation results are compared with prior calculations and with experimental data. Author

N80-22517* Stanford (John D.), University Heights, Ohio.
GENERAL DESIGN METHOD FOR THREE-DIMENSIONAL POTENTIAL FLOW FIELDS, 1: THEORY Final Report
John D. Stanitz Washington, D.C. Aug. 1980 82 p refs (Contract NAS3-21605) (NASA-CR-3288) Avail. NTIS HC A05/MF A01 CSCL 01A A general design method was developed for steady, three dimensional, potential, incompressible or subsonic-compressible flow. In this design method, the flow field, including the shape of its boundary, was determined for arbitrarily specified, continuous distributions of velocity as a function of arc length along the boundary streamlines. The method applied to the design of both internal and external flow fields, including, in both cases, fields with planar symmetry. The analytic problems associated with stagnation points, closure of bodies in external flow fields, and prediction of turning angles in three dimensional ducts were reviewed. R.C.T.

N80-31351* United Technologies Research Center, East Hartford, Conn.
INFLUENCE OF MISTUNING ON BLADE TORSIONAL FLUTTER A. V. Srinivasan Aug. 1980 55 p refs (Contract NAS3-21603) (NASA-CR-165137; R80-814546-16) Avail. NTIS HC A04/MF A01 CSCL 01A A general design method was developed for steady, three dimensional, potential, incompressible or subsonic-compressible flow. In this design method, the flow field, including the shape of its boundary, was determined for arbitrarily specified, continuous distributions of velocity as a function of arc length along the boundary streamlines. The method applied to the design of both internal and external flow fields, including, in both cases, fields with planar symmetry. The analytic problems associated with stagnation points, closure of bodies in external flow fields, and prediction of turning angles in three dimensional ducts were reviewed. R.C.T.
An analytical technique for the prediction of fan blade flutter was evaluated by utilizing first stage fan flutter data from tests on an advanced high performance engine. The formulation includes both aerodynamic and mechanical coupling among all the blades of the assembly. Mistuning is accounted for in the analysis so that individual blade inertias, frequencies, or damping can be considered, and stability was predicted by calculating a flutter determinant, the eigenvalues of which indicate the extent of susceptibility to flutter. When blade to blade differences in frequencies are considered, a stable system is predicted for the test points examined. For a tuned system, it was found that torsional flutter can be predicted at a limited number of interblade phase angles. Examination of these phase angles indicated that they were "close" to the condition of acoustic resonance. For the range of Mach numbers and reduced frequencies considered, the so-called subcritical flutter cannot be predicted. The essential influence of mechanical coupling among the blades is to change the frequencies of the system with little or no change in damping; such diffusers are named Griffith diffusers. First the formulation of the inverse problem and the method of solution are outlined. Then the typical contour of a two-dimensional diffuser and velocity distributions across the flow channel at various stations are presented. For a Griffith diffuser to operate as it is designed, boundary layer suction is necessary. Discussion of the percentage of throughflow required to balance the effect of boundary layer control is given. Finally, reference is made to the latest version of a computer program for a two-dimensional diffuser requiring only area ratio, nondimensional length and suction percentage as inputs. (Author)

EFFECTS OF AXISYMMETRIC CONTRACTIONS ON TURBULENCE OF VARIOUS SCALES Final Report


A phenomenological model developed for the prediction of helicopter blade stall is presented. The model uses a system of procedure for turbulent compressible flow in axisymmetric ducts was used to successfully model the HIMAT duct flow. The analysis technique was further used to estimate the initiation of separation and delineate the steady and unsteady flow regimes in similar S-shaped ducts. (Author)


Contoured wall diffusers are designed by using an inverse method. The prescribed wall velocity distribution(s) was taken from the high lift airfoil designed by A. A. Griffith in 1938; therefore, such diffusers are named Griffith diffusers. First the formulation of the inverse problem and the method of solution are outlined. Then the typical contour of a two-dimensional diffuser and velocity distributions across the flow channel at various stations are presented. For a Griffith diffuser to operate as it is designed, boundary layer suction is necessary. Discussion of the percentage of throughflow required to balance the effect of boundary layer control is given. Finally, reference is made to the latest version of a computer program for a two-dimensional diffuser requiring only area ratio, nondimensional length and suction percentage as inputs. (Author)


In the present paper, a semi-actuator disk theory is reviewed that was developed previously for the distorted inflow to a single-stage axial-flow compressor. Flow distortion occurs far upstream; it may be a distortion in stagnation temperature, stagnation pressure, or both. Losses, quasi-steady deviation angles, and reference incidence correlations are included in the analysis, and both subsonic and transonic relative Mach numbers are considered. The theory is compared with measurements made in a transonic fan stage, and a parameter study is carried out to determine the influence of solidity on the attenuation of distortions in stagnation pressure and stagnation temperature. V.P.


An approximate analysis applicable to nonorthogonal coordinate systems having a curved centerline and planar transverse coordinate surfaces normal to the centerline, is presented for computation of three-dimensional subsonic flow in curved diffusers. The formulation is intended to facilitate the use of constructed coordinates in circumstances where it is difficult to maintain smooth behavior in higher derivatives; the use of local Cartesian variables and fluxes leads to governing equations which
require only first derivatives of the coordinate transformation. The analysis is applied to a particular family of duct and diffuser geometries having curved centerlines and superelliptic cross sections. Qualitative agreement with experimental measurements is observed with regard to streamwise vortices and distortion of the primary flow.


An implicit finite-difference code is developed to solve either inviscid or viscous flow about two-dimensional cascade blade elements. General coordinate transformations are used so that boundaries can coincide with coordinate lines, and an automatic grid generation routine based on elliptic partial differential equations is employed to mesh arbitrary cascade elements. Characteristic combinations of the differential equations are used at inflow and outflow boundaries. Computed results for both inviscid and viscous flow are compared with other existing cascade solutions and experimental data.


An analysis is presented which has been used to predict the unsteady aerodynamic behavior of a finite supersonic cascade of airfoils forced in harmonic oscillation with airfoil-to-airfoil variations in amplitudes. Theoretical predictions are compared with some recent experimental results at a reduced frequency representative of actual fan or compressor flutter cases. The similarity of the experimental situation in the finite cascade to the flutter of a severely mistuned rotor is noted.

(Author)
03 AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations, and aircraft accidents

For related information see also 16 Space Transportation and 85 Urban Technology and Transportation

N80-15059# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
SIMULTANEOUS CABIN AND AMBIENT OZONE MEASUREMENTS ON TWO BOEING 747 AIRPLANES, VOLUME 1
Porter J Perkins, J D Holdeman, and G D Nastrom (Control Data Corp., Minneapolis, Minn.) Jul 1979 826 p refs
(NASA•TM•79166, FAA•EE•79-05, E-196) Avail NTIS
HC A99/MF A01 CSCE 01C
Measurements of ozone concentrations both outside and in the cabin of an airline operated Boeing 747SP and Boeing 747-100 airliners are presented. Plotted data and the corresponding tables of observations taken at altitude between the departure and destination airports of each flight are arranged chronologically for the two aircraft. Data were taken at five or ten minute intervals by automated instrumentation used in the NACA Global Atmospheric Sampling Program.

The initiative for starting the Aircraft-to-Satellite Data Relay (ASDAR) Program came from a recognition that much of the world's weather originates in the data sparse area of the tropics which are primarily ocean. The ASDAR system consists of (1) a data acquisition and control unit to acquire, store and format these data; (2) a clock to time the data sampling and transmission periods; and (3) a transmitter and low-profile upper hemisphere coverage antenna to relay the formatted data via satellite to the National Weather Service ground stations, as shown schematically. The low-profile antenna is a conformal antenna based on the coplanar-slot approach. The antenna is circular polarized and has an on-axis gain of nearly 2.5 dB and a HPBW greater than 90 deg. The discussion covers antenna design, radiation characteristics, flight testing, and system performance.

S.D.
The resultant composite fairing reduces the overall aircraft drag 1%


It is noted that a significant fuel savings can be achieved by reducing bleed air used for cabin air conditioning. Air in the cabin can be recirculated to maintain comfortable ventilation rates but the quality of the air tends to decrease due to entrainment of smoke and odors. Attention is given to a development system designed and fabricated under the NASA Engine Component Improvement Program to define the recirculation limit for the DC-10. It is shown that with the system, a wide range of bleed air reductions and recirculation rates is possible. A goal of 0.8% fuel savings has been achieved which results from a 50% reduction in bleed extraction from the engine.

M.E.P.


An 0.8 percent fuel savings was achieved by a reduction in engine bleed air through the use of cabin air recirculation. The recirculation system was evaluated in revenue service on a DC-10. The cabin remained comfortable with reductions in cabin fresh air (engine bleed air) as much as 50 percent. Flight test verified the predicted fuel saving of 0.8 percent.

R.C.T.

AIRCRAFT DESIGN, TESTING
AND PERFORMANCE
Includes aircraft simulation technology
For related information see also 18 Spacecraft Design, Testing and Performance and 39 Structural Mechanics.


A critical examination of flap-lag stability of a centrally hinged, spring-restrained rigid blade in forward flight is presented. Several differences in the equations of motion for blade flap-lag stability in the existing literature are identified. A rigorous and systematic development of these equations for a rigid articulated blade in forward flight shows the existence of some linear aero-dynamic coupling terms associated with blade steady-state flapping and lagging in the perturbation equations. The differences identified are shown to be associated with whether or not the lag hinge flaps with the blade. The implications of these differences on stability are examined, and it is shown that the pitch-lag coupling terms associated with a hinge arrangement in which the lag hinge flaps with the blade have a marked influence on flap-lag stability, depending on the system parameters.

(Author)


In response to recent concerns over possibly high ozone levels in the cabins of aircraft flying in the stratosphere, simultaneous measurements of the cabin and ambient ozone levels have been made as part of the NASA Global Atmospheric Sampling Program. Examples of the data taken on commercially operated Boeing 747-SP aircraft are given for selected flights, together with summaries and statistics of over 6000 observations. Cabin ozone levels vary with the ambient level and, for unmodified aircraft, are higher on the 747-SP than on the 747-100. Modifications to the ventilation system of the 747-SP reduced cabin ozone levels by varying amounts up to a factor of 14.

(Author)


The paper describes an advanced composite fairing designed to reduce drag on DC-9 nacelles as a part of the NASA Engine Component Improvement Program. This fairing is the aft enclosure for the thrust reverser actuator system on JT8D engine nacelles and is subjected to a 500 F exhaust flow during the reverse thrust. A reduced-drag configuration was developed by using in-flight tuft surveys for flow visualization in order to identify areas with low-quality flow, and then modifying the aerodynamic lines to improve the flow. A fabrication method for molding the part in an autoclave was developed; this material system is suitable for 500 F. The resultant composite fairing reduces the overall aircraft drag 1% with a weight reduction of 40% when compared with a metal component.

A.T.
A preliminary wind tunnel investigation was undertaken to determine the flow correction for a vane angle of attack sensor over an angle of attack range from -10 deg to 110 deg. The sensor was mounted ahead of the wing on a 1/5 scale model of a general aviation airplane. It was shown that the flow correction was substantial, reaching about 15 deg at an angle of attack of 90 deg. The flow correction was found to increase as the sensor was moved closer to the wing or closer to the fuselage. The system measurements are made using optical transducers which are fixed to the case. Measurements made in this way are the equivalent of those obtained by placing three surface-normal displacement transducers at three positions on each blade of an operational rotor.
AEROPROPULSION

Joseph A. Ziemianskl

Along with engine design for improved fuel consumption. For individuals and structures for reliable engine components are covered supersonic propulsion for transport aircraft, and composite materials assessed. Noise and air pollution control techniques, advances in directed at advancing the technology of turboprop powered aircraft.

PORT

Discussed in terms of efficient and economical noise reduction techniques that do not penalize the engine performance or weight. Specific topics covered include fan noise, acoustic suppression, jet noise technology, combustor noise, and aircraft noise prediction.

AIRCRAFT ENERGY EFFICIENCY (ACEE) STATUS REPORT

Donald L. Nored, James F. Dugan, Jr., Neal T. Saunders, and Joseph A. Ziemianski. In its Aeropropulsion 1979 1979 p 1-58 refs (For primary document see NBO-10205 01-07) Avail: NTIS HC A20/MF A01 CSCL 21E Fuel efficiency in aeronautics, for fuel conservation in general as well as for its effect on commercial aircraft operating economics is considered. Projects of the Aircraft Energy Efficiency Program related to propulsion are emphasized. These include: (1) engine component improvement, directed at performance improvement and engine diagnostics for prolonged service life; (2) energy efficient engine, directed at proving the technology base for the next generation of turboshaft engines; and (3) advanced turboprop, directed at advancing the technology of turboshaft powered aircraft to a point suitable for commercial airline service. Progress in these technology areas is reported.

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g.: gas turbine engines and compressors; and on-board auxiliary power plants for aircraft. For related information see also 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

ALTERNATIVE JET AIRCRAFT FUELS

Jack Groberman. In its Aeropropulsion 1979 1979 p 129-148 refs (For primary document see NBO-10205 01-07) Avail: NTIS HC A20/MF A01 CSCL 21E Potential challenges in jet aircraft fuel specifications due to shifts in supply and quality of refinery feedstocks are discussed with emphasis on the effects these changes would have on the performance and durability of aircraft engines and fuel systems. Combustion characteristics, fuel thermal stability, and fuel pumpability at low temperature are among the factors considered. Combustor and fuel system technology needs for broad specification fuels are reviewed including prevention of fuel system fouling and fuel system technology for fuels with higher freezing points.

MATERIALS AND STRUCTURES TECHNOLOGY

Robert A. Signorelli, Thomas K. Glassgow, Gary R. Halford, and Stanley R. Levine. In its Aeropropulsion 1979 1979 p 149-186 refs (For primary document see NBO-10205 01-07) Avail: NTIS HC A20/MF A01 CSCL 21E Materials and structures performance limitations, particularly for the hot section of the engine, in which these limitations limit the life of components, are considered. Failure modes for components such as blades, vanes, and combustors and how they are affected by the environment for such components are discussed. Methods used to improve the materials used for such components are: (1) application of directional structures to turbine components for high strength at high temperatures; (2) improved coatings to increase oxidation and corrosion resistance; (3) increased strength and stiffness with reduced weight by applying higher specific properties of composite materials; and (4) cost effective processing such as near net shape powder methods applied to disks. Life prediction techniques developed to predict component life accurately in advance of service and progress in improving the intermediate and cold section components of turbine engines are covered.

TURBOMACHINERY TECHNOLOGY

Cavour H. Hauser, Jeffrey E. Haas (U.S. Army Res. and Technol. Labs., Cleveland, Ohio), Lonnie Reid, and Francis S. Stepka. In its Aeropropulsion 1979 1979 p 231-272 (For primary document see NBO-10205 01-07) Avail: NTIS HC A20/MF A01 CSCL 21E A technology assessment of turbomachinery is presented. The design of the fan, compressor, and turbine components for future advanced aircraft engines is discussed. Basic flow characteristics in compressors and turbines and the heat transfer phenomena in cooled turbines are also discussed.

COMPUTATIONAL FLUID MECHANICS OF INTERNAL FLOW

David N. Bowditch, William D. McNally, Bernhard H. Anderson, John J. Adamczyk, and Peter M. Sockol. In its Aeropropulsion 1979 1979 p 187-230 refs (For primary document see NBO-10205 01-07) Avail: NTIS HC A20/MF A01 CSCL 21E Major solution techniques for internal computational fluid mechanics are discussed and some examples are presented. The major steps involved in developing a large computer code are then discussed.

REFERENCES

10205 01-07) National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

10210 01-07) National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

10212 01-07) National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

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10207 01-07) National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

10208 01-07) National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

10209 01-07) National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANICAL COMPONENTS

William J. Anderson, Robert C. Bill, John J. Coy, and David Fleming. In its Aeropulsion 1979 1979 p 273-308 refs (For primary document see N80-10205 01-07)

Avail. NTIS HC A20/MF A01 CSCL 21E

Research on bearings, gears, seals, and rotor dynamics (specifically high speed balancing and dampers) is presented. The research pertains to problems in both aircraft turbine engines and helicopter transmissions. R.E.S.

INSTRUMENTATION TECHNOLOGY

William C. Nieburding, David R. Englund, Jr., and George E. Glawe. In its Aeropulsion 1979 1979 p 309-328 refs (For primary document see N80-10205 01-07)

Avail. NTIS HC A20/MF A01 CSCL 21E

Some of the efforts made in applying technologically new tools to today's propulsion measurement problems are described. They include: (1) a blade-tip clearance system; (2) a pulsed thermocouple system used to measure gas temperature with a thermocouple at temperatures above the melting point of the thermocouple; (3) an optical technique for measuring blade flutter; (4) a probe for dynamic flow and flow angle measurement; and (5) a laser anemometer system for rapidly mapping the flow profiles between the blades of a rotating compressor. R.E.S.

SUPERSONIC PROPULSION TECHNOLOGY

John R. Szuch. In its Aeropulsion 1979 1979 p 329-344 refs (For primary document see N80-10205 01-07)

Avail. NTIS HC A20/MF A01 CSCL 21E

An overview of engine control technology is presented with emphasis on gas turbine engine controls. The role of the government, and NASA in particular, in advancing this technology is discussed. R.E.S.

SUPERSONIC PROPULSION TECHNOLOGY


Avail. NTIS HC A20/MF A01 CSCL 21E

Propulsion concepts for commercial supersonic transports are discussed. It is concluded that variable cycle engines, together with advanced supersonic inlets and low noise coaxial nozzles, provide good operating performance for both supersonic and subsonic flight. In addition, they are reasonably quiet during takeoff and landing and have acceptable exhaust emissions. K.L.

HYPERSONIC PROPULSION

H. Lee Beach, Jr. In its Aeropulsion 1979 1979 p 387-408 refs (For primary document see N80-10205 01-07)

Avail. NTIS HC A20/MF A01 CSCL 21E

Research on hydrogen fueled scramjet engines for hypersonic flight is reviewed. Component developments, computational methods, and preliminary ground tests of subsonic scramjet engine modules at Mach 4 and 7 are emphasized. Airframe integration, structures, and flow diagnostics are also discussed. It is shown that mixed-mode perpendicular and parallel fuel injection controls heat release over a wide Mach range and the fixed geometry inlet gives good performance over a wide range of Mach numbers. K.L.

VERTICAL TAKEOFF AND LANDING (VTOL) PROPULSION TECHNOLOGY

Carl C. Ciepluch, John M. Abbott, Royce D. Moore, and James F. Sellers. In its Aeropulsion 1979 1979 p 409-444 refs (For primary document see N80-10205 01-07)

Avail. NTIS HC A20/MF A01 CSCL 21E

Propulsion problems and advanced technology requirements of VTOL aircraft are discussed. Specific topics covered include inlets with high angle of attack capability, rapid thrust modulation fans, and propulsion-system/aircraft-control integration. K.L.

INFLUENCE OF COOLANT TUBE CURVATURE ON FILM COOLING EFFECTIVENESS AS DETECTED BY INFRARED IMAGERY


Thermal film cooling footprints observed by infrared imagery from straight, curved, and looped coolant tube geometries are compared. It was hypothesized that the differences in secondary flow and in the turbulence structure of flow through these three tubes should influence the mixing properties between the coolant and the mainstream. A flow visualization tunnel, an infrared camera and detector, and a Hilische were employed to test the hypothesis. A.W.H.
data, it was demonstrated that the blade-order sampling of pressure data may yield erroneous results due to the interference caused by blade vibration. Two methods are presented which effectively eliminate this interference yielding the blade-pressure-difference spectra. The phase difference between the differential-pressure and the displacement spectra was evaluated.

Author

N80-13047*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ATOMIZING CHARACTERISTICS OF SWIRL CAN COMBUSTOR MODULES WITH SWIRL BLAST FUEL INJECTORS


Cold flow atomization tests of several different designs of swirl can combustor modules were conducted in a 7.6 cm diameter duct at airflow rates (per unit area) of 7.3 to 25.7 g/sq cm sec and water flow rates of 6.3 to 18.9 g/sec. The effect of air and water flow rates on the mean drop size of water sprays produced with the swirl blast fuel injectors were determined. Also, from these data it was possible to determine the effect of design modifications on the atomizing performance of various fuel injector and air swirler configurations. The trend in atomizing performance, as based on the mean drop size, was then compared with the trends in the production of nitrogen oxides obtained in combustion studies with the same swirl can combustors. It was found that the fuel injector design that gave the best combustor performance in terms of a low NOx emission index also gave the best atomizing performance as characterized by a spray of relatively small mean drop diameter. It was also demonstrated that when constant inlet air stream momentum the nitrogen oxides emission index was found to vary inversely with the square of the mean drop diameter of the spray produced by the different swirl blast fuel injectors. Test conditions were inlet air static pressures of 100,000 to 200,000 N/sq m at an inlet air temperature of 293 K. Author

N80-14121*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STATIC TEST-STAND PERFORMANCE OF THE YF-102 TURBOFAN ENGINE WITH SEVERAL EXHAUST CONFIGURATIONS FOR THE QUIET SHORT-HAUL RESEARCH AIRCRAFT (QSRA)


The performance of a YF-102 turbofan engine was measured in an outdoor test stand with a bellmouth inlet and seven exhaust-system configurations. The configurations consisted of three separate-flow systems of various fan and core nozzle sizes and four confluent-flow systems of various nozzle sizes and shapes. A computer program provided good estimates of the engine performance and of thrust at maximum rating for each exhaust configuration. The internal performance of two different-shaped core nozzles for confluent-flow configurations was determined to be satisfactory. Pressure and temperature surveys were made with a traversing probe in the exhaust-nozzle flow for some confluent-flow configurations. The surface temperature data was measured flow rates, were used to calculate the static-pressure variation along the exhaust nozzle length. The computed pressures compared well with experimental wall static-pressure data. External-flow surveys were made, for some confluent-flow configurations, with a large fixed rake at various locations in the exhaust plume. A.R.H.

SUBJECTED TO INTERNAL AND EXTERNAL AERIAL TRANSIENTS

N80-14126*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DYNAMIC RESPONSE OF A MACH 2.5 AXIASSYMETRIC INLET AND TURBOJET ENGINE WITH A POPPET-VALUE CONTROLLED INLET STABILITY BYPASS SYSTEM WHEN

N80-14124*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TURBOJET-EXHAUST-NOZZLE SECONDARY-AIRFLOW PUMPING AS AN EXIT CONTROL OF AN INLET-STABILITY BYPASS SYSTEM FOR A MACH 2.5 AXIASSYMETRIC MIXED-COMPRESSION INLET


The throat of a Mach 2.5 inlet that was attached to a turbojet engine was fitted with large, porous bleed areas to provide a stability bypass system that would allow a large, stable airflow range. Exhaust-nozzle, secondary-airflow pumping was used as the exit control for the stability bypass airflow. Propulsion system response and stability bypass performance were obtained for several transient airflow disturbances, both internal and external. Internal airflow disturbances included reductions in overboard bypass airflow, power lever angle, and primary-nozzle area, as well as compressor stall. Nozzle secondary pumping as a stability bypass exit control can provide the inlet with a large stability margin with no adverse effects on propulsion system performance. Author
Takeoff and Landing aircraft engines, and to verify this technology in full-scale engine tests in 1983. The program consists of three phases: Combustor Concept Screening, Combustor Optimization Testing, and Engine Verification Testing. The development and screening of the combustion system designs for the CF6-80 engine and the JT9D-7 engine, respectively, in high-pressure sector test rigs are reported.

N80-14128* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LASER-OPTICAL BLADE TIP CLEARANCE MEASUREMENT SYSTEM

A laser-optical measurement system was developed to measure single blade tip clearances and average blade tip clearances between a rotor and its gas path seal in rotating component rigs and complete engines. The system is applicable to fan, compressor and turbine blade tip clearance measurements. The engine mounted probe is particularly suitable for operation in the extreme turbine environment. The measurement system consists of an optical subsystem, an electronic subsystem and a computing and graphic terminal. Bench tests and environmental tests were conducted to confirm operation at temperatures, pressures, and vibration levels typically encountered in an operating gas turbine.

N80-16127* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

Q U I E T  P O W E R E D - L I F T  P R O P U L S I O N
1979 426 p. refs Conf. held at Cleveland, Ohio, 14-15 Nov. 1978
(NASA-CP-2077; E-9906) Avail: NTIS HC A19/MF A01 CSCL 21E

Latest results of programs exploring new propulsion technology for powered-lift aircraft systems are presented. Topics discussed include results from the "quiet short-haul experimental engine" program and progress reports on the 'quiet short-haul research aircraft' and "ill-rotor research aircraft" programs. In addition to these NASA programs, the Air Force AMST YC 14 and YC 15 programs were reviewed.

R.E.S.

N80-15128* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

D I R E C T  I N T E G R A T I O N  O F  T R O T O R  D Y N A M I C S
(NASA-TP-1597; AWRADCOM-Tr-79-42; E-101) Avail: NTIS HC A02/MF A01 CSCL 21E

An implicit method was developed for integrating the equations of motion for a lumped mass model of a rotor dynamics system. As an aside, a closed form solution to the short bearing theory was also developed for a damper with arbitrary motion. The major conclusions are that the method is numerically stable and that the computation time is proportional to the number of elements in the rotor dynamics model rather than to the cube of the number. This computer code allowed the simulation of a complex rotor bearing system experiencing nonlinear transient motion and displayed the vast amount of results in an easily understood motion picture format - a 10 minute, 16 millimeter, color, sound motion picture supplement. An example problem with 19 mass elements in the rotor dynamics model took 0.7 second of central processing unit time per time step on an IBM 360-67 computer in a time sharing mode.

N80-15132* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


The use of computerized simulations of the steady state and transient performance of jet engines throughout the flight regime is discussed. In addition, installation effects on thrust and specific fuel consumption are accounted for as well as engine weight, dimensions and cost. The availability throughout the government and industry of analytical methods for calculating these quantities are pointed out.

N80-15133* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


A description is presented of an orderly test program that progresses from the simplest stationary geometry to the more complex, three dimensional, rotating turbine stage. The instrumentation requirements for this evolution of testing are described. The heat transfer instrumentation is emphasized. Recent progress made in devising new measurement techniques has greatly improved the development and confirmation of more accurate analytical methods for the prediction of turbine performance and heat transfer. However, there remain challenging requirements for novel measurement techniques that could advance the future research to be done in rotating blade rows of turbomachines.

N80-15134* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


A subscale HiMAT forebody and inlet was investigated over a range of Mach numbers to 1.4. The inlet exhibited a transitory separation within the diffuser but steady state data indicated reattachment at the diffuser exit. A finite difference procedure for turbulent compressible flow in axisymmetric ducts was used to successfully model the HiMAT duct flow. The analysis technique was further used to estimate the initiation of separation and delineate the steady and unsteady flow regimes in similar S-shaped ducts.

N80-17071* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

(NASA-TP-1610; E-136) Avail: NTIS HC A06/MF A01 CSCL 21E

The aerodynamic performances of four stator-blade rows are presented and evaluated. The aerodynamic designs of two of these stators were compromised to reduce noise, a third design was not. On a calculated operating line passing through the design point pressure ratio, the best stator had overall pressure-ratio and efficiency decrements of 0.031 and 0.044, respectively, providing a stage pressure ratio of 1.483 and efficiency of 0.865. The other stators showed some correctable deficiencies due partly to the design compromises for noise. In the end-wall regions blade-element losses were significantly less for the shortest chord studied.

Author
NBO-18039\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

**METHOD AND APPARATUS FOR RAPID THRUST INCREASES IN A TURBOFAN ENGINE** Patent
Jack E. Cornett (GE, Cincinnati, Ohio), Ralph C. Conley (GE, Cincinnati, Ohio), Thomas O. Frear (GE, Cincinnati, Ohio), and Andrew A. Saunders, Jr., inventors (to NASA) (GE, Cincinnati, Ohio) Issued 22 Jan 1980 9 p Filed 9 Dec. 1977 Sponsored by NASA


Upon landing, the normal compressors were temporarily closed to substantially reduce the speed to the takeoff thrust level by advancing the engine speed through the use of high load compressor speed in order to maintain fan speed and thrust. This running of the compressor at an off-design speed substantially reduces the time required to subsequently advance the engine speed to the takeoff thrust level by advancing the throttle and opening the compressor stators.

Official Gazette of the U.S. Patent and Trademark Office

NBO-18043\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

**AEROPROPELLUSION IN YEAR 2000**

21A A sampling of probable future engine types, such as convertible engines for helicopters, turboprops for high-speed aircraft and variable-cycle engines for supersonic transports are presented. Related technology improvements in propellers, materials, noise suppression, etc. are reviewed R.E.S.

NBO-18110\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

**PRELIMINARY STUDY OF VTO THRUST REQUIREMENTS FOR A V/STOL AIRCRAFT WITH LIFT PLUS LIFT/CRUISE PROPULSION**

A preliminary assessment was made of the VTO thrust requirements for a supercritical (Type 8) aircraft with a lift plus lift/cruise propulsion system. A baseline aircraft with a takeoff gross weight (TOGW) of 13,608 kg (30,000 lb) was assumed. Pitch, roll, and yaw control efforts (i.e., the thrusts needed for aircraft attitude control in the flight hover mode) were estimated based on a specified set of maneuver acceleration requirements for V/STOL aircraft. Other effects (such as installation losses, suction, reentry, etc.), which add to the thrust requirements for VTO were also estimated. For the baseline aircraft, the excess thrust required for attitude control of the aircraft during VTOL and flight hover was estimated to range from 36.3 to 50.9 percent of the TOGW. It was concluded that the total thrust requirements for the aircraft propulsion system are large and significant. In order to achieve the performance expected of this aircraft propulsion system, reductions must be made in the excess thrust requirements.

J.M.S.

NBO-20274\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

**OPTIMUM SUBSONIC, HIGH-ANGLE-OF-ATTACK NACELLES**

21E The optimum design of nacelles that operate over a wide range of aerodynamic conditions and their inlets is described. For low speed operation the optimum internal surface velocity distributions and skin friction distributions are described for three categories of inlets: those with BLC, and those with inlets with high and low skin friction. At cruise speed the effect of factors that reduce the nacelle external surface area and the local skin friction is illustrated. These factors are cruise Mach number, inlet throat size, fan-face Mach number, and nacelle contour. The interrelation of these cruise speed factors with the design requirements for good low speed performance is discussed. J.M.S.

NBO-20275\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

**EXPERIMENTAL EVALUATION OF A SPINNING-MODE ACOUSTIC-TREATMENT DESIGN CONCEPT FOR AIRCRAFT INLETS**

21E An aircraft inlet noise suppressor method based on mode cutoff ratio was quantitatively checked by testing a series of liners on a YF-102 turbofan engine. Far-field directivity of the blade passing frequency was measured in order to evaluate the results. The trends and observations of the test data lend much qualitative
AERODYNAMIC PERFORMANCES OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 METERS PER SECOND AND PRESSURE RATIO OF 1.54. RELATION OF ANALYTICAL CODE CALCULATIONS TO EXPERIMENTAL PERFORMANCE. 

Thomas F. Gelder, James F. Schmidt, and Genevieve M. Esgar. 

A hub-to-shroud and a blade-to-blade internal-flow analysis code, both inviscid and basically subsonic, were used to calculate the flow parameters over the middle and rear sections of the stators. The predicted potential benefits of a blade designed with the aid of these flow analysis codes are illustrated by a proposed redesign of one of the four stators studied. An overall efficiency improvement of 1.6 points above the flow parameters within four stator-blade rows. The produced a suppression at design frequency of 19 dB per unit length. 

Author

AERODYNAMIC PERFORMANCES OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 METERS PER SECOND AND PRESSURE RATIO OF 1.54. RELATION OF ANALYTICAL CODE CALCULATIONS TO EXPERIMENTAL PERFORMANCE. 

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A hub-to-shroud and a blade-to-blade internal-flow analysis code, both inviscid and basically subsonic, were used to calculate the flow parameters over the middle and rear sections of the stators. The predicted potential benefits of a blade designed with the aid of these flow analysis codes are illustrated by a proposed redesign of one of the four stators studied. An overall efficiency improvement of 1.6 points above the peak measured for that stator is predicted for the redesign. 

Author

AERODYNAMIC PERFORMANCES OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 METERS PER SECOND AND PRESSURE RATIO OF 1.54. RELATION OF ANALYTICAL CODE CALCULATIONS TO EXPERIMENTAL PERFORMANCE. 

Thomas F. Gelder, James F. Schmidt, and Genevieve M. Esgar. 

A hub-to-shroud and a blade-to-blade internal-flow analysis code, both inviscid and basically subsonic, were used to calculate the flow parameters over the middle and rear sections of the stators. The predicted potential benefits of a blade designed with the aid of these flow analysis codes are illustrated by a proposed redesign of one of the four stators studied. An overall efficiency improvement of 1.6 points above the peak measured for that stator is predicted for the redesign. 

Author
and advanced general aviation engines is described. Current research is directed at the near-term improvement of conventional air-cooled spark-ignition piston engines and at future alternative engine systems based on all-new spark-ignition piston engines, lightweight diesels, and rotary combustion engines that show potential for meeting program goals in the mid-term and long-term future. The conventional piston engine activities involve efforts on applying existing technology to improve fuel economy, investigation of key processes to permit leaner operation and reduce drag, and the development of cost-effective technology to permit flight at high-altitudes where fuel economy and safety are improved. The advanced engine concepts activities include engine conceptual design studies and enabling technology efforts on the critical or key technology items.

R.E.S.

N80-22340ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

POSITIVE DISPLACEMENT TYPE GENERAL-AVIATION ENGINES: SUMMARY AND CONCLUDING REMARKS


Avail NTIS HC A19/MF A01 CSCL 21E

The activities of programs investigating various aspects of aircraft internal combustion engines are briefly described including developments in fuel injection technology, cooling systems and drag reduction, turbocharger technology, and stratified-charge rotary engines.

M.G.

N80-22341ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA PROPELLER TECHNOLOGY PROGRAM


Avail NTIS HC A19/MF A01 CSCL 21E

A program on propeller technology applicable to both low and high speed general aviation aircraft is summarized, and the overall program objectives and approach are outlined.

M.G.

N80-22344ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HIGH-SPEED-PROPELLER WIND-TUNNEL AEROACOUSTIC RESULTS


Avail NTIS HC A19/MF A01 CSCL 21E

Some aerodynamic concepts are presented together with an explanation of how these concepts are applied to advanced propeller design. The unique features of this propulsion system are addressed with emphasis on the design concepts being considered for the high speed turboprop. More particular emphasis is given to the blade sweep, long blade chords, and the large number of blades.

R.C.T.

N80-22345ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ADVANCED PROPELLER AERODYNAMIC ANALYSIS

Lawrence J. Bober In Its Gen. Aviation Propulsion Mar. 1980 p 335-336 (For primary document see N80-22327 13-07)

Avail NTIS HC A19/MF A01 CSCL 21E

The analytical approaches as well as the capabilities of three advanced analyses for predicting propeller aerodynamic performance are presented. It is shown that these two of these analyses use a lifting line representation for the propeller blades, and the third uses a lifting surface representation.

R.C.T.

N80-22346ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF THERMAL CYCLING ON ZrO2-Y2O3 THERMAL BARRIER COATINGS


A study was made of the comparative life of plasma sprayed ZrO2-Y2O3 thermal barrier coatings on NiCrAlY bond coats on Rene 41 in short (4 min) and long (57 min) thermal cycles to 1400 C in a Mach 1.3 Mach flame. Short cycles greatly reduced the life of the ceramic coating in terms of time at temperature as compared to longer cycles. Appearance of the failed coating indicated compressive failure. Failure occurred at the bond coat-ceramic coat junction. At heating rates greater than 550 kw/sq m, the calculated coating detachment stress was in the range of literature values of coating adhesive cohesive strength. Methods are discussed for decreasing the heating rate by avoiding compressive stress.

Author

N80-22350ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY STUDY OF ADVANCED TURBOPROP AND TURBOSHAFIT ENGINES FOR LIGHT AIRCRAFT


The effects of engine configuration, advanced component technology, compressor pressure ratio and turbine rotor-inlet temperature on such figures of merit as vehicle gross weight, mission fuel, aircraft acquisition cost, operating, cost and life cycle cost are determined for three fixed- and two rotary-wing aircraft. Compared with a current production turboprop, an advanced technology (1988) engine results in a 23 percent decrease in specific fuel consumption. Depending on the figure of merit and the mission, turbine engine cost reductions required to achieve aircraft cost parity with a current spark ignition reciprocating (SIR) engine vary from 0 to 60 percent and from 6 to 24 percent with a hypothetical advanced SIR engine. Compared with a hypothetical turboshaft using currently available technology (1978), an advanced technology (1988) engine installed in a light twin-engine helicopter results in a 16 percent reduction in mission fuel and about 11 percent in most of the other figures of merit.

A R.H.

N80-22331ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SIGNIFICANCE OF THERMAL CONTACT RESISTANCE IN TWO-LAYER THERMAL-BARRIER-COATED TURBINE VANES


The importance of thermal contact resistance between layers in heat transfer through two-layer plasma sprayed, thermal barrier coatings applied to turbine vanes was investigated. Results obtained with a system of NiCrAlY bond and yttria stabilized zirconia ceramic show that thermal contact resistance between layers is negligible. These results also verified other studies which showed that thermal contact resistance is negligible for a different coating system of NiCr bond calcium stabilized zirconia ceramic. The zirconia stabilized ceramic thermal conductivity data scatter presented in the literature is ±20 to ±10 percent about a curve fit of the data. More accurate predictions of heat transfer and metal wall temperatures are obtained when the thermal conductivity values are used at the ±20 percent level.

E.D.K.

N80-22332ʃ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DEVELOPMENT OF IMPROVED-DURABILITY PLASMA SPRAYED CERAMIC COATINGS FOR GAS TURBINE ENGINES

Irving E. Sumner and Duane L. Ruckie (Pratt and Whitney Aircraft, Lewis Research Center, Cleveland, Ohio.

18
As part of a NASA program to reduce fuel consumption of current commercial aircraft engines, methods were investigated for improving the durability of plasma sprayed ceramic coatings, with a focus on vane platforms in the JT90 turbofan engine. Increased durability concepts under evaluation include use of improved strain tolerant microstructures and control of the substrate temperature during coating application. Initial burner rig test conducted at temperatures of 1010°C (1850°F) indicate that improvements in cyclic life greater than 20:1 over previous ceramic coating systems were achieved. Three plasma sprayed coating systems applied to first stage vane platforms in the JT90 engine showed increased lifetime, strain tolerant microstructures, and better control of the substrate temperature during coating application.

The acoustic suppression capability of bulk absorber material designed for use in the fan exhaust duct walls of the quiet clean short haul experiment engine (OCSEE UTW) was evaluated. The acoustic suppression to the original design for the engine fan duct which consisted of phased single degree-of-freedom wall treatment was tested with a splitter and also with the splitter removed. Peak suppression was about as predicted with the bulk absorber configuration, however, the broadband characteristics were not attained. Post test inspection revealed surface oil contamination on the bulk material which could have caused the loss in bandwidth suppression.

The acoustic suppression capability of bulk absorber material designed for use in the unsteady inflow distortion modes (turbulence) were eliminated. Inflow control devices (ICD's) apparently introduced propagating modes which could be recognized by additional lobes in the speeds; at supersonic fan tip speed the smallest (CD's had some measurable loss, but the largest had no loss. Data from a typical transducer show that the unsteady inflow distortion modes (turbulence) were eliminated or significantly reduced when either of the ICD's was installed. However, some steady inflow distortion modes remained.

The four stage turbine configuration produced design equivalent specific work of 78.84 J/g at an engine turbine tip speed of 579.1 m/sec. At design speed and pressure ratio, the total efficiency of the turbine was 78% with a difference from the 0.855 obtained for the complete 4 1/2 stage turbine in a previous investigation. The turbine was designed and the procedure embodied the following design features: (1) controlled vortex flow, (2) tailored radial work distribution, and (3) control of the location of the boundary-layer transition point on the airfoil suction surface. The efficiency

To enable accurate simulation of in-flight fan tone noise during ground static tests, four devices intended to reduce inflow disturbances and turbulence were tested with a JT15D-1 turbofan engine. These inflow control devices (ICD's) consisted of honeycomb/screen structures mounted over the engine inlet. The ICD's ranged from 1.6 to 4 fan diameters in size, and differed in shape and fabrication method. All the ICD's significantly reduced the BPF noise in the far-field directivity patterns, but the smallest ICD's apparently introduced propagating modes which could be recognized by additional lobes in the speeds; at supersonic fan tip speed the smallest ICD's had some measurable loss, but the largest had no loss. Data from a typical transducer show that the unsteady inflow distortion modes (turbulence) were eliminated or significantly reduced when either of the ICD's was installed. However, some steady inflow distortion modes remained.

A cooperative government-industry effort, the Energy Efficient Engine Project, to develop the advanced technology base for future commercial development of a new generation of more fuel conservative turbofan engines for airline use is described. Engine configurations that are dependent upon technology advances in each major engine component are defined and current design and development of the advanced components are included.

A solid version of a 50.8 cm single stage core turbine designed for high temperature was tested in cold air over a range of speed and pressure ratio. Design equivalent specific work was 75.84 J/g at an engine turbine tip speed of 579.1 m/sec. At design speed and pressure ratio, the total efficiency of the turbine was 88.9% percent, which is 0.8 point lower than the design value of 89.2%. The corresponding mass flow was 4.0 percent greater than design.
TURBINE SHROUDS: HEAT TRANSFER ANALYSIS
compared to an all impingement air cooled, all metal shroud, determine the layer thicknesses required to maintain a limiting
of ceramic and porous metal layer thicknesses and of porous
shroud consisting of a ceramic thermal barrier layer bonded to
poppet. The graphite composite poppet in combination with a
ACTUATORS
porous metal layer which, in turn, is bonded to a metal baFr,
(NASA-TM-81539; E-402) Avail: NTIS HC A02/MF A01 CSCL
sponsored by Soc. of Automotive Engr.
use in digital electronic controls for gas turbine engines. E.D.K.
was evident in an aluminum poppet and in graphite composite
was tested for over 100 million cycles. Serious damage was

THE QUIET SHORT-HAUL RESEARCH AIRCRAFT
inefficient component.
The porous metal layer serves to mitigate the strain differences
with fan discharge pressure, to simulate the QSR A bleed
requirements, No stability, surge, stall, overtemperaturs, combustor
with fan discharge pressure, to simulate the QSRA bleed
system, For the steady-state tests, the engine operated satisfac-
size to the quiet short-haul research aircraft (QSRA) exhaust
system. For the steady-state tests, the engine operated satisfactor-
with core bleed up to 14 percent of the core inlet flow. For the
transient tests the engine accelerated and decelerated satisfactorily with no core bleed and with core bleed up to
11 percent of the core inlet flow (maximum tested). For some of the tests the core-bled flow rate was scheduled to vary
with a two dimensional cascade analysis

N80-29300*/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIRCRAFT RESEARCH AND TECHNOLOGY FOR FUTURE FUELS
Jul. 1980 229 p refs Symp, held in Cleveland, Ohio, 16-17 Apr. 1980
(NASA-CP-21446; E-398) Avail: NTIS HC A11/MF A01 CSCL

N80-27363* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
NUMERICAL CALCULATION OF TRANSONIC AXIAL TURBOMACHINERY FLOWS
(NASA-TM-81544, E-600) Avail NTIS HC A02/MF A01 CSCL 21E
A numerical method and the results of a computer program are presented for solving an exact, three dimensional, full potential
equation that models rotating and nonrotating inviscid, absolutely
irrotational, homentropic flows. Besides calculating the flows
through an arbitrarily shaped rotor or stator blade row mounted on
an axisymmetric hub and confined in an axisymmetric duct, the computer program is also capable of analyzing flow fields
about arbitrarily shaped wing body combinations, propellers,
helicopter rotors in hover, and wind turbine rotors. The governing
equation is solved numerically in a fully conservative form by
using an artificial time concept, a finite volume technique, rotor
type dependent differencing, successive line overrelaxation, and
sequential boundary conforming grid refinement. An artificial
viscosity is added in fully conservative form, and an initial guess
for the potential field is applied, as determined by a two
dimensional cascade analysis

N80-27362* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
COMPOSITE WALL CONCEPT FOR HIGH TEMPERATURE TURBINE SHROUDS: HEAT TRANSFER ANALYSIS
(NASA-TM-81539; E-402) Avail: NTIS HC A02/MF A01 CSCL 21E
A heat transfer analysis was made of a composite wall shroud consisting of a ceramic thermal barrier layer bonded to a porous metal layer which, in turn, is bonded to a metal base. The porous metal layer serves to mitigate the strain differences between the ceramic and the metal base. Various combinations of ceramic and porous metal layer thicknesses and of porous metal densities and thermal conductivities were investigated to determine the layer thicknesses required to maintain a limiting temperature of 30 percent of the ceramic layer temp. Analysis showed that the composite wall offered significant air cooling flow reductions compared to all impingement air cooled, all metal shroud.
The potential characteristics of future aviation turbine fuels and the property effects of these fuels on propulsion system components are examined. The topics that are discussed include jet fuel supply and demand trends, the effects of refining variables on fuel properties, shale oil processing, the characteristics of broadened property fuels, the effects of fuel property variations on combustor and fuel system performance, and combustor and fuel system technology for broadened property fuels. For individual titles, see N80-29301 through N80-29330.

**FUTURE AVIATION FUELS OVERVIEW**


**N80-29301** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

**FUELS CHARACTERIZATION STUDIES**


**N80-29303** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

**GAS TURBINE TECHNOLOGY PROGRAM**


**N80-29317** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

**PRELIMINARY STUDIES OF COMBUSTOR SENSITIVITY TO ALTERNATIVE FUELS**


**N80-29324** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

**ANTIMISTING KEROSENE**


**N80-29319** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

**ALTERNATIVE FUELS**


**N80-29310** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
Alternative fuels or crude substitutes are examined with respect to satisfying aviation fuel needs for the next 50 years. The thermal stability of potential future fuels is discussed and the effects of these characteristics on aircraft fuel systems are examined. Advanced fuel system technology and design guidelines for future fuels with lower thermal stability are reported.

FUEL SYSTEM TECHNOLOGY OVERVIEW

Reliable flight toads and component clearances on performance are affected by fuel temperatures. Fuel systems for high freezing point fuels; characteristics of the fuel; topics include: (1) analysis of in-flight conducted to investigate the correlations and interactions of fuel system research and technology studies are being conducted to investigate the correlations and interactions of fuel Topics include: (1) analysis of in-flight fuel temperatures, (2) fuel systems for high freezing point fuels, (3) experimental study of low temperature pumpability, (4) full scale fuel tank simulation, and (5) rapid freezing point measurement.

INVESTIGATION OF PERFORMANCE DETERIORATION OF THE CF6/JT9D, HIGH-BYPASS RATIO TURBOFAN ENGINES


The aircraft energy efficiency program within NASA is developing technology required to improve the fuel efficiency of commercial subsonic transport aircraft. One segment of this program includes engine diagnostics which is directed toward determining the sources and causes of performance deterioration in the Pratt and Whitney Aircraft JT9D and General Electric CF6 high-bypass ratio turbine engines and developing technology for minimizing the performance losses. Results of engine performance deterioration investigations based on historical data, special engine tests, and specific test to define the influence of flight loads and component clearances on performance are presented. The results of analysis of several damage mechanisms that contribute to performance deterioration such as blade tip rubs, aerofoil surface roughness and erosion, and thermal distortion are also included. The significance of these damage mechanisms on component and overall engine performance is discussed.

DESCRIPTION OF THE WARM CORE TURBINE FACILITY RECENTLY INSTALLED AT NASA LEWIS RESEARCH CENTER


The two net facilities were installed and operated at their design, or rated conditions. The important feature of both of these facilities is that the ratio of turbine inlet temperature to coolant temperature encountered in high temperature engines can be duplicated at moderate turbine inlet temperature. The limits of the facilities with regard to maximum temperature, maximum pressure, maximum mass flow rate, turbine size, and dynamometer torque-speed characteristics are discussed.

THE NASA HIGH-SPEED TURBOPROP PROGRAM


Technology readiness for Mach 0.7 to 0.8 turboproppowered aircraft with the potential for fuel savings, DOC reductions of up to 30 percent, and improvements in combat avionics, propulsion structures, turboprop installation performance, aircraft cabin environment, and advanced engine and aircraft studies are emphasized. Large scale propulsion characteristics and high speed propeller flight research tests using a modified testbed aircraft are also considered.
The Engine Component Improvement (ECI) Project formulated to address near term improvements for current engines is described. The technical and economical feasibility and the fuel saving potential of several damage mechanisms that contribute to performance deterioration such as blade tip rubs, airfoil surface toughness and erosion, and thermal distortion are also included. The significance of these damage mechanisms on component and overall engine performance is discussed.

E. D. K.

The objective of this paper is to utilize the design methods of modern control theory to realize a 'dual-adaptive' feedback control unit for a highly non-linear single spool airbreathing turbojet engine. Using a very detailed and accurate simulation of the non-linear engine as the data source, linear operating point models of unspecified dimension are identified. Feedback control laws are designed at each operating point for a prespecified set of sampling rates using sampled-data output regulator theory. The control system sampling rate is determined by an adaptive sampling algorithm in correspondence with turbojet engine performance. The result is a 'dual-adaptive' control law that is functionally dependent upon the sampling rate selected and environmental operating conditions. Simulation transients demonstrate the utility of the dual-adaptive design to improve on-board computer utilization while maintaining acceptable levels of engine performance.

(Author)

Improving fuel efficiency, new sources of jet fuel, and noise and emission control subjects of NASA's aeronautics program. Projects aimed at achieving a 5% fuel savings for existing engines and a 13-22% savings for the next generation of turbofan engines using advanced technology are described. The paper concludes with a discussion of the current status of each of the 16 program, an Evolution of commercial air transports with 30-40% savings over conventional turbofan aircraft at comparable speeds and altitudes, is discussed. Fuel sources are considered in terms of reduced hydrogen and higher aromatic contents and resultant higher liner temperatures, and attention is given to lean burning, improved fuel atomization, higher freezing-point fuel, and deriving jet fuel from shale oil or coal. Noise sources include the fan, turbine, combustion process, and flow over internal struts, and attenuation using acoustic treatments, are discussed, with near-term reduction of polluting gaseous emissions at both low and high power, and far-term defining of the minimum gaseous-pollutant levels possible from turbine engines are also under study.

J.P.B.


The paper discusses the availability throughout the government and industry of analytical methods for calculating both the steady state and transient performance of an aircraft engine during an entire flight regime. The historical development of some of the analytical tools capable of evaluating installation effects on engine performance is traced and their present status is described.

C.F.W.


The Engine Component Improvement (ECI) Program is NASA sponsored and is specifically directed at reducing the fuel consumption of commercial aircraft in the near-term. As part of the ECI program, a Performance Improvement (PI) effort aimed at developing fuel saving and retention components for new production and retrofit of JT9D, JT8D, and TFE engines is underway. This paper reviews the manner in which the PI concepts were selected for development and summarizes the current status of each of the 16 NASA selected concepts.


A scale model performance test was conducted as part of the NASA Energy Efficient Engine (E3) Program, to investigate the geometric variables that influence the aerodynamics of exhaust system mixers for high-bypass, mixed-flow engines. Mixer configuration variables included lobe number, penetration and perimeter, as well as several cutback mixer geometries. Flowfield effectiveness and mixer pressure loss were determined using laser thrust and nozzle exit total pressure and temperature surveys. Results provide a data base to aid the analysis and design development of the E3 mixed-flow exhaust system.


The paper demonstrates that many advances can be anticipated in propulsion systems for aircraft in the next 20 years. A survey is presented of probable future engine types, including convertible engines for helicopters, turboprops for fuel efficient airliners, and variable cycle engines for supersonic transports. Also examined is the use of rotary engines in general aviation aircraft. Finally, a review is given of related technology improvements in propellers, materials, noise suppression, and digital electronic controls.

M.E.P.


The effects of turboprop engine environmental saturation moisture and temperatures up to 300 F on composites were investigated. It was found that epoxy resin composites absorbed the most moisture (2%) and were particularly sensitive to high moisture and 250 F. The effects of moisture and high temperature on the basic properties, e.g., modulus, strength, and fracture toughness, were determined. The significant role of environmental conditions on composite structure was also examined for a variety of environmental conditions.


The article suggests that the 1980's will see significant improvements in virtually all gas-turbine engine components and their materials and structural design methods. These improvements will be made possible by improved theoretical models, laser Doppler measurement techniques, advances in rotor-spool technology, the evolution of engine controls, etc. It is suggested that the engine components should be expected to be advanced in the technologies of flow, materials, and structures in terms of scope, precision, and tools of design.

B.J.


The paper studies calculated and measured metal wall temperatures of uncoated vanes and the same vanes coated with a thermal
barrier coating system of NiCrAlY bond and yttria-stabilized zirconia ceramic. It is shown that thermal contact between layers is negligible. The significance of data scatter and of published ceramic thermal conductivity values is discussed.

V.T.


The far-field radiation from the end of an exhaust duct is studied using both approximate and exact methods. Experimental data of narrow-band tone noise from static tests are compared to a multimodal radiation pattern. It is pointed out that possibly the exhaust noise in the far-field is inherently more difficult to attenuate than an inlet noise using duct suppressors.

V.T.


The paper describes the tests of four devices intended to reduce inflow disturbances and turbulence using a JT15D-1 turbofan engine. The tests were made to simulate the in-flight fan tone noise; the inflow control devices (ICD's) consisted of honeycomb/screen structures mounted over the engine inlet. The ICD's ranged from 1.6 to 4 fan diameters in size, and were made with several fabrication methods. All the ICD's significantly reduced the BPF tone in the far-field directly pattering: the smallest ICD's introduced large scale structures of this inflow condition. Comparison between the fan and core streams. A generic secondary flow vortex was observed both in the experiment and analysis at five axial stations showed good agreement and indicated that this vortex system was convected downstream and dominated the mixing process.

A. T.


Powered-lift acoustic tests of a quiet clean short-haul experimental engine (QCSEE) under-the-wing (UTW) engine are described. Engine and wing configurations are outlined, along with instrumentation and test facilities. The results of these tests are reported. In addition, the UTW engine powered-lift performance is compared with that of the previously tested QCSEE over-the-wing (OTW) engine.

V.T.


The paper reviews NASA's Energy Efficient Engine Project which was initiated to provide the advanced technology base for a new generation of fuel-conservative engines for introduction into airline service by the late 1980s. Efforts in this project are directed at advancing engine component and systems technologies to a point of demonstrating technology-readiness by 1984. Early results indicate high promise in achieving most of the goals established in the project.

V.P.


Static scale model tests were conducted to evaluate exhaust system mixers for a high bypass ratio engine as part of the NASA sponsored Energy Efficient program. Gross thrust coefficients were measured for a series of mixer configurations which included variations in the number of mixer lobes, tailpipe length, mixer penetration, and length. All of these parameters have a significant impact on exhaust system performance. In addition, flow visualization pictures and pressure/temperature traverses were obtained for selected configurations. Parametric performance trends are discussed and the results considered relative to the Energy Efficient Engine program goals.

(Author)


The General Electric CF6-50 engine nozzle was originally equipped with both fan nozzle and core nozzle thrust reversers. Many airline operators later deactivated the core reverser. Elimination of the core reverser enabled design changes to be made to help improve performance. A reduction in core nozzle length of approximately two feet was possible. This concept, as defined as the Short Core Exhaust Nozzle, was evaluated in engine ground tests, including performance, acoustic, and endurance tests under the NASA/Lewis Engine Component Improvement Program. The test results verified the performance predictions from scale model tests. The Short Core Exhaust Nozzle provides an internal cruise SFC reduction of 0.9% without an increase in engine noise.

The nozzle hardware successfully completed 1000 flight cycles of endurance testing with no signs of distress.

(Author)


An analytical and experimental study was performed to determine the influence of pressure driven secondary flows on the behavior of turbofan forced mixer nozzles. The basic secondary flow structure entering the nozzle was identified experimentally and was composed of a strong vortex system aligned with the radial interface between the fan and core streams. A generic secondary flow vortex structure was constructed for input to the analysis to represent the large scale structure of this inflow condition. Comparison between experiment and analysis at five axial stations showed very good agreement and indicated that this vortex system was connected downstream and dominated the mixing process.

(Author)


The paper presents a study of low aspect blading for the inlet stages of a high pressure ratio, high-speed core compressor. The basic overall design variables were stage pressure ratio and blade aspect ratio; these four stages represent two levels of total pressure ratio, two levels of rotor blade aspect ratio, and two levels of stator vane aspect ratios. Comparisons of the overall performance, radial distributions of performance parameters, diffusion factors at the near-stall conditions, blade element data, and the axial distribution.
of rotor tip static pressures yielded the following results: (1) higher peak pressure ratio, high stage and rotor efficiencies, and greater stall margin were obtained with the lower aspect ratio blading, (2) the lower aspect ratio blading showed improved performance over the entire blade span, and (3) the lower aspect ratio blading was more efficient at higher rotor speeds.

**A80-42154**

**Performance of annular prediffuser-combustor systems, W. B. Wagner, S. Tanrikut (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.), and D. E. Sokolowski (NASA, Lewis Research Center, Cleveland, Ohio).**


**Results** of an experimental investigation of the aerodynamic performance of several annular prediffuser-combustor systems are presented. Three curved wall, dump prediffusers of different length, area ratio, and turning angle were tested with and without a simulated combustor located downstream of the prediffuser. Performance was significantly influenced by the presence of the combustor. Pressure recovery and flow losses were determined as a function of prediffuser inlet velocity profile, flow extraction at the prediffuser inlet, axial and radial location of the combustor front end, and distribution of the flow in the combustor. Axial location of the combustor was found to be the most significant parameter influencing system performance.

**A80-42164**

**Atomizing characteristics of swirl can combustor modules with swirl blast fuel injectors, R. D. Ingebo (NASA, Lewis Research Center, Cleveland, Ohio).**


Cold flow atomization tests of several different designs of swirl can combustor modules were conducted in a 7.6 cm diameter duct at airflow rates (per unit area) of 7.3 to 25.7 g/sq cm sec and water flow rates of 6.3 to 18.8 g/s. The effect of air and water flow rates on the mean drop size of water sprays produced with the swirl blast fuel injectors was determined. Also, from these data it was possible to determine the effect of design modifications on the atomizing performance of various fuel injectors and air swirlier configurations. The trend in atomization performance, as based on the mean drop size, was then compared with the trends in the production of nitrogen oxides obtained in combustion studies with the same swirl can combustors.

**A80-42199**

**Low NOx/ heavy fuel combustor program, E. Lister (E.I. Du Pont de Nemours, Inc., Wilmington, Del.), R. W. Niedzwiecki, and L. Nichols (NASA, Lewis Research Center, Cleveland, Ohio).**


The paper deals with the ‘Low NOx/ Heavy Fuel Combustor Program’. Main program objectives are to generate and demonstrate the technology required to develop durable gas turbine combustors for utility and industrial applications, which are capable of sustained, environmentally acceptable operation with minimally processed petroleum residual fuels. The program will focus on ‘dry’ reductions of oxides of nitrogen (NOx)/, improved combustor durability and satisfactory combustion of minimally processed petroleum residual fuels. Other technology advancements sought include: fuel flexibility for operation with petroleum distillates, blends of petroleum distillates and residual fuels, and syngas (fuel oils derived from coal or shale); acceptable exhaust emissions of carbon monoxide, unburned hydrocarbons, sulfur oxides and smoke; and retrofit capability to existing engines.

**A80-42258**

**Results from tests on a high work transonic turbine for an energy efficient engine, D. E. Crow, H. Weina, L. D. Singer (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.), and M. R. Vancio (NASA, Lewis Research Center, Cleveland, Ohio).**


The experimental results of the high work, transonic, single-stage turbines investigated under the Energy Efficient Engine (E3) Program are presented. The objective of the E3 program is to provide an advanced technology base for a new generation of fuel-conservative turbofan engines. A single-stage turbine required fewer cooled airfoils, a reduced number of leakage paths and no interstage seals. These advanced energy efficient engines require higher engine pressure ratios resulting in high expansion ratios, transonic, turbine designs which must have high aerodynamic efficiency. The goal of the turbine program is to develop a high pressure turbine that is compatible with the overall engine design and has an uncooled efficiency of 90.8 percent.

**A80-42383**

**A theoretical and experimental investigation of propeller performance methodologies, K. D. Korkan, G. M. Gregorek (Ohio State University, Columbus, Ohio), and D. C. Mikkelsen (NASA, Lewis Research Center, Subsonic Propulsion Section, Cleveland, Ohio).**


This paper briefly covers aspects related to propeller performance by means of a review of propeller methodologies; presentation of wind tunnel propeller performance data taken in the NASA Lewis Research Center 10 x 10 wind tunnel; discussion of the predominant limitations of existing propeller performance methodologies; and a brief review of airfoil developments appropriate for propeller applications.

**A80-42384**

**CF6 fan performance improvement, R. F. Patt (General Electric Co., Evendale, Ohio) and D. C. Reemsnryder (NASA, Lewis Research Center, Cleveland, Ohio).**


A significant portion of the NASA-sponsored Performance Improvement Program for the CF6 engine was the development of an improved fan concept. This involved aerodynamic redesign of the CF6 fan blade to increase fan efficiency while retaining the mechanical integrity, operability, and acoustic characteristics of the existing blade. A further improvement in performance was obtained by adding an air case stiffener ring to decouple blade-case vibrational characteristics, permitting a significant reduction in running tip clearance. Engine testing was performed to establish the performance, mechanical and acoustic properties of the new design relative to the current fan, and to establish power management characteristics for the CF6-SC02/2E engine. A significant improvement in cruise power SFC of 1.8 percent was demonstrated in Sea Level conditions.

**A80-44230**


It is noted that increasing fuel costs and the decreasing availability of fuel supplies have lead to an increase in the importance of maintaining good specific fuel consumption over the life cycle of jet engines. Attention is given to an engine diagnostics program.
sponsored by NASA Lewis Research Center which has the objectives of identifying and quantifying the levels, trends, and causes of engine performance deterioration. It is reported that as part of the program, a series of installed engine calibrations were performed on two new Pan American World Airways 747 SP aircraft. A discussion of this specific test program and the results of the analysis of the data are presented.

M.E.P.


In order to assess the impact of aircraft noise on the environment in the vicinity of an airport, it is essential that a methodology be developed for predicting in-flight exhaust noise from static data. Such a methodology is presented in this paper and is compared with experimental data for several unssuppressed turbojet engines. For each engine, static data over a range of jet velocities are compared with the predicted jet mixing noise and shock-cell noise. The static noise data over and above the jet and shock noises is identified as 'excess' noise. The excess noise data are then empirically correlated to smooth the spectral and directivity relations and account for variations in test conditions. This excess noise is then projected to flight based on the assumption that the only effects of flight are a Doppler frequency shift and a level change. The effects of flight on jet mixing noise and shock noise are computed by published NASA methods. (Author)


The role of material thermal conductivity was analyzed for its effect on the thermal performance of air-cooled gas turbine components coated with a ceramic thermal barrier material when tested at reduced temperatures and pressures. This study shows that the thermal performance can be evaluated reliably at reduced gas and coolant conditions. However, thermal conductivity corrections are required for the data at reduced conditions. These corrections for a ceramic thermal barrier coated vane are significantly different than the corrections for an uncoated vane. Comparison of uncorrected test data, therefore, would show erroneously that the thermal barrier coating was ineffective. When thermal conductivity corrections are applied to the test data these data are then shown to be representative of engine data and also show that the thermal barrier coating increases the vane cooling effectiveness by 12.5 percent. (Author)


An analysis was performed of the effects of the hot-gas and coolant temperatures, the gas-to-blade and blade-to-coolant heat transfer coefficients, and the thermal conductances of a metal wall and a ceramic thermal-barrier coating on the prediction of local turbine-blade surface temperatures. The analysis was applied to the conditions of an advanced turbofan engine and a 1700 K, 4.0 atm turbine test rig, and to conditions that simulated the engine at 756 K and 15.6 atm. The results showed that with current information on boundary conditions, geometry, heat-transfer coefficients, and material thermal properties, the uncertainty in predicting and verifying local turbine-blade surface temperatures in an average engine is 98 kelvins or 7.6% of the reference metal absolute temperature for uncoated blades, and 62 kelvins or 5.7% for ceramic-thermal-barrier coated blades. A.T.

A80-10221* # Pratt and Whitney Aircraft Group, East Hartford, Conn.


NASA-CR-159694; PWA-5513-32) Avail: NTIS HC A05/MF A01 C56 21E

A three-stage Vorbix duct burner was evaluated to determine the performance and emissions characteristics of this concept and to refine the configuration to provide acceptable durability and operational characteristics for its use in the VCE Testbed Program. The tests were conducted at representative takeoff, transonic climb and supersonic cruise inlet conditions for the VCE-5028 study engine. The test results showed that NOx emissions were equivalent to 1 gm/kg at takeoff. The thrust efficiency exceeded the goal level of 94.5 percent reaching a value of 97 percent at supersonic cruise. SO2 emissions were moderate but in excess of the goal of 3 mg/kg at takeoff. Fuel consumption for the test was approximately 1.35 pounds per engine hour at takeoff. The thrust efficiency exceeded the goal level of 94.5 percent reaching a value of 97 percent at supersonic cruise. The total pressure loss across the duct burner, at 6.74 the loss mechanisms have been identified and, in one configuration 40 percent of this excess loss was eliminated without comprizing the emissions or thrust efficiency. A.R.H.

A80-10222* # Pratt and Whitney Aircraft, East Hartford, Conn.


Refined design definition of the variable steam control engine (VSCe) concept for advanced supersonic transports is presented. Operating and performance features of the VSCe are discussed, including the engine components, thrust specific fuel consumption, weight, noise, and emission system. A preliminary engine design is presented. A.W.H.

A80-12091* # Pratt and Whitney Aircraft Group, East Hartford, Conn.

DESIGN, DURABILITY AND LOW COST PROCESSING TECHNOLOGY FOR COMPOSITE FAN EXIT GUIDE VANES S. S. Blecherman Aug. 1979 139 p refs (Contract NAS3-21037)


A lightweight composite fan exit guide vane for high bypass ratio gas turbine engine application was investigated. Eight candidate material/design combinations were evaluated by NASTRAN finite element analyses. A total of four combinations were selected for further analytical evaluation, part fabrication by two vendors, and fatigue test in dry and wet condition. A core and shell vane design was chosen with a goal of achieving 90% of the graphite core fiber was the same for all candidates. The shell material, fiber orientation, and ply configuration were varied. Material tests were performed on raw materials, composite specimens to establish specification requirements. Post-test and post-test microstructural examination and nondestructive analyses were conducted to determine the effect of material variations on fatigue durability and failure mode. Relevant data were acquired with respect to design analysis, materials properties, inspection standards, improved durability, weight benefits, and part price of the composite fan exit guide vane. R.C.T.
FLIGHT TEST OF NAVIGATION AND GUIDANCE SENSOR ERRORS MEASURED ON STOL APPROACHES

A computerized method which utilizes the engine performance data and estimates the installed performance of aircraft gas turbine engines is presented. This installation includes: engine weight and dimensions, inlet and nozzle internal performance and drag, inlet and nacelle weight, and nacelle drag. The use of two data base files to represent the engine and the inlet/nozzle/aftbody performance characteristics is discussed. The existing library of performance characteristics for inlets and nozzle/aftbodies and inlet and nacelle weight, and nacelle drag. A computerized method which utilizes the engine performance data is described. The method estimates the installed performance of aircraft gas turbine engines. This installation includes: engine weight and dimensions, inlet and nozzle internal performance and drag, inlet and nacelle weight, and nacelle drag. A computerized method which utilizes the engine performance data and estimates the installed performance of aircraft gas turbine engines is presented. This installation includes: engine weight and dimensions, inlet and nozzle internal performance and drag, inlet and nacelle weight, and nacelle drag. A computerized method which utilizes the engine performance data and estimates the installed performance of aircraft gas turbine engines is presented. This installation includes: engine weight and dimensions, inlet and nozzle internal performance and drag, inlet and nacelle weight, and nacelle drag.

An acoustic and aerodynamic test program was conducted on a 1/6.25 scale model of the Quiet, Clean, Short-Haul Experimental Engine (QCSEE) forward thrust over-the-wing (OTW) nozzle and OTW thrust reverser. In reverse thrust, the effect of reverse geometry was studied by parametric variations in blocker spacing, blocker height, tip angle, and lip length. Forward thrust nozzle tests determined the jet noise levels of the cruise and takeoff nozzles, the effect of opening side doors to achieve takeoff thrust, and scrubbing noise of the cruise and takeoff jet on a simulated wing surface. Velocity profiles are presented for both forward and reverse thrust nozzles. An estimate of the reverse thrust was made utilizing the measured centerline turning angle.

The feasibility of employing the known attractive and distinguishing features of catalytic combustion technology to reduce nitric oxide emissions from gas turbine engines during ejector performance. These characteristic points determined which of nine possible ejector configurations provided optimal performance. Detailed examination of the thermodynamic cycle was made for representative cases and data was presented to illustrate the influence of ejectors upon conventional gas generator performance. The influence of nozzle loss, skin friction and flow separation, incomplete kinetic and thermal mixing, and boundary layer ingestion were taken into consideration in the analysis. Correlation with existing stationary solid and jet-diffuser ejector experiments showed excellent agreement between theory and experiment.

It has been shown that ejectors designed according to the methods described, can provide large improvement in propulsion system performance throughout the entire practical flight regime.
The acoustic considerations involved in the low source noise basic engine design and the design procedures followed in the development of the over-the-wing (OTW) nacelle. Acoustic design features include a near-sonic inlet, low fan and core pressure ratios, low fan tip speed, high and low frequency stacked core treatment, multiple thickness treatment, and fan frame and stator vane treatment. R.E.S.

N80-14119# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUICK CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) GRAPHITE/PMR COWL DEVELOPMENT

C. L. Ruggles Jul. 1978 75 p refs (Contract NAS3-19021)

(NASA-CR-135279; R78AE206) Avail: NTIS
HC A04/MF A01 CSCL 21E

The PMR process development, tooling concepts, testing conducted to generate materials properties data, and the fabrication of a subscale model of the inner cowl are presented. It was concluded that the materials, processes, and tooling concepts were satisfactory for making an inner cowl with adequate structural integrity. M.M.M.

N80-14120# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUICK CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEM TEST REPORT. VOLUME 2: AERODYNAMICS AND PERFORMANCE

Jul. 1978 49 p refs (Contract NAS3-19021)

(NASA-CR-135324; R78AE474Vol-2) Avail: NTIS
HC A03/MF A01 CSCL 21E

The design and testing of the over the wing engine, a high bypass, geared turbofan engine, are discussed. The propulsion system performance is examined for uninstalled performance and installed performance. The fan aerodynamic performance and the D nozzle and reverser thrust performance are evaluated. A.W.H.


FEASIBILITY OF SiC COMPOSITE STRUCTURES FOR 1966 K (2800 F) GAS TURBINE SEAL APPLICATION Final Report, Apr. 30 May 1979

R. Darolis Nov. 1979 120 p ref (Contract NAS3-20082)

(NASA-CR-135824; R78AE825) Avail: NTIS
HC A06/MF A01 CSCL 21E

The silicon carbide composites evaluated consisted of Si/SiC and sintered silicon carbide as substrates, both with attached surface layers containing BN as an additive. A total of twenty-eight candidates with variations in substrate type and density, and layer chemistry, density, microstructure, and thickness were evaluated for sealing capability, cold particle erosion resistance, static oxidation resistance, ballistic impact resistance, and fabricability. BN-free layers with variations in density and pore size were later added for evaluation. The most promising candidates were evaluated for Mach 1.0 gas oxidation/erosion resistance from 1477 K (2200 F) to 1644 K (2500 F). The as-fabricated rub layers did not perform satisfactorily in the gas oxidation/erosion tests. However, preoxidation was found to be beneficial in improving the hot gas erosion resistance. Overall, the laboratory and rig test evaluations show that material properties are suitable for 1477 K (2200 F) gas turbine seal applications. Further improvements are needed in hot gas erosion resistance and abradability to demonstrate feasibility to 1644 K (250 F). A.R.H.


THE CFS JET ENGINE PERFORMANCE IMPROVEMENT: NEW FRONT MOUNT

W. A. Fasching Dec. 1979 139 p refs (Contract NAS3-20629)

(NASA-CR-159639; R79AE366) Avail: NTIS
HC A07/MF A01 CSCL 21E

The New Front Mount was evaluated in component tests including stress, deflection/distortion and fatigue tests. The test results demonstrated a performance improvement of 0.1% in cruise SFC, 16% in compressor stall margin and 10% in compressor stator angle margin. The New Front Mount hardware successfully completed 35,000 simulated flight cycles endurance testing. Author

N80-14129# Detroit Diesel Allison, Indianapolis, Ind.

STUDY OF TURBOPROP SYSTEMS RELIABILITY AND MAINTENANCE COSTS Final Report

Jun. 1978 304 p refs (Contract NAS3-20057)

(NASA-CR-135192; EDR-9132) Avail: NTIS
HC A14/MF A01 CSCL 21E

The overall reliability and maintenance costs (R&M/C's) of past and current turboprop systems were examined. Maintenance cost drivers were found to be scheduled overhaul (40%), lack of modularity particularly in the propeller and reduction gearbox, and lack of inherent durability (reliability) of some parts. Comparisons were made between the 501-D13/54H60 turboprop system and the widely used JTBD turbofan. It was found that the total maintenance cost per flight hour of the turboprop was 75% higher than that of the JTBD turbofan. Part of this difference was due to propeller and gearbox costs being higher than those of the fan and reverser, but most of the difference was in the engine core where the older technology turboprop core maintenance costs were nearly 70 percent higher than for the turbofan. The estimated maintenance cost of both the advanced turboprop and advanced turbofan were less than the JTBD. The conclusion was that an advanced turboprop and an advanced turbofan, using similar cores, will have very competitive maintenance costs per flight hour. J.M.S.

N80-14130# Avco Lycoming Div., Williamsport, Pa.

EXHAUST EMISSION REDUCTION FOR INTERMITTENT COMBUSTION AIRCRAFT ENGINES

R. N. Moffet Oct. 1979 114 p (Contract NAS3-19754)

(NASA-CR-159757) Avail: NTIS HC A06/MF A01 CSCL 21E

Three concepts for optimizing the performance, increasing the fuel economy, and reducing the exhaust emission of the piston aircraft engine were investigated. High energy, multiple spark discharge and spark plug tip penetration, ultrasonic fuel vaporization, and variable valve timing were evaluated individually. Ultrasonic fuel vaporization did not demonstrate sufficient improvement in distribution to offset the performance loss caused by the additional manifold restriction. High energy ignition and revised spark plug tip location provided no change in performance or emissions. Variable valve timing provided some performance benefit; however, even greater performance improvement was obtained through induction system tuning which could be accomplished with far less complexity. A.R.H.


PHASE-LOCKED TELEMETRY SYSTEM FOR ROTARY INSTRUMENTATION OF TURBOMACHINERY, PHASE 1 Final Report

Alan Adler and Bas Hoeks Sep. 1978 192 p (Contract NAS3-20290; Avicus Proj. 6497)

(NASA-CR-159453; Acurex-78-284) Avail: NTIS
HC A09/MF A01 CSCL 09F

A telemetry system for on-engine measurement of the rotating components of high speed turbomachinery employs phase-locked transmitters, which offer greater measurement channel capacity and reliability than existing systems which employ L-C carrier oscillators. A prototype
transmitter module was tested at 175 C combined with 40,000 g's acceleration.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE SUBSYSTEM TEST REPORT
C. L. Stotler, Jr., E. A. Johnston, and D. S. Freeman Jul. 1977 83 p refs
(Contract NAS3-18021)
(NASA-CR-135075, R76AEG420) Avail. NTIS HC A05/MF A01 CSCL 21E

The element and subcomponent testing conducted to verify the under the wing composite nacelle design is reported. This composite nacelle consists of an inlet, outer cowl doors, inner cowl doors, and a variable fan nozzle. The element tests provided the mechanical properties used in the nacelle design. The subcomponent tests verified that the critical panel and joint areas of the nacelle had adequate structural integrity.

NBO-15101** General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). BALL SPLINE PITCH CHANGE MECHANISM DESIGN REPORT
Apr. 1978 73 p refs
(Contract NAS3-18021)
(NASA-CR-134873, R77AE327) Avail. NTIS HC A04/MF A01 CSCL 21E

Detailed design parameters are presented for a variable-pitch change mechanism. The mechanism is a mechanical system containing a ball screw/spline driving two counteracting master level gears meshing pinion gears attached to each of 18 fan blades.

NBO-15102** General Electric Co., Cincinnati, Ohio.
ACOUSTIC ANALYSIS OF AFT NOISE REDUCTION TECHNIQUE MEASURED ON A SUBSONIC TIP SPEED 50.8 cm (TWENTY INCH) DIAMETER FAN
D. L. Stimpert and A. Clemens Jan. 1977 149 p refs
(Contract NAS3-18021)
(NASA-CR-134891, R75AEG368) Avail. NTIS HC A07/MF A01 CSCL 21E

Sound data which were obtained during tests of a 50.8 cm diameter, subsonic tip speed, low pressure ratio fan were analyzed. The test matrix was divided into two major investigations: (1) source noise reduction techniques; and (2) aft duct noise reduction. The airfoil surface (source noise) reduction techniques were investigated which include minimizing second harmonic noise by varying vane/blade ratio, variation in spacing, and lowering the Mach number through the vane row to lower the broadband noise. Treatment in the aft duct which includes flow noise effects, faceplate porosity, rotor OGV treatment, slant cell treatment, and splitter simulation with variable depth on the outer wall and constant thickness treatment on the inner wall was investigated. Variable boundary conditions such as variation in treatment panel thickness and orientation, and mixed porosity combined with variable thickness were examined. Significant results are reported.

NBO-15103** Curtiss-Wright Corp., Wood-Ridge, N.J. Power Systems
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS TEST PROGRAM Final Report
D. W. Misel Mar. 1977 220 p refs
(Contract NAS3-18021)
(NASA-CR-134669, CW-WR-77-008) Avail. NTIS HC A10/MF A01 CSCL 21E

Sets of under the wing (UTW) engine reduction gears and sets of over the wing (OTW) engine reduction gears were fabricated for rig testing and subsequent installation in engines. The UTW engine reduction gears which have a ratio of 2.465:1 and a design rating of 9712 kW at 3157 rpm fan speed were operated at up to 105% s speed at 60% torque and 100% speed at 125% torque. The OTW engine reduction gears which have a ratio of 2.062:1 and a design rating of 12,615 kW at 3861 rpm fan speed were operated at up to 95% speed at 50% torque and 80% speed at 100% torque. Satisfactory operation was demonstrated at powers up to 12,172 kW, mechanical efficiency up to 99.1% UTW, and a maximum gear pitch line velocity of 112 m/s (223,300 fpm) with a corresponding star gear spherical roller bearing DN of 850,00 OTW. Oil and star gear bearing temperatures, oil churning, heat rejection, and vibratory characteristics were acceptable for engine installation.

NBO-15104** General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) CLEAN COMBUSTOR TEST REPORT
Dec. 1975 40 p refs
(Contract NAS3-18021)
(NASA-CR-134916, R75AEG449) Avail. NTIS HC A04/MF A01 CSCL 21E

A component pressure test was conducted on a F101 PFPT combustor to evaluate the emissions levels of this combustor design at selected under the wing and over the wing operating conditions for the quiet clean short haul experimental engine (QCSEE). Emissions reduction techniques were evaluated which included compressor discharge bleed and sector burning in the combustor. The results of this test were utilized to compare the expected QCSEE emissions levels with the emission goals of the QCSEE engine program.

NBO-15105** Curtiss-Wright Corp., Wood-Ridge, N.J.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS BEARING DEVELOPMENT PROGRAM Final Report
Dec. 1975 40 p
(Contract NAS3-18021)
(NASA-CR-134890) Avail. NTIS HC A03/MF A01 CSCL 21E

The viability of proposed bearing designs to operate at application conditions is described. Heat rejection variables were defined for the test conditions. Results indicate that there is potential for satisfactory operation of spherical roller bearing in the QCSEE main reduction gear application.

NBO-15106** Curtiss-Wright Corp., Wood-Ridge, N.J.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS DETAILED DESIGN REPORT Final Report
A. Defeo and M. Kuhna Jul. 1977 221 p
(Contract NAS3-18021)

Lightweight turbine engines with geared slower speed fans are considered. The design of two similar but different gear ratio, minimum weight, epicyclic star configuration main reduction gears for the under the wing (UTW) and over the wing (OTW) engines is discussed. The UTW engine reduction gear has a ratio of 2.465:1 and a 100% power design rating of 9885 kW (13,256 hp) at 3143 rpm fan speed. The OTW engine reduction gear has a ratio of 2.062:1 and a 100% power design rating of 12813 kW (17183 hp) at 3861 rpm fan speed. Details of configuration, stresses, deflections, and lubrication are presented.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) HAMILTON STANDARD CAM/HARMONIC DRIVE VARIABLE PITCH FAN ACTUATION SYSTEM DETAIL DESIGN REPORT

30
A variable pitch fan actuation system was designed which incorporates a remote nacelle-mounted blade angle regulator. The regulator drives a rotating fan-mounted mechanical actuator through a flexible shaft and differential gear train. The actuator incorporates a high-speed harmonic drive attached to a multiaxial spherical cam which changes blade pitch through individual cam follower arms attached to each blade trunnion. Detail design parameters of the actuation system are presented. These include the following: design philosophies, operating limits, mechanical, hydraulic and thermal characteristics, mechanical efficiencies, materials, weights, lubrication, stress analyses, reliability and failure analyses. 

Author

N80-16100 General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE COMPOSITE FAN BLADE DESIGN REPORT Final Report


(CartrNAS3-18021)

NASA-CR-135046; R77AEG177

Avail: NTIS

HC A04/MF A01 CSCL 21E

A total of 36 quiet clean short haul experimental engine under the wing composite fan blades were manufactured for various component tests, process and tooling, checkout, and use in the QCSEE UTW engine. The component tests included frequency characterization, strain distribution, bench fatigue, platform static load, whirligig high cycle fatigue, whirligig low cycle fatigue, whirligig strain distribution, and whirligig overload. All tests were successfully completed. All blades planned for use in the engine were subjected to and passed a whirligig proof spin test. R.C.T.


QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE): THE AERODYNAMIC AND MECHANICAL PRELIMINARY DESIGN OF THE QCSEE UNDER-THE-WING FAN

Mar. 1977 144 p

(Contract NAS3-18021)

NASA-CR-135009; R75AEG484

Avail: NTIS

HC A07/MF A01 CSCL 21E

The design, fabrication, and testing of two experimental high bypass geared turbofan engines and propulsion systems for short haul passenger aircraft are described. The aerodynamic and mechanical design of a variable pitch 1.34 pressure ratio fan for the under the wing (UTW) engine are included. The UTW fan was designed to permit rotation of the 18 composite fan blades into the reverse thrust mode of operation through both flat pitch and stall pitch directions. R.C.T.

N80-16110 General Electric Co., Cincinnati, Ohio.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) COMPOSITE FAN FRAME DESIGN REPORT

S. C. Mitchell Sep. 1978 97 p refs

(Contract NAS3-18021)

NASA-CR-136278; R77AEG439

Avail: NTIS

HC A04/MF A01 CSCL 21E

An advanced composite frame which is flight-weight and integrates the functions of several structures was developed for the over the wing (OTW) engine and for the under the wing (UTW) engine. The composite material system selected as the basic material for the frame is Type AS graphite fiber in a Hercules 3501 epoxy resin matrix. The frame was analyzed using a finite element digital computer program. This program was used in an iterative fashion to arrive at practical thicknesses and ply orientations to achieve a final design that met all strength and stiffness requirements for critical conditions. Using this information, the detail design of each of the individual parts of the frame was completed and released. On the basis of these designs, the required tooling was designed to fabricate the various component parts of the frame. To verify the structural integrity of the critical joint areas, a full-scale test was conducted on the frame before engine testing. The testing of the frame established critical spring constants and subjected the frame to three critical load cases. The successful static load test was followed by 153 and 58 hours respectively of successful running on the UTW and OTW engines. J.M.S.

N80-16111 General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UTW FAN PRELIMINARY DESIGN

Feb. 1975 107 p

(Contract NAS3-18021)

NASA-CR-134842; R75AEG213

Avail: NTIS

HC A06/MF A01 CSCL 21E

High bypass geared turbofan engines and propulsion systems designed for short-haul passenger aircraft are described. The propulsion technology required for future externally blown flap aircraft with engines located both under the wing and over the wing is emphasized. The aerodynamic and mechanical preliminary design of the QCSEE over the wing 1.34 pressure ratio fan with variable blade pitch is presented. Design information is given for two pitch change actuation systems which will provide reverse thrust. J.M.S.

N80-16112 General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE): THE AERODYNAMIC AND PRELIMINARY MECHANICAL DESIGN OF THE QCSEE OTW FAN

Feb. 1975 80 p

(Contract NAS3-18021)

NASA-CR-134841; R75AEG381

Avail: NTIS

HC A05/MF A01 CSCL 21E

The aerodynamic and mechanical preliminary design of the QCSEE over the wing 1.36 pressure ratio fan is presented. Design information is given for both the experimental and flight designs. J.M.S.

N80-16113 General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE COMPOSITE FAN BLADE DESIGN

May 1975 57 p

(Contract NAS3-18021)

NASA-CR-134840; R75AEG278

Avail: NTIS

HC A04/MF A01 CSCL 21E

The design and analysis of a composite fan blade for the under the wing (UTW) QCSEE is presented. The blade is designed for a variable pitch, 18 bladed rotor and is constructed from a hybrid composite combination of materials consisting of Kevlar-49, type AS graphite, boron, and S-glass fibers in a PR288 epoxy resin matrix. The blade has an attached platform which is constructed of AS-graphite, PR278 epoxy resin matrix and aluminum honeycomb. The blade is designed to satisfy aerostability and cyclic life and strength requirements with a light weight construction. The attached platform is designed for a fail-safe condition in that it is retainable by the blade, under centrifugal force loading, even in the event of blade to platform bond separation. Details of the blade design and the results of stress, vibration, and impact analysis are included. J.M.S.

N80-16114 General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING ENGINE AND CONTROL SIMULATION RESULTS

Oct. 1978 107 p refs

(Contract NAS3-18021)

NASA-CR-135048; R76AEG218

Avail: NTIS

HC A06/MF A01 CSCL 21E

31
A hybrid computer simulation of the over the wing turbofan engine was constructed to develop the dynamic design of the control. This engine and control system includes a high authority digital electronic control using compressor stator reset to achieve fast thrust response and a modified Kalman filter to correct for sensor failures. Fast thrust response for powered lift operations and accurate, fast responding, steady state control of the engine is provided. Simulation results for turbofan bursts from 62 to 100 percent takeoff thrust predict that the engine will accelerate from 62 to 95 percent takeoff thrust in one second.

J.M.S.

N80-15115* General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) BALL SPINE PITCH-CHANGE MECHANISM WHIRLIGIG TEST REPORT
Sep 1978 64 p refs
(Contract NAS3-19021)
(NASA-CR-135354, R77AEG394) Avail: NTIS
HC A04/MF A01 CSCL 21E

The component testing of a ball spline variable pitch mechanism is presented including a whirligig test. The variable pitch actuator successfully completed all planned whirligig tests including a fifty cycle endurance test at actuation rates up to 120 deg per second at 102 percent fan speed (3400 rpm).

J.M.S.

N80-15116* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) BOILER PLATE NACELLE AND CORE EXHAUST NOZZLE DESIGN REPORT
Oct. 1976 104 p
(Contract NAS3-19021)
(NASA-CR-135008, R76AEG222) Avail: NTIS
HC A06/MF A01 CSCL 21E

The mechanical design of the boiler plate nacelle and core exhaust nozzle for the QCSEE under the wing engine is presented. The nacelle, which features interchangeable hard-wall and acoustic panels, is to be utilized in the initial engine testing to establish acoustic requirements for the subsequent composite nacelle as well as in the QCSEE over the wing engine configuration.

J.M.S.

N80-15117* Hamilton Standard, Windsor Locks, Conn.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) WHIRL TEST OF CAM/HARMONIC PITCH CHANGE ACTUATION SYSTEM Contractor Report, 10 Nov. 1975 - 16 Feb. 1976
Apr. 1976 208 p refs
(Contract NAS3-19021)
(NASA-CR-135140; HSER-7002) Avail: NTIS
HC A10/MF A01 CSCL 21E

A variable pitch fan actuation system, which incorporates a remote nacelle mounted blade angle regulator, was tested. The regulator drives a rotating fan mounted mechanical actuator through a flexible shaft and differential gear train. The actuator incorporates a high ratio harmonic drive attached to a multitrack spherical cam which changes blade pitch through individual cam follower arms attached to each blade trunnion. Testing of the actuator on a whirl test rig, is reported. Results of tests conducted to verify that the unit satisfied the design requirements and was structurally adequate for use in an engine test are presented.

J.M.S.

N80-15118* General Electric Co., Cincinnati, Ohio.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEMS TEST REPORT. VOLUME 4: ACOUSTIC PERFORMANCE D. L. Simpant, Feb. 1979 144 p refs
(Contract NAS3-19021)
(NASA-CR-135326; R77AEG476-Volume 4) Avail: NTIS
HC A07/MF A01 CSCL 21E

A series of acoustic tests were conducted on the over the wing engine. These tests evaluated the fully suppressed noise levels in forward and reverse thrust operation and provided insight into the component noise sources of the engine plus the suppression achieved by various components. System noise levels using the contract specified calculation procedure indicate that in-flight noise level on a 152 m sideline at takeoff and approach are 97.2 and 94.6 EPNdB, respectively, compared to a goal of 95.0 EPNdB. In reverse thrust, the system noise level was 106.1 PNdB compared to a goal of 100 PNdB. Baseline source noise levels agreed very well with pretest predictions. Inlet radiated noise suppression of 14 PNdB was demonstrated with the high thrust Mach number inlet at 0.79 throat Mach number.

R.C.T.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) Final Report
William S. Willis Aug. 1979 408 p refs
(Contract NAS3-19021)
(NASA-CR-159473; R79AEG478) Avail: NTIS
HC A18/MF A01 CSCL 21E

The design, fabrication, and testing of two experimental propulsion systems for powered lift transport aircraft are given. Under the wing (UTW) engine was intended for installation in an externally blown flap configuration and the over the wing (OTW) engine for use in an upper surface blowing aircraft. The UTW engine included variable pitch composite fan blades, main reduction gear, composite fan frame and nacelle, and a digital control system. The OTW engine included a fixed pitch fan, composite fan frame, boiler plate nacelle, and a full authority digital control. Many acoustic, pollution, performance, and weight goals were demonstrated.

R.C.T.

N80-15121* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). DOUBLE-ANNULAR CLEAN COMBUSTOR TECHNOLOGY DEVELOPMENT REPORT
D. W. Bahr, D. L. Burrus, and P. E. Sable May 1979 149 p refs
(Contract NAS3-18021)
(NASA-CR-159483; R79AEG397) Avail: NTIS
HC A07/MF A01 CSCL 21E

A sector combustor technology development program was conducted to define an advanced double annular dome combustor sized for use in the quiet clean short haul experimental engine (QCSEE). A design which meets the emission goals, and combustor performance goals of the QCSEE engine program was developed. Key design features were identified which resulted in substantial reduction in carbon monoxide and unburned hydrocarbon emission levels at ground idle operating conditions, in addition to very low nitric oxide emission levels at high power operating conditions. Their significant results are reported.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). ACOUSTIC TREATMENT DEVELOPMENT AND DESIGN
Art Clemans May 1979 353 p ref
(Contract NAS3-18021)
(NASA-CR-135266, R76AEG379-1) Aval NTIS HC A16/MF A01 CSCL 21E

Acoustic treatment designs for the quiet clean short-haul experimental engines are defined. The procedures used in the development of each noise-source suppressor device are presented and discussed in detail. A complete description of all treatment concepts considered and the test facilities utilized in obtaining background data used in treatment development are also described. Additional supporting investigations that are complementary to the treatment development work are presented. The expected suppression results for each treatment configuration are given in terms of delta SPL versus frequency and in terms of delta PN dB. R.E.S.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). PRELIMINARY ANALYSES AND DESIGN REPORT, VOLUME 1
Oct. 1974 372 p
(Contract NAS3-18021)
(NASA-CR-134838, R74AEG479-Vol-1) Aval NTIS HC A16/MF A01 CSCL 21E

The experimental propulsion systems to be built and tested in the 'quiet, clean, short-haul experimental engine' program are presented. The flight propulsion systems are also presented. The following areas are discussed: acoustic design; emissions control; engine cycle and performance; fan aerodynamic design; variable-pitch actuation systems; fan rotor mechanical design; fan frame mechanical design, and reduction gear design. R.E.S.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). PRELIMINARY ANALYSES AND DESIGN REPORT, VOLUME 2
Oct. 1974 330 p
(Contract NAS3-18021)
(NASA-CR-134839, R74AEG479-Vol-2) Aval NTIS HC A15/MF A01 CSCL 21E

The mechanical performance of the over-the-wing engine is described with emphasis on the advanced technology components. The overall dynamic response of the engine was excellent. R.E.S.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEM TEST REPORT, VOLUME 1: SUMMARY REPORT
D. L. Stimpert and R. A. McFalls May 1975 131 p ref
(Grant NSG-3169)
(NASA-CR-135233, R77AEG473-Vol-1) Aval NTIS HC A04/MF A01 CSCL 21E

Sea level, static, ground testing of the over-the-wing engine and boilerplate nacelle components was performed. The equipment tested and the test facility are described. Summaries of the instrumentation, the chronological history of the tests, and the test results are presented. R.E.S.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEM TEST REPORT, VOLUME 3: MECHANICAL PERFOR-
Demonstration of Short Haul Aircraft Aft Noise Reduction Techniques on a Twenty Inch (50.8 cm) Diameter Fan, Volume 2

May 1977

The element and subcomponent testing conducted to verify the under-the-wing composite nacelle design is reported. This composite nacelle consists of an inlet, outer cowl doors, inner cowl doors, and a variable fan nozzle. The element tests provided the mechanical properties used in the nacelle design. The subcomponent tests verified that the critical panel and joint areas of the nacelle had adequate structural integrity.

General Electric Co., Cincinnati, Ohio

N80-15089®

Quiet Clean Short-Haul Experimental Engine (QCSEE) Preliminary Under-the-Wing Flight Propulsion System Analysis Report

Apr 1977

The preliminary design and installation of high bypass, geared turbofan engine with a composite nacelle forming the propulsion system for a short haul passenger aircraft are described. The technology required for externally blown flap aircraft with a variable unit (UTW) propulsion system installations for introduction into passenger service in the mid 1980's is included. The design, fabrication, and testing of the UTW experimental engine containing the required technology items for low noise, fuel economy, with composite structure for reduced weight and digital engine control are provided.

General Electric Co., Cincinnati, Ohio

N80-15090®

Quiet Clean Short-Haul Experimental Engine (QCSEE) under-the-Wing Engine Digital Control System Design Report

Jan 1978

A digital engine interface control was combined with conventional hydromechanical components to operate the four controlled variables on the under-the-wing engine: fuel flow, fan blade pitch, fan exhaust area, and core compressor stator angles. The engine and control combination offers improvements in noise, pollution, thrust response, operational monitoring, and pilot workload relative to current engines.

General Electric Co., Cincinnati, Ohio

N80-15091®

Quiet Clean Short-Haul Experimental Engine (QCSEE) under-the-Wing Engine Simulation Report

Jul 1977

The element and subcomponent testing conducted to verify the wing composite nacelle design is reported. This composite nacelle consists of an inlet, outer cowl doors, inner cowl doors, and a variable fan nozzle. The element tests provided the mechanical properties used in the nacelle design. The subcomponent tests verified that the critical panel and joint areas of the nacelle had adequate structural integrity.

General Electric Co., Cincinnati, Ohio

N80-15100®

Quiet Clean Short-Haul Experimental Engine (QCSEE) Under-the-Wing (UTW) Composite Nacelle Subsystem Test Report

C. L. Stotler, Jr., E. A. Johnston, and D. S. Freeman

Jul 1977

A summary of the mechanical design of the boiler plate nacelle for the QCSEE over the wing (OTW) engine is presented. The nacelle, which features a D-shaped nozzle/thrust reverser and interchangeable fan wall and acoustic panels, is utilized in the engine testing to establish the aerodynamic and acoustic requirements for nozzles and reversers of this type.

General Electric Co., Cincinnati, Ohio

N80-15101®

Quiet Clean Short-Haul Experimental Engine (QCSEE) COMPOSITE NACELLE SUBSYSTEM TEST REPORT

C. L. Stotler, Jr., E. A. Johnston, and D. S. Freeman

Jul 1977

A summary of the mechanical design of the boiler plate nacelle for the QCSEE over the wing (OTW) engine is presented. The nacelle, which features a D-shaped nozzle/thrust reverser and interchangeable fan wall and acoustic panels, is utilized in the engine testing to establish the aerodynamic and acoustic requirements for nozzles and reversers of this type.

General Electric Co., Cincinnati, Ohio
Hybrid computer simulations of the under-the-wing engine were constructed to develop the dynamic design of the controls. The engine and control system includes a variable pitch fan and a digital electronic control. Simulation results for throttle bursts from 62 to 100 percent net thrust predict that the engine will accelerate 62 to 95 percent net thrust in one second.

A control system incorporating a digital electronic control was designed for the over-the-wing engine. The digital electronic control serves as the primary controlling element for engine fuel flow and core compressor stator position. It also includes data monitoring capability, a unique failure indication and corrective action feature, and optional provisions for operating with a new type of servovalve designed to operate in response to a digital-type signal and to fail with its output device hydraulically locked into position.

Noise measurements were taken on a turbofan engine which uses the same core, with minor modifications, employed on the quiet short-haul experimental engine (QCSEE) propulsion system. Both nearfield and farfield noise measurements were taken in order to determine the core internally generated noise levels. The resulting noise measurements were compared to predicted combustor and turbine noise levels, to verify or improve the predicted QCSEE combustor and turbine noise levels. Author.

The performance test results of the final under-the-wing engine configuration are presented. One hundred and six hours of operation were conducted, including mechanical and performance checkout, baseline acoustic testing with a bellmouth inlet, reverse thrust testing, acoustic technology tests, and limited controls testing. The engine includes a variable pitch fan having advanced composite fan blades and using a ball-spline pitch actuation system.

The design and testing of high bypass geared turbofan engines with nacelles forming the propulsion system for short haul passenger aircraft are considered. Test results demonstrate the technology required for externally blown flap aircraft for introduction into passenger service in the 1980's. The equipment tested is described along with the test facility and instrumentation. A chronological history of the test and a summary of results are given.

Results of initial tests of the under the wing experimental engine and boilerplate nacelle are presented. The mechanical performance of the engine is reported with emphasis on the advanced technology components. Technology elements of the propulsion system covered include: dynamic systems, composite fan blades, reduction gear, lube and accessory drive system, fan frame, inlet, core cowl cooling, fan exhaust nozzle, and digital control system.

Full review of the thrust testing, acoustic technology tests, and limited controls testing conducted to verify the composite fan frame design of two experimental high bypass geared turbofan engines and propulsion systems for short haul passenger aircraft is described. Emphasis is placed on the propulsion technology required for future externally blown flap aircraft with engines located both under the wing and over the wing, including technology in composite structures and digital engine controls. The element tests confirmed that the processes used in the frame design would produce the predicted mechanical properties. The subcomponent tests verified that the detail composite structures and digital engine controls are among the topics included.

Economic studies are also presented and show that high bypass, low pressure ratio turbofan engines have the potential of providing an economical propulsion system for achieving the very quiet aircraft noise level of 95 EPNdB on a 1524 m sideline.

The element and subcomponent testing conducted to verify the composite fan frame design of two experimental high bypass geared turbofan engines and propulsion systems for short haul passenger aircraft is described. Emphasis is placed on the propulsion technology required for future externally blown flap aircraft with engines located both under the wing and over the wing, including technology in composite structures and digital engine controls. The element tests confirmed that the processes used in the frame design would produce the predicted mechanical properties. The subcomponent tests verified that the detail composite structures and digital engine controls are among the topics included.


The element and subcomponent testing conducted to verify the composite fan frame design of two experimental high bypass geared turbofan engines and propulsion systems for short haul passenger aircraft is described. Emphasis is placed on the propulsion technology required for future externally blown flap aircraft with engines located both under the wing and over the wing, including technology in composite structures and digital engine controls. The element tests confirmed that the processes used in the frame design would produce the predicted mechanical properties. The subcomponent tests verified that the detail composite structures and digital engine controls are among the topics included.
A summary of the mechanical design of the boiler plate nacelle for the CSE800 twin OTW engine is presented. The nacelle, which features a D-shaped nozzle/thrust reverser and interchangeable hard wall and acoustic panels, is utilized in the engine testing to establish the aerodynamic and acoustic requirements. The test was conducted to acquire simultaneous internal and far-field noise on the far-field measurements. The data includes internal and external noise.

**NO. 16061** Pratt and Whitney Aircraft Group, West Palm Beach, Fla.

**DISTRIBUTION ANALYSIS FOR ET1000(3) ENGINE Final Report**

W.A. Walter and M. Shaw Jan 1980 66 p refs

(NOAA·CR·159754, FR·12087) Avail NTIS

HC A04/MF A01 CSCL 21E

The F100(3) compression system response to inlet circumferential distortion was investigated using an analytical compressor flow model. Compression system response to several types of distortion, including pressure, temperature, and combined pressure/temperature distortions, was investigated. The predicted response trends were used in planning future F100(3) distortion tests. Results show that compression system response to combined temperature and pressure distortions depends upon the relative orientation, as well as the individual amplitudes and circumferential extents of the distortions. Also the usefulness of the analytical predictions in planning engine distortion tests is indicated.

J.M.S.

**NO. 16064** Pratt and Whitney Aircraft Group, East Hartford, Conn.

**EXPERIMENTAL EVALUATION OF A LOW EMISSIONS HIGH PERFORMANCE DUCT BURNER FOR VARIABLE CYCLE ENGINES (VCE) Final Report**

R.P. Lohmann and R.J. Mador Oct 1979 118 p refs

(NOAA·CR·159696, PWA·83381-2) Avail NTIS

HC A06/MF A01 CSCL 21A

An evaluation was conducted with a three stage Vorbix duct burner to determine the performance and emissions characteristics of the concept. The evaluation was performed to provide acceptable durability and operational characteristics for its use in the variable cycle engine (VCE) testbed program. The tests were conducted at representative takeoff, transonic climb, and supersonic cruise inlet conditions for the VSCE-5028 study engine. The test stand, the emissions sampling and analysis equipment, and the supporting flow visualization rigs are described. The performance parameters including the fuel-air ratio, the combustion efficiency, thrust efficiency, and gaseous emissions calculation are defined. The test procedures are reviewed and the results are discussed.

A.W.H.

**NO. 16065** Pratt and Whitney Aircraft Group, East Hartford, Conn.

**EXPANDED STUDY OF FEASIBILITY OF MEASURING IN-FLIGHT 747/TJD LOADS, PERFORMANCE, CLEARANCE, AND THERMAL DATA**


(NOAA·CR·20632) Avail: NTIS

HC A06/MF A01 CSCL 21E

The JT9D jet engine exhibits a TSFC loss of about 1% in the initial 50 flight cycles of a new engine. These early losses are caused by seal-wear induced opening of running clearances in the engine gas path. The causes of this seal wear have been identified as flight induced loads which deflect the engine cases and rotors, rotating blades to rub against the seal surfaces, producing permanent clearance changes. The real value of flight loads encountered during airplane acceptance testing and revenue service is the engine's response in the dynamic flight environment. The feasibility of direct measurement of these flight loads and their effects by concurrent measurement of 747/TJD propulsion system aerodynamic and inertia loads and the critical engine clearance and performance changes during 747 flight and ground operations was evaluated. A number of technical options were examined in relation to the total estimated program cost to facilitate selection of the most cost effective option. It is concluded that a flight test program meeting the overall objective of determining the levels of aerodynamic and inertia load levels to which the engine is exposed is feasible and desirable.

A specific recommended flight test program, based on the evaluation of cost effectiveness, is defined.

A.R.H.
Designed for NASA CR 168752. TR•2 TANDEM FAN V/STOL NACELLE of attack separation limits were evaluated at tunnel velocities W Rhoades and A H Ybarra Feb 1980 78 p refs NSO.

To the long aft inlet configuration due to the pressure disturbances attack and forward speed. The flow quality at the fan face was verified at all design forward speed and angle of attack conditions from 0 to 240 knots, angles of attack, 10 to 40 degrees and inlet flow rates representative of throat Mach numbers of 0.1 to 0.6. High inlet performance and stable operation was obtained for strain capability and ductile to brittle transition temperatures.

LOW SPEED TEST OF THE AFT INLET DESIGNED FOR A TANDEM FAN V/STOL NACELLE W W Rhoades and A H Ybarra Feb 1980 78 p refs

N80-18042 Vought Corp., Dallas, Tex.

LOW SPEED TEST OF THE AFT INLET DESIGNED FOR A TANDEM FAN V/STOL NACELLE W W Rhoades and A H Ybarra Feb 1980 78 p refs (Contract NAS5-21468)

An approximately 25 scale model of a Tandem Fan nacelle designed for a Type A V/STOL aircraft configuration was tested in a 10 by 10 foot wind tunnel. A 12 inch, tip driven, turbofan simulator was used to provide the suction source for the aft fan inlet. The front fan inlet was faired over for this test entry. Model variables consisted of a long aft inlet cowl, a short aft inlet cowl, a shaft simulator, blow-in door passages and diffuser vortex generators. Inlet pressure recovery, distortion, distortion angle of attack separation limits were evaluated at tunnel velocities from 0 to 240 knots, angles of attack from -10 to 40 degrees and inlet flow rates representative of throat Mach numbers of 0.1 to 0.6. High inlet performance and stable operation was verified at all design forward speed and angle of attack conditions. The short aft inlet configuration provided exceptionally high performance data, aircraft operating costs, and drawings of the resulting airplanes. The performance data show a vast improvement over current gasoline-powered aircraft.

Engine Design Study Final Report

A 300 kW, six-cylinder engine for twin engine general aviation aircraft was reinvestigated as an aircraft powerplant through design study conducted to arrive at engine configurations having a strong influence on compressors endwall loss. Both highly loaded, core compressors, aspect ratio was identified as a model variable. The effect of aspect ratio on the performance of core compressor exit stages was demonstrated using two stage, highly loaded, core compressors. Aspect ratio was identified as having a strong influence on compressors endwall loss. Both compressors simulated the last three stages of an advanced eight stage core compressor and were designed with the same 0.915 hub/tip ratio, 4.30 kg/sec (9.47 ibm/sec) inlet corrected flow, and 167 m/sec (547 ft/sec) corrected mean wheel speed. The first compressor had an aspect ratio of 0.81 and an overall pressure ratio of 1.357 at a design adiabatic efficiency of 88.3% with an average diffusion factor of 0.529. The aspect ratio of the second compressor was 1.22 with an overall pressure ratio of 1.324 at a design adiabatic efficiency of 88.7% with an average diffusion factor of 0.491.

N80-19112 Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

CORE COMPRESSOR EXIT STAGE STUDY. 1: AERODYNAMIC AND MECHANICAL DESIGN E. A. Burdall, E. Canal, Jr., and K. A. Lyons Sep. 1979 128 p ref

(Contract NAS5-20578)

N80-19114 NASA CR-159714; PWA 6561.55; Available: NTIS HC A05/MF A01 CSCL 21 E

The effect of aspect ratio on the performance of core compressor exit stages was demonstrated using two stage, highly loaded, core compressors. Aspect ratio was identified as having a strong influence on compressors endwall loss. Both compressors simulated the last three stages of an advanced eight stage core compressor and were designed with the same 0.915 hub/tip ratio, 4.30 kg/sec (9.47 ibm/sec) inlet corrected flow, and 167 m/sec (547 ft/sec) corrected mean wheel speed. The first compressor had an aspect ratio of 0.81 and an overall pressure ratio of 1.357 at a design adiabatic efficiency of 88.3% with an average diffusion factor of 0.529. The aspect ratio of the second compressor was 1.22 with an overall pressure ratio of 1.324 at a design adiabatic efficiency of 88.7% with an average diffusion factor of 0.491.

N80-20221 Teledyne Continental Motors, Muskegon, Mich.

A 150 AND 300 KW LIGHTWEIGHT DIELSEL AIRCRAFT ENGINE DESIGN STUDY Final Report Alex P. Brouwers Apr. 1980 149 p ref

(Contract NAS5-20560)

N80-20220, Rept 750; Available: NASA HC A07/MF A01 CSCL 211

The diesel engine was reinvestigated as an aircraft powerplant through design study conducted to arrive at engine configurations and applicable advanced technologies. Two engines are discussed, a 300 kW six-cylinder engine for twin engine general aviation aircraft and a 150 kW four-cylinder engine for single engine aircraft. Descriptions of each engine include concept drawings, performance analysis, stress and weight data, and a cost study. This information was used to develop two airplane concepts, a six-place twin and a four-place single engine aircraft. The aircraft study consists of installation drawings, computer generated performance data, aircraft operating costs, and drawings of the resulting airplanes. The performance data show a vast improvement over current gasoline-powered aircraft.

N80-21322 Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.


(Contract NAS5-20072)

Six filament-wound, composite spar-shell fan blades were impact tested in a wind tunnel, and two additional fan blades were impact tested in a simulated two pound bird into the path of the rotating blade. The performance of a hot isostatic pressed disk installed in an experimental engine and exposed to realistic operating conditions in a 150-hour engine test and a 1000 cycle endurance test is documented. Post test analysis, based on visual, fluorescent penetrant and dimensional inspection, revealed no defects in the disk and indicated that the disk performed satisfactorily.

N80-21323 Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

THERMAL FATIGUE AND OXIDATION DATA FOR DIRECTIONALLY SOLIDIFIED MAR-M 248 TURBINE BLADES V. L. Hill and V. E. Humphreys Jan. 1980 45 p ref

(Contract NAS5-19856)

(Contract NAS5-19579B; ITTR-M6003-53; Available: NTIS HC A03/MF A01 CSCL 21 E

Thermal fatigue and oxidation data were obtained for 11 plasma spray coated and 13 uncoated directionally solidified and single crystal MAR-M 248 blades. Blade coatings on the airfoil included several metal-oxide thermal barrier layers based on AI203, Cr203, or ZrO2. The 24 turbine blades were tested simultaneously for 3000 cycles in fluidized beds maintained at 950 and 25 C using a symmetrical 360 set thermal cycle. In 3000 cycles, only uncoated turbine blades exhibited cracking on the trailing edge near the platform; 3 of the 13 uncoated blades did not crack. Cracking occurred over the range 400 to 2750 cycles, with single crystal blades indicating the poorest thermal fatigue resistance. Oxidation of the uncoated blades was limited to 3000 cycles. All coatings indicated microscopically visible spalling at the trailing edge radius after 3000 cycles. General spalling on the airfoil was observed for two multilayered coatings.


(Contract NAS5-20585)

(Contract NAS5-19578; AIR Research-21-3071; Available: NTIS CR)
A model TFE731-1 engine was used as a baseline for the NASA quiet general aviation turbofan engine and nacelle program designed to demonstrate the applicability of large turbofan engine technology to small general aviation turbofan engines. Significant reductions in noise and pollutant emissions while reducing or maintaining fuel consumption levels. All new technology design for rotating parts and all items in the engine and nacelle that contributed to the acoustic and pollutant characteristics of the engine system were of flight design, weight, and construction. The major noise, emissions, and performance goals were met. Noise levels estimated for the three FAR Part 36 conditions, are 10 to 15 ENPaB below FAA requirements, emission values are considerably reduced below current technology engines; and the engine performance represents a TSFC improvement of approximately 9 percent over other turbofan engines.

N80-21332# Pratt and Whitney Aircraft Group, East Hartford, Conn.
Lawrence T. Shamebom Jan. 1980 80 p
(Contract NAS3-20590)
(NASA-CR-159801), PWA-5568)
Avail: NTIS
HC A05/MF A01 CSCL 21E

N80-21334# Pratt and Whitney Aircraft Group, West Palm Beach, Fla.
DATA ANALYSIS OF P SUB T/P SUB S NOSEBOOM PROBE TESTING ON F100 ENGINE PBS0072 AT NASA LEWIS RESEARCH CENTER Final Report
C. H. Foote Mar. 1980 23 p
(Contract NAS3-19442)
(NASA-CR-159816), PWA-FR-12540)
Avail: NTIS
HC A02/MF A01 CSCL 21E

N80-22323# Massachusetts' Inst of Tech , Cambridge, Aeronastic and Structures Research Lab.
TWO-DIMENSIONAL FINITE-ELEMENT ANALYSES OF SIMULATED ROTOR-FRAGMENT IMPACTS AGAINST RINGS AND BEAMS COMPARED WITH EXPERIMENTS
Thomas R Stagliano, Emmett A Witmer, and Jose J. A. Rodal Dec. 1979 363 p refs
(Grant NGR 22-009-339)
(NASA-CR-159645), ASRL-TR-154-13)
Avail: NTIS
HC A16/MF A01 CSCL 21E

N80-22324# Pratt and Whitney Aircraft Group, East Hartford, Conn.
PERFORMANCE DETERIORATION BASED ON EXISTING (HISTORICAL) DATA; JT9D JET ENGINE DIAGNOSTICS PROGRAM
G Phil Sallee 20 Apr 1979 228 p refs
(Contract NAS3-20032)
(NASA-CR-138448), PWA-5512-21)
Avail: NTIS
HC A11/MF A01 CSCL 21E

N80-22325# Solar Turbines International, San Diego, Calif.
ADVANCED CERAMIC MATERIAL FOR HIGH TEMPERATURE TURBINE TIP SEALS Final Report, Feb. 1976 - May 1979
J W Vogan, N G Solomon, and A R Stetson Jan. 1980 97 p refs
(Contract NAS3-20081)
(NASA-CR-159774), SRT9-R-4482-43, RDR-1831-43)
Avail: NTIS
HC A05/MF A01 CSCL 11A

N80-22326# Teledyne Continental Motors, Muskegon, Mich.
DESIGN STUDY: A 186 kW LIGHTWEIGHT DIESEL AIRCRAFT ENGINE Final Report
Alex P Brouwers Apr. 1980 24 p
(Contract NAS3-20830)
(NASA-CR-32371) Avail: NTIS
HC A02/MF A01 CSCL 21E

and limitations of the two dimensional structural response computer code CIVM-JET 4B for predicting the transient, large deflection, elastic plastic, structural responses of two dimensional beam and/or ring structures which are subjected to rigid fragment impact were investigated. The applicability of the CIVM-JET 4B analysis and code for the prediction of steel containment ring response to impact by complex deformable fragments from a flibra burst of a TS8 turbine rotor was studied. Dimensional analysis considerations were used in a parametric examination of data from engine rotor burst containment experiments and data from sphere beam impact experiments. The use of the CIVM-JET 4B computer code for making parametric structural response studies on both fragment-containment structure and fragment-deflector structure was illustrated. Modifications to the analysis/computation procedure were developed to alleviate restrictions. E.D.K.
The design of an aircraft engine capable of developing 186 kW shaft power at a 7620 m altitude is described. The 186 kW design takes into account expected new developments in aircraft designs resulting in a reassessment of the power requirements at the cruise mode operation. Based on the results of this analysis, a three-phase technology development project is projected resulting in production dates of 1985, 1992, and 2000. R.E.S.


A fan module was developed using an existing turbofan engine. The fan was designed using the latest in large engine noise control technology. A mixer was added to reduce the already low exhaust noise and an acoustic end treatment was provided for the test engine. A noise prediction model was used through the design process to evaluate the various design alternatives. Acoustic tests were then made to development of advances in combustion systems, electronics, materials, and control systems. R.E.S.

N80-23309# General Electric Co., Cincinnati, Ohio. CF6 JET ENGINE PERFORMANCE IMPROVEMENT: NEW FAN W. A. Fasching May 1980 202 p (Contact NAS3-20629) (NASA-CR-159699); R78AE4143 Avail. NTIS HC A10/MF A01 CSCL 21E

As part of the NASA sponsored engine component improvement program, and fan package was developed to reduce fuel consumption in current CF6 turbofan aircraft engines. The new fan package consists of an improved fan blade, reduced fan tip clearance due to a fan case stiffener, and a smooth fan casing tip shroud. CF6 engine performance and acoustic tests demonstrated a 1.8% improvement in cruise sfc without an increase in engine noise. Power management thrust/fan speed characteristics were defined. Mechanical and structural integrity was demonstrated in model fan rotor photoelastic stress tests, full-size fan blade bench fatigue tests, and CF6 engine bird ingestion, crosswind, and garlic endurance tests. The fan was certified in the CF6-500c2/E2 engines and is in commercial service on the Boeing 747-200, Douglas DC-10-30, and Airbus industrie A300B aircraft. A.R.H.


Results of acoustic tests of three 62.2 cm (24.5 inch) diameter models of the prop-fan (a small diameter, highly loaded, Multi-bladed variable pitch advanced turboprop) are presented. Results show that there is little difference in noise produced by unswept and slightly swept designs. However, the model designed for noise reduction produces substantially less noise at test conditions simulating 0.8 Mach number cruise speed or at conditions simulating takeoff and landing. In the rear field at cruise conditions the acoustically designed. In the far field at takeoff and landing conditions the acoustically designed model is 5 db quieter than unswept or slightly swept designs. Correlation between noise measurement and theoretical predictions as well as comparisons between measured and predicted acoustic pressure pulses generated by the prop-fan blades are discussed. The general characteristics of the pulses are predicted. Shadow graph measurements were obtained which showed the location of bow and trailing waves. R.C.T.


A total of two three-stage compressors were designed and tested to determine the effects of aspect ratio on compressor performance. The first compressor was designed with an aspect ratio of 0.81; the other, with an aspect ratio of 1.22. Both compressors had a hub-tip ratio of 0.915, representative of the rear stages of a core compressor, and both were designed to achieve a 15.0% surge margin at design pressure ratios of 1.357 and 1.324, respectively, at a mean wheel speed of 167 m/sec. At design speed the 0.81 aspect ratio compressor achieved a pressure ratio of 1.346 at a corrected flow of 4.28 kg/sec and an adiabatic efficiency of 86.1%. The 1.22 aspect ratio design achieved a pressure ratio of 1.314 at 4.35 kg/sec flow and 87.0% adiabatic efficiency. Surge margin to peak efficiency was 24.0% with the lower aspect ratio blading, compared with 12.4% with the higher aspect ratio blading. R.C.T.


The conceptual design for an improved gas turbine (IGT) powertrain and vehicle was investigated. Cycle parameters, rotor systems, and component technology were reviewed and a dual rotor gas turbine concept was selected and optimized for best vehicle fuel economy. The engine had a two stage centrifugal compressor with a design pressure ratio of 5.28, two axial turbine stages with advanced high temperature alloy integral wheels, variable power turbine nozzle for turbine temperature and output torque control, catalytic combustor, and annular ceramic recuperator. The engine was rated at 54.81 kW, using water injection on hot days to maintain vehicle acceleration. The estimated vehicle fuel economy was 11.9 km/l in the combined driving cycle, 43 percent over the 1976 compact automobile. The estimated IGT production vehicle selling price was 10 percent over the comparable piston engine vehicle, but the improved fuel economy and reduced maintenance and repair resulted in a 9 percent reduction in life cycle cost. R.C.T.


Studies conducted as part of the NASA-Lewis CF6 jet engine diagnostics program are summarized. An 82-engine sample of DC-10-10 aircraft engine checkout data that were gathered to define the extent and magnitude of CF6-6D short term performance deterioration were analyzed. These data are substantiated by the performance testing and analytical teardown of CF6-6D short term deterioration engine serial number (ESN) 451507. R.C.T.

A redesigned, fuel efficient fan for the JT9D-7 engine was tested. Tests were conducted to determine the effect of the 3.8 AR fan on performance, stability, operational characteristics, and noise of the JT9D-7 engine relative to the current 4.6 AR Bill-of-Material fan. The 3.8 AR fan provides increased fan efficiency due to a more advanced blade airfoil with increased chord, eliminating one part span shroud and reducing the number of fan blades and fan exit guide vanes. Engine testing at simulated cruise conditions demonstrated the predicted 1.3 percent improvement in specific fuel consumption with the redesigned 3.8 AR fan. Flight testing and sea level stand engine testing demonstrated exhaust gas temperature margins, fan and low pressure compressor stability, operational suitability, and noise levels comparable to the Bill-of-Material fan.


refs
(Contract NAS3-20809)
(NASA-CR-159980; PWA-5883-58) Avail: NTIS
HC A12/ MF A01 CSCL 21E

A single stage, low aspect ratio, compressor with a 442.0 m/sec (1450 ft/sec) tip speed and a 0.597 hub/tip ratio typical of an advanced core compressor front stage was tested. The test stage incorporated an inlet duct which was representative of an engine transition duct between fan and high pressure compressors. At design speed, the rotor stator stage achieved a peak adiabatic efficiency of 86.6 percent at a flow of 44.35 kg/sec (97.8 lbm/sec) and a pressure ratio of 1.8. Surge margin was 12.5 percent from the peak stage efficiency point.

N80-25325† Detroit Diesel Allison, Indianapolis, Ind.

EXPERIMENTAL DETERMINATION OF UNSTEADY BLADE ELEMENT AERODYNAMICS IN CASCADES. VOLUME 1: TORSION MODE CASCADE Final Report
(Contract NAS3-20055)
(NASA-CR-159831; EDR-10119-Vol-1) Avail: NTIS
HC A14/ MF A01 CSCL 21E

A two dimensional cascade of harmonically oscillating airfoils was designed to model a near tip section from a rotor which was known to have experienced supersonic torsional flutter. This five bladed cascade had a solidity of 1.17 and a setting angle of 1.07 rad. Graphite epoxy airfoils were fabricated to achieve the realistically high reduced frequency level of 0.4%. The cascade was tested over a range of static pressure ratios approximating the blade element operating conditions of the rotor along a constant speed line which penetrated the flutter boundary. The time-steady and time-unsteady flow field surrounding the center cascade airfoil were investigated. The effects of reduced solidity and decreased setting angle on the flow field were also evaluated.


PERFORMANCE DETERIORATION BASED ON IN-SERVICE ENGINE DATA: JT9D JET ENGINE DIAGNOSTICS PROGRAM
G. P. Sallee 27 Apr. 1979 185 p
refs
(Contract NAS3-20832)
(NASA-CR-159525; PWA-5515-114) Avail: NTIS
HC A04/ MF A01 CSCL 21E

Results of analyses of engine performance deterioration trends and levels with respect to service usage are presented. Thirty-two JT9D-7A engines were selected for this purpose. The selection of this engine fleet provided the opportunity of obtaining engine performance data starting before the first flight through initial service such that the trend and levels of engine deterioration related to both short and long term deterioration could be more carefully defined. The performance data collected and analyzed included in-flight, on-wing (ground) and test stand prerepair and postrepair performance calibrations with expanded instrumentation where feasible. The results of the analyses of these data were used to: (1) close gaps in previously obtained historical data as well as augment the historical data with more carefully obtained data; (2) refine preliminary models of performance deterioration with respect to usage; (3) establish an understanding of the relationships between ground and altitude performance deterioration trends; (4) refine preliminary recommendations concerning means to reduce and control deterioration; and (5) identify areas where additional effort is required to develop an understanding of complex deterioration issues.

E.R.
The improved single shank high pressure turbine design was evaluated in component tests consisting of performance, heat transfer and mechanical tests, and in core engine tests. The instrumented core engine test verified the thermal, mechanical, and aeromechanical characteristics of the improved turbine design. An endurance test subjected the improved single shank turbine to 1000 simulated flight cycles, the equivalent of approximately 3000 hours of typical airline service. Initial back-to-back engine tests demonstrated an improvement in cruise sfc of 1.3% and a reduction in exhaust gas temperature of 10 C. An additional improvement of 0.3% in cruise sfc and 6 C in EGT is projected for long service engines.


CF6-6D ENGINE PERFORMANCE DETERIORATION
(NASA-CR-159786; R80AEG218) Avail: NTIS HC A13/MF A01 CSCL 21E

Cruise cockpit records and test cell performance data in conjunction with hardware inspection data from aircraft overhaul shops were analyzed to define the extent and magnitude of performance deterioration of the General Electric CF6-6D model engine. These data indicated that the deterioration is from the longer term, and defined areas where a significant reduction in aircraft energy requirements for the 1980's can be realized. Unrestored losses which remain after engine refurbishment represent over 70% of the loss at engine shop visit. Sixty-three percent of the unrestored losses are cost-effective to restore which could reduce fuel consumed by CF6-6D engines in 1980 by 10.9 million gallons.

N80-29302* Department of Energy, Washington, D. C.

OUTLOOK FOR ALTERNATIVE ENERGY SOURCES

Predictions are made concerning the development of alternative energy sources in the light of the present national energy situation. Particular emphasis is given to the impact of alternative fuels development on aviation fuels. The future outlook for aircraft fuels is that for the near term, there possibly will be no major fuel changes, but minor specification changes may be possible if engine development of aviation fuels. In the mid-term, a broad cut fuel may be used if current development efforts are successful. As synfuel production levels increase beyond the 1990's there may be some mixtures of petroleum-based and synfuel products with the possibility of some shale distillate and indirect coal liquefaction products near the year 2000.


CURRENT JET FUEL TRENDS

Data concerning the properties of commercial jet fuels during a period between 1974 and 1979 are discussed. During this period the average aromatics content of fuels increased from 16% to 17.5%. It is evident that the arrival of Alaska North Slope crude in 1977 had a significant impact upon the aromatics content of jet fuel supply at West Coast points with less effect upon the entire United States domestic market. This increase in aromatics has not been accompanied by a corresponding reduction in burning quality as measured by smoke point. There has been a reduction of 0.6 smoke point on the average. Looking at hydrogen content as a measure of burning quality, the all refinery average calculated hydrogen for 1978 was approximately 13.7%. The relationship between hydrogen content and aromatics content shows a slope of 0.043% reduction in hydrogen for 1% increase in aromatics.

M.G.


AVIATION FUELS OUTLOOK

Options for satisfying the future demand for commercial jet fuels are analyzed. It is concluded that the most effective means to this end are to attract more refiners to the jet fuel market and encourage development of processes to convert oil shale and coal to transportation fuels. Furthermore, changes in the refiners fuel specification would not significantly alter jet fuel availability.

M.G.

N80-29305* California Univ. at Los Angeles. School of Engineering and Applied Science.

A METHODOLOGY FOR LONG-RANGE PREDICTION OF AIR TRANSPORTATION INTERESTS

A framework and methodology for long term projection of demand for aviation fuels is presented. The approach taken includes two basic components. The first is a technique for establishing the socio-economic environment within which the future aviation industry is embedded. The concept utilizes a definition of an overall societal objective for the very long run future. Within a framework so defined, a set of scenarios by which the future will unfold are then written. These scenarios provide the determinants of the air transport industry operations and accordingly provide an assessment of future fuel requirements. The second part was the modeling of the industry in terms of an abstracted set of variables that represent the overall industry performance on a macro scale. The model was validated by testing the desired output variables from the model with historical data over the past decades.

M.G.

N80-29306* Exxon Research and Engineering Co., Linden, N.J.

EFFECT OF REFINING VARIABLES ON THE PROPERTIES AND COMPOSITION OF JP-5
Avail: NTIS HC A11/MF A01 CSCL 21D

Potential future problem areas that could arise from changes in the composition, properties, and potential availability of JP-5 produced in the near future are identified. Potential fuel problems
concerning thermal stability, lubricity, low temperature flow, combustion, and the effect of the use of specific additives on fuel properties and performance are discussed. An assessment of available crudes and refinery capabilities is given. M.G.


The effects of broadening the specifications for JP-4 and JP-8 fuels on the performance and cost of all USAF aircraft presently using JP-4 as well as those expected to be introduced into the force structure by 1983 are investigated. Test results indicated that there was no impact on engine performance, turbine durability, and coking, however there was a small maintenance cost increase as a result of a small combustor life decrease. Using JP-4 as standard fuel will avoid the high cost of high demand middle distillate fuels and extendative use of JP-8 in the United States will increase middle distillate demand and cause a slight increase in engine hot-section maintenance. It is also concluded that the maximum allowable freeze point of JP-4 or JP-8 cannot be increased without degrading system performance and safety as critical conditions are approached. M.G.


Investigations leading to a specification for aviation turbine fuel produced from whole crude oil are described. Refining methods involving hydrocracking, hydrotreating, and extraction processes are briefly examined and their production capabilities are assessed. M.G.


Advanced combustor concepts are evaluated as a means of accommodating possible future broad specification fuels. The three advanced double annular combustor concepts consisted of (1) a concept employing high pressure drop fuel nozzles for improved atomization, (2) a concept with premixing tubes in the main stage, and (3) a concept with the pilot stage on the inside and the main stage on the inside, which is the reverse of the other two concepts. All of the advanced concepts showed promise for reduced sensitivity to full hydrogen content. Some hardware problems were encountered, but these problems could be quickly resolved if refinement tests were conducted. The design with the premixing main stage was selected for a parametric test because of its low NOx emissions level, carbon free done, and very low dome temperatures which were essentially independent of fuel type. The other advanced designs also had low dome temperatures. The premixing dome design liner temperatures exhibited less sensitivity to fuel type than did the base-line combustor, although more sensitivity than observed for concept 1. The inner liner hot spot and the observed smoke results for the premixing design suggest that the fuel-air mixture was not as uniform as desired. M.G.


The effects of select fuel property variations on two major engine classifications are summarized. Thirteen refined and blended fuels were used which exhibited significant variations in hydrogen content, aromatic type, initial boiling point, final boiling point, and viscosity. Trends were very similar but the degree of fuel sensitivity was not constant. For both systems the dominant fuel property during high pressure operation was found to be fuel hydrogen content. For operation at low pressure test points the fuel volatility and viscosity became the dominant fuel properties for both systems. Aromatic type and final boiling point did not significantly affect combustion data. Correlations of other fuel properties with those and other performance parameters are presented. E.D.E.


A program for the determination of fuel property effects on aircraft gas turbine engine mainburners and turbines is discussed. The six engines selected as test candidates are the J79, J85, J57, TF30, TF39, and F100. Fuels election is the responsibility of the contractors with two fuels as exceptions. The petroleum JP-4 is to be used as a baseline in all tests. The shale JP-4 is to be used in nearly all tests. Fuel properties are to be correlated with combustion system performance parameters. In addition, life predictions are to be made for combustor and turbine hardware. These predictions are to be based on a typical mission for each system, measured metal temperatures and temperature gradients, and oxidation/corrosion effects. E.D.E.


The impact of the use of broadened specification fuels on combustor design was investigated. Particular emphasis was placed on establishing the viability of various combustor modifications to permit the use of broadened specification fuels while meeting exhaust emissions and performance specifications and maintaining acceptable combustor operational and durability characteristics. Three different combustor concepts will be evaluated. Various design modifications on the operating capability of each of the combustors were made. Referees broadened specification and modifications that were evaluated included perturbation of the combustor airflow schedules to alter local stoichiometry and time histories to the fuel injectors or/and in liner cooling including the use of thermostatic controls and/or advanced cooling concepts. R.C.T.


The use of broad specification fuels in aircraft turbine engine combustion systems was examined. Three different
Combustor design concepts were evaluated for their ability to use broad specification fuels while meeting several specific emissions, performance, and durability goals. These combustor concepts covered a range from those having limited complexity and relatively low technical risk to those having high potential for achieving all of the program goals at the expense of increased technical risk.

R.C.T.

N80-28319‡ Purdue Univ., Lafayette, Ind.

ATOMIZATION OF BROAD SPECIFICATION AIRCRAFT FUELS


Avail: NTIS HC A11/MF A01 CSCL 21D

The atomization properties of liquid fuels for the potent use in aircraft gas turbine engines are discussed. The significance of these properties are addressed with respect to the ignition and subsequent combustion performance of the fuel spray/air mixture. It is shown that the fuel properties which affect the atomization behavior (viscosity, surface tension, and density) are less favorable for the broad specification fuels as compared to those for conventional fuels.

R.C.T.

N80-28320‡ Massachusetts Inst. of Tech., Cambridge.

SOOT FORMATION AND BURNOUT IN FLAMES


Avail: NTIS HC A11/MF A01 CSCL 21E

The amount of soot formed when burning a benzene/hexane mixture in a turbulent combustor was examined. Soot concentration profiles in the same combustor for kerosene fuel are given. The chemistry of the formation of soot precursors, the nucleation, growth and subsequent burnout of soot particles, and the effect of mixing on the previous steps were considered.

R.C.T.

N80-28321‡ Exxon Research and Engineering Co., Linden, N.J.

FUEL PROPERTY EFFECTS IN STIRRED COMBUSTORS

In NASA. Lewis Res. Center Aircraft Res. and Technol., for Future Fuels Jul. 1980 p 139-146 Sponsored by DOE (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSCL 21E

Soot formation in strongly backmixed combustion was investigated using the jet-stirred combustor (JSC). This device provided a combustion volume in which temperature and combustion were uniform. It simulated the recirculating characteristics of the gas turbine primary zone; it was in this zone where mixture conditions were sufficiently rich to produce soot. Results indicate that the JSC allows study of soot formation in an aerodynamic situation relevant to gas turbines.

R.C.T.

N80-28322‡ Southwest Research Inst., San Antonio, Tex.

EFFECT OF FUEL MOLECULAR STRUCTURE ON SOOT FORMATION IN GAS TURBINE COMBUSTION


Avail: NTIS HC A11/MF A01 CSCL 21B

The effect of fuel variations at the same hydrogen content on the formation of soot in a gas turbine combustor was studied. Six fuels were burned to a combustor over a matrix of about 180 kPa (5-18 atm) pressure and 500-1000 K burner inlet temperature; fuel-air ratios were varied from 0.008 to 0.024. Flame radiation measurements were made through a sapphire window toward the end of the primary zone. The hydrogen content of the six test fuels ranged from 12.80 to 12.85%. Five fuels emphasized hydrocarbon types: (mono, di, and tricyclic), napthenes (decalin) and partially hydrogenated aromatics (tetralin); the sixth fuel emphasized final boiling point.

R.C.T.

N80-28323‡ United Technologies Research Center, East Hartford, Conn.

EXPERIMENTAL STUDY OF TURBINE FUEL THERMAL STABILITY IN AN AIRCRAFT FUEL SYSTEM SIMULATOR


Avail: NTIS HC A11/MF A01 CSCL 21D

The thermal stability of aircraft gas turbines fuels was investigated. The objectives were: (1) to design and build an aircraft fuel system simulator; (2) to establish criteria for qualitative assessment of fuel thermal degradation; and (3) to measure the thermal degradation of Jet A and an alternative fuel. Accordingly, an aircraft fuel system simulator was built and the coking tendencies of Jet A and a model alternative fuel (No. 2 heating oil) were measured over a range of temperatures, pressures, flows, and fuel inlet conditions.

R.C.T.

N80-28324‡ Naval Air Propulsion Test Center, Trenton, N.J.

DETERMINATION OF JET FUEL THERMAL DEGRADATION DEPOSIT RATE USING A MODIFIED JFTOT


Avail: NTIS HC A11/MF A01 CSCL 21D

Three fuels having different breakpoint temperatures were studied in the modified jet fuel thermal oxidation tester. The lower stability fuel with a breakpoint of 240°C was first stressed at a constant temperature. After repeating this procedure at several different temperatures, an Arrhenius plot was drawn from the data. The correlation coefficient and the energy of activation were calculated to be 0.97 and 9 kcal/mole respectively. Two other fuels having breakpoint temperatures of 271°C and 285°C were also studied in a similar manner. A straight line was drawn through the data at a slope equivalent to the slope of the lower stability fuel. The deposit formation rates for the three fuels were determined at 250°C, and a relative deposit formation rate at this temperature was calculated and plotted as a function of the individual fuel's breakpoint temperatures.

R.C.T.

N80-29227‡ Colorado School of Mines, Golden.

MECHANISMS OF NITROGEN HETEROCYCLE INFLUENCE ON TURBINE FUEL STABILITY


Avail: NTIS HC A11/MF A01 CSCL 21D

Lewis bases were extracted from a Utah COED syncrude via ligand exchange. Addition of this extract to Jet A at levels as low as 0.05 ppm produce deterioration of stability in both JFTOT and accelerated storage tests (7 days at 394 K with 13:1 air to fuel ratio). Comparable effects on Jet A stability were obtained by addition of pyridine and quinoline, while pyrrole and indole were less detrimental at the same concentration level. The weight of deposit produced accelerated storage tests was found to be proportional to the concentration of added nitrogen compound. Over the narrow temperature range accessible with the experimental method, Arrhenius plots obtained by assuming specific rate to be proportional to the weight of material deposited in seven days exhibit greater slopes in the presence of those nitrogen compounds producing the greater deposition rates. It is shown that despite variation in appearance the elemental composition and spectral characteristics of the deposits are affected by addition of the nitrogen compounds. The linearity of the Arrhenius plots and of a plot of Arrhenius slope versus intercept for all the compounds suggests a constancy of mechanism over the range of temperature and heterocycles studied.

R.C.T.

N80-29329‡ Boeing Military Airplane Development, Seattle,
Wash.

HIGH-FREEZING-POINT FUEL STUDIES
Considerable progress in developing the experimental and analytical techniques needed to design airplanes to accommodate fuels with less stringent low temperature specifications is reported. A computer technique for calculating fuel temperature profiles in full tanks was developed. The computer program is being extended to include the case of partially empty tanks. Ultimately, the completed package is to be incorporated into an aircraft fuel tank thermal analysers code to permit the designer to vary thermal exposure patterns, study fuel temperatures versus time, and determine holdup.

N80-29297# General Electric Co, Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE TEST REPORT. VOLUME 2: ACOUSTIC PERFORMANCE
D. L. Stimpert Nov. 1979 124 p refs 2 Vol. (Contract NAS3-19021)
High bypass geared turbofan engines with nacelles forming the propulsion system for short-haul passenger aircraft were tested for use in externally blown flap-type aircraft. System noise levels for a four-engine, UTW-powered aircraft operating in the powered lift mode were calculated to be 97.2 and 95.7 EPNdB at takeoff and approach, respectively, on a 152.4 m (500 ft) sideline compared to a goal of 95.0 EPNdB.

N80-29298# General Electric Co, Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE COMPOSITE FAN BLADE: PRELIMINARY DESIGN TEST REPORT
May 1975 63 p (Contract NAS3-19021)
High bypass geared turbofan engines with nacelles forming the propulsion system for short-haul passenger aircraft were tested for use in externally blown flap-type aircraft. System noise levels for a four-engine, UTW-powered aircraft operating in the powered lift mode were calculated to be 97.2 and 95.7 EPNdB at takeoff and approach, respectively, on a 152.4 m (500 ft) sideline compared to a goal of 95.0 EPNdB.

N80-29299# General Electric Co, Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
ACOUSTIC PERFORMANCE OF A 50.8-cm (20-INCH) DIAMETER VARIABLE-PITCH FAN AND INLET. VOLUME 2: ACOUSTIC DATA Final Report
Results from acoustic tests on a 50.8 cm (20 inch) GCSEE Under-the-Wing (UTW) engine, variable pitch fan and inlet simulator are tabulated. Tests were run in both forward and reverse thrust modes with a bellmouth inlet, five accelerating inlets (one hardwall and four treated), and four low Mach number inlets (one hardwall and three treated). The 1/3 octave-band acoustic data are presented for the model size on the measured 5.2 m (17.0 ft) arc and also data scaled to full GCSEE size 71.20 on a 152.4 m (500 ft) sideline.

N80-29300# Lockheed-California Co., Burbank
LOW TEMPERATURE FUEL BEHAVIOR STUDIES
Aircraft fuels at low temperatures near the freezing point. The principal objectives was an improved understanding of the flowability and pumpability of the fuels in a facility that simulated the heat transfer and temperature profiles encountered during flight in the long range commercial wing tanks.

N80-29331# TRW, Inc., Cleveland, Ohio.
TUNGSTEN WIRE/FeCrAIY MATRIX TURBINE BLADE FABRICATION STUDY
P. Melnyk and J. N. Fleck Dec. 1979 99 p refs (Contract NAS3-20391)
(NASA-CR-159788; TRW-ER-8101) Avail: NTIS HC A05/MF A01 CSCL 21E
The object was to establish a viable FRS monotape technology base to fabricate a complex, advanced turbine blade. All elements of monotape fabrication were addressed. A new process for incorporation of the matrix, including bi-alloy matrices, was developed. Bonding, cleaning, cutting, sizing, and forming parameters were established. These monotapes were then used to fabricate a 48 ply solid JT9D-7F 1st stage turbine blade. Core technology was then developed and first a 12 ply and then a 7 ply shell hollow aifoil was fabricated. As the fabrication technology advanced, additional aifoils incorporated further elements of sophistication, by introducing in sequence bonded cost blocks, cross-plying, bi-metallic matrix, tip cap, trailing edge slots, and impingement inserts.

(NASA-CR-159500; R80FE428) Avail: NTIS HC A09/MF A01 CSCL 21E
The double bypass, variable cycle engine (VCE) used as the propulsion system for a Mach 2.4 cruise supersonic commercial transport was examined in the following areas: (1) the acoustic and performance payoffs of the high flow mode of the double bypass VCE; (2) possible cycle improvements for noise; (3) manufacturing cost, reliability and maintainability of the VCE compared to other engine concepts; (4) an assessment of the performance and economic payoffs of the features used in the double bypass VCE. The high flow capability of the double bypass VCE did show acoustic and performance payoffs both with unsuppressed and with mechanically suppressed coannular exhaust systems. At lower noise goals, changes to the baseline VCE cycle improved takeoff gross weight for a design version by up to 4%. The double bypass feature of the VCE provided performance and acoustic flexibility that resulted in lower takeoff gross weight for all noise levels, utilizing unsuppressed coannular nozzle, suppressed coannular nozzle, and single stream fully suppressed nozzle. The manufacturing cost, reliability, and maintainability of the double bypass VCE compares favorably with the simpler concepts studied (within 1 to 5.5%).

N80-31398# TRW, Inc., Cleveland, Ohio. Materials Technology.
COST ANALYSIS OF COMPOSITE FAN BLADE MANUFACTURING PROCESSES Final Report
T. S. Stelson and C. F. Barth Jun. 1980 87 p refs (Contract NAS3-21352)
(NASA-CR-159876; TRW-ER-8064) Avail: NTIS HC A05/MF A01 CSCL 21E
The relative manufacturing costs were estimated for large high technology fan blades prepared by advanced composite fabrication methods using seven candidate materials/processes.
systems. These systems were identified as laminated resin matrix composite, filament wound resin matrix composite, superhybrid solid laminate, superhybrid spar/shell, metal matrix composite, metal matrix composite with a spar and shell, and hollow titanium. The costs were calculated utilizing analytical process models and all cost data are presented as normalized relative values where 100 was the cost of a conventionally forged solid titanium fan blade whose geometry corresponded to a size typical of 42 blades per disc. Four costs were calculated for each of the seven candidate systems to relate the variation of cost on blade size. Geometries typical of blade designs at 24, 30, 36 and 42 blades per disc were used. The impact of individual process yield factors on costs was also assessed as well as effects of process parameters, raw materials, labor rates and consumable items.


ENERGY EFFICIENT ENGINE


The feasibility of meeting or closely approaching the emissions goals established for the Energy Efficient Engine (E3) Project with an advanced design, single annular combustor was determined. A total of nine sector combustor configurations and one full-annular-combustor configuration were evaluated. Acceptable levels of carbon monoxide and hydrocarbon emissions were obtained with several of the sector combustor configurations tested, and several of the configurations tested demonstrated reduced levels of nitrogen oxides compared to conventional, single annular designs. None of the configurations tested demonstrated nitrogen oxide emission levels that meet the goal of the E3 Project.


In the first practical application of laser anemometry to an actual gas turbine engine combustor, the mean velocity and turbulent intensity profiles were measured in a steady-flow combustion rig across an annulus simulating a turbine inlet; to establish a basis for comparison with similar measurements to be made in an operating engine and to confirm current turbine aerodynamics and heat transfer design assumptions. It was necessary to develop a new experimental technique for traversing the annulus due to differential thermal expansion of the cantilevered combustion rig and a new computer-graphics analysis technique for analyzing the velocity histograms due to the high background light intensity. The axial mean velocity and turbulent intensity were uniform across the annulus under all operating conditions and the flow had little or no swirl component. The isothermal mean velocity was doubled by the burning of fuel, however, the isothermal turbulent intensity was relatively unaffected.


Results of NASA sponsored acoustic tests of three 2 ft. diameter models of the Prop-Fan (a small diameter, highly loaded, many-bladed variable pitch advanced turboprop) are presented. The highly swept model designed for noise reduction produces substantially less near field noise at simulated 0.8 Mach number cruise conditions than the unswep or slightly swept models. It also produces less far field noise at conditions simulating takeoff and landing. The noise reduction mechanism is discussed. Correlation between harmonic noise measurements and theoretical predictions and between measured and predicted acoustic pressure pulses is good. Shadowgraph measurements which show the location of turbulent acoustic wave patterns were obtained. Predicted and measured wave locations show good agreement. Full scale near and far field noise is predicted.


The broad objectives of this paper are the following: (1) to summarize the Curtiss-Wright design, development and field testing background in the area of rotary aircraft engines; (2) to briefly summarize past activity and update development work in the area of stratified charge rotary combustion engines; and (3) to discuss the development of a high-performance direct injected unthrottled stratified charge rotary combustion aircraft engine. Efficiency improvements through turbocharging are also discussed.


Fuel consumption for subsonic transport aircraft. One technology concept being pursued is active control of rotor tip clearances. Potential fuel savings with active control of rotor tip clearances is given to rotor tip clearance considerations and an overview of preliminary study results as well as the General Electric Energy efficient control approach is presented. Finally, potential fuel savings with active control of rotor clearances for a typical EEE mission are predicted.


This paper describes the results of a study in which a systematic approach has been taken in studying the effect of selected propeller parameters on the character and magnitude of propeller noise. Four general aviation aircraft were chosen, i.e., a Cessna 172, Cessna 210, Cessna 411, and a 19 passenger commuter concept, to provide a range in flight velocity, engine horsepower, and gross weight. The propeller parameters selected for examination consisted of number of blades, rpm reduction, thickness/chord reduction, activity factor reduction, propells, aerofoil improvement, sweep, position of maximum blade loading, and diameter reduction.
AIRCRAFT STABILITY AND CONTROL
Includes aircraft handling qualities, piloting, flight controls, and autopilots

N80-28369*F National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
SINGLE-STAGE ELECTROHYDRAULIC SERVOSYSTEM FOR ACTUATING ON AIRFLOW VALVE WITH FREQUENCIES TO 500 HERTZ
(NASA TP-1678, E-252) Avail NTIS HC A03/MF A01 CSCL C11C
An airflow valve and its electrohydraulic actuation servosystem are described. The servosystem uses a high-power, single-stage servovalve to obtain a dynamic response beyond that of systems designed with conventional two-stage servovalves. The electrohydraulic servosystem is analyzed and the limitations imposed on system performance by such nonlinearities as signal saturations and power limitations are discussed. Descriptions of the mechanical design concepts and developmental considerations are included. Dynamic data, in the form of sweep-frequency test results, are presented and comparison with analytical results obtained with an analog computer model is made. R K G
RESEARCH AND SUPPORT
FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

For related information see also 14 Ground Support Systems and Facilities (Space).

MBO-32404
Southampton Univ. (England). Dept. of Aeronautics and Astronautics.

SELECTED DATA FROM A TRANSONIC FLEXIBLE WALLED TEST SECTION Semiannual Progress Report
S.W. D. Wolf Sep, 1980 108 p refs
(Grant NsG-7172)
(NASA-CR-159360) Avail: NTIS HC A06/MF A01 CSCL 148

Twenty four test runs of the Transonic Self-Streamlining Wind Tunnel were performed with the flexible walls 'streamlined' around a two dimensional section of four inch chord, over the Mach number range 0.3 to 0.89. Relevant wall and model data for the streamlined cases are presented. L.F.M.

This paper presents the results of a study to determine the directions that electric propulsion technology should take to meet the primary propulsion requirements for earth-orbital missions of the next three decades in the most cost-effective manner. Discussed are the mission set requirements, state-of-the-art electric propulsion technology and the baseline system characterized by it, adequacy of the baseline system to meet the mission set requirements, cost-optimum electric propulsion system characteristics for the mission set, and sensitivities of mission costs and design points to system-level electric propulsion parameters. It is found that the efficiency-specific impulse characteristic generally has a more significant impact on overall costs than specific masses or costs of propulsion and power systems. (Author)


The program reviewed in the present paper has provided information of the reduced-gravity behavior of fluids, thermal control of cryogenic tankage, and fluid management system design. The studies are currently shifting from the utilization of in-house experimental facilities to the development of Spacelab experiments. The cryogenic fluid management experiment, currently undergoing detailed design, is expected to provide an orbital evaluation of a subcritical liquid hydrogen storage and supply system, as part of the Shuttle/Spacelab program. Efforts are continuing to develop computer techniques for simulating reduced-gravity fluid dynamic processes. V.P.
14 GROUND SUPPORT SYSTEMS
AND FACILITIES (SPACE)

Includes launch complexes, research and production facilities, ground support equipment, mobile transporters, and simulators.

For related information see also 09 Research Support Facilities (Air).


An existing test facility was modified to provide for extended testing of multiple electric propulsion thruster subsystems. A program to document thruster subsystem characteristics as a function of time is currently in progress. The facility is capable of simultaneously operating three 2.7-kW, 30-cm mercury ion thrusters and their power processing units. Each thruster is installed via a separate air lock so that it can be extended into the 7m x 10m main chamber without violating vacuum integrity. The thrusters exhaust into a 3m x 5m frozen mercury target. An array of cryopanels collect sputtered target material. Power processor units are tested in an adjacent 1.5m x 2m vacuum chamber or accompanying forced convection enclosure. The thruster subsystems and the test facility are designed for automatic unattended operation with thruster operation computer controlled. Test data are recorded by a central data collection system scanning 200 channels of data a second every two minutes. Results of the Systems Demonstration Test, a short shake down test of 500 hours, and facility performance during the first year of testing are presented. (Author)

N80-27403* # General Dynamics/Convair, San Diego, Calif.
CONCEPTUAL DESIGN OF TWO-PHASE FLUID MECHANICS AND HEAT TRANSFER FACILITY FOR SPACELAB
B. F. North and M. E. Hill Jun. 1980 190 p refs (Contract NAS3-21750)

Five specific experiments were analyzed to provide definition of experiments designed to evaluate two phase fluid behavior in low gravity. The conceptual design represents a fluid mechanics and heat transfer facility for a double rack in Spacelab. The five experiments are two phase flow patterns and pressure drop, flow boiling, liquid reorientation, and interface bubble dynamics. Hardware was sized, instrumentation and data recording requirements defined, and the five experiments were installed as an integrated experimental package. Applicable available hardware was selected in the experiment design and total experiment program costs were defined. Author
LAUNCH VEHICLES AND SPACE VEHICLES
Includes boosters, manned orbital laboratories, reusable vehicles, and space stations.

STUDY OF ADVANCED COMMUNICATIONS SATELLITE SYSTEMS BASED ON SS-FDMA
John Kiesling, May 1980, 359 p (Contract NAS3-21746)
(NASA-CR-159778, DOC-80SDS42177) Avail. NTIS HC A16/MF A01 CSCL 228

A satellite communication system based on the use of a multiple, contiguous beam satellite antenna and frequency division multiple access (FDMA) is studied. Emphasis is on the evaluation of the feasibility of SS (satellite switching) FDMA technology, particularly the multiple, contiguous beam antenna, the onboard switch and channelization, and on methods to overcome the effects of severe Ka band fading caused by precipitation. This technology is evaluated and plans for technology development and evaluation are given. The application of SS-FDMA to domestic satellite communications is also evaluated. Due to the potentially low cost Earth stations, SS-FDMA is particularly attractive for thin route applications up to several hundred kilobits per second, and offers the potential for competing with terrestrial facilities at low data rates and over short routes. The onboard switch also provides added route flexibility for heavy route systems. The key beneficial SS-FDMA strategy is to simplify and thus reduce the cost of the direct access Earth station at the expense of increased satellite complexity.

CONCEPTS FOR 20/30 GHZ SATCOM SYSTEMS FOR DIRECT-TO-USER APPLICATIONS

A baseline technique is described for implementing a direct-to-user (DTU) satcom communications system at 20/30 GHz transmission frequency. The purpose of this application is to utilize the high capacity frequency spectrum at K(A) band for communications among thousands of small terminals located at or close to a customer's facility. The baseline DTU system utilizes a TDMA method of communications with OFSK modulation. Twenty-five coverage beams from a geosynchronous orbit spacecraft provide full coverage of CONUS. Low cost terminals are limited to less than 4.5 meters diameter. The impact of rain attenuation on communications availability is examined. Other techniques including satellite switched antenna beams and critical K(A)-band technology developments are identified.

(Author)
16 SPACE TRANSPORTATION

Includes passenger and cargo space transportation e.g., shuttle operations, and rescue techniques.

For related information see also 02 Air Transportation and Safety and 85 Urban Technology and Transportation.

N80-20304* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

L0LC REDUCED GRAVITY FLUID MANAGEMENT TECHNOLOGY PROGRAM

John C. Aydelott and E. Patrick Symons (1980) 19 p refs
(NASA-TM-81450, E-371) Avail. NTIS HC A02/MF A01 CSCL

A survey of the reduced gravity fluid management technology program is presented. Information on reduced gravity fluid behavior, techniques for thermal control of cryogenic tankage, and design for fluid management systems are discussed. The development of Spacelab experiments, propellant management systems for orbit transfer vehicles, and computer techniques for simulating reduced gravity fluid dynamic processes is reported.

A.W.H


The experimental Communications Technology Satellite (CTS), also called Hermes, uses a high power transmitter and 12 and 14 GHz frequencies for wideband (two- and one-way television) and narrowband (voice, data) communications. In the joint program, both Canada and the United States have conducted a variety of communications experiments. This report concentrates on U.S. CTS experiments and minieperiments that used ground antennas from 0.6 to 5 meters in diameter. The U.S. CTS experiments program is summarized in this report. The use of CTS for simulated and actual disasters is summarized.

(Author)
17 SPACECRAFT
COMMUNICATIONS, COMMAND
AND TRACKING

Includes telemetry; space communications networks;
astronavigation; and radio blackout.
For related information see also 04 Aircraft Communications
and Navigation and 32 Communications.

N80-21412# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
A DIGITALLY IMPLEMENTED COMMUNICATIONS EXPERI-
MENT UTILIZING THE COMMUNICATIONS TECHNOLOGY
SATELLITE, HERMES
H D Jackson and J Fiala Mar 1980 19 p refs
(NASA-TM-81452, E-379) Avail NTIS HC A02/MF A01 CSCL
17B

Developments which will reduce the costs associated with
the distribution of satellite services are considered with emphasis
on digital communication link implementation. A digitally
implemented communications experiment (DICE) which demon-
strates the flexibility and efficiency of digital transmission of
television video and audio, telephone voice, and high-bit-rate
data is described. The utilization of the DICE system in a full
duplex teleconferencing mode is addressed. Demonstration
teleconferencing results obtained during the conduct of two
sessions of the 7th AIAA Communication Satellite Systems
Conference are discussed. Finally, the results of link characteriza-
tion tests conducted to determine (1) relationships between the
Hermes channel 1 EIRP and DICE model performance and
(2) channel spacing criteria for acceptable multichannel operation,
are presented. J.M.S.
18 SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes spacecraft thermal and environmental control; and attitude control.

For life support systems see 54 Man/ System Technology and Life Support. For related information see also 05 Aircraft Design, Testing and Performance and 39 Structural Mechanics.

N80-18200‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONFIGURATION EFFECTS ON SATELLITE CHARGING RESPONSE


The response of various spacecraft configurations to charging environments is considered. The configuration features geometry, type of insulation, and charging response. The response is evaluated for both operating voltage configurations while computing charged particle trajectories in the electric fields around the satellite. Particular attention is paid to the possibility of contaminants reaching a mirror surface inside a dielectric tube because this mirror represents a shielded optical surface in the satellite model used. Deposition of low energy charged particles from other parts of the spacecraft onto the mirror was found to be possible in the assumed moderate substorm environment condition. In the assumed severe substorm environment condition, however, voltage build up on the inside and edges of the dielectric tube in which the mirror is located prevents contaminants from reaching the mirror surface.

N80-18095‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASCAP MODELLING COMPUTATIONS ON LARGE OPTICS SPACECRAFT IN GEOSYNCHRONOUS SUBSTORM ENVIRONMENTS


The NASA Charging Analyzer Program (NASCAP) is used to evaluate qualitatively the possibility of charged spacecraft contamination on a conceptual version of a large satellite. The evaluation is made by computing surface voltages on the satellite due to encounters with substorm environments and then computing charged particle trajectories in the electric fields around the satellite. Particular attention is paid to the possibility of contaminants reaching a mirror surface inside a dielectric tube because this mirror represents a shielded optical surface in the satellite model used. Deposition of low energy charged particles from other parts of the spacecraft onto the mirror was found to be possible in the assumed moderate substorm environment condition. In the assumed severe substorm environment condition, however, voltage build up on the inside and edges of the dielectric tube in which the mirror is located prevents contaminants from reaching the mirror surface.

N80-32428‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MODELING OF ENVIRONMENTALLY INDUCED DISCHARGES IN GEOSYNCHRONOUS SATELLITES


The NASCAP computer code was used to compute the charging and discharging characteristics of a typical communications satellite in geosynchronous orbit. For the case of a severe substorm satellite surface differential charging in sunlight was found to be substantially less than that required to produce discharges in ground simulation studies. A discharge process was postulated involving discharges triggered at edges (or imperfection) followed by discharges to space. The characteristics of such discharges was parametrically varied to evaluate the possible effects on the satellite. Results indicated that discharge characteristics inferred from satellite monitors could be caused by predicted space discharges, that single cell discharges to space can reduce surface potential over entire satellite, and that low density electron trajectory computations indicate that discharge generated electrons do not return to the satellite by long trajectories. Current transients predicted do not agree with available ground simulation results indicating that additional work must be done both analytically and experimentally to understand and fully explain these discrepancies.

A.W.H.

N80-16094‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTED VOLTAGE DISTRIBUTIONS AROUND SOLAR ELECTRIC PROPULSION SPACECRAFT


The NASA Charging Analyzer Program is used to conduct preliminary computations of the voltage distributions around such large spacecraft in geomagnetic substorm environments at geosynchronous altitudes. Both a standard operating voltage (+ - 150 volts on solar arrays) and direct-drive (+1200 volts on arrays) configurations are considered. Thruster-off simulations are computed for both operating voltage configurations while the effect of simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only...

A study of the charging and discharging characteristics of a typical geosynchronous satellite experiencing time-varying geomagnetic substorms, in sunlight, is conducted. The NASA Charging Analyzer Program (NASCAP) is used as an electric field criteria for subcritical cryogenic storage and supply tankage. V.T. Stevens and C. K. Purvis (NASA, Lewis Research Center, Cleveland, Ohio). Society of Photo-Optical Instrumentation Engineers, Los Angeles Technical Symposium, North Hollywood, Calif., Feb. 4-7, 1980, Paper. 18 p. 20 refs.

Satellites in geosynchronous orbits have been found to be charged to significant negative voltages during encounters with geomagnetic substorms. When satellite surfaces are charged, there is a probability of enhanced contamination from charged particles attracted back to the satellite by electrostatic forces. This could be particularly disturbing to large satellites using sensitive optical systems. In this study the NASA Charging Analyzer Program (NASCAP) is used to evaluate qualitatively the possibility of such enhanced contamination on a conceptual version of a large satellite.

The evaluation is made by computing surface voltages on the satellite due to encounters with substorm environments and then computing charged-particle trajectories in the electric fields around the satellite. Particular attention is paid to the possibility of contaminants reaching a mirror surface inside a dielectric tube because this mirror represents a shielded optical surface in the satellite model used. Deposition of low energy charged particles from other parts of the spacecraft onto the mirror was found to be possible in the assumed moderate substorm environment condition. In the assumed severe substorm environment condition, however, voltage build up on the inside and edges of the dielectric tube in which the mirror is located prevents contaminants from reaching the mirror surface.


The paper describes the cryogenic fluid management experiment (CFME) as a Shuttle payload. The experiment includes a liquid hydrogen tank containing a fine-mesh screen acquisition device, and a thermal control system consisting of a thermodynamic vent system to intercept heat leak to the hydrogen tank and control tank pressure. Engineering data obtained will be used to establish design criteria for subcritical cryogenic storage and supply tankage. V.T.


This paper discusses the potential application of electric propulsion for orbit transfer of a large spacecraft structure from low earth orbit to geosynchronous altitude in a deployed configuration. The electric power was provided by the spacecraft nuclear reactor space power system on a shared basis during transfer operations. Factors considered with respect to system effectiveness included nuclear power source size, electric propulsion thruster concept, spacecraft deployment constraints, and orbital operations and safety. It is shown that the favorable total impulse capability inherent in electric propulsion provides a potential economic advantage over chemical propulsion orbit transfer vehicles by reducing the number of Space Shuttle flights in ground-to-orbit transportation requirements.


A study is presented in which the sensitivity of predicted equilibrium potential to changes in secondary electron yield parameters is investigated using MATCHG, a simple charging code which


The paper uses the NASCAP computer code to compute voltage distributions around a Solar Electric Propulsion (SEP) spacecraft as it develops in the NASCAP (NASA Charging Analyzer Program code, Space Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, Paper 80-0236. 16 p. 23 refs.

The satellite surface potential monitor (SSPM) has been developed for the P78-2 SCATHA (Spacecraft Charging At The High Altitudes) satellite to determine the response of selected spacecraft materials to charged-particle environmental fluxes. Since the monitor infers total surface voltages from a single point on the interior side of insulators, a ground simulation program was undertaken to develop analytical techniques to model the monitors and to obtain an experimental calibration of the relationship between the flight measurement techniques and actual measurements. The experimental testing was conducted using monenergetic electron beams irradiating samples in the dark. An analytical computer model was developed in the NASA Charging Analyzer Program (NASCAP) code. The analytical model material properties for Kapton that controlled backscatter and secondary yield were adjusted to obtain a single set of values that produced reasonable fits for both voltages and currents. The analytical techniques developed in the ground technology investigation have been applied to space flight conditions. Predictions were compared with limited flight data. The agreement is very good indicating that the technique, and NASCAP, can be used to predict spacecraft material charging behavior. Details of the testing, the analytical modelling technique and flight data comparisons are presented.


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A80-32829 * NASCAP modelling computations on large optics spacecraft in geosynchronous substorm environments. N. J.
incorporates the NASCAP material property formulations. It is found that equilibrium potential is a sensitive function of one of the two parameters specifying secondary electron yield due to proton impact and of essentially all the parameters specifying yield due to electron impact. In addition, it is found that information on the electron generated secondary yield parameters can be obtained from monenergetic beam charging data if charging rates as well as equilibrium potentials are accurately recorded. M.E.P.


A satellite experiment, designed to measure potential charging of typical thermal-control materials at near-geosynchronous altitude, was flown as part of the spacecraft charging at high altitudes program. Direct observations of charging of typical materials in a natural charging event greater than or equal to 5 keV are presented. The results show some features which differ significantly from previous laboratory simulations of the environment. (Author)

ABO-466830 * Active control of spacecraft charging. C. K. Purvis (NASA, Lewis Research Center, Cleveland, Ohio) and R. D. Bartlett (NASA, Goddard Space Flight Center, Greenbelt, Md.). In: Space systems and their interactions with earth's space environment. (ABO-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 289-317. 23 refs. [the concept of active control of spacecraft charging by charged particle emission is described. Active potential control experiments using the ATS-5 and ATS-6 geostationary spacecraft are discussed, and results of these experiments are presented. Previously reported results are summarized, and a guide to reports on NASA charging is provided. Experimental evidence presented indicates that emission of electrons only is not effective in maintaining spacecraft potential near plasma potential for spacecraft with electrically insulating surfaces. Emission of a low energy plasma, however, is effective for this purpose. (Author)

ABO-46691 * A three-dimensional spacecraft-charging computer code. A. G. Rubin (USAF, Geophysics Laboratory, Bedford, Mass.), I. Katz, M. Mandell, G. Schnuelle, P. Steen, D. Parks, J. Cassidy (Systems Science and Software, Inc., La Jolla, Calif.), and J. Roche (NASA, Lewis Research Center, Cleveland, Ohio). In: Space systems and their interactions with earth's space environment. (ABO-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 318-336. 9 refs. A computer code is described which simulates the interaction of the space environment with a satellite at geosynchronous altitude. Employing finite elements, a three-dimensional satellite model has been constructed with more than 1000 surface cells and 15 different surface materials. Free space around the satellite is modeled by nesting drifts within grids. Applications of this NASA spacecraft charging analyzer program (NSCAP) code to the study of a charged particles and the differential charging of the SCATHA (satellite charging at high altitudes) satellite in eclipse and in sunlight are discussed. In order to understand detector response when the satellite is charged, the code is used to trace the trajectories of particles reaching the SCATHA detectors. Particle trajectories from positive and negative emitters on SCATHA also are traced to determine the location of returning particles, to estimate the escape time, and to simulate active control of satellite potentials. (Author)


Large, high-voltage space power systems are being proposed for future space missions. These systems must operate in the charged particle environment of space, and interactions between this environment and the high-voltage surfaces are possible. Ground simulation testing has indicated that dielectric surfaces that usually surround biased conductors can influence these interactions. For positive voltages greater than 100 V, it has been found that the dielectrics contribute to discharges. Using these experimental results a large, high-voltage power system operating in geosynchronous orbit was analyzed with the NASCAP code. Results of this analysis indicated that very strong electric fields exist in these power systems. A technology investigation is required to understand the interactions and develop techniques to alleviate any impact on power system performance. (Author)


Charged and neutral particle transport from an 8-cm mercury ion thruster to the surfaces of the P80-1 spacecraft, the Teal Ruby sensor and the ECOM-501 sensor was examined. Evaluation of particle transport modes utilized both laboratory measurements and analysis. Line-of-sight particle transport considered deposition of Group I (high energy-high angle mercury charge exchange) ions and neutral mercury on solar array surfaces. None-line-of-sight transport modes studied were recirculation/reinterception of mercury ions in magnetic fields and refraction of low energy mercury charge exchange (Group IV) ions by local electric fields. (Author)


A computer model of the three-dimensional sheet formation and plasma current collection by high voltage spacecraft has been developed. By using new space charge density and plasma collection algorithms, it is practical to perform calculations for large, complex spacecraft. The model uses NASCAP compatible objects and geometries. Results indicate that ion focusing observed in the laboratory during high voltage collection experiments is probably due to the electric field gradients on the collecting surfaces. (Author)
20 SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components e.g., rocket engines, and spacecraft auxiliary power sources.

For related information see also Q7 Aircraft Propulsion, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

N80-13168# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ION THRUSTER COMPONENT TESTING


Electron bombardment thrusters, under development to provide both auxiliary and primary propulsion functions for a large variety of spacecraft missions, are discussed. The performances of the cathode, vaporizer, and isolators during fatigue testing which requires life tests of durations of the order of the time anticipated in space applications, are discussed. The life time and reliability of an electron bombardment thruster is dependent upon the performance of several critical components. The impacts on payloads of total cost to parameters such as mission duration, array cost, cover glass thickness, and concentration ratio were determined along with cost tradeoffs between silicon and gallium arsenide arrays for selected mission classes. Results indicate that development of the technology for low cost, light weight concentrators should be increased and that cost reduction efforts for gallium arsenide cells be pursued.

R.C.T.

N80-16097# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

UPPER STAGES UTILIZING ELECTRIC PROPULSION


The payload characteristics of geocentric missions which utilize electric propulsion on thuster systems are discussed. A baseline LEO to GEO orbit transfer mission was selected to describe the payload capabilities. The impacts on payloads of both mission parameters and electric propulsion technology options were evaluated. The characteristics of the electric propulsion thrust system and the power requirements were specified in order to predict payload mass. This was completed by utilizing a previously developed method which provides a detailed thrust system description after the final mass on orbit, the thrusting time, and the specific impulse are specified. The impact on payloads of total mass in LEO, thrusting time, propulsion type, specific impulse, and power source characteristics was evaluated.

A.W.H.

N80-15204# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF GaAs AND Si SOLAR CELL ARRAYS FOR EARTH ORBITAL AND ORBIT TRANSFER MISSIONS


Silicon and gallium arsenide arrays were studied and compared for low earth orbit (LEO), geosynchronous orbit (GEO) and LEO to GEO electric propulsion orbit transfer missions. The sensitivities of total cost to parameters such as mission duration, array cost, cover glass thickness, and concentration ratio were determined along with cost tradeoffs between silicon and gallium arsenide arrays for selected mission classes. Results indicate that development of the technology for low cost, light weight concentrators should be increased and that cost reduction efforts for gallium arsenide cells be pursued.

R.C.T.

N80-15138# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ANALYTICAL INVESTIGATION OF TWO HYDROGEN OXYGEN ROCKET ENGINE SYSTEMS FOR LOW-THRUST APPLICATION


Two hydrogen oxygen rocket engine system concepts were analyzed parametrically over a thrust range from 100 to 10000 pounds and a chamber pressure range from 175 to 10000 psia. Both concepts were regeneratively cooled with hydrogen and were pumped by electric motor driven positive displacement pumps. Electric power was provided by either a turboalternator (turbogenerator concept) or some means external to the engine system (auxiliary power concept). The turboalternator concept is discussed. The computer program used to conduct analyses along with the design characteristics of the major engine system components is described. The feasible design range of the systems over the parametric range of thrust is discussed in terms of allowable chamber pressure. Engine system estimated performance, mass, and dimensional envelope parametric data within the feasible design range are presented.

A.W.H.
of the design and fabrication of a low Earth orbit, 2 kW photovoltaic/battery, space qualified power system. A commercially available computer program called PRICE (programmed review of information for costing and evaluation) was used to conduct the analysis. The sensitivity of the various cost factors to the assumptions used is discussed. Total cost of the power system was found to be $246 million with the solar array accounting for 70.5%. Using the assumption that the prototype becomes the flight system, 77.3% of the total cost is associated with manufacturing. Results will be used to establish whether the cost of space qualified hardware can be reduced by the incorporation of commercial design, fabrication, and quality assurance methods. J.M.S.

N80-23365# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COOLING OF HIGH PRESSURE ROCKET THRUST CHAMBERS WITH LIQUID OXYGEN

An experimental program using hydrogen and oxygen as the propellants and supercritical liquid oxygen (LOX) as the coolant was conducted at 4.14 and 8.274 MN/square meters (600 and 1200 psia) chamber pressure. Data on the following are presented: the effect of LOX leaking into the combustion region through small cracks in the chamber wall; and verification of the supercritical oxygen heat transfer correlation developed from heated tube experiments; A total of four thrust chambers with throat diameters of 0.066 m were tested. Of these, three were cyclically tested to 4.14 MN/square meters (600 psia) chamber pressure until a crack developed. One had 23 additional hot cycles accumulated with no apparent metal burning or distress. The fourth chamber was operated at 8.274 MN/square meters (1200 psia) pressure to obtain steady state heat transfer data. Wall temperature measurements confirmed the heat transfer correlation. R.C.T.

N80-30382# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ANALYTICAL INVESTIGATION OF TWO HYDROGEN-OXYGEN ROCKET ENGINE SYSTEMS FOR LOW-THRUST APPLICATION
Dean D. Scheer In APL The 1980 JANNAF Propulsion Meeting, Vol. 5 Mar. 1980 p 1-20 refs (For primary document see N80-30381 21-20) Avail: Issuing Activity CSCL 21H

Two hydrogen-oxygen rocket engine system concepts were analyzed parametrically over a thrust range from 100 to 1000 pounds and a chamber pressure range from 175 to 1000 psia. Both concepts were regeneratively cooled with hydrogen and were pump fed by electric motor driven positive displacement pumps. Electric power was provided by either a turboalternator (turboalternator concept) or some means external to the engine system (auxiliary power concept). The computer program used to conduct the analyses along with the design characteristics of the major engine system components are briefly described. The feasible design range of each system is presented. An upper envelope parametric data within the feasible design range is presented. A summary of the critical interactions that were considered during the analyses and a summary of the critical interactions that were considered during the analyses is presented. J.M.S.

N80-30383# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

DSTC REDUCED GRAVITY FLUID MANAGEMENT TECHNOLOGY PROGRAM

An overview of studies addressing reduced gravity fluid management problems using scale model propellant tanks in drop towers that provided up to five seconds of reduced gravity test time is given. The Cryogen Fluid Management Experiment designed to provide an orbital evaluation of a subcritical liquid hydrogen storage and supply as part of the shuttle/Spacelab program is described. An experiment to study orbital transfer of liquids and a Spacelab, i.e., capable of housing multiple fluid dynamic and heat transfer experiments are also discussed. Progress in the analytical evaluation of propellant management systems for both low and high thrust orbit transfer propulsion systems and the development of computer techniques for simulating reduced gravity fluid dynamic processes is reported. A.R.H.
Power systems are summarized. A variety of technology areas are devoted to the development of analytical tools to define propulsion system properties for a wide variety of application. (Author)

The synchronous technology requirements for large space power systems are summarized. A variety of technology areas including photovoltaics, thermal management, and energy storage, and power management are addressed for individual titles, see N80-33466 through N80-33475.

The power program in NASA and DOD are discussed with particular emphasis on thrust system technology in the ten to one thousand pound thrust range. Key technology issues include high performance of cooled low thrust engines, small cryogenic pumps, multiple starts-shutdowns (10) with slow ramps (approximately 10 seconds); thrust variation -4/1 in flight and 20/1 between flights; long life (100 hours); improved system weight and size, and propellant selection. A.R.H.

The synchronous technology requirements for large space power systems are summarized. A variety of technology areas are devoted to the development of analytical tools to define propulsion system properties for a wide variety of application. (Author)
periodic thruster status has been reported while waiting for normal DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov., 1979, AIAA Paper 79-2063, 13 p., 9 refs. The SERT II spacecraft, launched in 1970, has been maintained in an operational, but intermittently active status since 1971. Periodic thruster status has been reported while waiting for normal orbit precession to return the spacecraft to continuous sunlight in 1979. Now, the thruster has been operated for 600 hours in the first quarter of 1979. Thruster startup and operation in 1979 is unchanged after 9 years in space. The ion thruster was gimbaled and used to maintain spin stabilization of the spacecraft. Minor components of the spacecraft have failed, but have not interfered with the functional status of the spacecraft.


Orbit precession returned the SERT II spacecraft to continuous sunlight in January 1979 for the first time since early 1972, and new experiments were planned and conducted. Neutralization of an ion beam was accomplished by a second neutralizer cathode located 1 meter away. Plasma potential measurements were made of the plasma surrounding the ion beam and connecting the beam to the second neutralizer. When the density of the connecting plasma was increased by turning on the main discharge of a neighboring ion thruster, the neutralization of the ion beam occurred with improved (lower) coupling voltage. These and other tests reported should aid in the future design of spacecraft using electric thruster systems. Data taken indicate that cross neutralization of ion thrusters in a multiple thruster array should occur readily.


The characteristics of power processors strongly impact the overall performance and cost of electric propulsion systems. A program was initiated to evaluate simplifications of the thruster-power processor interface requirements. The power processor requirements are mission dependent with major differences arising for those missions which require a nearly constant thruster operating point (typical of geocentric and some inbound planetary missions) and those requiring operation over a large range of input power (such as outbound planetary missions). This paper describes the results of these tests which have indicated that as many as seven of the twelve power supplies may be eliminated from the present Functional Model Power Processor used with 30-cm diameter Hg ion thrusters.


The payload capabilities of upper stages using electric propulsion for a LEO to GEO orbit transfer mission are discussed. Payloads are calculated using an established methodology which employs assumptions concerning state-of-the-art electric propulsion technology. The effects on payloads are examined for variations of total mass in LEO (MLEO), thrusting (trip) times, propellant type, specific impulse, and power source specific mass. It is found that the ratios of payload masses to total mass in LEO are intensive to MLEO, which allows a highly condensed presentation of the overall payload capability. Electric stages are shown capable of delivering payloads in thrusting times less than 60 days with the payloads increasing rapidly with increase in thrusting times. Payload capabilities exceeding those attainable with chemical propulsion are possible using state-of-the-art electric propulsion technology.


This paper discusses the future of electric propulsion, circa 2000. Starting with the first generation Solar Electric Propulsion (SEP) technology as the first step toward the next century's advanced propulsion systems, the current status and future trends of other systems such as the magnetoplasmodynamic accelerator, the mass driver, the laser propulsion system, and the rail gun are described.

The paper employs relative defect concentrations, energy levels, capture cross sections, and minority carrier diffusion lengths in order to identify the defect responsible for the reverse annealing observed in a radiation damaged n+/p silicon solar cell. It is reported that the responsible defect, with the energy level at +0.30 eV, has been tentatively identified as boron-oxygen-vacancy complex. In conclusion, it is shown that removal of this defect could result in significant cell recovery when annealing at temperatures well below the currently required 400°C.


Two hydrogen-oxygen rocket engine system concepts were analyzed parametrically over a thrust range from 100 to 1000 pounds and a chamber pressure range from 175 to 1000 psia. Both concepts were regeneratively cooled with hydrogen and were pump-fed by electric motor driven positive displacement pumps. Electric power was provided by either a turboalternator (turboalternator concept) or some means external to the engine system (auxiliary power concept). The computer program used to conduct the analyses along with the design characteristics of the major engine system components are briefly described. The feasible design range of the systems over the parametric range of thrust is discussed in terms of allowable chamber pressure considering the constraints of thrust chamber cooling and cycle power. Engine system estimated performance, mass, and dimensional envelope parametric data within the feasible design range are presented.


An analytical and experimental study was conducted dealing with refining start baskets (capillary devices) with settled fluid. A computer program was written to include dynamic pressure, screen shaking, multiple-screen barriers, standpipe screens, variable vehicle mass for computing vehicle acceleration, and calculation of tank outflow rate and vapor pullthrough height. An experimental apparatus was fabricated and tested to provide data for correlation with the analytical model; the test program was conducted in normal gravity using a scale-model capillary device and ethanol as the test fluid. The test data correlated with the analytical model; the model is a versatile and apparently accurate tool for predicting start basket refining under actual mission conditions.


The paper discusses a potential application of electric propulsion to perform orbit transfer of a large spacecraft structure to geosynchronous orbit (GEO) from LEO, utilizing a nuclear reactor space power source in the spacecraft on a shared basis. The discussions include spacecraft, thrust system, and nuclear reactor space power system concepts. Emphasis is placed on orbital payload arrangements, spacecraft launch constraints, and spacecraft LEO assembly and deployment sequences.
Teal Ruby sensor and the ECOM 501 sensor of that spacecraft were investigated. Laboratory measurements and analyses were used to determine lifetime as determined by the depletion of barium from the thruster sputter shield. and the various spacecraft surfaces were examined. Plasma plume and the material boundaries of the thruster, the thruster sputter shield, and the various spacecraft surfaces were examined. The neutral particle transport modes of interest were identified as sputtered metal atoms from the thruster beam shield. Results, conclusions, and future considerations are presented.

N80-13158# Hughes Research Labs., Malibu, Calif.

R. L. Poschel and J. R. Beattie
Nov. 1979 186 p refs
(Contract NAS3-21040)
(NASA-CR-158668) Avail: NTIS HC A09/MF A01 CSCL 01C

An investigation of the 30-cm engineering-model-thruster technology with emphasis placed on the development of models for understanding and predicting the operational characteristics and wear-out mechanisms of the thruster as a function of operating or design parameters is presented. The task studies include:
1. The wear mechanisms and wear rates that determine the useful lifetime of the thruster discharge chamber;
2. Cathode lifetime as determined by the depletion of barium from the barium-aluminate-impregnated- porous-tungsten insert that serves as a barium reservoir;
3. Accelerator-grid-system technology;
4. The verification of the high-voltage propellant-flow- electrical isolation design developed under NASA contract NAS3-20395 for operation at 10-kV applied voltage and 10-A equivalent propellant flow with mercury and argon propellants. A model was formulated for predicting performance.

M.M.M.

N80-13164# Tennessee Technological Univ., Cookeville.

ANALYSIS OF COMBUSTION INSTABILITY IN LIQUID FUEL ROCKET MOTORS Ph.D. Thesis
Kin-Wong Wong and M. Ventrice
Nov. 1979 119 p refs
(Grant NGR-43-003-015)
(NASA-CR-159733) Avail: NTIS HC A06/MF A01 CSCL 21H

The development of a technique to be used in the solution of nonlinear velocity-sensitive combustion instability problems is described. The orthogonal collocation method was investigated. It found that the results are heavily dependent on the location of the collocation points and characteristics of the equations, so the method was rejected as unreliable. The Galerkin method, which has proved to be very successful in analysis of the pressure sensitive combustion instability was found to work very well. It was found that the pressure wave forms exhibit a strong second harmonic distortion and a variety of behaviors are possible depending on the nature of the combustion process and the parametric values involved. A one-dimensional model provides further insight into the problem by allowing a comparison of Galerkin solutions with more exact finite-difference computations.

A.R.H.

N80-13165# Tennessee Technological Univ., Cookeville.

STABILITY ANALYSIS OF A LIQUID FUEL ANNULAR COMBUSTION CHAMBER M.S. Thesis
G. H. McDonald
Nov. 1978 151 p refs
(Grant NGR-43-003-015)
(NASA-CR-159734) Avail: NTIS HC A08/MF A01 CSCL 21H

High frequency combustion instability problems in a liquid fuel annular combustion chamber are examined. A modified Galerkin method was used to produce a set of modal amplitude equations from the general nonlinear partial differential acoustic wave equation in order to analyze the problem of instability. From these modal amplitude equations, the two variable perturbation method was used to develop a set of approximate equations of a given order of magnitude. These equations were modeled to show the effects of velocity sensitive combustion instabilities by evaluating the effects of certain parameters in the given set of equations.

A.W.H.

N80-14119# Aerojet Liquid Rocket Co., Sacramento, Calif.

PERFORMANCE OF A TRANSPIRATION-REGENERATIVE COOLED ROCKET THRUST CHAMBER Final Report
H. W. Valler
Sep. 1979 414 p refs
(Contract NAS3-21029)
(NASA-CR-159742) Avail: NTIS HC A18/MF A01 CSCL 21H

The analysis, design, fabrication, and testing of a liquid rocket engine thrust chamber which is gas transpiration cooled in the high heat flux convergent portion of the chamber and water jacket cooled (simulated regenerative) in the barrel and divergent sections of the chamber are described. The engine burns LOX-hydrogen propellants at a chamber pressure of 600 psia. Various transpiration coolant flow rates were tested with resultant local hot gas wall temperatures in the 800 F to 1400 F range. The feasibility of transpiration cooling with hydrogen and helium, and the use of photo-etched copper platelets for heat transfer and coolant metering was successfully demonstrated.

R.C.T.

N80-17137# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.

Paul J. Wilbur
Dec. 1979 146 p refs
(Grant NGR-08-002-112)
(NASA-CR-159784) Avail: NTIS HC A07/MF A01 CSCL 21C

Experimental tests results demonstrating that reductions in screen grid thickness enhance the performance of ion thruster grids are presented. Shaping of the screen hole cross section is shown on the other hand not to affect performance substantially. The effect of the magnetic field in the vicinity of the hollow cathode on cathode performance is studied and test results are presented that show reductions in keeper voltages of a few volts can be realized by judicious applications of fields on the order of 100 gauss. The plasma downstream of a SERT 2 thruster operating without high voltage is studied. A model describing electron escape from the thruster under those conditions is discussed. A model defining the performance of the baffle aperture of an ion thruster is refined and experimental verification of the model is undertaken. 

Author
and RP-1 decomposition temperature on chamber pressure limits. Chamber and nozzle design parameters are presented for the unenhanced and enhanced designs. The maximum regenerative cooled chamber pressure limits were attained with the O2/CH4 propellant combination. The O2/RP-1 designs relied on a carbon layer and liquid gas injection chamber contour. Short chamber to be competitive with the other two propellant combinations. This was attributed to the low decomposition temperature of RP-1.

N80 15202*# Rocksteadyne, Canoga Park, Calif.


The design, fabrication, and demonstration of a 111 newton (25 lb) thrust, integrated auxiliary propulsion system (IAPS) thruster for use with LH2/L02 propellants was described. This thruster was designed to operate in both pulse mode and steady state mode for vehicle attitude control, space maneuvering, and as an abort backup in the event of failure of the main propulsion system. A dual sleeve, truss axial injector system was designed that utilized primary injector/combustor where 100 percent of the oxygen and 8 percent of the hydrogen is introduced, a secondary injector/combustor where 45 percent of the hydrogen is introduced, and a boundary layer injector that uses the remaining 45 percent of the hydrogen to cool the thrust throat/nozzle design. Hot-fire evaluation of this thruster with a BLC injection distance of 2.79 cm (1.10 in.) indicated that a specific impulse value of 390 sec can be attained using a coated molybdenum thrust chamber. Pulse mode tests indicated that a chamber pressure buildup to 90 percent thrust can be achieved in a time on the order of 48 msec. Some problems were encountered in achieving ignition of each pulse during pulse train. This was interpreted to indicate that a higher delivered spark energy level (< 100 mJ) would be required to maintain ignition reliability of the plasma torch ignition system under the extra cold conditions resulting during pulsing.

Author

N80 15008*# Boeing Aerospace Co., Seattle, Wash.

**ELECTRIC PROPULSION FOR NEAR-EARTH SPACE MISSIONS** Final Report, Feb. 1978 - Apr. 1979

A set of missions was postulated that was considered to be representative of those likely to be desirable/feasible over the next three decades. The characteristics of these missions, and their payloads, that most impact the choice/design of the requisite propulsion system were determined. A system-level model of the near-Earth transportation process was constructed, which incorporated these mission/system characteristics, as well as the fundamental parameters describing the technology/performance of an ion bombardment-based electric propulsion system. The model was used for sensitivity studies to determine the impact of technology descriptors, program costs, and to establish the most cost-effective directions for technology advancement. The most important factor was seen to be the costs associated with the duration of the mission, and this in turn makes the development of advanced electric propulsion systems having moderate to high efficiencies (95 percent) at intermediate ranges of specific impulse (approximately 1000 seconds) very desirable.

Author

N80 24321*# Colorado State Univ., Fort Collins, Dept. Of Mechanical Engineering

**INERT GAS THRUSTERS** Annual Report

Inert gas thrusters considered for space propulsion systems were investigated. Electromagnetic analysis across a magnetic field was examined utilizing a basic model. The production of doubly charged ions was correlated using only overall performance parameters. The use of this correlation is therefore possible in the design stage of large gas thrusters, where detailed plasma properties are not available. Argon hollow cathode performance was investigated over a range of emission currents, with the positions of the inert, keeper, and anode varied. A general trend observed was that the maximum ratio of emission to flow rate increased at higher propellant flow rates. It was also found that an enclosed keeper enhanced maximum cathode emission at high flow rates. The maximum cathode emission at a given flow rate was associated with a noisy high voltage mode. Although this mode has some similarities to the pume mode found at low flows and emissions, it is encountered by being initially in the spot mode and increasing emission. A detailed analysis of large, inert-gas thruster performance was carried out. For maximum thruster efficiency, the optimum beam diameter increases from less than a meter at under 2000 sec specific impulse to several meters at 10,000 sec. The corresponding range in input power rates from several kilowatts to megawatts.

J.M.S.

N80 27424*# Xerox Electro-Optical Systems, Pasadena, Calif.

**INERT GAS ION THRUSTER DEVELOPMENT** Interim Report, Apr. 1978 - Feb. 1979

Two 12 cm magneto-electrostatic containment (MESEC) ion thrusters were performance mapped with argon and xenon. The first, hexagonal, thruster produced optimized performance of 48.5 to 79 percent argon mass utilization efficiencies at discharge energies of 240 to 425 eV/ion, respectively. Xenon mass utilization efficiencies of 78 to 95 percent were observed at discharge energies of 220 to 290 eV/ion with the same optimized hexagonal thruster. Changes to the cathode baffle reduced the discharge anode potential during xenon operation from approximately 40 volts to about 30 volts. Preliminary tests conducted with the second, hemispherical, MESEC thruster showed a nonuniform anode magnetic field adversely affected thruster performance. This performance degradation was partially overcome by changes in the boundary anode placement. Conclusions drawn the hemispherical thruster tests gave insights into the plasma processes in the MESEC discharge that will aid in the design of future thrusters.

Author

Avail. Activity CSCL 21H

These cycles include conventional propellant turbine drives, turboelectric/electric motor pump drive, and fuel cell/electric motor pump drive as well as pressure fed engines. Thrust chamber cooling analysis results are presented for regenerative/radiation and film/radiation cooling.


Avail. Activity CSCL 21H

One approach being considered for transporting large space structures from low Earth orbit (LEO) to geosynchronous equatorial orbit (GEO) is the use of low thrust chemical propulsion systems. A variety of chemical rocket engine cycles evaluated for this application for oxygen/hydrogen and oxygen/hydrocarbon propellant combinations and chemical and thermal engine concepts are discussed. These cycles include conventional propellant turbine drives, turboalternator/electric motor pump drive, and fuel cell/electric motor pump drive as well as pressure fed engines. Thrust chamber cooling analysis results are presented for regenerative/radiation and film/radiation cooling.


Avail. Activity CSCL 21H

The space transportation system (STS) will be the principal technology that would provide flexibility, performance, and economic benefits to future Air Force missions. Three generic types of structural concepts and nonstructural surface densities were selected and compared to representative potential LSS applications. The design characteristics of various classes of large space systems that are impacted by primary propulsion thrust requirements to effect orbit transfer were identified. The effects of propulsion system thrust-to-mass ratio, thrust transients, and performance on the mass, area, and orbit characteristics of large space systems were determined.


Avail. Activity CSCL 21H

Low thrust chemical (hydrogen/oxygen) propulsion systems designed specifically for low acceleration orbit transfer of large space structures were studied in order to evaluate the required additional data to better compare new, low thrust chemical propulsion systems with other propulsion approaches such as advanced electromechanical systems. Study results indicate that it is cost-effective and least risk to combine the low thrust OTV and the space transportation system (STS) as the principal technology that would provide flexibility, performance, and economic benefits. Three general types of structural concepts and nonstructural surface densities were selected and compared to representative potential LSS applications. The design characteristics of various classes of large space systems that are impacted by primary propulsion thrust requirements to effect orbit transfer were identified. The effects of propulsion system thrust-to-mass ratio, thrust transients, and performance on the mass, area, and orbit characteristics of large space systems were determined.


Avail. Activity CSCL 21H

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system weights were excessive. The staged combustion cycle achieved the next highest chamber pressure but the preburner operational feasibility was in question.

N80-31449*† Martin Marietta Corp., Lewis Center, Md.

LOW-THRUST CHEMICAL ORBIT TO ORBIT PROPULSION SYSTEM PROPELLANT MANAGEMENT STUDY Progress Report, 14 Sep. 1979 - 14 Nov. 1980.


Avail. NTIS HS 15/MF A01 CSCL 21H

Propellant requirements, tankage configurations, preferred propellant management techniques, propulsion system weights, and technology deficiencies for low thrust expendable propulsion systems are examined. A computer program was utilized which provided a cost estimate for a given tankage configuration including bid-off for cryogenic cases, pressurant and propellant tank dimensions for a given ullage, pressurant requirements, insulation requirements, and mass. The output also includes the weight of all tanks, the mass of the insulation, engines and other components, total wet system and burnout mass; system mass fraction, total impulse and burn time.


SOLAR ROCKET SYSTEM CONCEPT ANALYSIS Final Report


Avail. NTIS HS 15/MF A01 CSCL 21H

The use of solar energy to heat propellant for application to Earth orbit/planetary propulsion systems is of interest because of its performance capabilities. The achievable specific impulse values are approximately double those delivered by a chemical rocket system, and the thrust is at least an order of magnitude greater than that produced by a mercury bombardment ion propulsion thruster. The primary advantage the solar heater thruster has over a mercury ion bombardment system is that its significantly higher thrust permits a marked reduction in mission trip time. The development of the space transportation system, offers the opportunity to utilize the full performance potential of the solar rocket. The requirements for transfer from low Earth orbit (LEO) to geosynchronous equatorial orbit (GEO) was examined as the return trip, GEO to LEO, both with and without payload. Payload weights considered ranged from 2000 to 100,000 pounds. The performance of the solar rocket was compared with that provided by LO2-LH2, N2O4-MH2, and mercury ion bombardment systems.

N80-33474*§ Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

STATUS OF NICKEL-HYDROGEN CELL TECHNOLOGY

Don R. Warnock / NASA Lewis Space Flight Center Synchronous Energy Technol. Sep 1980 p 97-105 (For primary document see N80-33465 24-20) Avail. NTIS HS A07/MF A01 CSCL 10C

Nickel hydrogen cell technology has been developed which solves the management, oxygen management, electrolyte management, and electrical and mechanical design peculiar to this new type of battery. This technology was weight optimized for low orbit operation using computing modeling programs but is near optimum for other orbits. Cells ranging in capacity up to about 70 ampere-hours can be made from components of a single standard size and are available from two manufacturers. The knowledge gained is now being applied to the development of two extensions to the basic design: a second set of larger standard components that will cover the capacity range up to 150 ampere-hours, and the development of multicell common pressure vessel modules to reduce volume, cost and weight. A manufacturing technology program is planned to optimize the producibility of the cell design and reduce cost. The most important areas for further improvement are life and reliability which are governed by electrode and separator technology.

N80-33476*† Colorado State Univ Fort Collins Dept of Mechanical Engineering


John R. Brophy, Jr and Paul J. Wilbur Oct 1980 78 p refs (Grant NGR-06-002-112) (NASA CR 165164) Avail. NTIS HC A05/MF A01 CSCL 21C

A simple theoretical model which can be used as an aid in the design of the baffle apertures of a hollow cathode equipped ion thruster was developed. An analysis of the ion and electron currents in both the main and cathode discharge chambers is presented. From this analysis a model of current flow through the aperture, which is required as an input to the design model, was developed. This model was verified experimentally. The dominant force driving electrons through the aperture was the force due to the electrical potential gradient. The diffusion process was modeled according to the Bolt diffusion theory. A number of simplifications were made to limit the amount of detailed plasma information required as input to the model to facilitate the use of the model in thruster design. This simplified model gave remarkably consistent results with experimental results obtained with a given thruster geometry over substantial changes in operating conditions. The model also accounts for a factor of two for different thruster cathode region geometries. The design usefulness was limited by this factor of two uncertainty and by the accuracy to which the plasma parameters required as inputs to the model were specified.

A80-13311 *§ 8-cm Engineered Model Thruster Technology - A review of recent developments.


Recent testing of the NASA Lewis Research Center/Hughes 8-cm Engineering Model Thruster (EMT) and Power Processing Unit has centered on two primary areas of investigation: integration of porous-tungsten cathode thruster designed for the 30-cm EMT and of the new cathodes has demonstrated acceptable thruster performance and cathode ignition parameters; the only perceived change in thrustor performance has been that a small amount of cathode heater power is required to maintain nominal keeper voltages. Thermal modeling of the cathode structure has facilitated design revisions which reduce this power requirement.

A80-20962 *§ A model for predicting the wearout lifetime of the LaRC/Hughes 30-cm mercury ion thruster.


An investigation of parameters that affect the erosion rates of 30-cm-diameter mercury-ion-thruster components is described. A sputter-erosion model is formulated in terms of the design, operational, and material characteristics of the thruster. The erosion model is applied to the screen electrode, which is assumed to be the life-limiting component of the 30-cm thruster, resulting in a model of wearout lifetime. Results of short-term erosion-rate tests are presented that illustrate the dependence of component wear rates on variables such as discharge voltage, accelerator-grid open-area fraction, ion energy, electrode material, and the partial pressure of...
facility residual gases such as nitrogen. Test results are compared with wearout rates predicted by the sputter-erosion model. (Author)


A new approach has been developed for the computation of the three-dimensional viscous supersonic flow with embedded subsonic regions adjacent to solid boundaries and is applied to a mixed-compression supersonic inlet typical of current designs. The approach uses a reduced form of the three-dimensional Navier-Stokes equations so that the resultant equations can be treated as an initial boundary value problem and thus be solved by non-iterative forward marching in space. The numerical procedure utilizes an efficient consistent-split linearized block implicit technique to solve the finite difference analogues to the set of governing partial differential equations. (Author)


The impact of natural sources of electrical-mechanical oscillations induced by the environment on the solar sail system is evaluated. The study indicates that, to the level of accuracy (first order) of the analysis, none of the natural sources studied, which range from plasma wave interactions to E X B forces, will have a significant impact on the proposed solar sail design. The study is not intended as an exhaustive analysis, and further analysis, particularly in the area of artificially induced oscillations, is needed. (Author)


Advanced technologies developed in support of ion Propulsion power processing, including the power circuitry portion of the Series L-C Resonant Inverter, Beam Supply, power components, packaging and heat pipe cooling of the 30 cm Ion Engine Power Processor are described. Both the transistorized and SCR versions of the Series L-C Resonant Inverter Beam Supply are discussed. A BIMOD Ion Thruster/Power Processor Prototype Assembly is undergoing environmental and life testing. Those advanced technologies can be applied advantageously to other applications of future high power space power processing equipment. (Author)


The effects on life cycle costs of a number of technology areas are examined for a LEO, 500kW space solar array. A baseline system conceptual design is developed and the life cycle costs estimated in detail. The baseline system requirements and design technologies are then varied and their relationships to life cycle costs quantified. For example, the thermal characteristics of the baseline design are determined by the array materials and masses. The thermal characteristcs in turn determine configuration, performance and hence life cycle cost.
23 CHEMISTRY AND MATERIALS
(GENERAL)
Includes biochemistry and organic chemistry

An experimental effort has been undertaken to examine the effect of plasma pretreatment of various substrate materials coated with a polymer in the parylene family. This report describes the procedure and discusses initial data which indicate using plasmas of argon and oxygen to promote adhesion of parylene coatings upon many difficult to bond substrates. Substrates investigated were gold, nickel, Kovar, teflon (FEP), kapton, silicon, tantalum, titanium, and tungsten. Without plasma treatment, 180 deg peel tests yield a few g/cm (oz/in) strengths. With dc plasma treatment in the deposition chamber, followed by coating, peel strengths are increased by one to two orders of magnitude. (Author)


The paper deals with a NASA-sponsored, computer-based program - Modeling and Analysis of Power Processing Systems (MAPPS). Three major MAPPS subprograms, Design Optimization, Control Design, and Performance Analysis are considered. The program makes it possible to reduce the design, analysis, and development time, and thus the cost, in achieving the required performance for power processing equipment and systems. (Author)

Peritoneal implants were fabricated from poly 2-OH, ethyl methacrylate (HEMA), polyetherurethane (polytetramethylene glycol 1000 MW, 1,4 methylene disocynate, and ethyl diamine), and untreated and sputter treated polytetrafluoroethylene (PTFE). The sputter treated PTFE implants were produced by an 8 cm diameter argon ion source. The treated samples consisted of ion beam sputter polished samples, sputter etched samples (to produce a microscopic surface cone texture) and surface pitted samples (produced by ion beam sputtering to result in 50 micron wide by 100 micron deep square pits). These materials were implanted in rats for periods ranging from 30 minutes to 14 days. The results were evaluated with regard to cell type and attachment kinetics onto the different materials. Scanning electron microscopy and histological sections were also evaluated. In general the smooth hydrophobic surfaces attracted less cells than the ion etched PTFE or the HEMA samples. The ion etching was observed to enhance cell attachment, multinucleated giant cell (MNGC) formation, cell to cell contact, and fibrous capsule formation. The cell responded in the case of ion etched PTFE to an altered surface morphology. However, equally interesting was the similar attachment kinetics of HEMA versus the ion etched PTFE. However, HEMA resulted in a markedly different response with no MNGC's formation, minimal to no capsule formation, and sample coverage by a uniform cell layer. R.C.T.
Elastica and thermal properties

Micromechanics of intraply hybrid composites

A thermal barrier coating system was developed to protect the surfaces of metal components, gas turbines, and other heat engine parts that are exposed to fuels contaminated with metallic impurities which are normally corrosive to previously known metallic coatings. The coating system includes a metal alloy bond coating, the alloy containing nickel, cobalt, iron, or a combination of these metals. The system also includes a corrosion resistant thermal barrier oxide coating containing at least one alkaline earth silicate. The preferred oxides are calcium silicate, barium silicate, magnesium silicate, or a combination of these silicates.

Author

Corrosion resistant thermal barrier coating

Composite micromechanics are used to derive equations for predicting the elastic and thermal properties of unidirectional intraply hybrid composites. The equations are compared with those predicted using approximate equations based on the rule of mixtures, linear laminate theory, finite element analysis and limited experimental data. The comparisons for three different intraply hybrids indicate that all four methods predict approximately the same elastic properties and are in good agreement with measured data. The micromechanics equations and linear laminate theory predict about the same values for thermal expansion coefficients. The micromechanics equations predict through-the-thickness properties which are in good agreement with the finite element results.

Author

Improving fiber retention by the use of fillers in graphite fiber/resin matrix composites

A variety of matrix fillers were tested for their ability to prevent loss of fiber from graphite fiber/epoxy composite in a fire. The fillers tested included powders of boron, boron carbide, lime glass, lead glass, and aluminum. Boron was the most effective and prevented any loss of graphite fiber during burning. Mechanical properties of composites containing boron fiber were measured and compared to those of composites containing no filler.

Author

Burning characteristics and fiber retention properties

Graphite fiber reinforced resin matrix composites were subjected to controlled burning conditions to determine their burning characteristics and fiber retention properties. Small samples were
burned with a natural gas fired torch to study the effects of fiber orientation and structural flaws such as holes and slits that were machined into the laminates. Larger laminate samples were burned in a modified heat release rate calorimeter. Undirectional epoxy/graphite and polyimide/graphite composites and boron powder filled samples of each of the two composite systems were burn tested. The composites were exposed to a thermal radiation of 5.3 Btu/min ft² in air. Samples of each of the unfilled composite were decomposed anaerobically in the calorimeter. Weight loss data were recorded for burning and decomposition times up to thirty-five minutes. The effects of fiber orientation, flaws, and boron filler additives to the resin were evaluated. A high char forming polyimide resin was no more effective in retaining graphite fibers than a low char forming epoxy resin when burned in air. Boron powder additions to both the polyimide and the epoxy resins stabilized the chars and effectively controlled the fiber release. A R H.

N80-18102‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FRACURE MODES OF HIGH MODULUS GRAPHITE/EPXY ANGLEPLIED LAMINATES SUBJECTED TO OFF-AXIS TENSIILE LOADS

Angled laminates of high modulus graphite fiber/epoxy were studied in several ply configurations at various tensile loading angles to the zero ply direction in order to determine the effects of ply orientations on tensile properties, fracture modes, and fracture surface characteristics of the various plies. It was found that fracture modes in the plies of angled laminates can be characterized by scanning electron microscope observation. The characteristics of one mode are similar to those of the same fracture mode in unidirectional specimens. However, no simple load angle range can be associated with a given fracture mode.

N80-18107‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PREDICTION OF FIBER COMPOSITE MECHANICAL BEHAVIOR MADE SIMPLE

The elastic properties and failure stresses of angled fiber composite laminates were determined using a pocket calculator. The procedure uses simple equations and appropriate graphs of elastic properties versus angle plies, and can handle all types of fiber composites including hybrids. The versatility and generality of the method is illustrated in several step-by-step numerical examples.

N80-18106‡ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
APPLICATION OF COMPOSITE MATERIALS TO TURBOFAN ENGINE FAN EXIT GUIDE VANE

A program was conducted by NASA with the JT9D engine manufacturer to develop a lightweight, cost effective, composite material fan exit guide vane design having satisfactory structural durability for commercial engine use. Based on the results of a previous company supported program, eight graphite/epoxy and graphite-glass/epoxy guide vane designs were evaluated and four were selected for fabrication and testing. Two commercial fabricators each fabricated 13 vanes. Fatigue tests were used to qualify the selected design configurations under nominally dry, 38 C (100 F) and fully wet and 60 C (140 F) environmental conditions. Cost estimates for a production rate of 1000 vanes per month ranged from 1.7 to 2.6 times the cost of an all aluminum vane. This cost is 50 to 80 percent less than the initial program target cost ratio which was 3 times the cost of an aluminum vane. Application to the JT9D commercial engine is projected to save a weight savings of 236 N (53 lb) per engine.

N80-18107‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FIRE TEST METHOD FOR GRAPHITE FIBER REINFORCED PLASTICS

A potential problem in the use of graphite fiber reinforced resin matrix composites is the dispersal of graphite fibers during accidental fires. Airborne, electrically conductive fibers originating from the burning composites could enter and cause shorting in electrical equipment located in surrounding areas. A test method for assessing the burning characteristics of graphite fiber reinforced composites and the effectiveness of the composites in retaining the graphite fibers has been developed. The method utilizes a modified rate of heat release apparatus. The equipment and the testing procedure are described. The application of the test method to the assessment of composite materials is illustrated for two resin matrix/graphite composite systems.

N80-20313‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
DYNAMIC MODULUS AND DAMPING OF BORON, SILICON CARBIDE, AND ALUMINA FIBERS

The dynamic modulus and damping capacity for boron, silicon carbide, and silicon carbide coated boron fibers were measured from 190 to 800 C. The single fiber vibration test also allowed measurement of transverse thermal conductivity for the silicon carbide fibers. Temperature dependent damping capacity data for alumina fibers were calculated from axial damping results for alumina. The data on silicon carbide and aluminum fibers indicates essentially elastic behavior for both the silicon carbide and aluminum fibers. In contrast, the boron based fibers are strongly anelastic, displaying frequency dependent moduli and very high microstructural damping. The single fiber damping results were compared with composite damping data in order to investigate the practical and basic effects of employing the four fiber types as reinforcement for aluminum and titanium matrices.

N80-20314‡ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
CALCULATION OF RESIDUAL PRINCIPAL STRESSES IN CVD BORON ON CARBON FILAMENT

A three-dimensional finite element model of the chemical vapor deposition of boron on a carbon substrate (B/C) is developed. The model includes an expansion of the boron after deposition due to atomic rearrangement and includes creep of the boron and carbon filaments. The dynamics fiber data indicate essentially elastic behavior for both the silicon carbide and alumina fibers, in contrast the boron based fibers are strongly anelastic, displaying frequency dependent moduli and very high microstructural damping. The single fiber damping results were compared with composite damping data in order to investigate the practical and basic effects of employing the four fibers as reinforcement for aluminum and titanium matrices.

K.L.
and the build up of residual stresses must be limited by significant boron and carbon creep rates.

Author: K. L.

N80-21462# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PREDICTING THE TIME-TEMPERATURE DEPENDENT AXIAL FAILURE OF B/A1 COMPOSITES


Experimental and theoretical studies were conducted in order to understand and predict the effects of time, temperature, and stress on the axial failure modes of boron fibers and B/A1 composites. Due to the anelastic nature of boron fiber deformation, it was possible to determine simple creep functions which can be employed to accurately describe creep and fracture stress of as-produced materials. An analysis of testing and strength data for B/6061 A1 composites indicates that fiber creep effects of creep on fiber fracture are measurably reduced by the composite fabrication process. The creep function appropriate for fibers with B/A1 composites was also determined. A fracture theory is presented for predicting the time-temperature dependence of the axial tensile strength for metal matrix composites in general and B/A1 composites in particular. 

Author: James A. DiCarlo 1980 28 p refs

N80-23370# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ENGINE ENVIRONMENTAL EFFECTS ON COMPOSITE BEHAVIOR


A series of programs were conducted to investigate and develop the application of composite materials to turbojet engines. A significant part of that effort was directed to establishing the impact resistance and defect growth characteristics of composite materials over the wide range of environmental conditions found in commercial turbojet engine operations. Both analytical and empirical efforts were involved. The experimental programs and the analytical methodology development as well as an evaluation program for the use of composite materials as fan exit guide vanes were summarized.

R.C.T.

N80-28389# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A SILICON-SLURRY/ALUMINIDE COATING Patent Application


A low cost coating is disclosed which protects metallic base system substrates from high temperatures, high gas velocity oxidation, thermal fatigue and hot corrosion. The coating is particularly useful for protecting vanes and blades in aircraft and land based gas turbine engines. A lacquer slurry comprising cellulose nitrate containing high purity silicon powder is sprayed onto the superalloy substrates. The silicon layer is then aluminumized to complete the coating. The Si-Al coating is less costly to produce than advanced aluminides and protects the substrate from oxidation and thermal fatigue for a much longer period of time than the conventional aluminide coatings. While more expensive Pt-Al coatings and physical vapor deposited MgAlY coatings on certain superalloys in high gas velocity oxidation and thermal fatigue. Also, the Si-Al coating increased the resistance of certain superalloys to hot corrosion.

N80-27429# National Aeronautics and Space Administration.

LEWIS RESEARCH CENTER, CLEVELAND, OHIO

FEASIBILITY OF KEVLAR 49/PMR-15 POLYIMIDE FOR HIGH TEMPERATURE APPLICATIONS


Kevlar 49 aramid organic fiber reinforced PMR-15 polyimide laminates were characterized to determine the applicability of the material to high temperature aerospace structures. Kevlar 49/3501-6 epoxy laminates were fabricated and characterized for comparison with the Kevlar 49/PMR-15 polyimide material. Flexural strengths and moduli and interlamellar shear strengths were determined from 75 F to 600 F for the PMR-15 and from 75 F to 450 F for the Kevlar/3501-6 epoxy material. The effects of hydrothermal and long-term elevated temperature exposures on the flexural strengths and moduli and the interlamellar shear strengths were also studied.

Author: Morgan P. Hanson 1980 16 p refs

N80-28444# National Aeronautics and Space Administration.

PROPERTIES OF PMR POLYIMIDE COMPOSITES MADE WITH IMPROVED HIGH STRENGTH GRAPHITE FIBERS


High strength, intermediate modulus graphite fibers were obtained from various commercial suppliers, and were used to fabricate PMR-15 and PMR-2 polyimide composites. The effects of the improved high strength graphite fibers on composite properties after exposure in air at 600 F were investigated. Two of the improved fibers were found to have an adverse effect on the long term performance of PMR composites. The influence of various factors such as fiber physical properties, surface morphology and chemical composition were also examined.

N80-29431# National Aeronautics and Space Administration.

POSSIBLE RELEAS OF FIBERS FROM BURNING CARBON COMPOSITES


A comprehensive experimental carbon fiber source program was conducted to determine the potential for the release of conductive carbon fibers from burning composites. Laboratory testing determined the relative importance of several parameters influencing the amounts of single fibers released, while large-scale aviation jet fuel pool fires provided realistic confirmation of the laboratory data. The dimensions and size distributions of fine-released carbon fibers were determined, not only for those of concern in an electrical sense, but also for those of potential interest from a health and environmental standpoint. Fire plume and chemistry studies were performed with large pool fires to provide an experimental input into an analytical modelling of simulated aircraft crash fires. A study of a high voltage spark system resulted in a promising device for the detection, counting, and sizing of electrically conductive fibers, for both active and passive modes of operation.

N80-29432# National Aeronautics and Space Administration.

INFLUENCE OF EXCESS DIAMINE ON PROPERTIES OF PMR POLYIMIDE RESINS AND COMPOSITES


By varying the stoichiometry of the reactants in the preparation of PMR polyimide resin, changes occur in molecular weight distribution which influence the rheological properties and thus the processability of the resin, as well as the mechanical properties of the composite. The influence of 1-10 percent molar
excess MDA on the molecular weight distribution and rheological properties of an imidized PMR system were exposed. Molecular weight distribution is characterized by gel permeation chromatography of the imidized molding compound. Shear viscosity is related to changes in average molecular weight. The thermo-oxidative stability at 600 °C glass transition temperature, flexural and interlaminar shear properties of PMR-polymerized/Collon 6000 graphite fiber composites are compared as a function of the percent excess MDA in the monomer-reactant mixture.

A R H

N80-33484* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

METHOD OF MAKING BEARING MATERIAL Patent


A composite material is described which will provide low friction surfaces for materials in rolling or sliding contact and is self lubricating and oxidation resistant up to and in excess of about 930 °C. The composite is comprised of a metal component which tends strength and elasticity to the structure, a fluoride salt component which provides lubrication and, lastly, a glass component which not only provides oxidation protection to the metal but may also enhance the lubrication qualities of the composite.

Official Gazette of the US Patent and Trademark Office

A80-10038* Fatigue behavior of SiC reinforced titanium matrix composites. R. T. Bhatt and H. H. Grimes (NASA, Lewis Research Center, Cleveland, Ohio). American Society for Testing and Materials, Symposium on Fatigue of Fibrous Composite Materials, San Francisco, Calif., May 22, 23, 1979. Paper. 18 p. 12 refs. The low cycle axial fatigue properties of 26 and 44 fiber volume percent SiC/Ti(BA14V) composites were measured at room temperature and at 550 °C. At room temperature, the S-N curves for the composites show a higher improvement over bulk matrix behavior. Although axial and transverse tensile strength results suggest a degradation in TiC fiber strength during composite fabrication, it appears that the poor fatigue life of the composite was caused by a reduced fatigue resistance of the reinforced Ti(BA14V) matrix. Microstructural studies indicate that the reduced matrix behavior was due, in part, to the presence of flawed and fractured fibers created near the specimen surfaces by preparation techniques. Another possible contributing factor is the large residual tensile stresses that can exist in fiber-reinforced matrices. These effects, as well as the effects of fatigue testing at high temperature, are discussed. (Author)

A80-20954* Mechanical property characterization of intraply hybrid composites. C. C. Chamis, D. F. Lark, and J. H. Sinclair (NASA, Lewis Research Center, Cleveland, Ohio). American Society for Testing and Materials, Symposium, Dearborn, Mich., Oct. 2, 3, 1979. Paper. 24 p. 8 refs. An investigation of the mechanical properties of intraply hybrids made from graphite fiber/epoxy matrix hybridized with secondary glass or Kevlar 49 fiber composites is presented. The specimen stress-strain behavior was determined, showing that mechanical properties of intraply hybrid composites can be measured with available methods such as the tensile degree-of-axis test for intralaminar shear, and conventional tests for tensile, flexure, and impact properties. The results also showed that combinations of high modulus graphite/epoxy matrix composites exist which yield intraply hybrid laminates with the best 'balanced' properties, and that the translation efficiency of mechanical properties from the constituent composites to intraply hybrids may be assessed with a simple equation. A. T.


An investigation was conducted to determine the effects of low level damage induced by monotonic load, cyclic load and/or residual stresses on the vibration frequencies and damping factors of fiber composite angleplied laminates. Two different composite systems were studied: low modulus fiber and ultra high modulus fiber composites. The results obtained showed that the frequencies and damping factors of angleplied laminates made from low modulus fiber composites are sensitive to low level damage while those made from ultra high modulus composites are not. Also, vibration tests may not be sufficiently sensitive to assess concentrated local damage in angleplied laminates. Furthermore, dynamic response determined from low-velocity impact coupled with the Fast Fourier Transform and packaged in a minicomputer can be a convenient procedure for assessing low-level damage in fiber composite angleplied laminates. (Author)


Composite micromechanics are used to derive equations for predicting the elastic and thermal properties of unidirectional intraply hybrid composites. The results predicted using these equations are compared with those predicted using approximate equations based on the rule of mixtures, linear laminate theory, finite element analysis and limited experimental data. The comparisons for three different intraply hybrids indicate that all four methods predict approximately the same elastic properties and are in good agreement with measured data. The micromechanics equations and linear laminate theory predict about the same values for thermal expansion coefficients. The micromechanics equations predict through-the-thickness properties which are in good agreement with the finite element results. (Author)

A80-31169* Fire test method for graphite fiber reinforced plastics. K. J. Bowles (NASA, Lewis Research Center, Cleveland, Ohio). International Conference on Fire Safety, 5th, Millbrae, Calif., Jan. 14-16, 1980. Paper. 11 p. 12 refs. A potential problem in the use of graphite fiber reinforced resin matrix composites is the dispersal of graphite fibers during accidental fires. Airborne, electrically conductive fibers originating from the burning composites could enter and cause shorting in electrical equipment located in surrounding areas. A test method for assessing the burning characteristics of graphite fiber reinforced composites and the effectiveness of the composites in retaining the graphite fibers has been developed. The method utilizes a modified Ohio State University Rate of Heat Release apparatus. The equipment and the testing procedure are described. The application of the fire test method to the assessment of composite materials is illustrated for two resin matrix/graphite composite systems. (Author)

A80-32062* Burning characteristics and fiber retention of graphite/resin matrix composites. K. J. Bowles (NASA, Lewis Research Center, Cleveland, Ohio). In: Rising to the challenge of the
I injected to controlled burning conditions to determine their burning characteristics and fiber retention properties. Two types of burning equipment were used. Small samples were burned with a natural gas fired torch to study the effects of fiber orientation and structural flaws such as holes and slits that were machined into the laminates. Larger laminate samples were burned in a Heat Release Rate Calorimeter. Unidirectional epoxy/graphite and polyimide/graphite composites and boron powder filled samples of each of the two composite systems were burn tested and exposed to a thermal radiation. The effects of fiber orientation, flaws, and boron filler additives to the resins were evaluated. A high char forming polyimide resin was no more effective in retaining graphite fibers than a low char forming epoxy resin when burning in air.

A potential problem in the use of graphite fiber reinforced resin matrix composites is the dispersal of graphite fiber during accidental fires. Airborne electrically conductive fibers originating from burning composites could enter and cause shorting in electrical equipment located in surrounding areas. A variety of matrix fillers have been tested for their ability to prevent loss of fiber from graphite fiber/PMR polyimide and graphite fiber/epoxy composites in a fire. The fillers tested included powders of boron, boron carbide (BC), fiber/PMR polyimide and graphite fiber/epoxy composites in a fire. The fillers tested included powders of boron, boron carbide (BC), lime glass, lead glass, and aluminum. Of these fillers, boron was the most effective and prevented any loss of graphite fiber during burning. Mechanical properties of composites containing boron filler were measured and compared to those of composite containing no filler.

A method for making aluminum-mica particle composites is presented in which mica particles are stirred in molten aluminum alloys followed by casting in permanent molds. Magnesium is added either as an alloying element or in the form of pieces on the surface of the alloy melts to disperse up to 3 wt% mica powders in the melts and to obtain high recoveries of mica in the castings. The mechanical properties of the aluminum alloy-mica composite decrease with increasing mica content; however, even at 2.2% it has a tensile strength of 14.22 kg/sq mm with 1.1% elongation, a compression strength of 42.61 kg/sq mm, and an impact strength of 0.30 kg/sq cm. Cryogenic and self-lubricating bearing are mentioned applications.


The need for advanced nondestructive evaluation (NDE) techniques for quantitative assessment of the mechanical strength and integrity of fiber composites during manufacture and service and following repair operations is stressed. The discussion covers problems and different approaches in regard to acceptance criteria, calibration standards, and methods for NDE of composites in strength critical applications. Finally, it is concluded that acousto-ultrasonic techniques provide the ‘methods of choice’ in this area.


Studies were performed to synthesize a novel class of bis (imide-amine) curing agents for epoxy matrix resins. Glass transition temperatures and char yield data of an epoxy cured with various bis (imide-amines) are presented. The room temperature and 350 F mechanical properties, and char yields of unidirectional graphite fiber laminates prepared with conventional epoxy and imide-modified epoxy resins are presented.


Theoretical and experimental studies are reviewed whose objective was to gain insight into and predict the effects of time, temperature, and stress on the axial failure modes of boron fibers and B/Al composites. Owing to the inelastic nature of boron fiber deformation, it proved possible to develop simple creep functions which can be used to describe accurately the creep and fracture stress of as-produced fibers. Analysis of damping and stress data for B/6061 Al composites indicates that fiber creep and the effects of creep of fiber fracture are measurably reduced by the composite fabrication process.

Dynamic modulus and damping of boron, silicon carbide, and alumina fibers. J. A. DiCarlo (NASA, Lewis Research Center, Cleveland, Ohio) and W. Williams (Lincoln University, Lincoln University, Pa.), American Ceramic Society, Annual Conference on Composites and Advanced Materials, 4th, Cocoa Beach, Fla., 1980, paper, 4 p. 21 refs.
The dynamic modulus and damping capacity for boron, silicon carbide, and silicon carbide-coated boron fibers were measured from 700 to 1000 °C. The single fiber vibration test also allowed measurement of transverse thermal conductivity for the silicon carbide fibers. Temperature-dependent damping capacity data for alumina fibers calculated from axial damping results for alumina-aluminum composites. The dynamic fiber data indicate essentially elastic behavior for both the silicon carbide and alumina fibers. In contrast, the boron-based fibers are strongly anelastic, displaying frequency-dependent moduli and very high microstructural damping. The single fiber damping results were compared with composite damping data in order to investigate the practical and basic effects of employing the four fiber types as reinforcement for aluminum and titanium matrices.


A three-dimensional finite element model of the chemical vapor deposition (CVD) of boron on a carbon substrate (B/C) is developed. The model includes an expansion of the boron after deposition due to atomic rearrangement and includes creep of the boron and carbon. Curves are presented to show how the principal residual stresses and the film thickness vary as the parameters defining deposition strain and creep are varied. The calculated results are compared with experimental axial residual stress and elongation measurements made on B/C films. This comparison requires that for good agreement between calculated and experimental results, the deposited boron must continue to expand after deposition, and that the build-up of residual stresses is limited by significant boron and carbon creep rates.


Yttria-stabilized zirconium oxide (Zyttrite) additions to purified silicon nitride markedly improved the high temperature strength, stress rupture and creep properties of hot pressed samples. Room temperature bend strengths, however, of four (4) compositions evaluated were each about one-third lower than the NC-132 material samples. All compositions appeared to follow deformation kinetics related to a visco-elastic mechanism, i.e., glassy phase diffusion creep of grain boundary sliding.


The application of reaction sintered Si3N4 energy absorbing surface layers to hot-pressed Si3N4 was investigated. The surface layer was formed by in-place nitridation of silicon powder. It was found that reaction sintered Si3N4 layers of 1 mm thickness, fabricated from either -100, -200, -325 mesh Si powder and nitrided in 98% N2/2% H2 so that approximately 20-25 vol % unoxidized Si remained in the layer, resulted in a significant increase in ballistic impact resistance of a 0.64 cm thick hot-pressed Si3N4 substrate from RT 1370°C, NBO-26382, to RT 1370°C, NC-132. Neat Si3N4 with MgO additive, and NCX-34 Si3N4, with Y2O3 additive, were evaluated as substrate material. The finer grain size -200 and 325 mesh nitrided Si layers were for their use in N2/H2 mixtures, rather than pure N2, resulted in a microstructure that did not substantially degrade the strength of the hot pressed Si3N4 substrate. Thermal cycling tests on the RSSN/HPSN combinations from 200°C to 1370°C for 75 cycles in air did not degrade the impact resistance nor the interfacial bonding, although a large amount of internal silica formation occurred within the RSSN layer. Mach 0.5 hr, hot gas erosion tests showed no surface recession of RSSN layers at 1200°C and slight surface recession at 1370°C.


A second generation polymerization monomeric reactants (PMR) polyimides matrix system (PMR 2) was characterized in both neat resin and composite form with two different graphite fiber reinforcements. Three different formulated molecular weight levels of laboratory prepared PMR 2 were examined, in addition to a purchased experimental fully formulated PMR 2 precursor solution. Isothermal aging of graphite fibers, neat resin samples and composite specimens in air at 316°C were investigated. Humidity exposures at 65°C and 97 percent relative humidity were conducted for both neat resin and composites for eight day periods. Anaerobic char of neat resin and fire testing of composites were conducted with PMR 15. PMR 2, and an epoxy system. Composites were fire tested on a burner rig developed for this program. Results indicate that neat PMR 2 resins exhibit excellent isothermal resistance and that PMR 2 composite properties appear to be influenced by the thermo-oxidative stability of the reinforcing fiber.


The development of silicon modified resins for graphite fiber laminates which will prevent the dispersal of graphite fibers when the composites are burned is discussed. Eighty-five silicone modified resins were synthesized and evaluated including unsaturated polyesters, thermosetting methacrylates, epoxies, polyimides, and phenolics. Neat resins were judged in terms of Si content, homogeneity, hardness, Char formation, and thermal stability. Char formation was estimated by thermogravimetry to 1,000°C in air and in N2. Thermal stability was evaluated by isothermal weight loss measurements for 200 hrs in air at three temperatures. Four silicone modified epoxies were selected for evaluation in unidirectional filament wound graphite laminates. Neat samples of these resins had 1,000°C char residues of 25 to 50%. The highest flexural values measured for the laminates were a strength of 140 ksi and a modulus of 10 Msi. The highest interlaminary shear strength was 5.3 kpsi.

N80-25382* # Hamilton Standard, Windsor Locks, Conn. DIFFUSION BONDED BORON/ALUMINUM SPAR-SHELL
C. E. K. Carlson, J. L. Cutler, W. J. Fisher, and J. V. W. Memmott
Design and process development tasks intended to demonstrate composite blade application in large high by-pass ratio turbofan engines are described. Studies on a 30 aspect ratio space and shell construction fan blade indicate a potential weight savings for the first stage fan rotor of 39% when a hollow titanium spar is employed. An alternate design which featured substantial blade internal volume filled with titanium honeycomb inserts achieved a 14% potential weight savings over the B747 rudder system. This second configuration requires a smaller development effort and entails less risk to translate a design into a successful product. The feasibility of metal joining large subsonic spar and shell fan blades was demonstrated. Initial aluminum alloy foam core material indicates a distinct preference for AA6061 aluminum alloy for use as a joint material. The simulated airfoil pressurings established the necessity of rigid air surfaces when joining materials of different compressive rigidities. The two aluminum alloy matrix choices both were successfully formed into blade shells. A.R.H.

Sudden Stretching of a Four Layered Composite Plate Interim Report
An approximate theory of laminated plates is developed by assuming that the extensional and thickness mode of vibration are coupled. The mixed boundary value crack problem of a four layered composite plate is solved. Dynamic stress intensity factors for a crack subjected to suddenly applied stress are found to vary as a function of time and depend on the material properties of the laminate. Stress intensification in the region near the crack front can be reduced by having the shear modulus of the inner layers to be larger than that of the outer layers. Author

Sudden Bending of Cracked Laminates Interim Report
A dynamic approximate laminated plate theory is developed with emphasis placed on obtaining effective solution for the crack configuration where the 1/square root of r stress singularity and the condition of plane strain are preserved. The radial distance r is measured from the crack edge. The results obtained show that the crack moment intensity tends to decrease as the crack length to laminate plate thickness is increased. Hence, a laminated plate has the desirable feature of stabilizing a through crack as it increases its length at constant load. Also, the level of the average load intensity transmitted to a through crack can be reduced by making the inner layers to be stiffer than the outer layers. The present theory, although approximate, is useful for analyzing laminate failure to crack propagation under dynamic load conditions. Author

Fabrication and Evaluation of Low Fiber Content Alumina Fiber/Alumina Composites Final Report
The mechanical fabrication of low volume percent fiber, polycrystalline alumina fiber reinforced aluminum composites was accomplished. Wire preform material was prepared by liquid-metal infiltration of alumina fiber bundles. The wires were subsequently encapsulated with aluminum foil and fabricated into bulk composite material by hot-drawing. Extensive mechanical, thermal and chemical testing was conducted on preform and bulk material to develop a process and material data base. In addition, a preliminary investigation of mechanical forming of bulk alumina fiber reinforced aluminum composite material was conducted. Author

Statistical Aspects of Carbon Fiber Risk Assessment Modeling
Donald Gross, Douglas R Miller, and Richard M Soland
The probabilistic and statistical aspects of the carbon fiber risk assessment modeling of fire accidents involving commercial aircraft are examined. Three major sources of uncertainty in the modeling effort are identified. These are (1) imprecise knowledge in establishing the model; (2) parameter estimation, and (3) Monte Carlo sampling error. All three sources of uncertainty are treated and statistical procedures are utilized and/or developed to control them wherever possible. A.R.H.

Fabric Release Characteristics of Graphite Hybrid Composites
The paper considers different material concepts that can be fabricated of hybridized composites which demonstrate improved graphite fiber retention capability in a severe fire without significant reduction to the composite properties. More than 30 panels were fabricated for mechanical and fire tests, the details and results of which are presented. Methods of composites hybridization investigated included the addition of oxidation resistant fillers to the resin, mechanically interlocking the graphite fibers by the use of woven fabrics, and the addition of glass fibers and glass additives designed to melt and fuse the graphite fibers together. It is concluded that a woven fabric with a serving of glass around each graphite tow is by far the superior of those evaluated: not only is there a coalescing effect in each graphite layer, but also there is a definite adhesion of each layer to its neighbor. J.P.B.
25 INORGANIC AND PHYSICAL CHEMISTRY

Includes chemical analysis, e.g., chromatography, combustion theory, electrochemistry, and photochemistry.

For related information see also 77 Thermodynamics and Statistical Physics.

A80-24388*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

AN INTERACTIVE MODULAR DESIGN FOR COMPUTERIZED PHOTOMETRY IN SPECTROCHEMICAL ANALYSIS


A graphic general functional description of totally automatic photometry of emission spectra is not available for an operating environment in which the sample compositions and analysis procedures are low-volume and non-routine. The advantages of using an interactive approach to computer control in such an operating environment are demonstrated. This approach includes modular subroutines selected at multiple-option, menu-style decision points. This style of programming is used to trace elemental determinations, including the automated reading of spectrographic plates produced by a 3.4-m Ebert mount spectrograph using a dc-arc in an argon atmosphere. The simplified control logic and modular subroutine approach facilitates innovative research and program development, yet is easily adapted to routine tasks. Operator confidence and control are increased by the built-in options including degree of automation, amount of intermediate data printed out, amount of user prompting, and multidirectional decision points.


Sodium chloride is one of the primary contaminants that enter gas turbine engines and contribute, either directly or indirectly, to the hot corrosion degradation of hot-gas-path components. The paper surveys the results of laboratory experiments along with thermodynamic and mass transport calculations, intended for elucidating the behavior of sodium chloride in combustion environments. It is shown that besides being a source of sodium for the formation of corrosive liquid Na2SO4, the NaCl itself contributes to other indirect ways to the material degradation associated with the high-temperature environmental attack. In addition, the experimental results lend credence to the conceptual scheme presented schematically (behavior of NaCl in a turbine engine combustion gas environment) and resolve conflicting aspects of relevant NaCl misconceptions.


The study was carried out by observing the decay of the zincate concentration gradient at a horizontal zinc cathode after charging. This decay was found to approximate first order kinetics as expected from a proposed boundary layer model. The decay half life was shown to be a linear function of the thickness of porous zinc deposit on the cathode indicating a very rapid transport of zincate through porous zinc metal. The rapid transport is attributed to an electrochemical mechanism. The data also indicated a relatively sharp transition between the diffusion and convection transport regions. The diffusion of zincate ion through asbostos submerged in alkaline electrolyte was shown to be comparable with that predicted from the bulk diffusion coefficient of the zincate ion in alkali.


In order to investigate the mechanism of carbon combustion, normal and zero gravity experiments were conducted in which spectroscopic carbon rods were resistance ignited and burned in an oxygen environment. Direct mass spectrometric sampling was used in the normal gravity tests to measure gas phase concentrations. The gas sampling probe was positioned near the circumference of the horizontally mounted carbon rods, either at the top or at angles of 45 or 90 deg from the top, and yielded concentration profiles of CO2, CO, and O2 as a function of distance from the carbon surface. The experimental concentrations were compared to those predicted by a stagnant film model. Zero gravity drop-thru tests were conducted in order to assess the effect of convection on the normal gravity combustion process. The ratio of flame diameter to rod diameter as a function of time for oxygen pressures of 5, 10, 15, and 20 psi was obtained for three different diameter rods. It was found that this ratio was inversely proportional to both the oxygen pressure and the rod diameter.


The paper presents new information on the durability of a CATCOM catalyst operating at low-emission combustion temperatures (about 1527 K) with a liquid fuel, No. 2 diesel. Information on the activity of No. 2 diesel after 1000 hr of aging is given. In addition, a unique in situ activity test developed for monitoring the subtle changes in the catalyst activity of the CATCOM catalyst is also detailed. The study demonstrated the feasibility of using a CATCOM catalyst in catalytically supported thermal combustion for extended operating periods.


An interactive, top-down structured program design is described which produces a general flexible description of totally automatic photometry of emission spectra in an operating environment in which sample compositions and analysis procedures are low-volume and non-routine. The use of this type of programming is illustrated by a project to computerize trace elemental determinations including the automated reading of spectrographic plates produced by a 3.4-m Ebert mount spectrograph using a dc-arc in an argon atmosphere.

The influence of ground-based gas turbine combustor operating conditions and fuel-bound nitrogen (FBN) found in coal-derived liquid fuels on the formation of nitrogen oxides and carbon monoxide is investigated. Analytical predictions of NOx and CO concentrations are obtained for a two-stage, adiabatic, perfectly-stirred reactor operating on a propellant-air mixture, with primary equivalence ratios from 0.5 to 1.7, secondary equivalence ratios of 0.5 or 0.7, primary stage residence times from 12 to 20 msec, secondary stage residence times of 1, 2 and 3 msec and fuel nitrogen contents of 0.5, 1.0 and 2.0 wt %. Minimum nitrogen oxide but maximum carbon monoxide formation is obtained at primary zone equivalence ratios between 1.4 and 1.5, with percentage conversion of FBN to NOx decreasing with increased fuel nitrogen content. Additional secondary dilution is observed to reduce final pollutant concentrations, with NOx concentration independent of secondary residence time and CO decreasing with secondary residence time; primary zone residence time is not observed to affect final NOx and CO concentrations significantly. Finally, comparison of computed results with experimental values shows a good semiquantitative agreement.

A.L.W.

NBO-121421 Pennsylvania State Univ., University Park
G. M. Faeth Jul. 1979 87 p refs (Grant NGR-39-009-077)
(NASA-CR-159697) Avail. NTIS HC A04/MA A01 CSCL 218

The general problem of spray combustion was investigated. The combustion of bipropellant droplets, combustion of hydroxyl fuels, and combustion of sprays were studied. A model was developed to predict mean velocities and temperatures in a combusting gas jet.

R.C.T.

NBO-131931 Tennessee Technological Univ., Cookeville
Dept. of Mechanical Engineering
AMPLIFICATION OF REYNOLDS NUMBER DEPENDENT PROCESSES BY WAVE DISTORTION Final Report, 1 Jan. 1972 - 31 Oct. 1979
M. Ventrice Nov. 1979 59 p refs (Grant NGR-43-003-018)
(NASA-CR-159732) Avail. NTIS HC A04/MA A01 CSCL 218

The amplification of a Reynolds number dependent process by wave distortion and the possibility of applying the results to other similar Reynolds number dependent processes were investigated. The process investigated was that associated with the operation of a constant-temperature hot-wire anemometer. The application of vaporization limited combustion, the type of combustion typically associated with liquid propellant rocket engines, was studied. A series of experiments were carried out to determine the effect of wave distortion on a Reynolds number dependent process and to establish the analogy between the anemometer process and the combustion process. Parametric trends, behavior common to different chamber geometries, and stability boundaries were identified. The results indicate a high degree of similarity between the two processes and the possibility of using the anemometer system to investigate combustion instability. The nonlinear aspects of a Reynolds number dependent process appear to be the dominant mechanisms controlling instability.

J.M.S.

The Symposium focused on deflagration to detonation transition, deform combustion, turbulent combustion interactions, kinetics, furnace combustion, inhibition and ignition, flame structure and chemistry, combustion studies, measurement techniques, fire and explosion, engine combustion, and precombustion and explosives.


The durability of the CATCOM catalyst for use in catalytically supported thermal combustion has been demonstrated at 5 atm, complementing a previous 1000 hour durability study at 1 atm. Both of these studies were conducted at about 840 K air preheat temperature at a reference velocity of about 14 m/s, the adiabatic flame temperature of the fuel/air mixture was about 1530 K. The catalyst proved to be capable of low emissions operations after 1000 hours of diesel fuel aging. However, more severe deactivation occurred in the 5 atm test, this was attributed to a loss in kinetic (ignition) activity.

B.L.
26 METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of metals, e.g., corrosion and metallurgy.

N80-10344f National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ANALYSIS OF THE RESPONSE OF A THERMAL BARRIER COATING TO SODIUM AND VANADIUM DOPED COMBUSTION GASES

Robert A. Miller 1979 23 p refs Presented at 8th Midwest High Temperature Chemistry Conf. Milwaukee, Wis., 4-6 Jun 1979 Sponsored in part by DOE (Contract EF 77 A 01 2593) (NASA-TM-79205 DOE/NASA/2593-79/7, E 090) Avail NTIS HC A02/MF A01 CSCL 11F Published data on the behavior of zirconia based thermal barrier coatings exposed to combustion gases doped with sodium and vanadium were analyzed with respect to calculated condensate dew points and melting points. Coating temperatures, failure locations, and depths were reasonably well correlated. Author.

N80-11188f National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MECHANICAL PROPERTIES AND OXIDATION AND CORROSION RESISTANCE OF REDUCED CHROMIUM 304 STAINLESS STEEL ALLOYS

Joseph R. Stephens, Charles A. Barrett, and Charles A. Gyorgak Washington Nov 1979 22 p refs (NASA-TP-1557 E 065) Avail NTIS HC A02/MF A01 CSCL 11F An experimental program was undertaken to identify effective substitutes for part of the Cr in 304 stainless steel as a method of conserving the strategic element Cr. Although special emphasis was placed on tensile properties, oxidation and corrosion resistance were also examined. Results indicate that over the temperature range of -196 C to 540 C the yield stress of experimental alloys with only 12 percent Cr compare favorably with the 18 percent Cr in 304 stainless steel. Oxidation resistance and in most cases corrosion resistance for the experimental alloys were comparable to the commercial alloy. Effective substitutes for Cr included Al, Mo, Si, Ti, and V, while Ni and Mn contents were increased to maintain an austenitic structure. R.C.T.

N80-11189f National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF THERMALLY INDUCED POROSITY ON AN AS-HIP POWDER METALLURGY SUPERALLOY

R. L. Dreshfield and R. V. Miner, Jr. Washington 1979 20 p refs To be presented at Ann. Meeting of the Am. Inst. of Mining, Met, and Petol. Engr., Las Vegas, Nev., 24-28 Feb. 1980 (NASA-TM-79263, E-178) Avail. NTIS HC A02/MF A01 CSCL 11F The impact of thermally induced porosity on the mechanical properties of an as-hot-iso-statically-pressed and heat treated pressing made from low carbon Astroloy was determined. Porosity in the disk-shape pressing studied ranged from 2.5 percent at the core to 14 percent at the rim. Tensile, yield strength, ductility, and rupture life of the rim of the porous pressing was only slightly inferior to the rim of sound pressings. The strength, ductility, and rupture life of the core of the porous pressing was severely degraded compared to sound pressings. At strain rates typical of commercial jet engine designs, the rim of the porous pressing had slightly inferior fatigue life to sound pressings. A.R.H.

N80-14232f National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

IMPROVED REFRACTORY COATINGS AND METHOD OF PRODUCING THE SAME Patent Application W. A. Braund and D. R. Wheeler, inventors (to NASA) Filed 12 Jul 1979 7 p (NASA-Case-LEW-13122-1, US-Patent-Appl-SN-102003) Avail NTIS HC A02/MF A01 CSCL 11F A thin sputtered film that exhibits improved adherence to a substrate and has improved friction and wear characteristics is described. These improvements are achieved by coating the substrate by rf sputtering with a film of titanium carbide using an argon sputtering plasma. A small nitrogen partial pressure from about 0.5% to 2.5% is added in the initial stages of the deposition during which the interface is formed. The improvements in adhesion of the titanium carbide coating to the substrate results from the presence of both nitrogen nitride and a nitride of the substrate in the interfacial region. NASA.

N80-14234f National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CORROSION RESISTANCE OF SODIUM SULFATE COATED COBALT-CHROMIUM-ALUMINUM ALLOYS AT 900 C, 1000 C, AND 1100 C

G. J. Santoro Nov 1979 28 p refs (NASA-TM-79311, E-267) Avail NTIS HC A03/MF A01 CSCL 11F The corrosion of sodium sulfate coated cobalt alloys was measured and the results compared to the cyclic oxidation of alloys with the same composition, and to the hot corrosion of compositionally equivalent nickel-base alloys. Cobalt alloys with sufficient aluminum content to form aluminum containing scales corrode less than their nickel-base counterparts. The cobalt alloys with lower aluminum levels form CoO scales and corrode more than their nickel-base counterparts which form NiO scales. M.G.

N80-15234f National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ADHESION AND FRICTION OF IRON-BASE BINARY ALLOYS IN CONTACT WITH SILICON CARBIDE IN VACUUM

Kazuhisa Miyoshi and Donald H Buckley Jan. 1980 13 p refs (NASA-TP-1604, E-120) Avail. NTIS HC A02/MF A01 CSCL 11F Single pass sliding friction experiments were conducted with various iron base binary alloys (alloying elements were Ti, Cr, Mn, Ni, Rh, and W) in contact with a single crystal silicon carbide /0001/ surface in vacuum. Results indicate that atomic size and concentration of alloying elements play an important role in controlling adhesion and friction properties of iron base binary alloys. The coefficient of friction generally increases with an increase in solute content. The coefficient of friction increases linearly as the solute to iron atomic radius ratio increases or decreases from unity. The chemical activity of the alloying elements was also an important parameter in controlling adhesion and friction of alloys, as these latter properties are highly dependent upon the d bond character of the elements. R.C.T.

N80-15236f National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF SODIUM, POTASSIUM, MAGNESIUM, CALCIUM, AND CHLORINE ON THE HIGH TEMPERATURE CORROSION OF IN-100, U-700, IN-792, AND MAR M-509

Carl E. Lowell, Steven M. Sidik, and Daniel L. Deadmore 1980 28 p refs Proposed for presentation at 25th Ann. Intern. Gas Turbine Conf., New Orleans, 9-13 Mar. 1980; sponsored by the ASME (Contract EF-77-A-01-2593) (NASA-TM-79309, E-265; DOE/NASA/2593-79/12) Avail NTIS HC A03/MF A01 CSCL 07D The effects of potential impurities such as Na, K, Mg, Ca, and Cl, in coal-derived liquid fuels on accelerated corrosion of IN-100, U-700, IN-792, and Mar M-509 were investigated using a Mach 0.3 burner rig for times to 200 hours in one hour cycles. These impurities were injected in combination as aqueous
solutions into the combustor. Other variables were time, temperature, and fuel-to-air ratio. The experimental matrix was a central composite fractional factorial design divided into blocks to allow modification of the design as data was gathered. The extent of corrosion was determined by metal consumption. The time exponent was near 0.1 for the least corrosion resistant alloys U-700 and IN 100, near 0.8 for the moderately resistant IN 792, and close to Mar-M505, the most corrosion resistant alloy. As anticipated, corrosion rapidly increased with increasing temperature as well as Na and K concentrations, while corrosion decreased somewhat as the Ca concentration increased for all alloys. Mg was beneficial for the Ni-base alloys but had little effect on the Co-base alloy. Surprisingly, the effect of increasing Cl was to decrease the corrosion of all alloys. Little interaction among the dopents was noted.

MAL-IMPINGEMENT EROSION OF DUCTILE METALS

William A. Brandim and Joshua Salon, Jan 1980 11 p refs (NASA-TP-1608, E-085) Avail NTIS HC AO2/MF AO1 CSCL 11F

Scanning electron microscopy was used to characterize the erosion of annealed copper and aluminum surfaces produced by both single and multiple-particle impacts. Macroporous 2.2 mm diameter steel balls and microscopic, brittle erodent particles were projected by a gas gun system so as to impact at normal incidence at speeds up to 140 m/sec. During the impacts by the brittle erodent particles, at lower speeds the erosion behavior was similar to that observed for the larger steel balls. At higher velocities, particle fragmentation and the subsequent cutting by radial wash of debris created a marked change in the erosion mechanism.

N80-18147# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SCANNING ELECTRON MICROSCOPE STUDY OF NORMALL-IMPINGEMENT EROSION OF DUCTILE METALS

Robert C. Bill and Lawrence T. Shemesh, Ohio 1980 29 p refs (NASA-TP-1608, E-085) Avail NTIS HC AO2/MF AO1 CSCL 11F

A standard Hastelloy-X honeycomb material and a pack aluminized honeycomb material were evaluated as to their performance in labyrinth seal applications for high temperature gas turbine engines. Consideration from published literature was given to the fluid sealing characteristics of two honeycomb materials in labyrinth seal applications, and their rub characteristics, erosion resistance, and mechanical performance. The mechanical behavior of the single crystals was rationalized.

The influence of orientation on the tension and stress rupture behavior of 52 Mar-M247 single crystals was studied. Tensile tests were performed at temperatures between 723 and 1093 C. Stress rupture behavior was examined between 760 and 1038 C. The mechanical behavior of the single crystals was rationalized on the basis of the Schmid factor contours for the operative slip systems and the lattice rotations which the crystals underwent during deformation. The tensile properties correlated well with the appropriate Schmid factor contours. The stress rupture lives at lower testing temperatures were greatly influenced by the lattice rotations required to produce cross slip. A unified analysis was attained for the stress rupture life data generated for the Mar-M247 single crystals at 760 and 774 C under a stress of 724 MPa and the data reported for Mar-M200 single crystals tested at 760 C under a stress of 689 MPa. Based on this analysis, the stereographic triangle was divided into several regions which were ranked according to stress rupture life for this temperature regime.

N80-18156# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

PRELIMINARY STUDY OF A SOLAR SELECTIVE COATING SYSTEM USING BLACK COBALT OXIDE FOR HIGH TEMPERATURE SOLAR COLLECTORS


Black cobalt oxide coatings (high solar absorptance layer) were deposited on high temperature grade silicon (high emissivity layer) which had been previously deposited on oxidized (diffusion barrier layer) stainless steel substrates. The reflectance properties of these coatings were measured at various thicknesses of cobalt for integrated values of the solar and infrared spectrum. The values of absorptance and emissivity were calculated from the measured reflectance values, before and after exposure in air at 650 C for approximately 1000 hours. Absorptance and emittance were interdependent functions of the weight of cobalt oxide. Also, these cobalt oxide/noble metal/coxide diffusion barrier coatings have absorbances greater than 0.90 and emittances of approximately 0.20 even after about 1000 hours at 650 C.

N80-18157# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECTS OF IMPURITIES IN COAL-DERIVED LIQUIDS ON ACCELERATED HOT CORROSION OF SUPERALLOYS Final Report


Sodium sulfate induced hot corrosion of B-1900 and NASA-TRW VMA-4000 at 900 C was studied with special emphasis on the chemical reactions occurring during and immediately after the induction period. Thermogravimetric tests were run for set periods of time after which the samples were washed with water and water soluble metal salts and/or residual sulfates were analyzed chemically. Element distributions within the oxide layer were obtained from electron microprobe X-ray micrographs. A third set of samples was subjected to surface analysis by X-ray photoelectron spectroscopy. Evolution of CO2 was monitored throughout many of the hot corrosion tests. Results are interpreted in terms of acid-base fluxing mechanisms.
and 304 stainless steel. The impurities added as aqueous solutions to the combustor were salts of sodium, potassium, vanadium, molybdenum, tungsten, phosphorus, and lead. Extent of attack was determined by metal consumption and compared to the effects of sodium alone. Vanadium, molybdenum, tungsten, phosphorus, and lead in combination with sodium all resulted in increased attack as compared with sodium alone at some temperatures, apparently due in large part to the extension of the formation of liquid deposits. Varying the sodium-potassium ratio had little effect for ratios less than 1:3 for which reduced, but measurable, attack was observed.

N80-20370# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

AN EXPERIMENTAL, LOW-COST, SILICON-ALUMINIDE PHOSPHORIC AND LEAD IN COMBINATION WITH SODIUM ALL RESULTED WAS DETERMINED BY METAL CONSUMPTION AND COMPARED TO THE EFFECTS OF SODIUM ALONE. VANADIUM, MOLYBDENUM, TUNGSTEN, PHOSPHORUS, AND LEAD IN COMBINATION WITH SODIUM ALL RESULTED IN INCREASED ATTACK AS COMPARED WITH SODIUM ALONE AT SOME TEMPERATURES, APPARENTLY DUE IN LARGE PART TO THE EXTENSION OF THE FORMATION OF LIQUID DEPOSITS. VARYING THE SODIUM-POTASSIUM RATIO HAD LITTLE EFFECT FOR RATIOS LESS THAN 1:3 FOR WHICH REDUCED, BUT MEASURABLE, ATTACK WAS OBSERVED.

N80-21489# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

APPLICATION OF SUPERALLOY POWDER METALLURGY FOR AIRCRAFT ENGINES


In the last decade, Government/Industry programs have advanced powder metallurgy near-net shape technology to permit the use of hot isostatic pressed (HIP) turbine disks in the commercial aircraft fleet. These disks offer a 30% savings of input weight and an 8% savings in cost compared to cast-and-wrought disks. Similar savings were demonstrated for other rotating engine components. A compressor rotor fabricated from hot die-forged HIP superalloy billets revealed input weight savings of 54% and cost savings of 35% compared to cast-and-wrought parts. Engine components can be produced from compositions such as Rene 85 and Astroloy by conventional casting and forging, by forging of HIP powder billets, or by direct consolidation of powder by HIP. However, each process produces differences in microstructure or introduces different defects in the parts. As a result, their mechanical properties are not necessarily identical. Acceptance methods should be developed which recognize and account for the differences.

N80-21490# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

TRIBOLOGICAL PROPERTIES OF SPUTTERED MoS2 FILMS IN RELATION TO FILM MORPHOLOGY


Thin sputter deposited MoS2 films in the 2000 to 6000 A thickness range have shown excellent lubricating properties when sputtering parameters and substrate conditions are properly selected and precisely controlled. The lubricating properties of sputtered MoS2 films are strongly influenced by their crystalline-amorphous structure, morphology, and composition. The coefficient of friction can range from 0.04 to 0.10 which reflects an absence of lubricating properties. Visual screening and slight wiping of the as-sputtered MoS2 film can identify the integrity of the film. An acceptable film displays a black sooty surface appearance whereas an unacceptable film has a highly reflective, gray surface and the film is hard and brittle.

N80-21492# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

FOULING AND THE INHIBITION OF SALT CORROSION

FOR AIRCRAFT ENGINES


In an attempt to reduce fouling while retaining the beneficial effects of alkaline earth inhibitors on the hot corrosion of superalloys, the use of both additives and the intermittent application of the inhibitors were evaluated. Additions of alkaline earth compounds to combustion gases containing sodium sulfate were shown to inhibit hot corrosion. However, sulfates deposits can lead to turbine fouling in service. For that reason, dual additives and intermittent inhibitor applications were evaluated to reduce such deposit formation. Silicon in conjunction with vanadium showed some promise. Total deposition was significantly reduced while the inhibition of hot corrosion by barium was unplanned. The intermittent application of the inhibitor was found to be more effective and controllable.

N80-21493# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECTS OF FINE POROSITY ON THE FATTIGE BEHAVIOR OF A POWDER METALLURGY SUPERALLOY


Hot isostatically pressed powder metallurgy Astroloy was obtained which contained 1.4% which is close to the diagram. The pore averaged about 2 micrometers diameter and 20 micrometers spacing. They did influence fatigue crack initiation and produced a more intergranular mode of propagation. However, fatigue life was not drastically reduced. A large 25 micrometers pore in one specimen resulting from a hollow pore did not reduce life by 60 percent. Fatigue behavior of the porous material showed typical correlation with tensile behavior. The plastic strain range life relation was reduced proportionately with the reduction in tensile ductility.
but the elastic strain range-life relation was little changed reflecting the small reduction in sigma sub u/E for the porous material.

N80-24744** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

EFFECTS OF YTTRIUM, ALUMINUM AND CHROMIUM CONCENTRATIONS IN BOND COATINGS ON THE PERFORMANCE OF ZIRCONIA-YTTRIA THERMAL BARRIERS

A cyclic furnace study was conducted on thermal barrier systems to evaluate the effects of yttrium, chromium, and aluminum in nickel base alloy bond coatings and the effect of conditions that would result in minimum bond coat life. Without yttrium in the bond coatings, the zirconia coatings failed very rapidly. Increasing chromium and aluminum in the Ni-Cr bond coatings increased total coating life. This effect was not as great as that due to yttrium. Increased bond coat thickness was also found to increase life.

N80-33430** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

PRACTICAL APPLICATIONS OF SURFACE ANALYTIC TOOLS IN TRIBOLOGY

A brief description of many of the widely used tools is presented. Of this list, those which have the highest applicability for giving elemental and/or compound analysis for problems of interest in tribology along with being truly surface sensitive (that is less than 10 atomic layers) are presented. The latter group is critiqued in detail in terms of strengths and weaknesses. Emphasis is placed on post facto analysis of experiments performed under real conditions (e.g., in air with lubricants). It is further indicated that such equipment could be used for screening and quality control.

N80-28428** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

IMPROVED PFB OPERATIONS: 400-HOUR TURBINE TEST RESULTS

A pressurized fluidized bed (PFB) coal-burning reactor was used to provide hot effluent gases for operation of a small gas turbine. Preliminary tests determined the optimum operating conditions that would result in minimum bed particle carryover in the combustion gases. Solids were removed from the gases before they could be transported into the test turbine by use of a modified two stage cyclone separator. Design changes and refined operation procedures resulted in a significant decrease in particle carryover, from 2800 to 93 ppm (1.5 to 0.05 grains/std cu ft), with minimal drop in gas temperature and pressure. The achievement of stable burn conditions and low solids loadings made possible a 400 hr test of small superalloy rotor, 15 cm (6 in.) in diameter, operating in the effluent. Blades removed and examined metallographically after 200 hr exhibited accelerated oxidation over most of the blade surface, with subsurface alumina penetration to 20 micron m. After 400 hours, average erosion loss was about 25 micron m (1 mil). Sulfide particles, indicating hot corrosion, were present in depletion zones, and their presence corresponded in general to the areas of adherent solids deposit. Sulfidation appears to be a materials problem equal in importance to erosion.

A.R.H.

N80-28433** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio


An elastic stress analysis was performed on a wedge specimen (prismatic bar with double-edge wedge cross-section) subjected to thermal cycles in fluidized beds. Five alloys (IN 100, Mar-M 200, Mar-M 302, NASA TAZ-BA, and Rene 80) subjected to the same thermal cycling condition were analyzed. This condition was alternate 3 minute immersions in fluidized beds maintained at 316 C and 1098 C (600 and 1900 F). The analyses were performed as a joint effort of two laboratories using different models and computer programs (NASA and ISODAQ). Stress, strain, and temperature results are presented.

N80-31627** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

ADHERENCE OF ION BEAM SPUTTER DEPOSITED METAL FILMS ON H-13 STEEL

An electron bombardment argon ion source was used to sputter deposit 17 different metal and metal oxide films ranging in thickness from 1 to 8 micrometers on H-13 steel substrates. The film adherence to the substrate surface was measured using a tensile test apparatus. Comparisons in bond strength were made between ion beam, ion plating, and RF deposited films. A protective coating to prevent heat checking in H-13 steel dies used for aluminum die casting was studied. The results of exposing the coated substrates to temperatures up to 700 degrees are presented.

N80-32484* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

HIGH TOUGHNESS-HIGH STRENGTH IRON ALLOY

An iron alloy is provided which exhibits strength and toughness characteristics at cryogenic temperatures. The alloy consists essentially of about 10 to 16 percent by weight nickel, about 0.1 to 1.0 percent by weight aluminum, and 0 to about 3 percent by weight copper, with the balance being essentially iron. The iron alloy is produced by a process which includes cold rolling at room temperature and subsequent heat treatment. Official Gazette of the U.S. Patent and Trademark Office

N80-32486* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

FRACTURE TOUGHNESS-BRITTLE MATERIALS DETERMINED WITH CHEVRON NOTCH SPECIMEN
The use of chevron-notch specimens for determining the plane strain fracture toughness ($K_{IC}$) of brittle materials is discussed. Three chevron-notch specimens were investigated: short bar, short rod, and four-point-bend. The dimensionless stress intensity coefficient used in computing $K_{IC}$ is derived for the short bar specimen from the superposition of ligament-dependent and ligament-independent solutions for the straight-through crack, and also from experimental compliance calibration. Coefficients for the four-point bend specimen were developed by the same superposition procedure, and with additional refinement using the slice model of Bluhm. Short rod specimen stress intensity factors were determined only by experimental compliance calibration. Performance of the three chevron-notch stress intensity factor relations were evaluated by tests on hot-pressed silicon nitride and sintered aluminum oxide. Results obtained with the short bar and the four-point-bend specimens on silicon nitride are in good agreement and relatively free of specimen geometry and size effects within the range investigated. Results on aluminum oxide were affected by specimen size and chevron-notch geometry, believed due to a rising crack growth resistance curve for the material. Only the short bar results for the short bar specimen are presented in detail.

**N80-32487**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**PERFORMANCE OF TWO-LAYER THERMAL BARRIER SYSTEMS ON DIRECTIONALLY SOLIDIFIED Ni-Al-Mo AND COMPARATIVE EFFECTS OF ALLOY THERMAL EXPANSION ON SYSTEM LIFE**

A promising two-layer thermal barrier coating system (TBS), Ni-16.4Cr-5.1Al-0.16Y/ZrO2-6.1Y2O3 (all in weight percent), was identified for directionally solidified Ni-Al-Mo (gamma/alpha) alloy. In cyclic furnace tests at 1095°C this system on gamma/magma' alpha' was better than Ni-16.4Cr-5.1Al-0.16Y/ZrO2-7.2Y2O3 by about 50 percent. In natural gas - oxygen torch rig tests at 1250°C the Y2O3-6.1Y2O3 coating was better than the ZrO2-7.2Y2O3 coating by 95 percent, on MAR-M509 substrates and by 60 percent on gamma/magma' alpha' substrates. Decreasing the coefficient of thermal expansion of the substrate material from 17-18x10^-6 to the -6 power/C (MAR-M200 + HF and MAR-M509) to 11x10 to the -6 power/C (gamma/magma' alpha') also resulted in improved TBS life. For example, in natural gas - oxygen torch rig tests at 1250°C, the life of Ni-16.4Cr-5.1Al-0.16Y/ZrO2-6.1Y2O3 was about 30 percent better on gamma/magma' alpha' than on MAR-M509 substrates. Thus compositional changes in the bond and thermal barrier coatings were shown to have a greater effect on TBS life than does the coefficient of thermal expansion.

Author

**N80-32488**
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**CREEP-RUPTURE BEHAVIOR OF SEVEN IRON-BASE ALLOYS AFTER LONG TERM AGING AT 760 DEG IN LOW PRESSURE HYDROGEN**

Seven candidate iron-base alloys for heater tube application in the Stirling automotive engine were aged for 3500 hours at 760°C in argon and hydrogen. Aging degraded the tensile and creep-rupture properties. The presence of hydrogen during aging caused additional degradation of the rupture strength in fine grain alloys based on current design criteria for the Mod 1 Stirling engine, N-155 and 19-9DL are considered the only alloys in this study with strengths adequate for heater tube service at 760°C.

Author

**N80-32489**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**LONG-TIME CREEP BEHAVIOR OF THE TANTALUM ALLOY ASTAR 811C**

The high vacuum creep behavior of Astar 811C (Ta-BW-1Re-0.7Hf-0.02C) was studied over the temperature range 800°C to 1700°C as a function of stress, temperature, and grain size in order to develop a relation for predicting long term creep. Primary creep rates were related to time by the Garofalo exponential function, and a second exponential term was developed to describe the tertiary creep portion of the creep curve. No significant periods of secondary (linear) creep were observed. The creep curves were well expressed by a relation that includes terms for primary and tertiary creep. The initial and tertiary creep rates were obtained by differentiating the respective terms from the strain time relation and can be related to temperature by using a dual activation energy to account for lattice and dislocation core diffusion. The strain parameters were determined as power functions of the applied stress.

A.R.H.

**N80-33565**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**LONG TIME CREEP BEHAVIOR OF THE NIOBIUM ALLOY C-103**

The creep behavior of C-103 was studied as a function of stress, temperature, and grain size for test times to 19000 hr. Over the temperature range 827°C to 1204°C and the stress range 689 to 138 MPA, only tertiary (accelerating) creep was observed. The creep strain epsilon can be related to time $t$ by an exponential relation $\varepsilon(t) = \varepsilon_0 + kt$, where $\varepsilon_0$ is initial creep strain, $k$ is the tertiary creep strain parameter, and $t$ is the tertiary creep rate parameter. The observed stress exponent $b$ is similar to the three power law generally observed for secondary (linear) creep of Class I solid solutions. The apparent activation energy $374$ kJ/mol is close to that observed for self diffusion of pure niobium. The initial tertiary creep rate was slightly faster for fine grained than for coarse-grained material. The strain parameter $K$ can be expressed as a combination of power functions of stress and strain, and an exponential function of temperature. Strain time curves generated by using calculated values for $k$ and $t$ showed reasonable agreement with observed curves to strains of at least 4 percent. The time to 1 percent strain was related to stress, temperature, and grain size in a similar manner as the initial tertiary creep rate.

R.K.G.

**N80-33566**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**IMPROVED BOND COATINGS FOR USE WITH THERMAL BARRIER COATINGS**

The potential for improving the durability of thermal barrier coatings (TBCs) being developed for coal derived fuel fired gas turbines was studied. Furnace oxidation behavior of plasma deposited bond coatings was improved by increasing the thickness from 0.010 cm to 0.015 cm and by depositing the coatings at 20 kW with argon 3.5 vol% hydrogen arc gas rather than at 11 kW with argon. The most oxidation resistant plasma deposited bond coatings were Ni-14, Cr-15.4Al-0.02Zr, Ni-14.3Cr-14.4Al, Ni-16.0Cr-15.4Al-0.02Zr, and Ni-15.8Cr-12.8Al-0.07Y2O3 on B-1900 + HF and Ni-30.3Cr-14.8Al-0.48Y on B-1900 + HF and Ni-30.3Cr-14.8Al-0.48Y on B-1900 + HF. The oxidation resistant bond coatings improved TBC life when the coatings were deposited on the specimens supported on a nail bed fixture during coating.

Author

**ASB-10043**
The erosion/corrosion of small superalloy turbine rotors operating in the effluent of a PFBC coal combustor. G.
Ph. D.


The paper deals with some preliminary results of the Mission Profile Life Test planned to conduct a program of long-term test segments of 30 cm diameter thrusters and power processing units under computer control. Thruster performance data and other operational characteristics taken at various times during a test segment are compared and the results are evaluated in light of the life-timeing mechanisms. Thruster control algorithms are also presented. The first 2700 hr of a planned 16000 hr test with a J-series 30 cm thruster, the fast 16000 hr used a functional mode power processing unit (PPU) operated in vacuum. The thruster-PPU was controlled by a computer with software developed to control start-ups, throttling, and variety of off-normal conditions.

V. T.


There is a wide variety of situations wherein metals are in solid state contact with dielectric materials. The paper reviews some of the factors that influence solid state interactions for metals in contact with dielectric surfaces. Since surfaces play an important part in these reactions, the use of analytical tools in characterizing surfaces is discussed. Adhesion, friction, and wear are utilized as indicators of the nature of interfacial bonding between metals and dielectrics and can be effectively determined with adhesion and friction force measurements. Films present on the surface, such as oxygen or water vapor, markedly alter adhesive bond strength which in turn affects friction force and interfacial fracture when attempts are made to separate the contact regions. Analytical surface tools such as the field ion microscope, Auger emission spectroscopy, and X-ray photoelectron spectroscopy are very effective in providing insight into the effect of contact on the surfaces of metals and dielectrics.

S.D.


The microstructural development of Al2O3 scales on NiCrAI alloys has been examined by transmission electron microscopy. Void has voids been observed within grains in scales formed on a pure NiCrAI alloy. Both voids and oxide grain growth were measured in oxidation time at 1100°C. The size and amount of porosity decreased towards the oxide-metal growth interface. It was postulated that the voids resulted from an excess number of oxygen vacancies near the oxide-metal interface. Short-circuit diffusion paths were discussed in reference to current growth stress models for oxide scales. Transient oxidations of pure, Y-doped, and Zr-doped NiCrAl were also examined. Oriented alpha-(Al,Cr)2O3 and NiAl(Cr)2O4 scales often coexisted in layered structures on all three alloys. Close-packed oxygen planes and directions in the corundum and spinel layers were parallel. The close relationships between oxide layers provided a gradual transition from initial transient scales to steady state Al2O3 growth.


A study of the flow strength, creep resistance and diffusion welding characteristics of the titanium alloy Ti-6Al-2Nb-1Ta-0.8Mo has been conducted. Two mill-processed forms of this alloy were examined. The forged material had been processed to the beta transus (approximately 1275 K) while the rolled form had been subjected to work below the beta transus. Between 1150 and 1250 K, the forging material was stronger and more creep resistant than the rolled alloy. Both forms exhibit superplastic characteristics in this temperature range. Strain measurements during diffusion welding experiments at 1200 K reveal that weld interfaces have no measurable effect on the overall creep deformation. Significant deformation appears to be necessary to produce a quality diffusion weld between superplastic materials. A 'soft' interlayer inserted between faying surfaces would seemingly allow manufacture of quality diffusion welds with little overall deformation.


Cyclic oxidation and hot corrosion tests of two cobalt-base and two nickel-base alloys are reported. The alloys were exposed to maximum temperatures of 900 and 1000°C in a Mach 0.3 burner rig whose flame was doped with various concentrations of sea salt and sodium sulfate for hot corrosion tests. The test data were subjected to a regression analysis for the development of model equations relating corrosion to temperature and for the effect of salt concentration and composition on corrosion. The corrosion resistance varied with temperature, sea salt concentration, and salt composition, concluding that the S-57 cobalt-base alloy was the most hot corrosion-resistant alloy, and the TD-NiCrAI nickel-base alloy was the least resistant. However, under straight oxidation conditions, the TD-NiCrAl was most resistant, while S-57 was the least resistant alloy.


Sputtered coatings of the refractory metal carbides are of great interest for applications where hard wear-resistant materials are desired. The usefulness of sputtered refractory carbides is often limited by a practical difficulty in obtaining a sufficient bond to the metal substrate. In this work improvements in the adherence of refractory carbides on iron, nickel, and titanium base alloys were obtained by using oxidation, reactive sputtering or sputtering interlayers to alter the coating-substrate interfacial region. X-ray photoelectron spectroscopy and argon ion
etching were used to characterize the interfacial regions, and an attempt was made to correlate adherence as measured in wear tests with the chemical nature of the interface. (Author)


The isothermal oxidation of Ni-14Cr-24Al-zr-type alloys was performed at still air at 1100, 1150, and 1200 C for times up to 200 hr. The zirconium content of the alloys varied from 0.63 atom percent Zr(Al). The oxidized surfaces were studied by optical microscopy, x-ray diffraction, and scanning electron microscopy. The base alloy was an aluminia-former with the zirconium-containing alloys also developing some ZrO2. The addition of zirconium above 0.637 a/o increased the rate of weight gain relative to the base alloy. Due to oxide penetration, the weight gain increased with Zr content; however, the scale thickness did not increase. The Zr did increase the adherence of the oxide, particularly at 1200 C. The delta WIA vs. time data fit the parabolic law of oxidation. The specific diffusion mechanism operative could not be identified by analysis of the calculated activation energies. Measurements of the Al2O3 scale lattice constants yielded the same values for all alloys. (Author)


The effect of thermally induced porosity on the mechanical properties of an as Hot-isostatically pressed and heat treated pressing made from low carbon Astroloy is examined. Tensile, stress rupture, creep, and low cycle fatigue tests were performed and the results were compared with industrial acceptance criteria. It is shown that the porous pressing has a porosity gradient from the rim to the bore with the bore having 1.121% greater porosity. Mechanical properties of the test ring below acceptance level are tensile reduction in area at room temperature and 538 C and time for 0.1% creep at 704 C. It is also found that the strength, ductility, and rupture life of the rim are slightly inferior to those of the ring of the sound pressings, while those of the bore are generally below the acceptable level. At strain ranges typical of commercial aircraft engines, the low cycle fatigue life of the rim of the porous pressings is slightly lower than that of the sound pressings. L. M. American Vacuum Society, International Conference on Metallurgical Coatings, San Diego, Calif., Apr. 21-25, 1980, Paper. 14. p. 10 refs.

A80-35500 * Preliminary study of a solar selective coating system using black cobalt oxide for high temperature solar collectors. G. MacDonald (NASA, Lewis Research Center, Cleveland, Ohio).


The effects of crystal orientation on the mechanical properties of single crystals of the nickel-based superalloy Mar-M247 are investigated. Tensile tests at temperatures from 23 to 1093 °C and stress rupture tests at temperatures from 700 to 1038 °C were performed for 32 single crystals at various orientations. During tensile testing between 23 and 760 °C, single crystals with high Schmid factors were found to be favorably oriented for slip and to exhibit lower strength and higher ductility than those with low Schmid factors. Crystals which required large rotations to become oriented for cross slip were observed to have the shortest stress rupture lives at 760 °C, while those which required little or no rotation had the longest lives. In addition, stereographic triangles obtained for Mar-M247 and Mar-M200 single crystals reveal that crystals with orientations near the -111 had the highest lives, those near the 001 had high lives, and those near the 011 had low lives.

A.L.W.

N80-13218* # Inco Research and Development Center, Saffern, N.V.

CHARACTERIZATION OF AN OXIDE DISPERSION STRENGTHENED SUPERALLOY, MA-6000E. FOR TURBINE BLADE APPLICATIONS Final Report

Y. G. Kim and H. F. Merrick May 1979 37 p refs
(Contract NAS3-20093) (NASA-CR-159493) Avail NTIS HC AO3/MF AO1 CSCL 11F

Alloy MA 6000E was developed by the mechanical alloying process for turbine blade applications. The nominal composition of the experimental alloy is Ni-15Cr-2Mo-4W-4.5Al-2.5Ti-2Ta-15Zr-0.5C-0.1B-1.1Y-203. The 1000 hour rupture strength in the longitudinal direction is about 145 MPa at 1093 °C and about 483 MPa at 760 °C. The alloy displays normal three-stage creep behavior. Typically, the creep elongation is 3.5% at 760 °C and 2% at 1093 °C. The alloy is notch ductile (K1C = 13.5). The rupture properties of the alloy are not significantly degraded by thermal cycling or prior stress isothermal exposure. The alloy also has excellent longitudinal high and low cycle fatigue resistance. Limited testing indicates that MA 6000E possesses good off-axis mechanical properties. The transverse tensile elongation at 760 °C is about 3%. The 100 hour transverse rupture strength is 331 MPa at 760 °C and about 55 MPa at 1093 °C.

A.R.H.


ABRASIBLE COMPRESSOR AND TURBINE SEALS. VOLUME 1

D. V. Sundberg, R. E. Dennis, and L. G. Hurst May 1979 178 p
(Contract NAS3-20073) (NASA-CR-159600: Airesearch-21-3213-1) Avail: NTIS HC AO9/MF AO1 CSCL 11A

The application and advantages of abradable coatings as gas-path seal versus a general aviation turbine engine were evaluated for use on the high-pressure compressor, the high-pressure turbine, and the low-pressure turbine shrouds. Topics covered include: (1) the initial selection of candidate materials for interim full-scale engine testing; (2) interim engine testing of the initially selected materials and additional candidate materials; (3) the design of the component required to adapt the hardware to permit full-scale engine testing of the most promising materials; (4) finalization of the fabrication methods used in the manufacture of engine test hardware; and (5) the manufacture of the hardware necessary to support the final full-scale engine tests.

A.R.H.

N80-15233* # Pittsburgh Univ., Pa. Dept. of Metallurgical and Materials Engineering


T. T. Huang and G. H. Menter 1979 70047 p refs
(Grant NoG 3214) (NASA CR 159718: SETEC MME 79 61, SAR 21) Avail: NTIS HC AO3/MF AO1 CSCL 11F

The commercial nickel base alloy, IN-738, and high purity laboratory alloys were prepared to simulate the effects of the major elements in IN-738. Results indicate that the initiation of hot corrosion attack of IN-738 and other similar alloys is the result of local penetration of molten salt through the protective oxide scale.

R.C.T.

N80-16142* # National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

STRESS CORROSION CRACKING EVALUATION OF MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS

(NASA-TM-78257) Avail: NTIS HC AO3/MF AO1 CSCL 11F

The resistance of the martensitic precipitation hardening stainless steels PH13-BMo, 15-5PH, and 17-4PH to stress corrosion cracking was investigated. Round tensile and c-ring type specimens taken from several heats of the three alloys were stressed up to 100 percent of their yield strengths and exposed to alternate immersion in salt water, to salt spray, and to a seacoast environment. The results indicate that 15-5PH is highly resistant to stress corrosion cracking in conditions H1000 and H1050 and is moderately resistant in condition H800. The stress corrosion cracking resistance of PH13-BMo and 17-4PH stainless steels in conditions H1000 and H1050 was sensitive to mill heats and ranged from low to high among several heats included in the tests. Based on a comparison with data from seacoast environmental tests, it is apparent that alternate immersion in 3.5 percent salt water is not a suitable medium for accelerated stress corrosion testing of these PH stainless steels.

A.R.H.

N80-18165* # United Technologies Research Center, East Hartford, Conn.

STUDY OF THE EFFECTS OF GASEOUS ENVIRONMENTS ON THE HOT CORROSION OF SUPERALLOY MATERIALS Final Report

John G. Smeggil and N. S. Bornstein 5 Feb. 1980 93 p

The effect of the gaseous corrosive NaCl on the high temperature oxidation and sodium sulfate induced hot corrosion behavior of alumina formers, chromia formers, and the superalloy B-1900 was examined. Isothermal experiments were conducted at 900 °C and 1050 °C in air in the presence and absence of NaCl vapors. Microstructural changes in oxide morphology and increased rates of oxidation were observed when NaCl(1) was present. It is hypothesized that the accelerated rates of oxidation are the result of removal of aluminum from the scale substrate interface and the weakening of the scale substrate bonds. The aluminum removed was redeposited on the surfaces in the form of alumina whiskers. For the superalloy B-1900, alumina whiskers are also formed, and the alloy oxidizes at catastrophic rates. In the case of Ni-25Cr alloy, NaCl vapors interact with the scale depleting it of chromium.

R.C.T.
A coated specimen of 262 HRC 38, 266 HRC 37 and 266 compared compared to alloys tested in prior programs. Author before cracks appeared. All the alloys showed little weight change coated specimen of 262 HRC 38, 40; 754; and 956. Specimens in the bare condition of hardness of HRC 38: 264 in systems, were cycled between fluidized beds maintained at HRC40 also survived 6000 cycles without cracking. A duplicate edge wedge specimens, both bare metal and coated for each saengthened alloy compositions or fabricating techniques, Double

Thermal fatigue and oxidation data were obtained 24 specimens representing 9 discrete oxide dispersion-strengthened alloy compositions of fabricating techniques. Double edge wedge specimens, both bare metal and coated for each systems, were cycled between fluidized beds maintained at 1130 C with a three minute immersion in each bed. The systems included alloys identified as 262 in hardness of HRC 38; 264 in hardness of HRC 38, 40 and 43; 265 HRC 39, 266 of HRC 37 and 40; 764; and 956. Specimens in the bare condition of 265 HRC 39 and 266 HRC 37 survived 6000 cycles without cracking on the small radius of the double edge wedge specimens. A coated specimen of 262 HRC 38, 266 HRC 37 and 266 HRC40 also survived 6000 cycles without cracking. A duplicate coated specimen of 262 HRC 38 alloy survived 5250 cycles before cracks appeared. All the alloys showed little weight change compared compared to alloys tested in prior programs. Author


The effect of SO3 pressure in the gas phase on the Na2SO4 induced hot corrosion of Co-Cr, Ni-Cr, and Co-Cr-Al alloys was measured as a function of temperature in the range 700 to 760 C. The degradation of the Co-Cr and Ni-Cr alloys was found to be associated with the formation of liquid mixed sulfates (CoSO4-Na2SO4 or NiSO4-Na2SO4) which provided a selective dissolution of the Co or Ni and a subsequent sulfidation oxidation mode of attack which prevented the maintenance of a protective Cr2O3 film. A clear mechanism was not developed for the degradation of Co-Cr-Al alloys. A pit corrosion morphology was induced by a number of different mechanisms. B.D.


An attempt was made to improve methods for producing powder metallurgy aircraft gas turbine engine parts from the nickel base superalloy known as Rene 95. The parts produced were the high pressure turbine aft shaft for the CF6-60 engine and the stages 5 through 9 compressor disk forgings for the CFM56/F101 engines. A 50% cost reduction was achieved as compared to conventional cast and wrought processing practices. An integrated effort involving several powder producers and a major forging source were included. R.C.T.


Several nickel-base aircraft turbine disk superalloys were evaluated at 650 C for resistance to fatigue crack initiation and propagation under cyclic and cyclic/dwell conditions. Controlled strain low cycle fatigue (LCF) and controlled load crack propagation tests were performed and results utilized to provide a direct comparison among the alloys. Tests were performed on selected alloys to evaluate the effects of hold times, mean stresses, stress-dwell cycle types, inert environment, and contractor test methods. At the lower total strain ranges of interest, the alloys exhibited generally increasing initiation life with increasing tensile strength for both cyclic (0.33 Hz) and cyclic/dwell (900-sec hold per cycle) conditions. Rank order of the alloys by fatigue initiation life changed substantially at higher strain ranges, approaching the rank order expected from monotonic tensile ductilities. The effect of the 900 sec (15 min) hold time fatigue life varied significantly from alloy to alloy. Generally, the higher-strength, fine-grained alloys exhibited more significant reductions in fatigue life due to the dwell. The effects of mean stress were found to be negligible and the effects of mean stress were pronounced. At high strain ranges the mean stress was near zero and did not contribute to reduction in life. At low strain ranges, however, mean stresses were large and significant reductions in LCF lives occurred.

A nickel-based powder metal disk alloy developed for use in advanced commercial gas turbines is described. Consideration is given to final alloy chemistry modifications made to achieve a desirable balance between tensile strength and stress rupture life and ductility. The effects of post-consolidation heat treatment are discussed. Preliminary mechanical properties obtained from full-scale turbine disks are presented.

A low-cost, exothermic directional-solvification (DS) process was developed to produce single-crystal (SC) Mar-M 247 high-pressure turbine blades. Stress-rapture data indicated that SC Mar-M 247 provides only marginal improvements in longitudinal strength relative to the columnar grained DS material. Removal of grain boundary strengthening elements (B, C, Zr, Hf) from the Mar-M 247 composition (which are also melting point depressants) permitted the alloy to be solutioned at significantly higher temperatures. An order of magnitude improvement in rupture life relative to SC Mar-M 247 was observed for several derivative alloys at 103.5 MPa (15 KSI) and 1093 C. Rupture lives of the modified SC alloys were significantly affected by both alloy purity and heat treatment. Critical aspects of vacuum induction refining, exothermic casting technology, alloy development and heat treatment, which contributed to this new class of turbine blades, are reviewed. (Author)
27 NONMETALLIC MATERIALS

Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials.

N90-13256* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHARACTERIZATION AND PROPERTIES OF CONTROLLED NUCLEATION THERMOCHEMICAL DEPOSITED (CNTD) SILICON CARBIDE

The microstructure of controlled nucleation thermochemical deposition (CNTD) - SiC material was studied and the room temperature and high temperature bond strength and oxidation resistance was evaluated. Utilizing the CNTD process, ultrafine grained (0.01-0.1 mm) SiC was deposited on W - wires (0.5 mm diameter by 20 cm long) as substrates. The deposited SiC rods had superior surface smoothness and were without any macrocolumnar growth commonly found in conventional CVD material. At both room and high temperature (1200 - 1380 C), the CNTD - SiC exhibited bond strength approximately 200,000 psi (1380 MPA), several times higher than that of hot pressed, sintered, or CVD SiC. The excellent retention of strength at high temperature was attributed to the high purity and fine grain size of the SiC deposit and the apparent absence of grain growth at elevated temperatures. The rates of weight change for CNTD - SiC during oxidation were lower than for NC-203 (hot pressed SiC), higher for GE'S Si3N4, and considerably below those for HS-130 (hot pressed Si3N4). The high purity, full density, and stable grain size CNTD - SiC material shows potential for high temperature structural applications; however, problem areas might include: scaling the process to make larger parts, deposition on removable substrates, and the possible residual tensile stress. J.M.S.

N90-13258* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIIONS OF CALCIUM ORTHOSILICATE AND BARIUM ZRCONATE WITH OXIDES AND SULFATES OF VARIOUS ELEMENTS
Calcium orthosilicate and barium zirconate were evaluated as the insulating layer of thermal barrier coatings for air cooled turbine components. Their reactions with various oxides and sulfates were studied at 1100 C and 1300 C for times ranging up to 400 and 200 hours, respectively. These oxides and sulfates represent potential impurities or additives in gas turbine fuels and in turbine combustion air. The results of these reactions were determined by X-ray diffraction analysis. BaZrO3 and 2CaO-SiO2 both reacted with P2O5, V2O5, Cr2O3, Al2O3, and SiO2. In addition, 2CaO-SiO2 reacted with Na2O, BaO, MgO, and CaO and Ba2ZrO3 reacted with Fe2O3. K.L.

N90-14249* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICITION AND WEAR OF PLASMA-SPRAYED COATINGS CONTAINING COBALT ALLOYS FROM 25 DEG TO 60 DEG IN AIR
Harold E. Slaney and Thomas P. Jacobson 1979 20 p refs (NASA-TM-79316; E-189) Avail: NTIS HC A02/ MF A01 CSCL 11F
Four different compositions of self-lubricating, plasma-sprayed, composite coatings with calcium fluoride dispersed throughout cobalt alloy-silver matrices were evaluated on a friction and wear apparatus. In addition, coatings of the cobalt alloys alone and one coating with a nickel alloy-silver matrix were evaluated for comparison. The wear specimens consisted of two, diametrically opposed, flat rub shoes sliding on the coated surface of a rotating disk. Two of the cobalt composite coatings gave a friction coefficient of about 0.25 and low wear at room temperature, 400 and 650 C. Wear rates were lower than those of the cobalt alloys alone or the nickel alloy composite coating. However, oxidation limited the maximum useful temperature of the cobalt composite coating to about 650 C compared to about 900 C for the nickel composite coating.

N90-16165* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANISMS OF LUBRICATION AND WEAR OF A BONDED SOLID LUBRICANT FILM
To obtain a better understanding of how bonded solid lubricant films lubricate and wear (in general), the tribological properties of polyimide-bonded graphite fluoride films were studied (in specific). A pin-on-disc type of testing apparatus was used; but in addition to sliding a hemispherically tipped rider, a ride with a 0.95 mm diameter flat area was slid against the film. This was done so that a lower, less variable contact stress could be achieved. Two stages of lubrication occurred. In the first, the film supported the load. The lubricating mechanism consisted of the shear of a thin surface layer (of the film) between the rider and the bulk of the film. The second occurred after the bonded film had worn to the substrate, and consisted of the shear of very thin lubricant films between the rider and flat plateaus generated on the metallic substrate asperities. The film wear mechanism was strongly dependent on contact stress. M.M.M.

N90-17220* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LUBRICATION AND WEAR MECHANISMS OF POLYIMIDE-BONDED GRAPHITE FLUORIDE FILMS SUBJECTED TO LOW CONTACT STRESS
Robert L. Fusaro Jan. 1980 27 p refs (NASA-TP-1584; E-9990) Avail NTIS HC A03/ MF A01 CSCL 11H
The tribological properties of polyimide-bonded graphite fluoride films were studied with a pin-on-disc friction apparatus. A 440 C HT stainless steel rider with a 0.95 millimeter diameter flat area was slid against the film in order to achieve a light, closely controlled contact stress. A 1 kilogram load was applied to this flat to give a projected contact stress of 14 megapascals. Two stages of lubrication were operating. In the first stage, the film supported the load and the lubricating mechanism appeared to be the shear of a thin surface layer of the film between the rider and the bulk of the film. The second stage began after the original film was worn away, and the lubricating mechanism appeared to be the shear of very thin lubricant layers between the flat area on the rider and flat plateaus generated on the sandblasted asperities of the metallic substrate. The major difference between the lubricating mechanisms of the hemispherical and flat riders was that the flat wore through the film much more slowly than did the hemisphere. K.L.

N90-18178* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WEAR PARTICLES OF SINGLE-CRYSTAL SILICON CARBIDE IN VACUUM
Kazushi Miyoshi and Donald H. Buckley Feb. 1980 24 p refs Submitted for publication (NASA-TP-1624; E-077) Avail NTIS HC A02/ MF A01 CSCL 20B
Sliding friction experiments, conducted in vacuum with silicon
The tribological properties of seven different polyimide films bonded to AISI 301 stainless steel disks at 25°C were studied. The films were subjected to cyclic thermal shock testing, and the coefficient of friction obtained with 1.2 to 2.5 equivalent percent of oxide additions was greater than or equal to 94 percent. The chemical activity of the alloying elements plays a dominant role in controlling adhesion, friction, and wear properties of iron-base binary alloys. The controlling mechanism of the alloy properties is an intrinsic effect involving the resistance to shear fracture of cohesive bonding in the alloy. The coefficient of friction generally increases with an increase in solute concentration. The friction coefficient increases as the solute-to-iron atomic radius ratio increases or decreases from unity. Alloys having higher solute concentration produce more transfer to silicon carbide than do alloys having low solute concentrations. The chemical activity of the alloying element is also an important parameter in controlling adhesion and friction of alloys.
An effort was undertaken to determine if the formation of the generally observed layer of large porosity adjacent to the as-nitride surfaces of reaction bonded silicon nitrides could be prevented during processing. Isoostatically pressed test bars were prepared from wet vibratory milled Si powder. Sintering and nitriding were each done under three different conditions: (1) bars directly exposed to the furnace atmosphere; (2) bars backed in Si powder; (3) bars packed in Si3N4 powder. Packing the bars in either Si or Si3N4 powder during sintering retarded formation of the layer of large porosity. Only packing the bars in Si prevented formation of the layer during nitridation. The strongest bars (316 MPa) were those sintered in Si and nitrided in Si3N4 despite their having a layer of large surface porosity, failure initiated at very large pores and inclusions. The alpha/beta ratio was found to be directly proportional to the oxygen content; a possible explanation for this relationship is discussed.
A method is disclosed for fabricating chemically inert ceramic bodies that are both highly refractory and porous. A paste is formed by mixing alumina grain having uniform particle size with collodial silica that is stabilized with ammonia. After drying, the cast body has sufficient green strength to be handled, and it is transferred to a furnace for curing. A green body prepared in this fashion does not undergo shrinkage during curing nor during prolonged subsequent heating.

**NBO-32518**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

**METHOD OF CROSS-LINKING POLYVINYL ALCOHOL AND OTHER WATER SOLUBLE RESINS**
Patent
Warren H. Phillip, Charles E. May, Li-Chen Hsu, and Dean W. Shebley, inventors (to NASA) Issued 19 Aug 1980 4 p Filed 20 Dec 1978 Supersedes N79-14172 (17 - 05, p 0571)

A method is disclosed for crosslinking polyvinyl alcohol and other water soluble resins by heating an aqueous solution of a water-soluble resin (e.g., polyvinyl alcohol) with a crosslinkable monomer (e.g., a vinyl monomer) to form a three-dimensional polymer network. The crosslinkable monomer is dissolved in an aqueous solution containing a polymerizable surfactant (e.g., polyethylene oxide) and a crosslinkable initiator (e.g., a peroxide). The crosslinked polymer can be used as a binder or as a thermostable material.

**A80-12094**

The effect of thermal aging on the tribological properties of polyimide films and polyimide-bonded graphite fluoride films was studied. The films were subjected to thermal aging at various temperatures to investigate changes in their friction, wear, and other tribological properties. The results indicated that thermal aging significantly affects the tribological performance of these materials, with changes in friction coefficient, wear rate, and other properties observed. The mechanisms of these changes were discussed, and the implications for the use of these materials in tribological applications were considered.
stainless steel thin foils was studied. The films were exposed at temperatures of 315, 345, 370 or 400 °C for 100 hours or more and then evaluated at temperatures of 25, 315 or 345 °C in atmospheres of dry or moist air. Polymide films were found to be brittle after thermal exposure, but polyimide-bonded graphite fluoride films possessed good adhesion and gave low friction and wear results. Thus, polyimide-bonded graphite fluoride films appear to be good candidates for solid lubrication applications where long thermal soak times are prevalent. (Author)


Results are presented for an investigation designed to characterize the microstructure of controlled nucleation thermocromic deposition (CVD) produced SiC material with respect to grain size, stoichiometry, phase analysis, etc., and to evaluate the room-temperature and high-temperature fracture and oxidation behavior. By using the CVD process, ultrafine-grained SiC is deposited on tungsten wires as substrates, with superior surface smoothness and with the macrocrummer growth commonly observed in conventional CVD materials. The results suggest that the high-purity, fully dense, and stable grain size SiC material produced by CVD shows potential for high-temperature structural applications, provided that pertinent problems are resolved. S.D.

A80-130065 # Mechanical and chemical effects of inner-texturing biomedical polymers. A. J. Weigand and M. A. Cenkus (NASA, Lewis Research Center, Cleveland, Ohio), Alliance for Engineering in Medicine, Annual Conference of Engineering in Medicine and Biology, 32nd, Denver, Colo., Oct. 6-10, 1979, Paper, 27 p, 17 refs.


Improvements in gas turbine performance are approaching the limits imposed by alloy properties and excessive cooling air requirements. Thin ceramic coatings can increase the difference between gas temperature and metal temperature by several hundred degrees. Thus, they are potentially a major step forward in surface protection. These coatings offer the potential to reduce fuel consumption by permitting reduced coolant flow or higher turbine inlet temperature or to improve durability by reducing metal temperatures and transient thermal stresses. At NASA Lewis, in-house and contractual programs are in place to bring this promising technology to engine readiness in the early 1980's. Progress towards this goal is summarized in this paper. (Author)


A liquid chromatographic method has been developed capable of providing a chemical fingerprint of PMR-15 resin solutions and prepreg. The amounts of two of the monomers can be quantified so that their experimentally determined molar ratio can be compared to the formulated one. Only the monomers were detected in fresh resin solution, whereas several additional components, resulting from an association or reaction between the norbornyl endcap and the amine, were detected in a resin solution aged for three days. Two commercial preps showed fingerprints similar to that of laboratory material, but three others contained additional components corresponding to higher esters and nitriles. (Author)


Silicon powder wet milled in heptane was dried, compacted into test bar shape, helium-sintered, and then reaction bonded in nitrogen-4 % vol% hydrogen. As nitrided bend strengths averaged approximately 280 MPa at both room temperature and 1400 °C. Fracture initiation appeared to be associated with subsurface flaws in high-strength specimens and both subsurface and surface flaws in low-strength specimens. (Author)


Thin sputter-deposited MoS2 films with thicknesses ranging from 2000 to 6000 Å have shown excellent lubricating properties when sputtering parameters and substrate conditions are properly selected and controlled. The lubricating properties are strongly influenced by the crystalline-amorphous structure, morphology, and composition of the films. The coefficient of friction can range from 0.04 (which is effective lubrication) to 0.4 (no lubricating action), V.P.


The paper studies the comparative life of plasma-sprayed ZrO2-Y2O3 thermal barrier coatings on NiCoAlY bond coats on Rene 41 in short (4 min) and long (57 min) thermal cycles at 1040 °C in a 0.3 Mach flame. Attention is given to determining the effect of short and long-duration cycles on ZrO2-Y2O3 coatings, the cause of any cycle frequency effects, and methods to improve tolerance to thermal stress. Short cycles greatly reduced the life of the ceramic coating in terms of time at temperatures as compared to longer cycles, the failed coating indicating compressive failure. The experiments and stress calculations show that repeatedly subjecting a ceramic coating to high rates of initial heating has a more destructive influence on the coating than sustained operation at temperature. The effect of such thermal compressive stresses might be minimized through coating deposition and thickness control and by turbine cycle measurement to keep starting heat rates below critical values. S.D.


An investigation is reported of improving the durability of plasma sprayed ceramic coatings for the vane platforms in the JT9D turbofan engine. The program aims for reduced fuel consumption of commercial aircraft engines; the use of improved strain tolerant
microstructures and control of the substrate temperature during coating application are being evaluated. The initial burner rig tests at temperatures up to 1010 °C indicated that improvements in cyclic life greater than 20:1 over previous ceramic coatings were achieved. Three plasma sprayed coating systems applied to first stage vane platforms at the high pressure turbine were subjected to a 1000 cycle JT8D engine endurance test with only minor damage occurring to the coatings. A.T.


The effect of tungsten and tungsten carbide contamination on the oxidation and cracking in air of yttria-doped silicon nitride ceramics is investigated. Silicon nitride powder containing 8 wt % Y2O3 was doped with 2 wt % W, 4 wt % W, 4 wt % WC or left undoped, and sintered in order to simulate contamination during milling, and specimens were exposed in air to 500, 750 and 1350°C for various lengths of time. Scanning electron and optical microscopy and X-ray diffraction of the specimens in the as-sintered state revealed that the addition of W or WC does not affect the phase relationships in the system, composed of alpha and beta Si3N4, mullite and an amorphous phase. Catastrophic oxidation is observed at 750°C in specimens containing 2 and 4 wt % W, accompanied by the disappearance of alpha Si3N4 and mullite from the structure. At 1350°C, the formation of a protective glassy oxide layer was observed on all specimens without catastrophic oxidation, and it is found that pre-oxidation at 1350°C also improved the oxidation resistance at 750°C of bars doped with 4 wt % W. It is suggested that tungsten contamination from WC grinding balls may be the major cause of the intermediate-temperature cracking and instability frequently observed in Si3N4-Y2O3. A.L.W.


The coefficients of friction have been determined for some metallic glasses using a single sliding friction rig. Calculated values of the coefficients have also been obtained from consideration of the simple adhesion model which predicts that the coefficient of friction is the ratio of the shear strength and the yield pressure of the contacting materials. Comparisons of the calculated and measured coefficients reveal large discrepancies, in marked contrast to the good agreement obtained for polymers. (Author)


Ease of preparation and testing are advantages unique to the chevron-notch specimen used for the determination of the plane strain fracture toughness of extremely brittle materials. During testing, a crack develops at the notch tip and extends stably as the load is increased. For a given specimen and notch configuration, maximum load always occurs at the same relative crack length independent of the material. Fracture toughness is determined from the maximum load with no need for crack length measurement. Chevron-notch acuity is relatively unimportant since a crack is produced during specimen loading. In this paper, the authors use their previously determined stress intensity factor relationship for the chevron-notch short bar specimen to examine the performance of this specimen in determining the plane strain fracture toughness of silicon nitride and aluminum oxide. (Author)


Microstructural examination of reaction bonded silicon nitride (RBSN) has shown that there is often a region adjacent to the as-sintered surfaces that is even more porous than the interior of this already quite porous material. Because this layer of large porosity is considered detrimental to both the strength and oxidation resistance of RBSN, a study was undertaken to determine if its formation could be prevented during processing. All test bars studied were made from a single batch of Si powder which was milled for 4 hours in heptane in a vibratory mill using high density alumina cylinders as the grinding media. After air drying the powder, bars were compacted in a single acting die and hydropressed. (Author)

SYNTHESIS OF IMPROVED POLYESTER RESINS Final Report

Eighteen aromatic unsaturated polyester prepolymers prepared by a modified interfacial condensation technique were investigated for their solubility in vinyl monomers and ability to provide high char yield forming unsaturated polyester resins. The best resin system contained a polyester prepolymer of phthalic, fumaronic and diphencic acids reacted with 2,7-naphthalene diol and 9,9-bis(4-hydroxyphenyl)fluorene. This prepolymer is very soluble in styrene, divinyl benzene, trilalyl cyanurate, diallyl isophthalate and methylvinylylpyridine. It provided anaerobic char yields as high as 41 percent at 800°C. The combination of good solubility and char yield represents a significant improvement over state-of-the-art unsaturated polyester resins. The majority of the other prepolymers had only low or no solubility in vinyl monomers. Graphite composites from this prepolymer with styrene were investigated. The cause for the observed low char strengths of the composites was not determined, however 12-week aging of the composites at 82°C showed that essentially no changes in the composites had occurred. (Author)

SINTERED SILICON NITRODE RECIPIREL FABRICATION Final Report

The preliminary design and a demonstration of the feasibility of fabricating submodules of an automotive Stirling engine recuperator for waste heat recovery at 370°C are described. Sinterable silicon nitride (Si3N4) tubing and plates were fabricated by extrusion and hydrostatic pressing, respectively, suitable for demonstrating a potential method of constructing ceramic recuperator-type heat exchangers. These components were fixed in nitrogen atmosphere to 1800°C without significant scale

90
formation so that they can be used in the as fired condition. A refractory glass composition (Al2O3 x 4.5 CaO MgO x 11SiO2) was used to join and seal component parts by a brazing technique which formed strong, recuperative submodules capable of withstanding repeated thermal cycling to 1370 C. The corrosion resistance of these materials to Na2SO4 • NaCl carbon mixtures was also assessed in atmospheres of hydrogen and CO2 N2 H2O mixtures at both 870 C and 1370 C for times to 1000 hours. No significant reaction was observed under any of these test conditions.

**REFERENCES**

A suitable method for the direct measurement of moisture concentrations after humidity/thermal exposure on state of the art epoxy and polycrystalline basalt and graphite fiber reinforcements was investigated. Methods for the determination of moisture concentration profiles, moisture diffusion modeling and moisture induced dimensional changes were examined. Carefully fabricated, precharacterized epoxy and polycrystalline materials were exposed to humid conditions using heavy water (D2O) at ambient and elevated temperatures. These specimens were fixture to theoretically limit the D2O permeation to a unidirectional penetration axis. The analytical techniques evaluated were (1) laser pyrolysis gas chromatography mass spectrometry, (2) solids probe mass spectrometry, (3) laser pyrolysis conventional infrared spectroscopy, and (4) infrared imaging thermovision. The most reproducible and sensitive technique was solids probe mass spectrometry. The fabricated exposed specimens were analyzed for D2O profiling after humidity/thermal conditioning at three exposure time durations.

**ANALYSES OF MOISTURE IN POLYMERS AND COMPOSITES**

L. E. Ryan and R. W. Vaughan
11 Jan 1980 99 p refs

**HIGH TEMPERATURE SELF-LUBRICATING COATINGS FOR THE MOTOR VEHICLE ENGINE**

Bharat Bhusan
1 Jul 1980 232 p refs

**AIR LUBRICATED FOIL BEARINGS FOR THE AUTOMOTIVE GAS TURBINE ENGINE**

Bharat Bhusan
1 Jul 1980 232 p refs

**HIGH TEMPERATURE SELF-LUBRICATING COATINGS FOR AIR LUBRICATION FOIL BEARINGS FOR THE AUTOMOTIVE GAS TURBINE ENGINE**

Bharat Bhusan
1 Jul 1980 232 p refs

**THE 3500 HOUR DURABILITY TESTING OF COMMERCIAL CERAMIC MATERIALS**

W. D. Cullathers, D. W. Richerson, and K. W. Benn
Jul 1980 237 p refs

**SYNTHESIS OF IMPROVED PHENOLIC RESINS**

C. D. Delano and A. H. McLeod
4 Sep 1979 115 p refs

**THE 3500 HOUR DURABILITY TESTING OF COMMERCIALLY AVAILABLE CERAMIC MATERIALS UNDER SIMULATED AUTOMOTIVE GAS TURBINE COMBUSTOR DISCHARGE CONDITIONS**

W. D. Cullathers, D. W. Richerson, and K. W. Benn
Jul 1980 237 p refs

**HIGH TEMPERATURE SELF-LUBRICATING COATINGS FOR AUTOMOTIVE GAS TURBINE ENGINES**

Bharat Bhusan
1 Jul 1980 232 p refs

This paper presents the results of a program of analysis and tests to determine the dynamic properties of elastomers as a function of strain and ambient temperature. Measurements were also made to determine the temperature distribution in the elastomer samples during the tests. These measured properties were compared with analytical predictions based on a viscoelastic model designed to take into account the self-heating of the materials as a function of strain. The test method used was well established Base Excitation Resonant Mass Technique. The specimens tested were two cylindrical button compression specimens and a shear specimen. Strain was shown to be an important parameter in determining the dynamic properties of the elastomers. In general, these properties were much more sensitive to strain than to frequency. The self-heating effect was found to account for a portion of the strain sensitivity of these properties. (Author)


A two-year durability program was performed by Air Research Phoenix to evaluate four commercially available ceramic materials under simulated automotive gas turbine combustor discharge conditions. These conditions included extended cyclic thermal exposures up to 2500 F and 3500 hr. The four materials selected for evaluation were Norton NCX-34 hot pressed silicon nitride, Air Research RBN 101 reaction bonded silicon nitride, Carborundum pressureless sintered alpha-SiC and Pure Carbon Co. (British Nuclear Fuels, Ltd.) Refel reaction sintered silicon carbide. These materials were initially exposed to 350 hr/1750 cycles at 1200 and 1370 C. Subsequent exposures to 1050, 2100 and 3500 hr were performed on those materials maintaining 50% of baseline strength after the initial exposure. Additional evaluations of exposed bars included dimensional and weight changes, dye penetrant, specific damping capacity changes, SEM fractography, and X-ray diffraction. (Author)


Atmospheric burner rig tests have been conducted to evaluate the corrosion resistance of present-day thermal barrier coatings. The coatings are primarily plasma-sprayed and zirconia-based. Both duplex and graded coating systems were tested at a gas temperature of 2100 F and metal temperatures that range from 1475 F to 1650 F. The fuels ranged from clean GT No. 2 to that doped with impurity levels which simulate water-washed residual fuels. Results to date suggest that liquid sulfate condensates play an important role in the coating degradation mechanisms, whereas the role of vanadium and its salts is less clear. (Author)
28 PROPELLANTS AND FUELS

Includes rocket propellants, igniters, and oxidizers, storage and handling, and aircraft fuels.

For related information see also: Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, and 44 Energy Production and Conversion.

N80-13268* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

TEMPERATURE AND FLOW MEASUREMENTS ON NEAR-FREEZING AVIATION FUELS IN A WING-TANK MODEL
Robert Friedman and Francis J. Stockemer 1980 18 p refs

To be presented at the 25th Intern Gas Turbine Conf., New Orleans, 9-13 May 1980, sponsored by ASME.

(NASA-TM-79285, E-158) Avail. NTIS HC A02/MF A01 CSCL 21D.

Freezing behavior, pumpability, and temperature profiles for aviation turbine fuels were measured in a 190-liter tank chilled to simulate internal temperature gradients encountered in commercial airplane wing tanks. When the bulk of the fuel was above the specification freezing point, pumpout of the fuel removed all fuel except a layer adhering to the bottom chilled surfaces, and the unpumpable fraction depended on the fuel temperature near these surfaces. When the bulk of the fuel was at or below the freezing point, pumpout ceased when solids blocked the pump inlet, and the unpumpable fraction depended on the overall average temperature.

K L.

N80-18205* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

INITIAL CHARACTERIZATION OF AN EXPERIMENTAL REFERENCE BROADENED-SPECIFICATION (ERBS) AVIATION TURBINE FUEL
George M. Prok and Gary T. Seng Jan. 1980 10 p refs

(NASA-TR-81440, E-206) Avail. NTIS HC A02/MF A01 CSCL 21D.

Characterization data and a hydrocarbon compositional analysis are presented for a research test fuel designated as an experimental reference broadened-specification aviation turbine fuel. This research fuel, which is a special blend of kerosene and hydrotreated catalytic gas oil, is a hypothetical representation of a future fuel should it become necessary to broaden current kerosene specifications. It is used as a reference fuel in research investigations into the effects of fuel property variations on the performance and durability of jet aircraft components, including combustors and fuel systems.

J M S.

N80-20402* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ATOMIC HYDROGEN STORAGE Patent

Atomic hydrogen, for use as a fuel or as an explosive, is stored in the presence of a strong magnetic field in exfoliated layered compounds such as molybdenum disulfide or an elemental layer material such as graphite. The compound is maintained at liquid temperatures and the atomic hydrogen is collected on the surfaces of the layered compound which are exposed during delamination (exfoliation). The strong magnetic field and the low temperature hydrogen combine to retain the atoms of hydrogen from recombining to form molecules.

Official Gazette of the U.S. Patent and Trademark Office.

N80-21661* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

MECHANICAL IMPACT TESTS OF MATERIALS IN OXYGEN EFFECTS OF CONTAMINATION
Paul M. Ordin Washington Apr 1980 36 p refs

(NASA-TP-1871, E-047) Avail. NTIS HC A03/MF A01 CSCL 20K.

The effect of contaminants on the mechanical impact sensitivity of Teflon, stainless steel, and aluminum in a high-pressure oxygen environment was investigated. Uncontaminated Teflon did not ignite under the test conditions. The liquid contaminants - cutting oil, motor lubricating oil, and toolmaker dye - caused Teflon to ignite. Raising the temperature lowered the impact energy required for ignition. Stainless steel was insensitive to ignition under the test conditions with the contaminants used. Aluminum appeared to react without contaminants under certain test conditions, however, contamination with cutting oil, motor lubricating oil and toolmaker dye increased the sensitivity of aluminum to mechanical impact. The grit contaminants silicon dioxide and copper powder did not conclusively affect the sensitivity of aluminum.

A R H.

N80-23472* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

THE IMPACT OF FUELS ON AIRCRAFT TECHNOLOGY THROUGH THE YEAR 2000
Jack Grobman and Gregory M. Reck 1980 26 p refs

Presented at the Intern Meeting and Tech Display, Global Technol 2000, Baltimore, 5-11 May 1980, sponsored by AIAA.

(NASA-TR-81492, E-429) Avail. NTIS HC A03/MF A01 CSCL 21D.

The impact that the supply, quality, and processing costs of future fuels may have on aircraft technology is assessed. The potential range of properties for future jet fuels is discussed along with the establishment of a database of fuel property effects on propulsion system components. Also, the evolution and evaluation of advanced component technology that would permit the use of broader property fuel and the identification of technical and economic trade-offs within the overall fuel processing-air transportation system associated with variations in fuel properties are examined.

M G.

N80-25454* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ANALYTICAL AND EXPERIMENTAL EVALUATIONS OF THE EFFECT OF BROAD PROPERTY FUELS ON COMBUSTORS FOR COMMERCIAL AIRCRAFT GAS TURBINE ENGINES


(NASA-TR-81498, E-433) Avail. NTIS HC A02/MF A01 CSCL 21D.

The impacts of broad property fuels on the design, performance, durability, emissions, and operational characteristics of current and advanced combustors for commercial aircraft gas turbine engines were studied. The effect of fuel thermal stability on engine and airframe fuel system was evaluated. Tradeoffs between fuel properties, exhaust emissions, and combustor life were also investigated. Results indicate major impacts of broad property fuels on allowable metal temperatures in fuel manifolds and injector support, combustor cyclic durability, and somewhat lesser impacts on starting characteristics, lightoff, emissions, and smoke.

E D K.

N80-27608* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

USE OF PETROLEUM-BASED CORRELATIONS AND ESTIMATION METHODS FOR SYNTHETIC FUELS
A. C. Antoine Jun. 1980 23 p refs

(NASA-TR-81533; E-485) Avail. NTIS HC A02/MF A01 CSCL 21D.

Correlations of hydrogen content with aromatics content, heat of combustion, and smoke point are derived for some synthetic fuels prepared from oil and coal syngas. Comparing the results...
of the aromatics content with derived correlations for petroleum fuels shows that the shale derived fuels fit the petroleum-based correlations, but the coal derived fuels do not. The correlations derived for heat of combustion and smoke point are comparable to some found for petroleum-based correlations. Calculated values of hydrogen content and of heat of combustion are obtained for the synthetic fuels by use of ASTM estimation methods. Comparisons of the measured and calculated values show bases for the equations that exceed the critical statistics values.

Comparison of the measured hydrogen content by the standard ASTM combustion method with that by a nuclear magnetic resonance (NMR) method shows a decided bias. The comparisons of the calculated and measured NMR hydrogen contents show a difference similar to that found with petroleum fuels. Author

NBO-27510*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ADVANCED FUEL SYSTEM TECHNOLOGY FOR UTILIZING BROADERED PROPERTY AIRCRAFT FUELS

Possible changes in fuel properties are identified based on current trends and projections. The effect of those changes with respect to the aircraft fuel system are examined and some technological approaches to utilizing those fuels are described.

R.C.T.

NBO-29502*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOME ADVANTAGES OF METHANE IN AN AIRCRAFT GAS TURBINE

Liquid methane, which can be manufactured from any of the hydrocarbon sources such as coal, shale biomass, and organic waste considered as a petroleum replacement for aircraft fuels. A simple cycle analysis is carried out for a turboprop engine flying a Mach 0.8 and 10,688 meters (35,000 ft.) altitude. Cycle performance comparisons are rendered for four cases in which the turbine cooling air is cooled or not cooled by the methane fuel. The advantages and disadvantages of involving the fuel in the turbine cooling system are discussed. Methane combustion characteristics are appreciably different from Jet A and will require different combustor designs. Although a number of similar difficult technical problems exist, a highly fuel efficient turboprop engine burning methane appears to be feasible.

A.R.H

NBO-31621* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND EVALUATION OF HIGH PERFORMANCE ROCKET ENGINE INJECTORS FOR USE WITH HYDROCARBON FUELS

Avail: Issuing Activity CSDL 21/9

An experimental program to determine the feasibility of using a heavy hydrocarbon fuel as a rocket propellant is reported. A method of predicting performance of a heavy hydrocarbon in terms of experimental test results. Combustion length effects were explored over a range of 21.6 cm to 55.9 cm. Four injector types were tested, each over a range of mixture ratios. Further configuration modifications were obtained by reaming each injector several times to provide test data over a range of injector pressure drop.

E.D.K.


Analytical and experimental studies were conducted in three contract activities funded by the National Aeronautics and Space Administration, Lewis Research Center, to assess the impacts of broad property fuels on the design, performance, durability, emissions and operational characteristics of current and advanced combustors for commercial aircraft gas turbine engines. The effect of fuel thermal stability on engine and airframe fuel system was evaluated. Trade-offs between fuel properties, exhaust emissions and combustor life were also investigated. Results indicate major impacts of broad property fuels on allowable metal temperatures in fuel manifolds and injector support, combustor cyclic durability and somewhat lesser impacts on starting characteristics, lightoff, emissions and smoke.

NBO-19284*# Southwest Research Inst., San Antonio, Tex.


(NASA-CR-162822: MFD113) Avail: NTIS HC A03/MF A01 CSDL 21D

A high pressure research combustor operating over a wide range of burner inlet conditions was used to determine the effects
The contribution of polycyclic aromatics to soot formation was equivalent to a reduction in fuel hydrogen content of about one percent. The fuel sensitivity to soot formation due to the polycyclic aromatic contribution decreased as burner inlet pressure and fuel/air ratio increased.

Measurements of soot inside a flame-tube burner using a special water-flushed probe are discussed. The soot is measured at a series of points at each burner, and upon occasion gaseous constituents NO, CO, hydrocarbons, etc., were also measured. Four geometries of flame-tube burners were studied, as well as a variety of different fuels. The role of upstream geometry on soot formation was also studied. It was found that beyond a certain Reynolds number, the peak amount of soot formed in the burner is constant.

A conceptual design study was conducted to devise and evaluate techniques for the external vaporization of fuel for use in an aircraft gas turbine with characteristics similar to the Energy Efficient Engine (E3). Three vaporizer concepts were selected and they were analyzed from the standpoint of fuel thermal stability. Integration of the vaporizer system into the aircraft engine, engine and vaporizer dynamic response, startup and altitude restart, engine performance, control requirements, safety, and maintenance. One of the concepts was found to improve the performance of the baseline E3 engine without seriously compromising engine startup and power change response. Increased maintenance is required because of the need for frequent pyrolytic cleaning of the surfaces in contact with hot fuel. R.C.T.

A high-pressure research combustor operating over a wide range of burner inlet conditions was used to determine the effects of fuel molecular structure on soot formation. Six test fuels with equal hydrogen content (12.8 percent) were blended to stress different molecular components and final boiling points. The fuels containing high concentrations (20 percent) of polycyclic aromatics and partially saturated polycyclic structures such as tetralin, produced more soot than would be expected from a hydrogen content correlation for typical petroleum based fuels. Fuels containing naphthenes such as decalin agreed with the hydrogen content correlation. The contribution of polycyclic aromatics to soot formation was equivalent to a reduction in fuel hydrogen content of about one percent. The fuel sensitivity to soot formation due to the polycyclic aromatic contribution decreased as burner inlet pressure and fuel/air ratio increased.
ENGINEERING (GENERAL)

Includes vacuum technology; control engineering, display engineering, and cryogenics.

N80-13177# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EVALUATION OF CLEANERS FOR PHOTOVOLTAIC MODULES EXPOSED IN AN OUTDOOR ENVIRONMENT Final Report


Power recovery of silicone encapsulated and glass covered photovoltaic modules, exposed for two years in a suburban environment, was measured after washing with a variety of cleaners including detergents, abrasive soap, and hydrocarbon solvents. Silicone encapsulated modules in operating environments may experience significant power losses or require extensive periodic cleaning. Glass front-faced modules in similar situations were found to be about five times more effective than mild detergents in cleaning encapsulated modules. Author

N80-16232# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

HOMOGENEITY ALIGNMENT OF NEMATIC LIQUID CRYSTALS BY ION BEAM ETCHED SURFACES


A wide range of ion beam etch parameters capable of producing uniform homogeneous alignment of nematic liquid crystals on SiO2 films are discussed. The alignment surfaces were generated by obliquely incident (angles of 5 to 25 deg) argon ions with energies in the range of 0.5 to 2.0KeV, ion current densities of 0.1 to 0.6 mA sq cm and etch times of 1 to 9 min. A smaller range of ion beam parameters (2.0KeV, 0.2 mA sq cm, 5 to 10 deg and 1 to 5 min.) were also investigated with ZrO2 films and found suitable for homogeneous alignment. Extinction ratios were very high (1000), twist angles were small (< or = 3 deg) and tilt-bias angles very small (< or = 1 deg). Preliminary scanning electron microscope results indicate a parallel oriented surface structure on the ion beam etched surfaces which may determine alignment. Author


Cryogenic air-separation process cycle variations and compression schemes are examined. They are designed to minimize net system power required to supply pressurized, oxygen-enriched air to the combustor of an MHD power plant with a coal input of 2000 MWt. Power requirements and capital costs for oxygen production and enriched air compression for enrichment levels from 13 to 50% are determined. The results are presented as curves from which total compression power requirements can be estimated for any desired enrichment level at any delivery pressure. It is found that oxygen enrichment and recuperative heating of MHD combustor air to 1400 F yields near-term power plant efficiencies in excess of 46%. A minimum power compression system requires 167 MW to supply 330 lb of oxygen per second and costs roughly 100 million dollars. Author

Preliminary studies show MHD/steam power plants to be competitive with plants using high-temperature air preheaters burning gas. L.M.
32 COMMUNICATIONS
Includes land and global communications, communications theory, and optical communications.
For related information see also 04 Aircraft Communications and Navigation and 17 Spacecraft Communications, Command and Tracking.


As part of NASA's continuing assessment of future communication satellite requirements, a study was conducted to quantitatively scope current and future telecommunication traffic demand in the South Pacific Archipelagos. This demand was then converted to equivalent satellite transponder capacities. The inter-island telephony traffic for the Pacific Basin Region was analyzed. The results show that if all this traffic were carried by a satellite system one-third of a satellite transponder would be needed to satisfy the base-year (1976-1977) requirement and about two-thirds of a satellite transponder would be needed to satisfy the forecasted 1985 requirement. (Author)


The purpose of the paper is to investigate and study in-depth market and system analysis for improving satellite communications. The analyses fall into two categories: the broad, scoping efforts intended to screen potential candidates and studies to develop viable operational system configurations and identify critical technology elements. To illustrate the approach, the results of 30/20 GHz study efforts which have been under way in the past few years are reviewed in detail. C.F.W.


This paper discusses various aspects of the 30/20 GHz wideband technology verification activities of NASA. The discussion considers the objectives, approach, system requirements, possible experiment configuration and payload, and the supporting research and technology elements. (Author)


The development of a 1978 NASA study to identify technology requirements is surveyed, and its principal conclusions, recommendations, and priorities are summarized. In addition, antenna, traveling wave tube, and solid state amplifier developments representing selected items from the current communications technology development programs at the NASA Lewis Research and Goddard Space Flight Centers are described. M.E.P.


A program plan is presented for a space communications application utilizing the 30/20 GHz frequency bands (30 GHz uplink and 20 GHz downlink). Results of market demand studies and spacecraft systems studies which significantly affect the supporting research and technology program are also presented, along with the scheduled activities of the program plan. C.F.W.


It is noted that NASA is currently proceeding with a revitalized RSO program aimed at the development and demonstration of advanced communication satellite system concepts and the related enabling technologies. The paper reviews the important elements of this program thrust, the approach NASA is taking to assure proper involvement of both the system-supplier industry and the service supplier industry and the specific technology focus in the near term. Finally, highlights of the current NASA and industry activities related to opening up the 30/20 GHz frequency band for both commercial and military use are presented. M.E.P.


A mixed-user system is described which provides cost-effective communications services to a wide range of user terminal classes, ranging from one or two voice channel support to a direct-to-user mode, to multiple 500 mbps trunking channel support. Advanced satellite capabilities are utilized to minimize the cost of small terminals. In a system with thousands of small terminals, this approach results in minimum system cost. (Author)


The baseline 30/30 GHz satellite communication system, designed for cost-effective communications in the years 1990 to 2000, incorporates on-board satellite demodulation and routing of individual 64 kbps digital voice-grade circuits. This level of routing flexibility is necessary to provide efficient communications to the large number of direct-to-user terminals (DTU) projected. The circuit interfacing hardware is distributed among all the DTU and master control stations. The switching circuitry which provides full interconnectivity between 30 to 45 thousand circuits is in the satellite. The DTU terminal cost, perhaps the largest element in the system cost, represents the largest economic value element of the system because it avoids using terrestrial signal distribution
and routing and the charges associated with these functions. Satellite baseline design and power requirements for the system are examined.

A.R.H.


An initial definition of on-board processing requirements for an advanced satellite communications system to service domestic markets in the 1990's is presented. An exemplary system architecture with both RF on-board switching and demodulation/remodulation baseband processing was used to identify important issues related to system implementation, cost, and technology development.

R.C.T.


Abstracts are presented of a literature survey of reports concerning the application of signal processing concepts. Approximately 300 references are included.

R.C.T.


Demand for telecommunications services is forecasted for the period 1980-2000, with particular reference to that portion of the demand associated with satellite communications. Overall demand for telecommunications is predicted to increase by a factor of five over the period studied and the satellite portion of demand will increase even more rapidly. Traffic demand is separately estimated for voice, video, and data services and is also described as a function of distance traveled and city size. The satellite component of projected demand is compared with the capacity available in the C and Ku satellite bands and it is projected that new satellite technology and the implementation of Ka band transmission will be needed in the decade of the 1990's.

Author


A forecast of demand for telecommunications services through the year 2000 is presented with particular reference to demand for satellite communications. Estimates of demand are provided for voice, video, and data services and for various subcategories of these services. The results are converted to a common digital measure in terms of terabits per year and aggregated to obtain total demand projections.

J.M.S.
THE 18/30 GHz FIXED COMMUNICATIONS SYSTEM

A review of studies forecasting the communication market in the United States is given. The applicability of these forecasts to assessment of demand for the 30/20 GHz fixed communications system is analyzed. Costs for the 30/20 satellite trunking systems are presented and compared with the cost of terrestrial communications.

J.M.S.

THE 18/30 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT. VOLUME 2: MAIN TEXT


The total demand for voice, video, and data communications services, and satellite transmission services at the 4/6 GHz, 12/14 GHz, and 18/30 GHz frequencies is assessed. The services are voice, video, and data services. Traffic demand, by service, is distributed by geographical regions, population density, and distance between serving points. Further distribution of traffic is made among four major end user groups: government, business, institutions, and private individuals. A traffic demand analysis is performed on a multiple-beam antennas and signal processing. R. Davies, F. Chethik, and D. Storer (TRW Systems Engineering Laboratory, Redondo Beach, Calif.) In: Communications Satellite Systems Conference, 8th, Orlando, Fla., April 20-24, 1980, Technical Papers. (AIAA 80-29526 11-32) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 490-499. Contract No. NAS3-21745, (AIAA 80-0537)

A communication satellite with a multiple-beam antenna and onboard signal processing is considered for use in a 'message-switched' data relay system. The signal processor may incorporate demodulation, routing, storage, and remodulation of the data. A system user model is established and key functional elements for the signal processing are identified. With the throughput and delay requirements as the controlled variables, the hardware complexity, operational discipline, occupied bandwidth, and overall user end-to-end cost are estimated for (1) random-access packet switching and (2) reservation-access packet switching. Other aspects of this network (e.g., the adaptability to channel switched traffic requirements) are examined. For the given requirements and constraints, the reservation system appears to be the most attractive protocol. (Author)

A 20 GHz GaAs FET power amplifiers in the 5W range are recommended in addition to the fixed beams. Low power solid state 20 GHz GaAs FET power amplifiers in the 5W range and a general purpose digital baseband processor with gigahertz logic speeds and megabits of memory are also recommended.

A.R.H.
major characteristics: beam topology, realizable radiation characteristics, and realizable beamforming network architecture. Eight canonical topology plans have been developed and analyzed: angular separation between identical frequency cells, angular separation between orthogonally polarized identical frequency cells, number and configuration of cells forming coverage areas, and crossover level between nonidentical frequency band cells. A general topology plan is developed for the continental United States for 100-deg W synchronous satellite longitude.


The satellite communication system described provides communications for very small and very large (trunking) users. Independent combinations of FDMA and TDMA are used in the uplink and downlink designs to minimize terminal costs. Signal routing for small users is accomplished by a digital store-and-forward technique which greatly simplifies the terminal receiver, compared to satellite-switched TDMA. Different processing techniques are used for very high data rate users, but complete interconnectivity between all users is maintained. This avoids double-hop routing with excessive transmission delays.

(Author)


Research and development needs for millimeter-wave space communication systems are presented. Assumed propagation fade statistics are investigated along with high data rate diversity link and storage. The development of reliable ferrite switches, and high performance receivers and transmitters is discussed, in addition to improved tolerance of dish and lens fabrication for the antennas. The typical cost for using a simplex voice channel via a high capacity 40/50 GHz satellite is presented.

R.C.
33 ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability, components, e.g., tunnel diodes and transistors, microminiaturization, and integrated circuitry.

For related information see also 60 Computer Operations and Hardware and 76 Solid-State Physics.

N80-11327# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HEAT PIPE COOLING OF POWER PROCESSING MAGNETIC'S


A heat pipe cooled transformer and input filter were developed for the 2.4 kW beam supply of a 30 cm ion thruster system. This development yielded a mass reduction of 40% (1.76 kg)

N80-13281# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF 22.4-kW NONLAMINATED-FRAME dc SERIES MOTOR WITH CHOPPER CONTROLLER Final Report


Performance data obtained through experimental testing of a 22.4 kW traction motor using two types of excitation are presented. Ripple free dc from a motor-generator set for baseline data and pulse width modulated dc as supplied by a battery pack and chopper controller were used for excitation. For the same average values of input voltage and current, the motor power output was independent of the type of excitation. However, at the same speeds, the motor efficiency at low power output (corresponding to low duty cycle of the controller) was 5 to 10 percentage points lower than ripple free dc. The chopped locked rotor torque was approximately 1 to 3 percent greater than the ripple free dc torque for the same average current.

J.M.S.

N80-18300# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LIQUID METAL SLIP RING Patent Application


The liquid metal slip ring described comprises a rotor in the form of a range about an axis and a stator, the rotor being rotatable relative to the stator. The rotor has a channel in which the liquid metal is retained during operation by surface tension. The stator comprises a brush or probe which is partially immersed in the metal in the channel and is bidirectionally symmetrical so that whichever direction the rotor turns the probe presents the same physical resistance and affords the same electrical conductivity as a connection between the probe and the rotor.

Author

N80-18302# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMIONIC CATHODE LIFE TEST STUDIES


An update on the life testing of commercial, high current density impregnated tungsten cathodes is presented. The B-type cathodes, operated at a current density of 2 A/cm2 and a cathode temperature of 1100 C have now been run satisfactorily for more than four years. The M-cathode, at the same current density but at an operating temperature of only 1010 C, have been tested for more than three years. The M-cathodes show no degradation in current over their present operating life whereas the current from the B-cathodes degrade about 6 percent after four years of operation.

R.E.S.

N80-19425# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COUPLED CAVITY TRAVELING WAVE TUBE WITH VELOCITY TAPERING Patent Application

Dennis J. Connolly, inventor (to NASA) Filed 20 Feb. 1980 16 p


A coupled cavity traveling wave tube is described which has a velocity taper, i.e., gradual velocity reduction, which affords beam wave resynchronization and thereby enhances efficiency. The required wave velocity reduction is achieved by reducing the resonant frequencies of the individual resonant cavities in a function of the distance from the electron gun through changes in the internal cavity dimensions. The required changes in cavity dimensions are accomplished, for example, by gradually increasing the cavity radius or decreasing the gap length from cavity to cavity.

NASA

N80-20487# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CATALYST SURFACES FOR THE CHROMOUS/CHROMIC REDOX COUPLE Patent


An electricity producing cell of the reduction-oxidation (REDOX) type is described. The cell is divided into two compartments by a membrane, each compartment containing a solid inert electrode. A ferrous/ferric couple in a chloride solution serves as a cathode fluid which is circulated through one of the compartments to produce a positive electric potential disposed therein. A chromous/chromic couple in a chloride solution serves as an anode fluid which is circulated through the second compartment to produce a negative potential on an electrode disposed therein. The electrode is an electrically conductive, inert material plated with copper, silver or gold. A thin layer of lead plates onto the copper, silver or gold layer when the cell is being charged, the lead ions being available from lead chloride which was added to the anode fluid. If the REDOX cell is then discharged, the current flows through the electrodes causing the lead to deposit from the negative electrode and the metal coating on the electrode will act as a catalyst to cause increased current density.

Official Gazette of the U.S. Patent and Trademark Office

N80-21665# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MULTISTAGE DEPRESSED COLLECTOR WITH EFFICIENCY OF 90 TO 94 PERCENT FOR OPERATION OF A DUAL-MODE TRAVELING WAVE TUBE IN THE LINEAR REGION Patent

Peter Ramins and Thomas A. Fox Washington Apr. 1980 18 p refs

NASA (NASA-TM-81441; E-317) Avail: NTIS HC A02/MF A01 CSCL 09A

An update on the life testing of commercial, high current density impregnated tungsten cathodes is presented. The B-type cathodes, operated at a current density of 2 A/cm2 and a cathode temperature of 1100 C have now been run satisfactorily for more than four years. The M-cathode, at the same current density but at an operating temperature of only 1010 C, have been tested for more than three years. The M-cathodes show no degradation in current over their present operating life whereas the current from the B-cathodes degrade about 6 percent after four years of operation.

R.E.S.
A suggested. E.D., K.

Applications of improved TWTs and a new power supply are covered. For operation of the TWT in the linear, low distortion range, 90 percent and greater collector efficiencies were obtained leading to TWT overall efficiencies of 20 to 35 percent, as compared with 2 to 5 percent with an undepressed collector. With collectors of this efficiency and minimized beam interception losses, it becomes practical to design dual mode TWTs such that the low mode can represent operation well below saturation. Consequently, the required pulse up in beam current can be reduced or eliminated, and this mitigates beam control and dual mode TWT circuit design problems. For operation of the dual mode TWT at saturation, average collector efficiencies in excess of 85 percent were obtained for both the low and high modes across an octave bandwidth, leading to a three to fourfold increase in the TWT overall efficiency. Author

N80-22598* // National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**IMPROVED TRAVELING WAVE TUBES**


After a brief description of how a typical TWT works, multi-stage depressed collectors (MDC) are discussed. A quick method for computing the expected efficiency of a well engineered TWT is outlined to aid in estimating power supply needs. Applications of improved TWTs and a new power supply are suggested.

E.D.K.


A matrix formulation is presented for describing axisymmetric magnetic field data with ideal current loops. A computer program written in APL is used to invert the matrix and hence to solve for the coil strengths which are used to represent the field data. Examples are given of the coil representation for (1) measured magnetic data, (2) refocusing fields, and (3) PPM focusing fields.


An axisymmetric multistage depressed collector was evaluated in conjunction with a dual-mode TWT. Collector performance optimizations for the TWT operation in the linear range were stressed. Measured collector efficiencies in excess of 90 percent led to dramatic improvements in TWT overall efficiency.


Optical interferometry is used to measure the elastohydrodynamic (EHD) film thickness associated with artificially-produced, nonsmooth surfaces. The nonsmooth surfaces are produced by modifying the surfaces of highly-polished balls with irregularities in the form of multiple grooves and dents. By closely spacing these irregularities, it is possible not only to produce depressions on the surface of the balls but also to generate pseudo asperities. The average roughness wavelength of this artificially-produced, nonsmooth surface approximates the average fundamental roughness wavelength found on surfaces of some mechanical elements operating under concentrated contact. By comparing the measured film thickness profiles to the stylus traces of the irregularities, it is possible to observe the local deformations associated with micro-EHD pressure generation. In both pure rolling and pure sliding conditions, the artificially-produced 'asperities' are deformed and complete separation exists between them and the mating surface. Such findings demonstrate the importance of local surface topography and resulting micro-EHD effects on the film thickness between rough surfaces in concentrated contact. In addition, sliding data are presented which demonstrate a severe constriction, caused by the irregularities, at the exit of the Hertzian region.


An accurate representation of axisymmetric fields has been devised by extending the method of ideal current loops to off-axis fields. It is assumed that the data to be simulated are available through measurements or through a solution of a boundary value problem. The method provides an algebraic expression for the fields throughout a two-dimensional region of interest and eliminates the need for the axis expansion formula in approximating off-axis fields. The use of Gaussian and other functions as alternatives to the coil function is proposed. Examples of the technique in simulating a periodic permanent magnet (PPM) focusing field are presented and compared with a Fourier analysis of the problem.


The study deals with an empirical, simple formula extracted from a three-dimensional helical-TWT computer program that expresses the lowest energy in a spent beam in terms of beam permeance and electronic efficiency. The formula has a general validity down to 4 - 5 dB below saturation and gives 1 - delta V/V with less than 20% error down to 10 dB below saturation.


Techniques, pioneered by NASA, which will allow substantial improvements in traveling wave tube (TWT) amplifier efficiency, are described. It is shown that using design techniques developed at the Lewis Research Center, it is possible to approximate double the efficiency of the critical amplifier TWT. Attention is given to a quick method of computing the expected improvement to an ECM TWT. The benefits of such improvements such as less input power, a smaller and lighter power supply, and easier cooling are surveyed, and it noted that it is now possible to build efficient TWT's which

NASA-Lewis Research Center has conducted an ongoing life test program on commercial impregnated tungsten cathodes since 1971. This brief is an update of the information as of December 1979. B-type cathodes, operated at 1100 C have been run in simulated microwave tubes at 2 A/sq cm for more than four years with about 6-percent degradation in current at a constant reference anode voltage. M-type cathodes have been operated for 30,000 h at a cathode temperature of 1010 C and 2 A/sq cm with no degradation in current as a constant reference anode voltage. (Author)

**N80-11328**

Hughes Research Labs., Malibu, Calif.

**SOLID-STATE X-BAND COMBINER STUDY** Final Report


The feasibility of developing solid-state amplifiers at 4 and 10 GHz for application in spacecraft antennas was studied. Bipolar-transistor, field-effect-transistor, and IMPATT-diode amplifier designs based on 1980 solid-state technology are investigated. Several output power levels of the pulsed, low-duty-factor amplifiers are considered at each frequency. Proposed transistor and diode amplifier designs are illustrated in block diagrams. Projections of size, weight, and primary power requirements are given for each design. R.C.T.

**N80-13362**

TRW Defense and Space Systems Group, Redondo Beach, Calif. Power Conversion Electronics Dept.

**HEAT PIPE COOLED POWER MAGNETICS** Final Report

M. S. Chester Dec. 1979 176 p Revised (NASA-CR-159669; TRW-33572-6001-RU-00) Avail: NTIS HC A05/MF A01 CSCL 09A

A high frequency, high power, low specific weight (0.57 kg/kW) transformer developed for space use was redesigned with heat pipe cooling allowing both a reduction in weight and a lower internal temperature rise. The specific weight of the heat pipe cooled transformer was reduced to 0.4 kg/kW and the highest winding temperature rise was reduced from 40 C to 20 C in spite of 10 watts additional loss. The design loss/weight tradeoff was 18 W/kg. Additionally, allowing the same 40 C winding temperature rise as in the original design, the kVA rating is increased to 4.2 kVA, demonstrating a specific weight of 0.28 kg/kW with the internal loss increased by 50W. This space environment tested heat pipe cooled design performed as well electrically as the original conventional design, thus demonstrating the advantages of heat pipes integrated into a high power, high voltage magnetic. Another heat pipe cooled magnetic, a 3.7 kW, 20A input filter inductor was designed, developed, built, tested, and described. The heat pipe cooled magnetics are designed to be Earth operated in any orientation. Author

**N80-24560**

Three E Vehicles, San Diego, Calif.

**THE PERFORMANCE AND EFFICIENCY OF FOUR MOTOR/CONTROLLER/BATTERY SYSTEMS FOR THE SIMPLER ELECTRIC VEHICLES** Final Report


A test and analysis program performed on four complete propulsion systems for an urban electric vehicle (EV) is described and results given. A dc series motor and a permanent magnet (PM) motor were tested, each powered by an EV battery pack and controlled by (1) a series/parallel voltage-switching (V-switch) system; and (2) a system using a pulse width modulation, 400 Hz transistorized chopper. Dynamometer tests were first performed, followed by EV performance predictions and data correlating road tests. During dynamometer tests using chopper control; current, voltage, and power were measured on both the battery and motor sides of the chopper, using three types of instrumentation. Conventional dc instruments provided adequate accuracy for EV power and energy measurements, when used on the battery side of the controller. When using the chopper controller, the addition of a small choke inductor improved system efficiency in the lower duty cycle range (some 8% increase at 50 duty cycle) with both types of motors. Overall system efficiency rankings during road tests were: (1) series motor with V-switch; (2) PM motor with V-switch; (3) series motor with chopper; and (4) PM motor with chopper. Chopper control of the EV was smoother and required less driver skill than V-switch control. M.G.
FLUID MECHANICS AND HEAT TRANSFER

Includes boundary layers, hydrodynamics, fluids, mass transfer, and ablation cooling.

For related information see also 02 Aerodynamics and 77 Thermodynamics and Statistical Physics.

N80-11378* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
STREAKLINE FLOW VISUALIZATION STUDY OF A HORSESHOE VORTEX IN A LARGE-SCALE, TWO-DIMENSIONAL TURBINE STATOR CASCADE

Neutrally buoyant helium-filled bubbles were observed as they followed the streamlines in a horseshoe vortex system around the vane leading edge in a large scale, two dimensional, turbine stator cascade. Reynolds number, based on true chord, ranged between 100,000 to 300,000. Bubbles were introduced into the endwall boundary layer through a slot upstream of the vane leading edge. The paths of the bubbles were recorded photographically as streaklines on 16 mm movie film. Individual frames from the film were selected, and overlaid to show the details of the horseshoe vortex around the leading edge. The transport of the vortex core past the passage near the vane leading edge is clearly seen when compared to the streaks formed by bubbles carried in the main stream. Limiting streaklines on the endwall surface were traced by the flow of oil drops. Autho...

N80-13403* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MARANOGONI BUBBLE MOTION IN ZERO GRAVITY

It was shown experimentally that the Marangoni phenomenon is a primary mechanism for the movement of a gas bubble in a nonisothermal liquid in a low gravity environment. A mathematical model consisting of the Navier-Stokes and thermal energy equations, together with the appropriate boundary conditions for both media, is presented. Parameter perturbation theory is used to solve this boundary value problem; the expansion parameter is the Marangoni number. The zeroth, first, and second order approximations for the velocity, temperature and pressure distributions in the liquid and in the bubble, and the deformation and terminal velocity of the bubble are determined. Experimental results for a nitrogen bubble in ethylene glycol, ethanol, and silicone oil subjected to a linear temperature gradient were obtained using the NASA Lewis zero gravity drop tower. Calculational results for the bubble terminal velocity showed good agreement with the experimental measurements. The first and second order solutions for the bubble deformation and terminal velocity are valid for liquids having Prandtl numbers on the order of one, but there is a lack of appropriate data to test the theory fully. K.L.

N80-13404* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
COMBUSTION OF SOLID CARBON RODS IN ZERO AND NORMAL GRAVITY

In order to investigate the mechanism of carbon combustion, spectroscopic carbon rods were resistance ignited and burned in an oxygen atmosphere in normal and zero gravity. Direct mass spectrometric C\textsubscript{2}/C\textsubscript{1} and C\textsubscript{1}/C\textsubscript{2} was used in the normal gravity tests to obtain concentration profiles of CO\textsubscript{2}, CO, and O\textsubscript{2} as a function of distance from the carbon surface. The experimental concentrations were compared to those predicted by a stagnant film model. Zero gravity droptower tests were conducted to order to assess the effect of convection on the normal gravity combustion process. The ratio of flame diameter to rod diameter was a function of time for oxygen pressures of 5, 10, 15, and 20 psia. A three-dimensional model was obtained for three different diameter rods. It was found that this ratio was inversely proportional to both the oxygen pressure and the rod diameter. K.L.

N80-15361* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
COMPUTER PROGRAM FOR GENERATING INPUT FOR ANALYSIS OF IMPINGEMENT-COOLED, AXIAL FLOW TURBINE BLADE
David Rosenbaum Jan. 1980 57 p refs Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio (NASA-TP-1603; AVRADCOM-TR-79-34) Avail: NTIS HC A04/MF A01 CSCL 20D

A computer program, TACTGRID, was developed to generate the geometrical input for the TACT program, a program that calculates transient and steady state temperatures, pressures, and cooling flows in an impingement cooled turbine blade. Using spline curves, the TACTGRID program constructs the blade internal geometry from the previously designed external blade surface and newly selected wall and channel thicknesses. The TACTGRID program generates the TACT calculational grid, calculates the length between grid points required by TACT as input, and prepares the name list input data set used by TACT for the blade geometry. In addition, TACTGRID produces a computer plot of each blade slice, detailing the grid and calculational stations, and thus eliminates the need for intermediate drafting. J.M.S.

N80-15364* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
COMPUTATION OF THREE-DIMENSIONAL FLOW IN TURBOFAN MIXERS AND COMPARISON WITH EXPERIMENTAL DATA

A three-dimensional viscous computer code was used to calculate the mixing downstream of a typical turbofan mixer geometry. Experimental data obtained using pressure and temperature rakes at the lobe and nozzle exit stations were used to validate the computer results. The relative importance of turbulence in the mixing phenomenon as compared to the streamwise vorticity set up by the secondary flows was determined. The observations suggest that the generation of streamwise vorticity plays a significant role in determining the temperature distribution at the nozzle exit plane. K.L.

N80-15365* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
NUMERICAL SIMULATION OF SUPERSONIC INLETS USING A THREE-DIMENSIONAL VISOUS FLOW ANALYSIS

A three dimensional fully viscous computer analysis was evaluated to determine its usefulness in the design of supersonic inlets. This procedure takes advantage of physical approximations...
to limit the high computer time and storage associated with complete Navier-Stokes solutions. Computed results are presented for a Mach 74 hypersonic inlet. Good agreement was obtained between theory and data for both methods. Results of a mesh sensitivity study are also shown.

NBO-17397** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EFFECTS OF A CERAMIC COATING ON METAL TEMPERATURES OF AN AIR-COOLED TURBINE VANE**

Herbert J. Gladden and Curt H. Liebert Feb 1980 29 p refs (NASA-TM-1598; E-167) Avail NTIS HC A03/MF A01 CSCL 20D

The metal temperatures of air cooled turbine vanes both uncoated and coated with the NASA thermal barrier system were studied experimentally. Current and advanced gas turbine engine conditions were simulated at reduced temperatures and pressures. Airfoil metal temperatures were significantly reduced, both locally and on the average, by use of the the coating. However, at low gas Reynolds number, the ceramic coating tripped a laminar boundary layer on the suction surface, and the resulting higher heat flux increased the metal temperatures. Simulated coating loss was also investigated and shown to increase local metal temperatures. However, the metal temperatures in the leading edge region remained below those of the uncoated vane tested at similar conditions. Metal temperatures in the trailing edge region exceeded those of the uncoated vane.

K.L.

NBO-17398** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**VOLUME-ENERGY PARAMETERS AND TURBULENT-FLOW DENSITY FLUCTUATIONS**

Robert C. Hendricks Jan 1980 28 p refs (NASA-TP-1585; E-127) Avail NTIS HC A03/MF A01 CSCL 20D

Volume-energy relations determined from an equation of state were used to group many sets of heat transfer data for liquids and gases, including the near-critical region. The volume-gas energy parameter grouped these data better than did such other parameters as enthalpy, temperature, or internal energy.

K.L.

NBO-20532** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FACTORS AFFECTING CLEANUP OF EXHAUST GASES FROM A PRESSURIZED, FLUIDIZED-BED COAL COMBUSTOR**


The cleanup of effluent gases from the fluidized-bed combustion of coal is examined. Testing conditions include the type and feed rate of the coal and the sulfur sorbent, the coal-sorbent ratio, the coal-combustion air ratio, the depth of the reactor fluidizing bed, and the technique used to physically remove fly ash from the reactor effluent gases. Tests reveal that the particulate loading matter in the effluent gases is a function not only of the reactor-bed surface gas velocity, but also of the type of coal being burnt and the time the bed is operating. At least 98 percent of the fly ash particles in the effluent gas are removed by using a gas-solid separator under controlled operating conditions. Gaseous pollutants in the effluent (nitrogen and sulfur oxides) are held within the proposed Federal limits by controlling the reactor operating conditions and the type and quantity of sorbent material.

M.G.

NBO-21708** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**SIMILARITY TESTS OF TURBINE VANES, EFFECTS OF CERAMIC THERMAL BARRIER COATINGS**


The role of material thermal conductivity was analyzed for its effect on the thermal performance of air-cooled gas turbine components coated with a ceramic thermal barrier material when tested at reduced temperatures and pressures. It is shown that the thermal performance can be evaluated reliably at reduced gas and coolant conditions; however, thermal conductivity corrections are required for the data at reduced conditions. Corrections for a ceramic thermal barrier-coated vane are significantly different than for an uncoated vane. Comparison of uncorrected test data, therefore, would show erroneously that the thermal barrier coating was ineffective. When thermal conductivity corrections are applied to the test data these data are then shown to be representative of engine data and also show that the thermal barrier coating increases the vane cooling effectiveness by 12.5 percent.

A.R.H.

NBO-24673** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**HEAT EXCHANGER AND METHOD OF MAKING**


A heat exchange of increased effectiveness is disclosed. A porous metal matrix is disposed in a metal chamber or between walls through which a heat-transfer fluid is directed. The porous metal matrix has internal bonds and is bonded to the chamber in order to remove all thermal contact resistance within the composite structure. Utilization of the invention in a rocket chamber is disclosed as a specific use. Also disclosed is a method of constructing the heat exchanger.

Official Gazette of the U.S. Patent and Trademark Office

NBO-24677** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EXTENSION OF SIMILARITY TEST PROCEDURES TO COOLED ENGINE COMPONENTS WITH INSULATING CERAMIC COATINGS**

Herbert J. Gladden May 1980 16 p refs (NASA-TP-1615; E-337) Avail. NTIS HC A02/MF A01 CSCL 20D

Material thermal conductivity was analyzed for its effect on the thermal performance of air cooled gas turbine components, both with and without a ceramic thermal-barrier material, tested at reduced temperatures and pressures. The analysis shows that neglecting the material thermal conductivity can contribute significant errors when metal-wall-temperature test data taken on a turbine vane are extrapolated to engine conditions. This error in metal temperature for an uncoated vane is of opposite sign from that for a ceramic-coated vane. A correction technique is developed for both ceramic-coated and uncoated components.

Author

NBO-27632** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**INFLUENCE OF PRESSURE DRIVEN SECONDARY FLOWS ON THE BEHAVIOR OF TURBOFAN FORCED MIXERS**


A finite difference procedure was developed to analyze the three dimensional subsonic turbulent flows in turbofan forced mixer nozzles. The method is based on a decomposition of the velocity field into primary and secondary flow components which are determined by solution of the equations governing primary flow.
momentum, secondary vorticity, thermal energy, and continuity. Experimentally, a strong secondary flow pattern was identified which is associated with the radial inflow and outflow characteristics of the core and fan streams and forms a very strong vortex system aligned with the radial interface between the core and fan streams. A procedure was developed to generate a similar generic secondary flow pattern in terms of two constants representing the average radial outflow or inflow in the core and fan streams as a percentage of the local streamwise velocity. This description of the initial secondary flow gave excellent agreement with experimental data. By identifying the nature of large scale secondary flow structure and associating it with characteristic mixer nozzle behavior, it is felt that the cause and effect relationship between lobe design and nozzle performance can be understood.

E.D.K.

N80-29623* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TOWARD THE USE OF SIMILARITY THEORY IN TWO-PHASE CHOKED FLOWS


Comparison of two phase choked flows in normalized coordinates were made between pure components and available data using a reference fluid to compute the thermophysical properties. The results are favorable. Solution of the governing equations for two LNG mixtures show some possible similarities between the normalized choked flows of the two mixtures, but the departures from the pure component loci are significant.

Author

N80-29624* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY RESULTS FROM A FOUR-WORKING SPACE, DOUBLE-ACTING PISTON, STIRLING ENGINE CONTROLS MODEL


A four working space, double acting piston, Stirling engine simulation is being developed for controls studies. The development method to construct two simulations, one for detailed fluid behavior, and a second model with simple fluid behavior but containing the four working space aspects and engine inertias, validate these models separately, then upgrade the four working space model by incorporating the detailed fluid behaviour model for all four working spaces. The single working space (SWS) model contains the detailed fluid dynamics. It has seven control volumes in which continuity, energy, and pressure loss effects are simulated. Comparison of the SWS model with experimental data shows reasonable agreement in net power versus speed characteristics for various mean pressure levels in the working space. The four working space (FWS) model was built to observe the behaviour of the whole engine. The drive dynamics and vehicle inertia effects are simulated. To reduce calculation time, only three pressures are used in each working space and the gas temperature are fixed (no energy equation). Comparison of the FWS model predicted power with experimental data shows reasonable agreement. Since all four working spaces are simulated, the unique capabilities of the model are exercised to look at working fluid supply transients, short circuit transients, and piston ring leakage effects.

Author

N80-32689* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WIND TUNNEL INVESTIGATION OF THE TITAN FORWARD SKIRT COMPARTMENT VENT FROM A FREE-STREAM MACH NUMBER OF 0.80 TO 1.96


A test was conducted to determine the flow characteristics of the Titan forward skirt compartment vent over a free stream Mach number range of 0.80 to 1.96. The vent was mounted in a flat plate and the plate was flush mounted to the tunnel side wall with converging center lines. Air was discharged from a duct, located on the tunnel side wall behind the plate, through a canted at 30 deg honeycomb vent into the free stream. Data for the analysis of the Titan forward skirt compartment venting during ascent through the atmosphere are provided. Full scale simulated flight hardware, such as the honeycomb vent, duct corrugations and field joint ring were used. Boundary layer thicknesses were used to vary boundary height. The highest vent discharge coefficients for any given Mach number and vent pressure ratio generally occurred at the maximum displacement thickness. With no vent flow the static pressure in the vent region was generally less than the free stream static pressure. With vent flow, the static pressures upstream of the vent increased, and those downstream of the vent decreased.

RKG


The paper examines major constraints involved in the Borda free jet phenomena. Under certain conditions, inlets with a Borda type geometry show sufficiently strong separation effects to permit the working fluid to flow through the duct as if it were a ‘free jet’. Mass limiting flow data and associated pressure profiles for tubes with L/D’s ranging from 14 to 105 with a Borda type inlet were considered to determine bounds of the ‘free jet’ phenomena using fluid nitrogen. For a given tube roughness, the limits appear to be one dimensional and dependent only on inlet stagnation conditions. For smooth tubes, the upper L/D boundary is defined by an equation relating reduced pressure to reduced temperature, and the lower boundary represents saturation conditions at the inlet. Similar ‘free jet’ effects were found for fluid hydrogen indicating that fluid jetting may be common to all fluids.

A.T.


Mass flow measurements associated with choked flows through four Borda-type inlet geometries: circular, square, triangular, and rectangular (two-dimensional) and two sharp-edged geometries are discussed for a wide range of inlet stagnation conditions. The results obtained indicate that the mass flux is independent of the inlet cross-section geometry, while it is dependent on the inlet stagnation conditions. The results also suggest that parallel surfaces found in seals, dampers, bearings, and heat exchanger tubes of rectangular cross section with Borda-type inlet configurations are subject to large forces. It is noted that the reduced mass flux is independent of working fluid.

V.I.


The effects of free-jet phenomena, jetting, in a 90deg-sharp-edge inlet tube by analyzing, mass-limiting flow data and associated pressure profiles for tubes of 53, 64, 73 and 105 L/D with a 90 deg-sharp-edge or orifice-type inlet are compared to Borda-type inlet data to determine bounds of the free-jet phenomena. For smooth
tubes the limits appear to be one-dimensional and dependent only on inlet stagnation conditions. The upper L/D boundary is related by stagnation characteristics and the lower bound appears to be stagnation conditions at the inlet. It is noted that similar free jet effects were found for fluid hydrogen indicating that fluid jetting might be common to all fluids flowing through 90 deg sharp-edge inlet geometries.

V.T.


A80-10039 * # Application of the principle of similarity fluid mechanics. R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio) and J. V. Singers (Maryland, University, College Park, Md.), International Association for Properties of Steam, International Conference on the Properties of Steam, 5th, Munich, West Germany, Sept. 8-14, 1979, Paper. 47 p. 90 refs. Grant No. NGR-21-002-344.

Possible applications of the principle of similarity to fluid mechanics is described and illustrated. In correlating thermophysical properties of fluids, the similarity principle transcends the traditional corresponding states principle. In fluid mechanics the similarity principle is useful in correlating flow processes that can be modeled with one independent variable (i.e., one-dimensional flows). In this paper we explore the concept of transforming the conservation equations by combining similarity principles for thermophysical properties with those for fluid flow. We illustrate the usefulness of the procedure by applying such a transformation to calculate two phase critical mass flow through a nozzle. (Author)

V.T.


Evolution of a rotating flow in a body of fluid bounded by a stationary flat surface is discussed. The calculated results show that the radial pressure gradient is substantially reduced in the region close to the surface, so that letting that gradient be independent of distance from the surface would be expected to give only rough or quantitative estimates. However, the reduced rotation near the stationary surface is still large enough to cause an inflow near the surface and to set up a recirculation pattern. The concentration of vorticity by the radial inflow is not great enough to increase the tangential velocities near the center of rotation. V.T.


Reported herein are comparative thermal film cooling footprints observed by infrared imagery from straight, curved and looped coolant tube geometries. It was hypothesized that the difference in secondary flow and turbulence structure of flow through these three tubes should influence the mixing properties between the coolant and mainstream. The coolant was injected across an adiabatic plate through a hole angled at 30 deg to the surface of line with the free stream flow. The data cover a range of blowing rates from 0.37 to 1.26 (mass flow per unit area of coolant divided by free stream). Average temperature difference between coolant and tunnel air was 25 C. Data comparisons confirmed that coolant tube curvature significantly influences film cooling effectiveness. (Author)

A80-20958 * # Marangoni bubble motion in zero gravity. R. L. Thompson (NASA, Lewis Research Center, Cleveland, Ohio) and K. J. De Witt (Toledo, University, Toledo, Ohio), American Institute of Chemical Engineers, Annual Meeting, 72nd, San Francisco, Calif., Nov. 25-29, 1979, Paper, 36 p. 10 refs.

It is shown experimentally that the Marangoni phenomenon is a primary mechanism for the movement of a gas bubble in a nonisothermal liquid in a low-gravity environment. In such two-phase flow systems, local variations in bubble surface tension are caused by a temperature gradient in the liquid. Shearing stresses thus generated at the bubble surface lead to convective motion of the bubble which the bubble begins to move. A mathematical model consisting of the Navier-Stokes equations and the thermal energy equations, along with the appropriate boundary conditions for both media, is proposed. V.P.


The constant demand for increased power and reduced mass has raised the internal thermal power of conventionally cooled power magnets toward the upper limit of acceptability. The conflicting demands of electrical isolation, mechanical integrity, and thermal conductivity preclude significant further advancements using conventional approaches. However, the size and mass of multikilowatt power processing systems may be further reduced by the incorporation of heat pipe cooling directly into the power magnets. Additionally, by maintaining lower more constant temperatures, the life and reliability of the magnetic devices will be improved. A heat pipe cooled transformer and input filter have been developed for the 2.4 kW beam supply of a 30-cm ion thruster system. This development yielded a mass reduction of 40% (17.6 kg) at lower mean winding temperature (20 C lower). While these improvements are significant, preliminary designs predict even greater benefits to be realized at higher power. This paper presents the design details along with the results of thermal vacuum operation and the component performance in a 3 kW breadboard power processor. (Author)


An experimental work is discussed whose objective was to obtain data that show the effect of temperature and temperature fluctuations on surface noise. This was accomplished experimentally by immersing a small chamber in the top half of a hot jet. The theory and experiment reported by Olsen (1976) provided a guide for designing and validating the hot jet experiment and for interpreting the data. It is shown that increased temperature causes a small decrease in the sound levels; at the same time it causes a shift in the spectra that is smaller but similar to the shift observed with subsonic hot jet noise. S.D.

A numerical procedure for the efficient simulation of steady inviscid flow is described and its utility is demonstrated. The method is uniformly valid for application in the subsonic, transonic and supersonic flow regimes. It does not rely on the introduction of additional assumptions beyond those necessary to obtain the Euler equations from the Navier-Stokes equations, nor does it make use of a time-asymptotic solution of the unsteady equations of motion. Application of the herein-defined surrogate equation technique allows the formulation of stable, fully-conservative, type-dependent finite difference equations for use in obtaining numerical solutions to systems of first-order partial differential equations, such as the steady-state Euler equations or their various approximations. Computational results are presented for the full Euler equations used to simulate rotational subsonic flow and for the transonic small disturbance equations. For the latter case, a computational efficiency greater than that obtained by means of the standard perturbation potential approach is indicated. 

(Author)

N80-10480## Battelle Columbus Labs., Ohio

**SPRAY NOZZLE DESIGNS FOR AGRICULTURAL AVIATION APPLICATIONS**


(NASA-CR-159702) Avail: NTIS HC A06/MF A01 CSCL 20D

Techniques of generating monodisperse sprays and information concerning chemical liquids used in agricultural aviation are surveyed. The periodic dispersion of liquid jet, the spinning disk and estimates of the operational characteristics are presented. Performance requirements for the designs are described and estimates of the operational characteristics are presented. 

A.W.H.


**DEVELOPMENT OF A THREE-DIMENSIONAL SUPERSONIC INLET FLOW ANALYSIS**

Final Report

R. C. Buggein, H. McDonald, R. Levy, and J. P. Kreiskovsky

Jan. 1980 122 p refs (Contract NAS3-21003)

(NASA-CR-3218) Avail: NTIS HC A06/MF A01 CSCL 20D

A method for computing three dimensional flow in supersonic inlets is described. An approximate set of governing equations is given for viscous flows which have a primary flow direction. The governing equations are written in general orthogonal coordinates. These equations are modified in the subsonic region of the flow to prevent the phenomenon of branching. Results are presented for the two sample cases: a Mach number equals 2.5 flow in a square duct, and a Mach number equals 3.0 flow in a research jet engine inlet. In the latter case the computed results are compared with the experimental data. A users manual is included. 

Author


**MONODISPERSE ATOMIZERS FOR AGRICULTURAL AVIATION APPLICATIONS**

Final Report

Larry S. Christensen and Sidney L. Steely

Feb. 1980 81 p refs (Contract NAS3-21582)

(NASA-CR-159777) Avail: NTIS HC A05/MF A01 CSCL 20D

Conceptual designs of two monodisperse spray nozzles are described and the rationale used in each design is discussed. The nozzles were designed to eliminate present problems in agricultural aviation applications, such as ineffective plant coverage, drift due to small droplets present in the spray being dispersed, and nonuniform swath coverage. Monodisperse atomization techniques are reviewed and a synopsis of the information obtained concerning agricultural aviation spray applications is presented. 

A.W.H.

N80-23599## Sigma Research, Inc., Richland, Wash.

**TWO-PHASE WORKING FLUIDS FOR THE TEMPERATURE RANGE OF 50 TO 350 DEG. PHASE 2**

Final Report

E. W. Saaski and J. H. Harti

Mar. 1980 57 p refs (Contract NAS3-21202)

(NASA-CR-159847) Avail: NTIS HC A04/MF A01 CSCL 20D

Several two phase heat transfer fluids were tested in aluminum and carbon steel reflux capsules for over 25,000 hours at temperatures up to 300 C. Several fluids showed very good stability and would be useful for long duration heat transfer applications over the range 100 to 350 C. Instrumentation for the measurement of surface tension and viscosity were constructed for use with heat transfer fluids over the temperature range 0 to 300 C and with pressures from 0 to 10 atmospheres. The surface tension measuring device constructed requires less than a 1.0 cc sample and displays an accuracy of about 5 percent in preliminary tests, while the viscometer constructed for this program requires a 0.05 cc sample and shows an accuracy of about 5 percent in initial tests. 

E.D.K.

N80-32688## TRW Defense and Space Systems Group, Redondo Beach, Calif.

**DEPRIMING OF ARTERIAL HEAT PIPES: AN INVESTIGATION OF CTS THERMAL EXCURSIONS**

Final Report


D. Antoniak and D. K. Edwards

20 Aug 1980 214 p refs (Contract NAS3-21740)


Four thermal excursions of the Transmitter Experir

Package (TEP) were the result of the depimming of the art

in all three heat pipes in the Variable Conductance Heat pipe

system which cooled the TEP. The determined cause of the depriming of the heat pipes was the formation of bubbles of the nitrogen/helium control gas mixture in the arteries during the thaw portion of a freeze/thaw cycle of the active region of the condenser section of the heat pipe. Conditions such as suction freezeout or heat pipe turn-on, which moved these bubbles into the active region of the heat pipe, contributed to the depriming mechanism. Methods for predicing, or reducing the probability of, this type of failure mechanism in future applications of arterial heat pipes are included. 

Author


Wind tunnel experiments were carried out at Stanford between 1971 and 1977 to study the heat transfer characteristics of full-coverge film cooled surfaces with the following conditions: normal 30 deg slant, and 30 deg x 45 deg compound-angled injection. A flat full-coverge section and downstream recovery section comprised the heat transfer system. The experimental objectives were to determine, for each geometry, the effects on surface heat flux of injection blowing ratio, injection temperature ratio, and upstream initial conditions. Spanwise-averaged Stanton numbers were measured for blowing ratios from 0 to 1.3, and for two values of injection temperature at each blowing ratio. The heat transfer coefficient was defined on the basis of a mainstream-to-wall temperature difference. Initial momentum and enthalpy thickness Reynolds numbers were varied from 500 to about 3000. 

(Author)
Experimental research into heat transfer from full-coverage film-cooled surfaces with three injection geometries was described in Part I. This part has two objectives. The first is to present a simple numerical procedure for simulation of heat transfer with full-coverage film cooling. The second objective is to present some of the Stanton number data that was used in Part I of the paper. The data chosen for presentation are the low-Reynolds number, heated-starting-length data for the three injection geometries with five-diameter hole spacing. Sample data sets with high blowing ratio and with ten-diameter hole spacing are also presented. The numerical procedure has been successfully applied to the Stanton number data sets.

(Author)
TEMPERATURE AND PRESSURE MEASUREMENT TECHNIQUES FOR AN ADVANCED TURBINE TEST FACILITY
A high pressure, high-temperature turbine test facility constructed for use in turbine cooling research is described. Several recently developed temperature and pressure measuring techniques are used in this facility. The measurement techniques, their status, previous applications and some results are discussed. Noncontact surface temperature measurements are made by optical methods. Radiation pyrometry principles combined with photodiode scanning are used for rotating components and infrared photography for stationary components. Contact (direct) temperature and pressure measurements on rotating components are expected to be handled with an 80 channel rotary data package which mounts on and rotates with the turbine shaft at speeds up to 17,500 rpm. The data channels are time-division multiplexed and converted to digital words in the data package. A rotary transformer couples power and digital data to and from the shaft. M.M.M.

A study of some NASA and DOD programs to develop optical sensors is presented. Fiber optic systems offer some distinct advantages. Noise immunity is one important asset. Fiberoptic systems do not conduct electricity and therefore can be used in and near areas that contain explosive or flammable materials. One objective of these programs is to produce more reliable sensors and to improve the safety and operating economy of future aircraft and space vehicles. Author

A computerized video densitometry method is described which is approximately 50 times faster than a corresponding manual method of analysis, with no apparent sacrifice of accuracy. The object of the technique is to determine the temperature distribution across a heated surface. Infrared photographs of the heated surfaces provide the raw data. A video based, computer operated image analysis system provides the equipment. Infrared photograhic pyrometry using a flat bed microdensitometer forms the basis of the technique. The procedure is illustrated on a thermally cycled aircraft gas turbine blade. A.R.H.


The capability for accurate measurement of unsteady pressure on the surface of compressor and fan blades during engine operation was established. Tests were run on miniature semiconductor strain gage pressure transducers mounted in several arrangements. Both surface mountings and recessed flush mountings were tested. Test parameters included mounting arrangement, blade material, temperature, local strain in the blade, acceleration normal to the transducer diaphragm, centrifugal acceleration, and pressure. Test results showed no failures of transducers or mountings and indicated an uncertainty of unsteady pressure measurement of approximately +0.6%, plus 0.1 kPa for a typical application. V.T.

An apparatus is described in which hydrogen atoms were trapped at temperatures down to 1.1 K in the P T field of a large volume superconducting magnet. A high sensitivity thermal detector was used to study trapping and recombination of atoms on the detector surface. The apparatus permits the application of extremely high steady state magnetic fields to study the potential effects of electron spin polarization on the stabilization of hydrogen atoms.  

(Author)


Advances in the gas turbine technology level and the corresponding advances in measurement instruments and technique are reviewed for each of the past decades, starting with the forties. The review provides a picture of the gradual development from the earlier, relatively simple systems, to the present sophisticated machines. A look in the future indicates that continued advances in gas turbine technology will be needed, used, and supported and that substantial changes are underway as to how these advances will be achieved. Some projections of the type of advances and in technology and measurements to be expected in the decade of the eighties are presented.

V.P.


The need for blade tip clearance instrumentation has been intensified recently by advances in technology of gas turbine engines. A new laser-optical measurement system has been developed to measure single blade tip clearances and average blade tip clearances between a rotor and its gas path seal in rotating component rigs and complete engines. The system is applicable to fan, compressor and turbine blade tip clearance measurements. The engine mounted probe is particularly suitable for operation in the extreme turbine environment. The measurement system consists of an optical subsystem, an electronic subsystem and a computing and graphic terminal. Bench tests and environmental tests were conducted to confirm operation at temperatures, pressures, and vibration levels typically encountered in an operating gas turbine engine.  

(Author)


Innovative features of the anemometer include: (1) a rapid and efficient data acquisition system (A80-36126 14-35) that provides a detailed real-time graphic display of the data being accumulated, and (3) input laser beam positioning that maximizes the size of the intra-rotor region being mapped. Results demonstrate the anemometer's capability in flow mapping within a transonic axial-flow compressor rotor. The use of fluorescent seed particles allows flow measurements near the rotor hub and the casing window.  

(Author)


A laser anemometer system employing an efficient data acquisition technique has been used to make measurements upstream, within, and downstream of the compressor rotor. A fluorescent dye technique allowed measurements within endwall boundary layers. Adjustable laser beam orientation minimized shadowed regions and enabled radial velocity measurements outside of the blade row. The flow phenomena investigated include flow variations from passage to passage, the rotor shock system, three-dimensional flows in the blade wake, and the development of the outer endwall boundary layer. Laser anemometer measurements are compared to a numerical solution of the streamfunction equations and to measurements made with conventional instrumentation.  

(Author)


Some in the present paper, the current status of fluid and structural measurements is reviewed, and some potential improvements in gas turbine machinery, directly associated with the new measuring capability are discussed. Some considerations concerning the impact of the new capability on the methods and approaches that will be used in the further development of advanced technology, in general, and to aeropulsion gas turbine machinery, in particular, are presented.  

V.P.


The paper deals with an analysis procedure, based on engine-order sampling, which eliminates effectively the engine harmonics from the overall flutter spectra obtained with a case-mounted static pressure transducer. Qualitative spectral analyses of pressure data performed on the basis of blade order sampling, are examined. The interference of blade motion with the pressure signal in the steep gradient portion of the blade passage is demonstrated, using optimal displacement spectra. Two methods which remove the contribution of blade motion from the blade-pressure-difference spectra are described.  

V.P.


The paper presents a technique for measuring blade tip displacements which employs optical probes and an array of microcomputers. A system directly digitizing a minimum of a 2048-point time-deflection history for each of the three measurement locations on each blade is described.  

V.T.

The progression of experimental programs is discussed from the simplest two-dimensional stationary geometry to the highly complex three-dimensional flow in a rotating blade row. Experimental methods and instrumentation techniques are described. Emphasis is placed on rotating blade row measurements. V.T.


A high pressure, high-temperature turbine test facility is being constructed at the NASA Lewis Research Center for use in turbine cooling research. Several recently developed temperature and pressure measuring techniques will be used in this facility. This paper describes these measurement techniques, their status, previous applications and some results. Noncontact surface temperature measurements will be made by optical methods. Radiation pyrometry principles combined with photoelectric scanning will be used for rotating components and infrared photography for stationary components. Contact (direct) temperature and pressure measurements on rotating components will be handled with an 8-channel rotary data package which mounts on and rotates with the turbine shaft at speeds up to 17,500 rpm. The data channels are time-division multiplexed and converted to digital words in the data package. A rotary transformer couples power and digital data to and from the shaft. (Author)


This report outlines the fatigue test performed on instrumentation rakes and probes intended for use in the air flow passages of jet-engines during full-scale engine tests at Lewis Research Center. Included is a discussion of each type of test performed, the results that may be derived and means of inspection. A design and testing sequence outlines the procedures and considerations involved in the generation of suitable instrument probes. (Author)


The increasing use of broadband, pulse-echo ultrasonics in nondestructive evaluation of flaws and material properties has generated a need for improved understanding of the way signals are modified by coupled and bonded thin-layer interfaces associated with transducers. This understanding is most important when using frequency spectrum analyses for characterizing material properties. In this type of application, signals emanating from material specimens can be strongly influenced by couplant and bond-layers in the acoustic path. Computer synthesized waveforms were used to simulate a range of interface conditions encountered in ultrasonic transducer systems operating in the 20- to 80-kHz regime. The adverse effects of thin-layer multiple reflections associated with various acoustic impedance conditions are demonstrated. The information presented is relevant to ultrasonic transducer design, specimen preparation, and couplant selection. (Author)


A fringe type laser anemometer is described. Features of the anemometer include: a rapid and efficient data acquisition process; a detailed real time graphic display of the data being accumulated; and input laser beam positioning that maximizes the size of the intrarotor region being mapped. Results are presented that demonstrate the anemometer’s capability in flow mapping within a transonic axial flow compressor rotor. A velocity profile, derived from 30,000 measurements along 1000 sequential circumferential positions covering 20 blade passages, was obtained in 30 seconds. The use of fluorescent seed particles allowed flow measurements near the rotor hub and the casing window. R.C.T.

Thin film temperature sensors were developed. The sensors were made of platinum-platinum/10 percent rhodium thermocouples with associated thin film-to-lead wire connections and sputtered on aluminum oxide coated simulated turbine blades for testing. Tests included exposure to vibration, low velocity hydrocarbon hot gas flow to 1250 K, and furnace calibrations. Thermal electromotive force was typically two percent below standard type S thermocouples. Mean time to failure was 42 hours at a hot gas flow temperature of 1250 K and an average of 15 cycles to room temperature. Failures were mainly due to separation of the platinum thin film from the aluminum oxide surface. Several techniques to improve the adhesion of the platinum are discussed. R.E.S.

The laboratory broadband optical temperature sensor based on the temperature dependent absorbitive characteristics of a rare earth (europium) doped optical fiber. The principles of operation, materials characterization, fiber and optical component design, and fabrication of an electrooptic interface unit, signal processing, and initial test results are discussed. Initial tests indicated that, after a brief warmup period, the output of the sensor was stable to approximately 1 C at room temperature or approximately 0.3 percent of point (K). This exceeds the goal of 1 percent of point. Recommendations are presented for further performance improvement. L.F.M.
The thermoelectronic laser energy converter (TELEC), was studied as a method of converting a 10.6 mm CO2 laser beam into electric power. The calculated characteristics of a TELEC seem to be well matched to the requirements of a spacecraft laser energy conversion system. The TELEC is a high power density plasma device which absorbs an intense laser beam by inverse bremsstrahlung with the plasma electrons. In the TELEC process, electromagnetic radiation is absorbed directly in the plasma electrons producing a high electron temperature. The energetic electrons diffuse out of the plasma striking two electrodes which are in contact with the plasma at the boundaries. These two electrodes have different areas: the larger one is designated as the collector, the smaller one is designated as the emitter. The smaller electrode functions as an electron emitter to provide continuity of the current. Waste heat is rejected from the collector electrode. An experiment was carried out with a high power laser using a cesium vapor TELEC cell with 30 cm active length. Laser supported plasma was produced in the TELEC device during a number of laser runs over a period of several days. Electric power from the TELEC was observed with currents in the range of several amperes and output potentials of less than 1 volt. The magnitudes of these electric outputs were smaller...
MODIFIED FACE SEAL FOR POSITIVE FILM STIFFNESS

An invention to improve the film stiffness of a face seal without increasing the sealing and dam area is described. The improved sealing apparatus has a primary seal ring in the form of a nose piece. A spring forces a sealing surface on the seal ring into sealing contact with a seat to form a face seal. A circumferential clearance seal restricts the flow of fluid from a main cavity to an intermediate cavity with a resulting circumferential clearance seal is formed in series with this face seal. Also, the clearance between the surface on the lip and the shaft is substantially the same as the spacing between the face sealing surfaces on the face seal when the shaft is rotating. The circumferential clearance seal restricts the flow of fluid from a main cavity to an intermediate cavity with a resulting pressure drop. The hydrostatic opening is strongly dependent on the face seal clearance, and the desired axial stiffness is achieved.

PATENT APPLICATION

Izhak Etsion (Technion-Israel Inst of Technol., Haifa) and Abraham Lipshitz, inventors (to NASA) (Technion-Israel Inst. of Technol., Haifa) Filed 7 Nov. 1979 7 p. Spons. by NASA (NASA-Case-LEW-12989-1; US-Patent-Appi-SN-092145); Avail: NTIS HC A02/MF A01 CSCL 11A


A procedure is described for using argon and oxygen plasmas to promote adhesion of parylene coatings upon many difficult-to-bond substrates. Substrates investigated were gold, nickel, Kovar, teflon (FEP), kapton, silicon, tantalum, titanium, and tungsten. Without plasma treatment, 180 deg peel tests yield a few g/cm (oz/in) strengths. With dc plasma treatment in the deposition chamber, followed by coating, peel strengths are increased by one to two orders of magnitude.

A.R.H.

N80-18340# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

TRIBOLOGICAL PROPERTIES OF SILICON CARBIDE IN METAL REMOVAL PROCESSES

Kazuhisa Miyoshi and Donald H. Buckley 1980 18 p. refs To be presented at Intern. Symp. on Metal Working Lubrication, San Francisco, 18-19 Aug. 1980; sponsored by ASME (NASA-TM-79238); Avail: NTIS HC A02/MF A01 CSCL 13H

Material properties are considered as they relate to friction, wear, and of single crystal silicon carbide in content with metals and alloys that are likely to be involved in a metal removal process such as grinding. Metal removal from adhesion between sliding surfaces in contact and metal removal as a result of the silicon carbide sliding against a metal, indenting into it, and plowing a series of grooves or furrows are discussed. Fracture and deformation characteristics of the silicon carbide surface are also covered. An analysis, friction, and metal transfer to silicon carbide is related to the relative chemical activity of the metals. The more active the metal, the higher the adhesion and friction, and the greater the metal transfer to silicon carbide. Atomic size and content of alloying elements play a dominant role in controlling adhesion, friction, and abrasive wear properties of alloys. The friction and abrasive wear (metal removal) decrease linearly as the shear strength of the bulk metal increases. They decrease as the solute to solvent atomic radius ratio increases or decreases linearly from unity, and with an increase of solute content. The surface fracture of silicon carbide is due to cleavages of 0001, 101-110, and/or 112-210 planes.

J.M.S.
The performance of 120.65 mm bore high speed design tapered roller bearings was examined at shaft speeds to 20,000 rpm under combined thrust and radial load. The test bearing design was computer optimized for high speed operation. Temperature in turbomachined bearing heat generation were determined as a function of shaft speed, radial and thrust loads, lubricant flow rates, and lubricant inlet temperature. The roller bearing operated successfully at shaft speeds up to 20,000 rpm under heavy thrust and radial loads. Cup cooling was effective in decreasing the high cup temperatures to levels equal to the cone temperature. K.L.

**REFERENCES**

- N80-17468# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. **SPUR-GEAR-SYSTEM EFFICIENCY AT PART AND FULL LOAD**

- N80-17467# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. **PERFORMANCE SENSITIVITY ANALYSIS OF DEPARTMENT OF ENERGY-CHRYSLER UPGRADED AUTOMOTIVE GAS TURBINE ENGINE, S/N 5-4 Final Report**

- N80-17469# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. **SIMPLIFIED FATIGUE LIFE ANALYSIS FOR TRACTION DRIVE CONTACTS**

- N80-18400# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. **GAS PATH SEAL Patent Application**

A gas path seal suitable for use with a turbine engine or compressor is described. A shroud wearable or abradable by the abrasion of the rotor blades of the turbine or compressor shrouds the rotor bades. A compliant backing surrounds the shroud. The backing is a yieldingly deformable porous material covered with a thin ductile layer. A mounting fixture surrounds the backing. NASA
shows good agreement with published data. Large diameter and exhibited statistically equivalent lives to AISI 9310, CBS 600 at low speeds. Author

98 percent except at very low torque levels. Tare (no-load) losses load efficiency. Gear efficiencies were generally greater than fine pitched gears had higher peak efficiencies but low part fracture at the tips of the gears. Author

Gear endurance tests and rolling-element fatigue tests were conducted to compare the performance of spur gears made from AISI 9310, CBS 600 and modified Vasco X-2 and to compare the pitting fatigue lives of these three materials. Gears manufactured from AISI 9310. However, rolling-element fatigue tests resulted in statistically equivalent lives. Modified Vasco X-2 exhibited statistically equivalent lives to AISI 9310, CBS 600 and modified Vasco X-2 gears exhibited the potential of tooth fracture occurring at a tooth surface fatigue pit. Case carburization of all gear surfaces for the modified Vasco X-2 gears results in fracture at the tips of the gears. Author

The results of an analysis of the effects of spur gear size, pitch, width, and ratio on total mesh power loss are generally a significant percentage of the full load loss except at very low torque levels. Tare (no-load) losses are generally a significant percentage of the full load loss except at low speeds. Author

The results of an analysis of the effects of spur gear size, pitch, width, and ratio on total mesh power loss are generally a significant percentage of the full load loss except at very low torque levels. Tare (no-load) losses are generally a significant percentage of the full load loss except at low speeds. Author

Damping in annular seals is calculated for an incompressible fluid. Results show that damping in tapered seals optimized for stiffness is considerably less than that in straight seals for the same minimum clearance. Damping in rotating seals can promote fractional frequency whirl. Neglecting fluid acceleration makes solution much easier, but leads to errors in calculated damping of up to 16 percent. K.L.

The operating characteristics for 118 mm bore cylindrical roller bearing are examined using the computer program CYBEAN. The predicted results of inner and outer-race temperatures and heat transferred to the lubricant generally compared well with experimental data for shaft speeds to 3 million DN (25,000 rpm), radial loads to 8900 N (2000 lb), and total lubricant flow rates to 0.0102 cu m/min (2.7 gal/min). M.G.


FISHER, C. (2024) Tribology, 50, 1, 1-12.


FISHER, C. (2026) Tribology, 52, 1, 1-12.


FISHER, C. (2028) Tribology, 54, 1, 1-12.

FISHER, C. (2029) Tribology, 55, 1, 1-12.

FISHER, C. (2030) Tribology, 56, 1, 1-12.

FISHER, C. (2031) Tribology, 57, 1, 1-12.

FISHER, C. (2032) Tribology, 58, 1, 1-12.
A gas path seal suitable for use with a turbine engine or compressor is provided. A shroud wearable or abradable by the abrasion of the rotor blades of the turbine or compressor shrouds the rotor blades. A compliant backing surrounds the shroud. The backing is a compliant material covered with a thin ductile layer. A mounting fixture surrounds the backing.

Official Gazette of the U.S. Patent and Trademark Office

DIESEL ENGINE CATALYTIC COMBUSTOR SYSTEM Patent Application


A low compression turbocharged diesel engine is described in which the turbocharger can be operated independently of the engine to power auxiliary equipment. Fuel and air are burned in a catalytic combustor to drive the turbine wheel of the turbine section which is initially caused to rotate by the starter motor. By opening a flapper valve, compressed air from the blower section is directed to the catalytic combustor when it is heated and expanded, serving to drive the turbine wheel and also to heat the catalytic element. To start the engine, one valve is closed, combustion is terminated in the catalytic combustor, and another valve is then opened to utilize air from the blower for the air driven motor. When the engine starts, the constituents in its exhaust gas react in the catalytic element and the heat generated provides additional energy for the turbine section.

Author
as a function of the inlet distance parameter and the film thickness for a fully flooded condition. Contour plots of pressure and film thickness in and around the contact are shown for fully flooded and starved conditions. The theoretical findings are compared directly with results obtained experimentally. Author


A circumferential shaft seal is described which comprises two sealing rings held to a rotating shaft by means of an elastomeric band. The rings are segmented and are of rigid or semi-rigid sealing material such as carbon or a polyimide and graphite fiber composite.

Official Gazette of the U.S. Patent and Trademark Office


A circumferential shaft seal is described which comprises two sealing rings held to a rotating shaft by means of an elastomeric band. The rings are segmented and are of rigid or semi-rigid sealing material such as carbon or a polyimide and graphite fiber composite.

Official Gazette of the U.S. Patent and Trademark Office

N80-29706* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ROTODYNAMIC INSTABILITY PROBLEMS IN HIGH-PERFORMANCE TURBOMACHINERY 1980 463 p. refs Cont. held at College Station, 12-14 May 1980; sponsored by Texas A and M Univ., Louisville Univ., and AROD (NASA-CP-2133; E-413) Avail: NTIS HC A20/MF A01 CSCL 13I

Diaphragm and relief methods concerning rotordynamic instability problems in high performance turbomachinery are discussed. Instabilities due to seal forces and work-fluid forces are identified along with those induced by rotor bearing systems. Several methods of rotor damping control are described including active feedback methods, the use of elastomeric elements, and the use of hydrodynamic journal bearings and supports. For individual titles, see N80-29707 through N80-29733.

N80-29716* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DAMPING IN RING SEALS FOR COMPRESSIBLE FLUIDS David P. Fleming In its Rotordyn. Instability Prob. in High-Performance Turbomachinery 1980 p 169-188 refs (For primary document see N80-29706 20-37) Avail: NTIS HC A20/MF A01 CSCL 13I

An analysis is presented to calculate damping in ring seals for a compressible fluid. Results show that damping in tapered ring seals (optimized for stiffness) is less than that in straight bore ring seals for the same minimum clearance. Damping in ring seals can promote fractional frequency whirl and can, thus, be detrimental. Thus, tapered seals can benefit rotor and seal stability by having lower damping as well as higher stiffness.

Use of incompressible results leads to large errors. Author


The performance of 120.65 mm (4.75 in.) bore high speed design, tapered roller bearings was investigated at shaft speeds to 20,000 rpm (2.4 million DN) under combined thrust and radial load. The test bearing design was computer optimized for high speed operation. Temperature distribution bearing heat generation were determined as a function of shaft speed, radial and thrust loads, lubricant flow rates, and lubricant inlet temperature. The high speed design, tapered roller bearing operated successfully at shaft speeds up to 20,000 rpm under heavy thrust and radial loads. Bearing temperatures and heat generation with the high speed design bearing were significantly less than those of a modified standard bearing tested previously. Cup cooling was effective in decreasing the high cup temperatures to levels equal to the cone temperature. Author


Film thickness equations are provided for four fluid-film lubrication regimes found in elliptical contacts. These regimes are isoviscous-rigid; viscous-rigid; elastohydrodynamic lubrication of low-elastic-modulus materials (soft EHL), or isoviscous-elastic; and elastohydrodynamic lubrication of high-elastic-modulus materials (hard EHL), or viscous-elastic. The influence or lack of influence of elastic and viscous effects is the factor that distiguishes these regimes. The results are presented as a map of the lubrication regimes, with film thickness contours on a log-log grid of the viscosity and elasticity for three values of the ellipticity parameter. E.D.K.


A displacer piston which is driven pneumatically by a high-pressure or low-pressure gas is included in a free-piston regenerative hydraulic engine. Actuation of the displacer piston circulates the working fluid through a heater, a regenerator and a cooler. The present invention includes an inertial mass such as a piston or a hydraulic fluid column to effectively store and supply energy during portions of the cycle. Power is transmitted from the working fluid to a hydraulic fluid across a diaphragm or lightweight piston to achieve a hydraulic power out-put. The displacer piston of the present invention may be driven pneumatically, hydraulically or electromagnetically. In addition, the displacer piston and the inertial mass of the present invention may be positioned on the same side of the diaphragm member or may be separated by the diaphragm member.

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119
EFFECT OF CAGE DESIGN ON CHARACTERISTICS OF
levels. Some photographs of the cavitation region are presented
were generated with the double outer land guided cage
radial load at nominal shaft speeds of 48,000 rpm, and an
of the bearing. Test conditions included a combined thrust and
cavitation zone of a submerged journal bearing are described,

CAVITATION REGION OF SUBMERGED JOURNAL

bearings. Test conditions included a combined thrust and

Visual observations and pressure measurements in the
cavitation zone of a submerged journal bearing are described.
Tests were performed at various shaft speeds and ambient pressure
levels. Some photographs of the cavitation region are presented
showing strong reverse flow at the downstream end of the
region. Pressure profiles are presented showing significant pressure
variations in the cavitation zone, contrary to common
assumptions of constant cavitation pressure

EFFECT OF CAGE DESIGN ON CHARACTERISTICS OF
HIGH-SPEED-JET-LUBRICATED 35-MILLIMETER-BORE
BALL BEARING

Frederick T. Schuller, Stanley J. Pinel (Industrial Tectonics, Compton,
Calif.). and Hans R. Signer (Industrial Tectonics, Compton, Calif.)

Parametric tests were conducted with a 35 mm bore angular
contact ball bearing with a double outer land guided cage.
Provisions were made for jet lubrication and outer-ring cooling
of the bearing. Test conditions included a combined thrust and
radial load at nominal shaft speeds of 48,000 rpm, and an
oil-in temperature of 394 K (250 F). Successful operation of
the test bearing was accomplished up to 2.5 million ON. Test
results were compared with those obtained with similar bearing
having a single outer land guided cage. Higher temperatures
were generated with the double outer land guided cage
bearing, and bearing power loss and cage slip were greater.
Cooling the outer ring resulted in a decrease in overall bearing
operating temperature.

The friction and wear of metals and binary
alloys in contact with an abrasive grit of single-crystal silicon carbide,
K. Miyoshi and D. H. Buckley (NASA, Lewis Research Center,
Cleveland, Ohio). American Society of Lubrication Engineers and
American Society of Mechanical Engineers, Lubrication Conference,

The leak rates through shaft seals with large pressure drops were
simulated using gaseous hydrogen, or nitrogen flowing through an
annulus with a nonrotating centerbody. The flows were choked. For
concentric or eccentric position of the rotor and parallel or
divergent tapered flow passages, data and analysis revealed that
mass flux or leak rate can be determined from a relation whose
normalizing parameters depend on the thermodynamic crit[ical]
constants of the working fluid and an average flow area expressed
in terms of the inlet and exit cross-sectional area. Using these
normalized relations, the flow data for parallel and three convergent,
tapered, shaft-seal configurations are in good agreement. Generaliza-
tion to any simple gas or gas mixtures is implied and demonstrated in
details.

Survey of ion plating sources. T. Spalvins (NASA, Lewis Research Center,
Cleveland, Ohio), American Vacuum Society, National Vacuum Symposium,

Ion plating is a plasma deposition technique where ions of the
gas and the evaporant have a decisive role in the formation of a
coating in terms of adherence, coherence, and morphological growth.
The range of materials that can be ion plated is predominantly
determined by the selection of the evaporation source. Based on the
type of evaporation source, gaseous media and mode of transport,
the following will be discussed: resistance, electron beam sputtering,
reactive, and ion beam evaporation. Ionization efficiencies and ion
energies in the glow discharge determine the percentage of atoms
which are ionized under typical ion plating conditions. The plating
flux consists of a small number of energetic ions and a large number
of energetic neutrals. The energy distribution ranges from thermal
ergies up to a maximum energy of the discharge. The various
reaction mechanisms which contribute to the exceptionally strong
adherence — formation of a graded substrate/coating interface are not
fully understood, however the controlling factors are evaluated.
The influence of process variables on the nucleation and growth
characteristics are illustrated in terms of morphological changes
which affect the mechanical and tribological properties of the
coating.

Some flow characteristics of conventional and
tapered high-pressure-drop simulated seals. R. C. Hendricks (NASA,
Lewis Research Center, Cleveland, Ohio). American Society of
Lubrication Engineers and American Society of Mechanical Engi-

ners, Lubrication Conference, Dayton, Ohio, Oct. 16-18, 1979,

Sanding friction experiments were conducted with various metals
and iron-base binary alloys (alloying elements Ti, Cr, Mn, Ni, Rh, and
W) in contact with single-crystal silicon carbide riders. Results
indicate that the coefficient of friction and groove height
(corresponding to the wear volume) decrease linearly as the shear
strength of the bulk metal increases. The coefficient of friction
and groove height generally decrease with an increase in solute content
of binary alloys. A separate correlation exists between the solute to iron

A80-13068 * // NASA gear research and its probable effect on
rotocraft transmission design. E. V. Zareskity, D. P. Townsend and
J. J. Coy (NASA, Lewis Research Center, Cleveland, Ohio).
American Helicopter Society, Meeting on Helicopter Propulsion

The NASA Lewis Research Center devised a comprehensive gear
technology research program beginning in 1969, the results of which
are being integrated into the NASA civilian Helicopter Transmission
System Technology Program. Attention is given to the results of this
gear research and those programs which are presently being under-
taken. In addition, research programs studying pitting fatigue, gear
steels and processing, life prediction methods, gear design and
dynamics, elastohydrodynamic lubrication, lubrication methods and
gear noise are presented. Finally, the impact of advanced gear
research technology on rotocraft transmission design is discussed.

A80-14727 * Some flow characteristics of conventional and
tapered high-pressure-drop simulated seals. R. C. Hendricks (NASA,
Lewis Research Center, Cleveland, Ohio), American Society of
Lubrication Engineers and American Society of Mechanical Engi-

ners, Lubrication Conference, Dayton, Ohio, Oct. 16-18, 1979,
atomic radius ratio and the decreasing rates of change of coefficient of friction and groove height with increasing solute content. The rates of change are minimum at a solute to iron atomic radius ratio of unity. They increase as the atomic ratio increases or decreases linearly from unity. The correlations indicate that atomic size is an important parameter in controlling friction and wear of alloys. (Author)

A80-15736 * #

This paper describes a method used to design elastomERICally damped supports for high-speed, flexible rotor-bearing systems. The procedure consists of using a damped natural frequency analysis to identify stiffness and damping requirements for the supports over the speed range. Optimum values for these coefficients are found and unbalance response analysis is used to calculate expected rotor behavior. Equations for calculating the shear and compressive stiffness and damping of button-type elastomeric mounts are given, as is a procedure for their application to the design of the elastomeric mounts. These techniques were successfully applied to the design of damped elastomeric supports for a high-speed rotor, which traverses two bending critical speeds. Results of the testing showed that the rotor was well behaved and showed linear response to unbalance. Measured modal damping exceeded expectations and tests were conducted with both high- and low-loss elastomers, enabling the exploration of the practical range of elastomer damping capability. (Author)

A80-24002 * #

This paper presents the results of a program of analysis and test to determine the dynamic properties of elastomer cartridge operating under a rotating load. These measured properties were compared to predictions based on results of unidirectional tests with the same elastomer material. The test method for the dynamic stiffness and damping measurements was essentially the same as the Base Excitation Resonant Mass Method. The primary difference is that the exciting force used for these most recent tests was exerted by rotating unbalance in a rotating test rig rather than a shake table. The specimen tested were: two rectangular cross-section, continuous rings of different cross-section and three cylindrical button cartridges of different button thickness. Tests were performed for strains from about 0.001 to about 0.01 (double amplitude). Material properties and prediction equations determined from reciprocating tests were used to make numerical predictions of stiffness, damping, and loss coefficient for the test elements, with encouraging results. Strain was shown to be an important parameter in determining these dynamic properties, particularly damping and loss coefficient. (Author)

A80-26010 * #
Wear of seal materials used in aircraft propulsion systems and grooved engine and the significance of wear for each type are presented. Material selection guidelines and the PV (contact pressure times sliding velocity) criteria for seal materials are discussed, and examples of wear mechanisms in positive contact seals are given. It is suggested that improved wear, erosion, and oxidation resistant materials will be required for improved seal durability; finally, a correlation is proposed between wear characteristics and a factor that includes material strength, ductility, specific heat and hot-working temperature to attain low porosity metallic gas path seal materials. A.T.

A80-31961 * #

In contrast to hydrodynamic bearings, which depend for low-friction characteristics on a fluid film between the journal and the bearing surfaces, roller-element bearings employ a number of balls or rollers that roll in an annular space. The paper briefly outlines the advantages and disadvantages of roller-element bearings as compared to hydrodynamic bearings. The discussion covers bearing types, rolling friction, friction losses in rolling bearings, contact stresses, deformation, stresses, and fatigue. The bearing dynamics including elastohydrodynamics, load distribution, lubrication (grease, solid oil, air-kinit), specific dynamic capacity and life, specific static capacity, and fatigue or wearout (elasto-hydrodynamics, wear). Rolling by air wear fac tor as a function of environment is plotted and discussed. S.D.

A80-42256 * #

Evaluation of power transmission shafting for high-speed balancing has shown that when axial torque is applied, the imbalance response is altered. An increase in synchronous excitation always occurs if the axial torque level is altered from the value used during balancing: this was the case even when the shaft was balanced with torque applied. The twisting of the long slender shaft produces a change in the imbalance distribution sufficient to disrupt the balanced state. This paper presents a review of the analytic development of a weighted least-squares approach to influence coefficient balancing and a review of experimental results. The analytic approach takes advantage of the fact that the past testing has shown that the influence coefficients are not significantly affected by the application of axial torque. The 3.60-m (12-ft) long aluminum shaft, 7.02 cm (3 in.) in diameter was run through the first flexural critical speed at torque levels ranging from zero-torque to 90.8 N-M (8000 lb-in.) in 112.9 N-M (1000 lb-in.) increments. Good comparison was achieved between predicted and experimental results. (Author)

A80-42272 * #

This paper describes the design and testing of an elastomer damper on a supercritical power transmission shaft. The elastomer were designed to provide acceptable operation through the fourth bending mode and to control synchronous as well as nonsynchronous vibration throughout the operating range. The design of the elastomer was such that it could be incorporated into the system as a replacement for a squeeze-film damper without a reassembly, which could have altered the imbalance of the shaft. This provided a direct comparison of the elastomer and squeeze-film dampers without having to assess the effect of shaft imbalance changes. (Author)

Existing theories of erosion of ductile metals based on cutting and deformation mechanisms predict no material removal at normal incidence which is contradictory to experience. Thus, other mechanisms may be involved. The possible role of adhesive material transfer during erosion is investigated by both single-particle impingement experiments and erosion by streams of particles. Examination of the rebounding particles as well as the eroded surfaces yields evidence of a significant adhesive mechanism for the ductile metals investigated.

(Author)


The tribological properties of polycrystalline graphite fluoride films were investigated. A spin-on disk type of testing apparatus was used; in addition to sliding a hemispherically tipped rider, a rider with a 0.95-mm diameter flat area slid against the film so that a lower, less variable contact stress could be achieved. Two stages of lubrication occurred: in the first, the film supported the load and the lubricating mechanism consisted of the shear of a thin surface layer between the rider and the bulk of the film. The second occurred after the bonded film had worn to the substrate, and consisted of the shear of a very thin lubricant film between the rider and flat plateaus generated on the metallic substrate asperities. The film wear mechanism was strongly dependent on contact stress.

(Author)


The Ferrograph was used to determine the types of quantities of wear particles generated during full-scale bearing fatigue tests. Deep-groove ball bearings made from AISI 52100 steel were used. A MIL-L-23699 tetraester lubricant was used in a recirculating lubrication system containing a 49-micron absolute filter. Test conditions included a maximum Hertz stress of 2.4 GPa, a shaft speed of 15,000 rpm, and a lubricant supply temperature of 74 C (165 F). Four fatigue failure were detected by accelerometers in this test set. In general, the Ferrograph was more sensitive (up to 23 h) in detecting wear particles generated during full-scale bearing fatigue tests, in addition to sliding a hemispherically tipped rider, a rider with a 0.95-mm diameter flat area slid against the film so that a lower, less variable contact stress could be achieved. Two stages of lubrication occurred: in the first, the film supported the load and the lubricating mechanism consisted of the shear of a thin surface layer between the rider and the bulk of the film. The second occurred after the bonded film had worn to the substrate, and consisted of the shear of a very thin lubricant film between the rider and flat plateaus generated on the metallic substrate asperities. The film wear mechanism was strongly dependent on contact stress.

(Author)


Four different compositions of self-lubricating, plasma-sprayed, composite coatings with calcium fluoride dispersed throughout cobalt alloy-silver matrices were evaluated on a friction and wear apparatus. In addition, coatings of the cobalt alloys alone and of one coating with a nickel alloy-silver matrix were evaluated for comparison. The wear specimens consisted of two, diametrically opposed, flat rub shoes sliding on the coated, cylindrical surface of a rotating disk. Two of the cobalt composite coatings gave a friction coefficient of about 0.25 and low wear at room temperature, 400 and 650 C. Wear rates were lower than those of the cobalt alloys alone or the nickel alloy composite coating by a factor of two. The nickel alloy composite coating gave high wear at low speeds but was worn to the substrate at high temperatures. The nickel alloy composite coating gave high wear at low speeds but was worn to the substrate at high temperatures. The nickel alloy composite coating gave high wear at low speeds but was worn to the substrate at high temperatures. The nickel alloy composite coating gave high wear at low speeds but was worn to the substrate at high temperatures. The nickel alloy composite coating gave high wear at low speeds but was worn to the substrate at high temperatures. The nickel alloy composite coating gave high wear at low speeds but was worn to the substrate at high temperatures.

(Author)


The results of the Materials for Advanced Turbine Engines (MATE) program initiated by NASA are presented. Mechanical properties comparisons are made for superalloy parts produced by as-HIP powder consolidation and by forging of HIP consolidated billets. The effect of various defects on the mechanical properties of powder parts are shown.

V.T.


A contact fatigue life analysis method for multiroller traction drives is presented. The method is based on the Lundberg-Palmgren analysis method for rolling element bearing life prediction, and also uses life test factors for materials, processing, lubrication, and effect of traction. The analysis method is applied in an optimization study to the multiroller traction drive, consisting of a single-stage planetary configuration with two rows of stepped planet rollers of five rollers per row. The drive was approximately 25 centimeters in diameter by 11 centimeters long, having a nominal ratio of 15:1. The theoretically predicted drive life was 2510 hours at a nominal continuous power and speed of 74.6 kW (100 hp) and 75,000 rpm.

(Author)


The results of an analysis of the effects of spur gear size, pitch, width and ratio on total mesh power loss for a wide range of operating conditions are presented. The analysis uses simple algebraic expressions to determine gear sliding, rolling and windage losses and also incorporates an approximate ball bearing power loss expression. The analysis shows good agreement with published data. Large diameter and fine-pitched gears had higher peak efficiencies but lower part-load efficiency. Gear efficiencies were generally greater than 98 percent except at very low torque levels. Tare (no-load) losses are generally a significant percentage of the full-load loss except at low speeds.

(Author)


The results of a test program to evaluate a compact, high performance, fixed-ratio traction drive are presented. This transmission, the Nasvytis Multiroller Traction Drive, is a fixed-ratio, single-stage planetary with two rows of stepped planet-rollers. Two versions of the drive were parametrically tested under back-to-back operating conditions at speeds to 73,000 rpm and power levels to 180 kW (240 hp). Parametric tests were also conducted with the Nasvytis drive
and E. V. Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio).

Gear endurance tests and rolling-element fatigue tests were conducted to compare the performance of spur gears made from AISI 9310, CBS 600 and modified Vasco X-2 and to compare the pitting fatigue lives of these three materials. Gears manufactured from CBS 600 exhibited lives longer than those manufactured from AISI 9310. However, rolling-element fatigue tests resulted in statistically equivalent lives, Modified Vasco X-2 exhibited statistically equivalent lives to AISI 9310. CBS 600 and modified Vasco X-2 gears exhibited the potential for tooth fracture occurring at a tooth surface fatigue pit. Case carburization of all gear surfaces for the modified Vasco X-2 gears results in fracture at the tips of the gears.

A gear tooth temperature analysis was performed using a finite element method combined with a calculated heat input, calculated oil jet impingement depth, and estimated heat transfer coefficients. Experimental measurements of gear tooth average surface temperatures and instantaneous surface temperatures were made with a fast response infrared radiometric microscope. Increased oil jet pressure had a significant effect on both average and peak surface temperatures at both the tooth root and tip. Increasing the speed at constant load and increasing the load at constant speed causes a significant rise in average and peak surface temperatures of gear teeth. The oil jet pressure required for adequate cooling at high speed and load conditions must be high enough to get full depth penetration of the teeth. Calculated and experimental results were in good agreement with high oil jet penetration but showed poor agreement with low oil jet penetration depth.

A simplified fatigue life analysis for traction drive contacts of arbitrary geometry is presented. The analysis is based on the Lundberg-Palmgren theory used for rolling-element bearings. The effects of torque, element size, speed, contact ellipse ratio, and the influence of traction coefficient are shown. The analysis shows that within the limits of the available traction coefficient, traction contacts exhibit longest life at high speeds. Multiple, load-sharing roller arrangements have an advantageous effect on system life, torque capacity, power-to-weight ratio and size.

The feasibility of silicon carbide composite structures was evaluated for 1644 K gas turbine seal applications. The silicon carbide composites evaluated consisted of SiC/Sicomp (Trademark) - and sintered silicon carbide as substrates, both with attached surface layers containing BN as an additive. A total of twenty-eight candidates with variations in substrate type and density, and layer chemistry, density, microstructure, and thickness were evaluated for abradability, cold particle erosion resistance, static oxidation resistance, ballistic impact resistance, and fabricability. The BN-free layers with variations in density and pore size were later added for evaluation. The most promising candidates were evaluated for Mach 1.0 gas oxidation/erosion resistance from 1477 K to 1644 K. The as-fabricated rub layers did not perform satisfactorily in the gas oxidation/erosion tests. However, preoxidation was found to be beneficial in improving the hot gas erosion resistance. Overall, the laboratory and rig test evaluations show that material properties are suitable for 1477 K gas turbine seal applications.

A study of fundamental rub behavior for ten dense sprayed materials and eight current compressor clearance materials has been conducted. A literature survey of a wide variety of metallurgical and thermophysical properties was conducted and correlated to rub behavior. Based on these results, the most promising dense rub material was Cu-9Al. Additional studies on the effects of porosity, incursion rate, blade solidity and ambient temperature were carried out on aluminum bronze (Cu-9Al-Fe) with and without a 515B Feltmetal underlayer.

The potential role of superalloys, refractory alloys, and ceramics in the hottest sections of engines operating with turbine
inlet temperatures as high as 1370 C is examined. The conventional superalloys, directionally solidified eutectics, oxide dispersion strengthened alloys, and tungsten fiber reinforced superalloys are reviewed and compared on the basis of maximum turbine blade temperature capability. Improved high temperature protective coatings and special fabrication techniques for these advanced alloys are discussed. Chromium, columbium, niobium, tantalum, and tungsten alloys are also reviewed. Molybdenum alloys are found to be the most suitable for mass produced turbine wheels. Various forms and fabrication processes for silicon nitride, silicon carbide, and SIALON's are investigated for use in high-stress and medium high temperature environments.

K. L.

N80-18402* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.


A tire and wheel assembly is described which consists of a low profile pneumatic tire with sidewalls that deflect inwardly under a load and a wheel having a narrow central channel and extended rim flanges. The extended rim flanges support the tire sidewalls under static and dynamic loading conditions to produce a combination particularly suited to aircraft applications. NASA


TESTING OF RECIPROCATING SEALS FOR APPLICATION IN A STIRLING CYCLE ENGINE J. F. Curulla and T. L. Beck Feb. 1980 76 p refs (Contract NASA-20612)

(NASA-CR-159820; DOE/NASA/1062-80/1; BCAC-68-48915) Avail: NTIS HC A05/MF A01 CSCL 11A

Six single stage reciprocating seal configurations to the requirements of the Stirling cycle engine were evaluated. The seals tested were: the Boeing Foot seal, NASA Chevron polyimide seal, Bell seal, Quad seal, Tetrasel, and Dynabak seal. None of these seal configurations met the leakage goals of 0.002 cc/sec at helium gas pressure of 1.22 x 10 to the 7th power, rod speed of 7.19 m/sec peak, and seal environmental temperature of 408 K for 1500 hours. All test seals failed due to high temperatures. Catastrophic failures were observed for a minimum number of test runs characterized by extremely high leakage rates and large temperature rises. The Bell seal attained 63 hours of run time at significantly lowered test conditions. E.D.K.

N80-22702* Kumm (Emerson L.), Tempe, Ariz.

DESIGN STUDY OF FLAT BELT CVT FOR ELECTRIC VEHICLES Emerson L. Kumm Mar. 1980 159 p refs (Contract DEN3-114; Contract EC-77-A-31-1044) (NASA-CR-159822; P-1006) Avail: NTIS HC A08/MF A01 CSCL 13A

A continuously variable transmission (CVT) was studied, using a novel flat belt pulley arrangement which couples the high speed output shaft of an energy storage flywheel to the drive train of an electric vehicle. A specific CVT arrangement was recommended and its components were selected and sized, based on the design requirements of a 1700 KG vehicle. A design layout was prepared and engineering calculations made of component efficiencies and operating life. The transmission efficiency was calculated to be significantly over 90% with the expected vehicle consistent with automotive practice for low future production costs was considered, together with maintainability. The technology advancements required to develop the flat belt CVT were identified and an estimate was made of how the size of the flat belt CVT scales to larger engine and smaller design output torques. The suitability of the flat belt CVT for alternate application to an electric vehicle powered by an electric motor without flywheel and to a hybrid electric vehicle powered by an electric motor with an internal combustion engine was studied. E.D.K.


The development, evaluation, and optimization of a preliminary design concept for a continuously variable transmission (CVT) to couple the high-speed output shaft of an energy storage flywheel to the drive train of an electric vehicle is discussed. An existing computer simulation program was modified and used to compare the performance of five CVT design configurations. Based on this analysis, a dual-cavity toroidal drive with regenerative gearing is selected for the CVT design configuration. Three areas are identified that will require some technological development: the ratio control system, the traction fluid properties, and evaluation of the traction contact performance. Finally, the suitability of the selected CVT design concept for alternate electric and hybrid vehicle applications and alternate vehicle sizes and maximum output torques is determined. In all cases the toroidal traction drive design concept is applicable to the vehicle system. The regenerative gearing could be eliminated in the electric powered vehicle because of the reduced ratio range requirements. In other cases the CVT with regenerative gearing would meet the design requirements after appropriate adjustments in size and reduction gearing ratio. M.G.

N80-24820* Chrysler Corp., Detroit, Mich.


Tests results on a baseline engine are presented to document the automotive gas turbine state-of-the-art at the start of the program. The performance characteristics of the engine and of a vehicle powered by this engine are defined. Component improvement concepts in the baseline engine were evaluated on engine dynamometer tests in the complete vehicle on the chassis dynamometer and on road tests. The concepts included advanced combustors, ceramic regenerators, an integrated control system, low cost turbine material, a continuously variable transmission, power-turbine-driven accessories, power augmentation, and lineless insulation in the engine housing. R.E.S.

N80-24621* Chrysler Corp., Detroit, Mich.


Automotive gas turbine concepts with significant technological advantages over the spark ignition (SI) engine were assessed. Possible design concepts were rated with respect to fuel economy and near-term application. A program plan which outlines the development of the improved gas turbine (IGT) concept that best met the goals and objectives of the study identifies the research and development work needed to meet the goal of entering a production engineering phase by 1983. The fuel economy goal is to show at least a 20% improvement over a conventional 1976 SI engine/vehicle system. On the basis of achieving the fuel economy goal, of overall suitability to mechanical design, and of automotive mass production cost, the powertrain selected was a single-stage engine with a radial turbine and a continuously variable transmission (CVT). Design turbine inlet temperature was 1150 C. Reflecting near-term technology, the turbine rotor would be made of advanced superalloy, and the transmission would be a hydromechanical CVT. With successful progress in long-lead R&D in ceramic technology and the belt-drive CVT, the turbine inlet temperature would be
Recommendations are made, based on experiences with stable and unstable compressors, which can be used as guides in future designs. High and low pressure compressors which operate well above their fundamental rotor-bearing lateral natural frequencies can suffer from destructive subsynchronous vibration. Usually the elements in the system design which contribute to this vibration, other than the shafting and the bearings, are the seals (both gas labyrinth and oil breakdown bushings) and the aerodynamic components.

A high pressure, low capacity, liquid hydrogen turbopump was designed, fabricated, and tested. The design configuration of the turbopump is summarized and the results of the analytical and test efforts are presented. Approaches used to pinpoint the cause of poor suction performance with the original design are described and performance data are included with an axial inlet design which results in excellent suction capability. E.D.K.

The problems which developed and the remedies attempted in each case are discussed. Instability problems resulted in lost compressor maintenance expenditures. The need for effective methods to identify the problem in the field and in the compressor design stage is emphasized, M.G.

The original design analysis and shop test data are presented for a three stage (poster) air compressor with impellers mounted on the extensions of a twin pinion gear, and driven by an 8000 hp synchronous motor. Also included are field test data, subsequent rotor dynamics analysis, modifications, and final rotor behavior. A subsynchronous instability existed on a geared, overhung rotor. State-of-the-art rotor dynamics analysis techniques provided a reasonable analytical model of the rotor. A bearing modification arrived at analytically eliminated the instability, M.G.

The measurability of destabilizing actions is demonstrated for a rotor built to produce a forward circular, self excited malfunction (gas whirl). It is argued that the continued use of past modeling techniques is unfortunate in that it has led to the use of inappropriate words to express what is happening and a lack of full understanding of the geometry of a forward circular whirl instability mechanisms. M.G.
An unstable asynchronous vibration problem in a high pressure centrifugal compressor and the remedial actions against it are described. Asynchronous vibration of the compressor took place when the discharge pressure (Pd) was increased, after the rotor was already at full speed. The typical spectral data of the shaft vibration indicate that as the pressure Pd increases, pre-unstable vibration appears and becomes larger, and large unstable asynchronous vibration occurs suddenly (Pd - 5.49MPa). A computer program was used which calculated the logarithmic decrement and the damped natural frequency of the rotor bearing systems. The analysis of the log-decrement is concluded to be effective in preventing unstable vibration in both the design stage and remedial actions. 

M. G.

N80-29714# Louisville Univ., Ky. Mechanical Engineering Dept.

TESTING OF TURBULENT SEALS FOR ROTODYNAMIC COEFFICIENTS

A test program developed for dynamic testing of straight and convergent-tapered seals, with the capability of separately determining both direct and cross-coupled stiffness, damping, and added mass coefficients is described. The test apparatus causes the seal journal to execute small-eccentricity centered circular orbits within its bearings. Dynamic measurements are made and recorded of the seal-displacement-vector components, and of the pressure field. The pressure field is integrated to yield seal reaction force components. The displacement and force vector components are analyzed via a generalized Newton-Raphson procedure to yield the desired seal dynamic coefficients. Representative test data are provided and discussed.

M. G.

N80-29715# Kobe Univ., (Japan). Engineering Dept.

EVALUATION OF INSTABILITY FORCES OF LABYRINTH SEALS IN TURBINES OR COMPRESSORS
Tkuskuzo Iwatsubo In NASA Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 139-167 refs (For primary document see N80-29706 20-37) Avail. NTIS HC A20/MF A01 CSCL 131

The effects of a force induced by the labyrinth seal on the stability of rotor systems and the factors of the seal which affect the stability are investigated. In the analysis, it is assumed that the fluid in the seal is steady and that the rotor is set vertically in order to avoid the effects of gravity force. The force induced by the seal is expressed in terms proportional to the velocity and displacement of the rotor and is deduced from that expression for the oil film force in journal bearings. That force is taken into account in the equations of motion; then the stability of the system is discussed by energy concept. The force induced by the labyrinth seal always makes the rotor system unstable, and the tendency is marked when seal leakages are small. The resonance point of the rotor system is also affected by the labyrinth seal (the resonance point of the rotor system is removed by the seal leakages). The force induced by the labyrinth seal was measured by using a water-tunnel experimental system which was designed to measure the labyrinth seal force by using the similarity between gas and liquid flow theory.

M. G.

Flow induced aerodynamic spring coefficients of labyrinth seals are discussed and the restoring force in the deflection plane of the rotor and the lateral force acting perpendicularly to it are also considered. The effects of operational conditions on the spring characteristics of these components are examined, such as differential pressure, speed, inlet flow conditions, and the geometry of the labyrinth seals. Estimation formulas for the lateral forces due to shaft rotation and inlet swirl, which are developed through experiments, are presented. The utilization of the investigations is explained and results of stability calculations, especially for high pressure centrifugal compressors, are added. Suggestions are made concerning the avoidance of exciting forces in labyrinths.

M. G.

N80-29719# California Inst. of Tech., Pasadena.

A TEST PROGRAM TO MEASURE FLUID MECHANICAL WHIRL-EXCITATION FORCES IN CENTRIFUGAL PUMPS

The hydraulic forces caused by annular pressure seal were investigated. The measured inlet and exit loss coefficients of the flow through the seals were much smaller than the conventional. The results indicate that the damping coefficient and the inertia coefficient of the fluid film in the seal are not affected much by the rotational speed or the eccentricity of the rotor, though the stiffness coefficient seemed to be influenced by the eccentricity.

R.C.T.

N80-29720# Technical Univ. of Denmark, Copenhagen.

EFFECT OF FLUID FORCES ON ROTOR STABILITY OF CENTRIFUGAL COMPRESSORS AND PUMPS
Jorgen Colding-Jorgensen In NASA Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 249-265 refs (For primary document see N80-29706 20-37) Avail. NTIS HC A20/MF A01 CSCL 131

A simple two dimensional model for calculating the rotodynamic effects of the impeller forces in centrifugal compressors and pumps is presented. It is based on potential flow theory with singularities. Equivalent stiffness and damping coefficients are calculated for a machine with a vanesless volute formed as a logarithmic spiral. It is shown that for certain operating conditions, the impeller force has a destabilizing effect on the rotor.

R.C.T.

N80-29721# Cornell Univ., Ithaca, N. Y.

NON-SYNCHRONOUS WHIRLING DUE TO FLUID-DYNAMIC FORCES IN AXIAL TURBOMACHINERY ROTORS
Shen Fu Shen and Vinod G. Mangle In NASA Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 267-284 refs (For primary document see N80-29706 20-37) Avail. NTIS HC A20/MF A01 CSCL 131

The role of fluid forces acting on the blades of an axial turborotor with regards to whirling was analyzed. The dynamic
equations were formulated for the coning mode of an overhung rotor. The exciting forces due to the motion were defined through a set of rotor stability derivatives, and analytical expressions of the aerodynamic contributions were found for the case of small mean stream deflection, high solidity and equivalent flat plate cascade. For a typical case, only a backward whirl was indicated when the phase shifting of the rotor wake effect was ignored.

A parametric study of the dynamic stability boundary method that a reduction in blade stagger angle. mass Row rate, fluid forces, elastic hysteresis, and forces from fluid flow through clearances were considered as possible origins, A theoretical evaluation was made to determine the dependence of the forces and damping coefficient per stage needed for stability is delta sub fluid. Results indicate that the average total damping coefficient per stage needed for stability is delta sub fluid > 1.85.

The limitations in the performance of turbomachines which arise as a result of selfexcited vibration were investigated. Bearing instability regions and types is considered for both unequal principal shaft stiffness (generators) and offset disc rotors (ventilators). Instability regions and types of instability are based on an axial groove bearing. Linear analysis precedes nonlinear simulation of some unstable conditions, The demonstra- tion of small limit cycles suggests that necessarily flexible rotors, e.g., helicopter tail rotors, may be practical without either tilt pad bearings or external dampers.

Avail: NTIS HC A20/MF A01 CSCL 131

The destabilizing effect of rotating damping was investigated, When the rotation was faster than the whirl, rotating damping drags the orbiting particle forward. When stationary damping was also present, the stability borderline was readily determined by balancing the backward and forward drags. A key notion was that a forward whirl at rate omega a sub n with respect to stationary axis appears to be a backward whirl at rate Omega - omega sub n with respect to a system rotating supercritically at rate Omega. The growth rate of unstable whirls (or the decay rate of stable whirls) was readily estimated by a simple energy balance.

Avail: NTIS HC A20/MF A01 CSCL 131

R.C.T.
resonances in the second case. Computed and experimental results are compared for laboratory machine models. A field case study of parametric vibrations in industrial ventilators is reported. Computed parametric resonances are confirmed in field measurements, and some industrial failures are explained. Also the dynamic influence and gyroscopic effect of supporting structures are shown and computed. R.C.T.

A new method for analyzing the first mode stability and unbalance response of multimass flexible rotors in multihub and pressure dam were considered. Optimum and nonoptimum geometric configurations were tested. The optimum geometric configurations were determined by using a theoretical analysis and then the bearings were constructed for a flexible rotor test rig. It was found that optimizing bearings using this technique produces a 100% or greater increase in rotor stability. It is shown that this increase in rotor stability is carried out in the absence of certain types of instability mechanisms such as aerodynamic crosscoupling. However, the increase in rotor stability should greatly improve rotating machinery performance in the presence of such forces as well. R.C.T.

Some of the considerations involved in the use of feedback control as a means of eliminating or alleviating rotordynamic instability are discussed. A simple model of a mass on a flexible shaft is used to illustrate the application of feedback control concepts. R.C.T.
Results are presented for the design and development of an upgraded engine. The design incorporated technology advancements which resulted from development testing on the Baseline Engine. The final engine performance with all retro-fitted components from the development program showed a value of 91 HP at design speed in contrast to the design value of 104 HP. The design speed SFC was 0.53 versus the goal value of 0.44. The mass in power was primarily due to missing the efficiency targets of small size turbomachinery. Most of the SFC components from the development program showed a value of 0.44. The miss in power was primarily due to missing the efficiency targets of small size turbomachinery. Most of the SFC deficit was attributed to missed goals in the heat recovery system relative to regenerator effectiveness and expected values of heat loss. Vehicular fuel consumption, as measured on a chassis dynamometer, for a vehicle inertia weight of 3500 lbs., was 15 MPG for combined urban and highway driving cycles. The baseline engine achieved 8 MPG with a 4500 lb. vehicle. Even though the goal of 18.3 MPG was not achieved with the upgraded engine, there was an improvement in fuel economy of 46% over the baseline engine, for comparable vehicle inertia weight.

A.R.H.


Analytical studies of phase change effects in parallel and tapered liquid face seals are presented. An isothermal and adiabatic model of low Reynolds number flow is considered by numerical integration of the descriptive equations for a real fluid, and its thermodynamic properties are calculated for each step, using a computer program for the steam tables or fluid thermodynamic properties. It was shown that low leakage rate the isothermal model is more accurate and for high leakage rates the adiabatic model is more accurate; that both models yield the same conclusions regarding stability; and that the transient of collapse is described by the adiabatic model which predicts a catastrophic collapse and then either failure or explosive return to a larger film thickness value. Finally, it is shown that converging seals may become unstable and the mass leakage rate is reduced significantly below the all liquid value when boiling occurs.

A.T.


This paper documents the analytic foundation and software architecture for the computerized mathematical simulation of high speed cylindrical rolling element bearing behavior. The software, CYBEAN (CYlindrical BEaring ANalysis), considers a flexible, variable geometry outer ring, EHD films, roller centrifugal and quasidynamic loads, roller tilt and skew, mounting fits, cage and flange interactions. The representation includes both steady state and time transient simulation of thermal interactions internal to and coupled with the surroundings of the bearing. A sample problem illustrating program use is presented.

S.D.
38 QUALITY ASSURANCE AND RELIABILITY
Includes product sampling procedures and techniques, and quality control

N80-15422* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. PHOTOVOLTAIC POWER SYSTEM RELIABILITY CONSIDERATIONS
(NASA-TM-79291, DOE/NASA/20370-79/19, E-235) Avail. NTIS HC A02/MF A01 CSCL 14D

An example was how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems is presented. This particular application is for a solar cell power system demonstration project designed to provide electric power requirements for remote villages. The techniques utilized involve a definition of the power system natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and FMEA methods, and use of fail-safe and planned spare parts engineering philosophy. J.M.S.

N80-22714* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. SIMULATION OF TRANSUDER-COUPLED EFFECTS ON BROADBAND ULTRASONIC SIGNALS

The increasing use of broadband, pulse-echo ultrasonics in nondestructive evaluation, flaws and material properties has generated a need for improved understanding of the way signals are modified by coupled and bonded thin-layer interfaces associated with transducers. This understanding is most important when using frequency spectrum analyses for characterizing material properties. In this type of application, signals emanating from material specimens can be strongly influenced by coupling and bond-layers in the acoustic path. Computer synthesized waveforms were used to simulate a range of interface conditions encountered in ultrasonic transducer systems operating in the 20 to 80 MHz regime. The adverse effects of thin-layer multiple reflections associated with various acoustic impedance conditions are demonstrated. The information presented is relevant to ultrasonic transducer design, specimen preparation, and couplant selection. Author

N80-24634* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. CONCEPTS AND TECHNIQUES FOR ULTRASONIC EVALUATION OF MATERIAL MECHANICAL PROPERTIES

Ultrasonic methods that can be used for material strength are reviewed. Emergency technology involving advanced ultrasonic techniques and associated measurements is described. It is shown that ultrasonic NDE is particularly useful in this area because it involves mechanical elastic waves that are strongly modulated by morphological factors that govern mechanical strength and also dynamic failure modes. These aspects of ultrasonic NDE are described in conjunction with advanced approaches and theoretical concepts for signal acquisition and analysis for materials characterization. It is emphasized that the technology is in its infancy and that much effort is still required before the techniques and concepts can be transferred from laboratory to field conditions. A.R.H.

N80-26882* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. QUANTITATIVE ULTRASONIC EVALUATION OF ENGINEERING PROPERTIES IN METALS, COMPOSITES AND CERAMICS

Ultrasonic technology from the perspective of nondestructive evaluation approaches to material strength prediction and property verification is reviewed. Emergent advanced technology involving quantitative ultrasonic techniques for materials characterization is described. Ultrasonic methods are particularly useful in this area because they involve mechanical elastic waves that are strongly modulated by the same morphological factors that govern mechanical strength and dynamic failure processes. It is emphasized that the technology is in its infancy and that much effort is still required before the techniques can be transferred from laboratory to industrial environments.


The ultrasonic nondestructive evaluation techniques discussed in this paper indicate potentials for material characterization and property prediction. Stress wave interaction and material transfer function concepts are examined as a basis for explaining correlations between material mechanical behavior and ultrasonically measured quantities. It is observed that the effect and criticality of any discrete flaw, such as crack, inclusion, or any other stress raiser, is definable only in terms of its material microstructural environment. This underscores the importance of ultrasonic techniques capable of characterizing the stress wave transfer properties of a material. V.P.

A80-39641* # Quantitative ultrasonic evaluation of engineering properties in metals, composites, and ceramics. A. Vary (NASA, Lewis Research Center, Cleveland, Ohio), National Research Council of Canada, Seminar on Advanced Ultrasonic Technology, 1st, Longueuil, Quebec, Canada, June 9, 10, 1980, Paper. 16 p. 84 refs.

Ultrasonic techniques that have demonstrated potential for material characterization are reviewed. These techniques rely on physical acoustic properties of materials and the interaction of elastic stress waves with morphological factors in the ultrasonic regime. The speed of wave propagation and energy loss by interaction with material microstructure and geometrical factors underlie ultrasonic determination of material properties. Two categories of ultrasonic measurements are discussed: those related to material strengths (e.g., elastic moduli, tensile strength, and fracture toughness) and those related to morphology and material conditions that govern strength and performance (e.g., microstructure, void content, residual stress, fatigue damage). It is shown that large-scale industrial application of ultrasonic NDE will depend on advancement in such areas as theory development, instrumentation, system automation, standardization, and coordination with design. V.L.


A finite element computer program using the initial stress
approach of elastic-plastic analysis was developed. Crack closure stresses were calculated for three different models. It was concluded that (1) the closure stress is highest in the strip necking model, lowest in the plane strain model, and intermediate in the plane stress model, and (2) the crack closure stress decreases if the separation occurs before the stress reaches the maximum value. Nonpropagating fatigue cracks in the two phase martensite-ferritic steels were also investigated. Unzipping increments were calculated for different crack lengths. At a prescribed stress intensity level, the shorter the crack length, the greater the unzipping increment is. This means that the shorter crack will grow faster than the longer one if both are subjected to the same K-level.
39 STRUCTURAL MECHANICS

Includes structural element design and weight analysis, fatigue, and thermal stress.


N80-13513*# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

COMPARISON TESTS AND EXPERIMENTAL COMPLIANCE CALIBRATION OF THE PROPOSED STANDARD ROUND COMPACT PLANE STRAIN FRACTURE TOUGHNESS SPECIMEN

D. M. Fisher and R. J. Buzzard Nov. 1979 21 p refs
(NASA-TM-81379; E-284) Avail. NTIS HC A02/MF A01 CSCL 20K

Standard round specimen fracture test results compared satisfactorily with results from standard rectangular compact specimens machined from the same material. The location of the loading pin holes was found to provide adequate strength in the load bearing region for plane strain fracture toughness testing. Excellent agreement was found between the stress intensity coefficient values obtained from compliance measurements and the analytic solution proposed for inclusion in the standard test method. Load displacement measurements were made using long arm displacement gages and hollow loading cylinders. Gage points registered on the loading hole surfaces through small holes in the walls of the loading cylinders. Author

N80-15428*# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

A RELATION BETWEEN SEMIEMPIRICAL FRACTURE ANALYSES AND R-CURVES

Thomas W. Orange Jan. 1980 45 p refs
(NASA-TP-1600; E-9963) Avail. NTIS HC A03/MF A01 CSCL 20K

The relations between several semiempirical fracture analyses (SEFA) and the R-curve concept of fracture mechanics are examined and the conditions for equivalence between a SEFA and an R-curve are derived. A hypothetical material is employed to study the relation analytically. Equivalent R-curves are developed for several real materials using data from the literature. For each SEFA there is an equivalent R-curve whose magnitude and shape are determined by the SEFA formulation and its empirical parameters. If the R-curve is indeed unique, then the various empirical parameters cannot be constant, and vice versa. However, for one SEFA the differences are small enough that they may be within the range of normal data scatter for real materials. Author

N80-22734*# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

NONLINEAR, THREE-DIMENSIONAL FINITE-ELEMENT ANALYSIS OF AIR-COOLED GAS TURBINE BLADES

Albert Kaufman and Raymond E. Gougler Apr. 1980 22 p refs
(NASA-TP-1669; E-074) Avail. NTIS HC A02/MF A01 CSCL 21E

Cyclic stress-strain states in cooled turbine blades were calculated for a simulated mission of an advanced-technology commercial aircraft engine. The MARC nonlinear, finite-element computer program was used for the analysis of impingement-cooled airfoils, with and without leading-edge film cooling. Creep was the predominant damage mode (ignoring hot corrosion), particularly around film-cooling holes. Radially angled holes exhibited less creep than holes with axes normal to the surface. Beam-theory analysis of all-impingement-cooled airfoils gave fair agreement with MARC results for initial creep. Author

N80-23864*# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

PRACTICAL IMPLEMENTATION OF THE DOUBLE LINEAR DAMAGE RULE AND DAMAGE CURVE APPROACH FOR TREATING CUMULATIVE FATIGUE DAMAGE

S. S. Manson (Case Western Reserve Univ.) and G. R. Halford Apr. 1980 50 p refs
(NASA-TP-16157; E-387) Avail. NTIS HC A03/MF A01 CSCL 20K

Simple procedures are presented for treating cumulative fatigue damage under complex loading history using either the damage curve concept or the double linear damage rule. A single equation is provided for use with the damage curve approach; each loading event providing a fraction of damage until failure is presumed to occur when the damage sum becomes unity. For the double linear damage rule, analytical expressions are provided for determining the two phases of life. The procedure involves two steps, each similar to the conventional application of the commonly used linear damage rule. When the sum of cycle ratios based on phase 1 lives reaches unity, phase 1 is presumed complete, and further loadings are summed as cycle ratios on phase 2 lives. When the phase 2 sum reaches unity, failure is presumed to occur. No other physical properties or material constants than those normally used in a conventional linear damage rule analysis are required for application of either of the two cumulative damage methods described. Illustrations and comparisons of both methods are discussed. Author

N80-27719*# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

COMPARISON OF ELASTIC AND ELASTIC-PLASTIC STRUCTURAL ANALYSES FOR COOLED TURBINE BLADE AIRFOILS

Albert Kaufman Jul. 1980 15 p refs
(NASA-TP-1679; E-241) Avail. NTIS HC A02/MF A01 CSCL 20K

Elastic plastic stress strain states in cooled turbine blade airfoils were calculated by three methods for the initial takeoff transient of an advanced technology aircraft engine. The three analytical methods compared were a three dimensional elastic plastic, finite element analysis, a three dimensional, elastic, finite element analysis, and a one dimensional, elastic plastic, beam theory analysis. Structural analyses were performed for eight cases involving different combinations of mechanical and thermal loading on impingement cooled airfoils with and without leading edge film cooling holes. The von Mises effective total strains at maximum takeoff computed from the elastic and elastic plastic finite element analyses agreed with 9 percent for rotating airfoils and 28 percent for stationary airfoils with the elastic results on the conservative side. Author

N80-32763*# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

THE METHOD OF LINES IN THREE DIMENSIONAL FRACTURE MECHANICS

A review of recent developments in the calculation of design parameters for fracture mechanics by the method of lines (MOL) is presented. The three-dimensional elastic and elasto-plastic formulations are examined and results from previous and current research activities are reported. The application of MOL to the appropriate partial differential equations of equilibrium leads to coupled sets of simultaneous ordinary differential equations. Solutions of these equations are obtained by the Peano-Baker and by the recurrence relations methods. The advantages and limitations of both solution methods from the computational standpoint are summarized.

R.K.G.


The paper presents simple spline-function equations for fracture mechanics calculations. A spline function is a sequence of piecewise polynomials of degree n greater than 1 whose coefficients are such that the function and its first n-1 derivatives are continuous. Second-degree spline equations are proposed for the point bend, and crack-line wedge-loaded specimens. Some expressions can be used directly, so that for a cyclic crack propagation test using a compact specimen, the equation given allows the crack length to be calculated from the slope of the load-displacement curve. For an R-curve test, equations allow the crack length and stress intensity factor to be calculated from the displacement and the displacement ratio.

A.T.


The stability of a beam subjected to compressive centrifugal forces arising from steady rotation about an axis which does not pass through the clamped end of the beam is analyzed to determine the critical rotational speeds for buckling in the in-plane and out-of-plane directions. The differential equations of motion are solved numerically using an integrating matrix method in combination with an eigenanalysis to determine the eigenvalues from which stability is assessed. The results clarify several differences which have been identified in the literature relating to the proper behavior of the critical rotational speed for buckling as the radius of rotation of the clamped end of the beam is reduced.


The method of Strainrange Partitioning is used to predict the cyclic lives of the Metal Properties Council's long time creep-fatigue intermission tests of several steel alloys. Comparisons are made with predictions based upon the Time- and Cycle-Fraction approach. The method of Strainrange Partitioning is shown to give consistently more accurate predictions of cyclic life than is given by the Time- and Cycle-Fraction approach.


A convenient procedure is described for the determination of the mechanical behavior (elastic properties and failure stresses of angleplied fiber composite laminates using a pocket calculator. The procedure consists of simple equations and appropriate graphs of (plus or minus theta) ply combinations. The procedure can handle all types of fiber composites including hybrids. The versatility and generality of the procedure is illustrated using several step-by-step numerical examples.


The paper presents data relevant to several types of aerelastic instabilities which have been obtained using several types of turbojet and turbofan engines. Special attention is given to data relative to separated flow (stall), compressor, engine flutter, and system mode instabilities. The discussion covers the characteristics of these instabilities, and a number of correlations are presented that help identify the nature of the phenomena.

M.E.P.


Developments in the analysis of creep-rupture data are reviewed with particular reference to time temperature relations for the correlation and extrapolation of creep and stress rupture data, the minimum commitment method, and successive regression methods. Some contributions to the development of time-temperature parameters are noted.

V.P.

A80-45364  * Vibration and buckling of rectangular plates under in-plane hydrostatic loading. R. E. Kielp (NASA, Lewis Research Center, Cleveland, Ohio) and L. S. Han (Ohio State University, Columbus, Ohio). Journal of Sound and Vibration, vol. 70, June 22, 1980, p. 543-555. 15 refs.

Numerical solutions are presented for the fundamental natural frequency and mode shape of a rectangular plate loaded by in-plane hydrostatic forces for a wide variety of aspect ratios, boundary conditions, and load magnitudes. All six possible combinations of simply supported and clamped edges are considered. The limiting conditions of unloaded vibration and buckling are discussed in detail, with emphasis on the preferred mode shape. Design curves and approximate formulae are presented which provide a simple means of determining the fundamental frequency parameter.


For the determination of fracture toughness especially with brittle materials, a short bar specimen with rectangular cross section and chevron notch can be used. As the crack propagates from the tip of the triangular notch, the load increases to a maximum then decreases. To obtain the relation between the fracture toughness and...
maximum load, calculations of Srawley and Gross for specimens with a straight-through crack were applied to the specimens with chevron notches. The specimens with a straight-through crack, an analytical expression was obtained. This expression was used for the calculation of the fracture toughness versus maximum load relation under the assumption that the change of the compliance with crack length for the specimen with a chevron notch is the same as for a specimen with a straight-through crack. (Author)

N8O-10613# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div

PERFORMANCE DETERIORATION EFFECT OF TIME DEPENDENT FLIGHT LOADS ON JT9D-7

A Jay and B L Lewis 21 Aug 1979 73 p refs
HC A04/MF A01 CSCL 01C

The results of a modal transient analysis of the engine/aircraft system are presented. The response of the JT9D to analytically simulated vertical gusts and landings was predicted using a NASTRAN finite element mathematical model of the JT9D/74 propulsion system. The NASTRAN finite element model of the propulsion system included engine structural models of the fan, low/high pressure compressors, diffuser/turbine cases, and high/low pressure rotors, as well as actuator models of the nacelle, tailcone, and wing pylon. The analysis conducted predicts that an insignificant level of JT9D-7 performance deterioration would occur due to a typical vertical gust encounter or a typical revenue service landing. Analysis of a high sink rate landing with a heavy fuel load indicates the possibility of local wear, however, the lack of an accurate dynamic rotor/seal interference model precludes an accurate quantitative evaluation of performance change for this once-per-inframe-life event. J M S.

N8O-20732# Mechanical Technology, Inc., Latham, N Y

DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING OF ELASTOMERS IN ENGINEERING APPLICATIONS, PART 6

A Rieger, G Burgess, and E Zordan Apr 1980 157 p refs
(Contract NAS3-18546)
(NASA-CR-159838, MTI-80TR29) Avail: NTIS
HC A08/MF A01 CSCL 20K

An elastomer damper was designed, tested, and compared with the performance of a hydraulic damper for a power transmission shaft. The six button Viton-70 damper was designed so that the elastomer damper or the hydraulic damper could be activated without upsetting the imbalance condition of the assembly. This permitted a direct comparison of damper effectiveness. The elastomer damper consistently performed better than the hydraulic mount and permitted stable operation of the power transmission shaft to speeds higher than obtained with the squeeze film damper. Tests were performed on shear specimens of Viton-78, Buna-N, EPDM, and Neoprene to determine performance limitations imposed by strain, temperature, and frequency. Frequencies of between 110 Hz and 1100 Hz were surveyed with imposed strains between 0,0005 and 0.08 at temperatures of 32 C, 66 C, and 80 C. A set of design curves was generated in a unified format for each of the elastomer materials.

N8O-27720# Massachusetts Inst. of Tech., Cambridge

INSTRUCTIONS FOR THE USE OF THE CIVM-JET 4C FINITE-STRAIN COMPUTER CODE TO CALCULATE THE TRANSIENT STRUCTURAL RESPONSES OF PARTIAL AND/OR COMPLETE ARBITRARILY-CURVED RINGS SUBJECTED TO FRAGMENT IMPACT

Jose J A. Rodel, Susan E French, Emmett A. Witmer, and Thomas R. Stagliano Dec, 1979 38 p refs
(Grant NGR-22-009-339)
HC A03/MF A01

The CIVM-JET 4C computer program for the 'finite strain' analysis of 2 d transient structural responses of complete or partial rings and beams subjected to fragment impact stored on tape as a series of individual files. Which subroutines are found in these files are described in detail. All references to the CIVM-JET 4C program are made assuming that the user has a copy of NASA CR-134907 (ASRL TR-154-9) which serves as a user's guide to (1) the CIVM-JET 4C computer code and (2) the CIVM-JET 4C computer code 'with the use of the modified input instructions' attached hereto.

N8O-28762# Massachusetts Inst. of Tech., Cambridge

FINITE-STRAIN LARGE-DEFLECTION VISCOPLASTIC FINITE-ELEMENT TRANSIENT RESPONSE ANALYSIS OF STRUCTURES

Jose J A. Rodel and Emmett A. Witmer Jul, 1979 567 p refs
(Grant NGR-22-009-339)
HC A24/MF A01 CSCL 20K

A method of analysis for thin structures that incorporates finite strain, elastic-plastic, strain hardening, time dependent material behavior implemented with respect to a fixed configuration and is consistently valid for finite strains and finite rotations is developed. The theory is formulated systematically in a body fixed system of convected coordinates with materially embedded vectors that deform in common with continuum. Tensors are considered as linear vector functions and use is made of the dyadic representation. The kinematics of a deformed continuum is treated in detail, carefully defining precisely all quantities necessary for the analysis. The finite strain theory developed gives much better predictions and agreement with experiment than does the traditional small strain theory, and at practically no additional cost. This represents a very significant advance in the capability for the reliable prediction of nonlinear transient structural responses, including the reliable prediction of strains large enough to produce ductile metal rupture.
A method and apparatus for safely reducing abnormally high intraocular pressure in an eye during a predetermined time interval is presented. This allows maintenance of normal intraocular pressure during glaucoma surgery. According to the invention, a pressure regulator of the spring biased diaphragm type is provided with additional bias by a column of liquid. The height of the column of liquid is selected such that the pressure at a hypodermic needle connected to the output of the pressure regulator is equal to the measured pressure of the eye. The hypodermic needle can then be safely inserted into the anterior chamber of the eye. Liquid is then bled out of the column to reduce the bias on the diaphragm of the regulator and, consequently, the output pressure of the regulator. This lowering pressure of the regulator also occurs in the eye by means of a small second bleed path provided between the pressure regulator and the hypodermic needle. Alternately, a second hypodermic needle may be inserted into the eye to provide a controlled leak off path for excessive pressure and clouded fluid from the anterior chamber.

Official Gazette of the U.S. Patent and Trademark Office
43 EARTH RESOURCES
Includes remote sensing of earth resources by aircraft and spacecraft, photogrammetry, and aerial photography. For instrumentation see 35 Instrumentation and Photography.

N80-18538' National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POSSIBLE METHODS FOR DISTINGUISHING ICEBERGS FROM SHIPS BY AERIAL REMOT' SENSING

The simplest methods for aerial remote sensing which are least affected by atmospheric opacities are summarized. Radar is preferred for targets off the flight path, and microwave radiometry for targets along the flight path. Radar methods are classified by ability to resolve targets. Techniques which do not require target resolution are preferred. Among those techniques, polarization methods appear most promising, specifically those which differentiate the expected relatively greater depolarization by icebergs from that by ships or which detect doubly-reversed circular polarization.

R.C.T.

N80-18497' National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL CALCULATION OF STEADY INVISCID FULL POTENTIAL COMPRESSIBLE FLOW ABOUT WIND TURBINE BLADES

An exact nonlinear mathematical model that accounts for three-dimensional cascade effects about the inner portions of the rotor blades and compressibility effects about the tip regions of the blades was derived. An artificially time dependent version was iteratively solved by a finite volume technique involving an artificial viscosity and a three-level consecutive mesh refinement. The exact boundary conditions were applied by generating a boundary conforming periodic computation mesh.

K.L.

N80-20787' National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ASSESSMENT OF SATELLITE AND AIRCRAFT MULTISPECTRAL SCANNER DATA FOR STRIP-MINE MONITORING

The application of LANDSAT multispectral scanner data to describe the mining and reclamation changes of a hilltop surface coal mine in the rugged, mountainous area of eastern Kentucky is presented. Original single band satellite imagery, computer enhanced single band imagery, and computer classified imagery are presented for four different data sets in order to demonstrate the land cover changes that can be detected. Data obtained with an 11 band multispectral scanner on board a C-47 aircraft at an altitude of 3000 meters are also presented. Comparing the satellite data with color, infrared aerial photography, and ground survey data shows that significant changes in the disrupted area can be detected from LANDSAT band 5 satellite imagery for mines with more than 100 acres of disturbed area. However, band-ratio (bands 5/6) imagery provides greater contrast than single band imagery and can provide a qualitative level 1 classification of the land cover that may be useful for monitoring either the disturbed mining area or the revegetation progress. However, if a quantitative, accurate classification of the barren or revegetated classes is required, it is necessary to perform a detailed, four band computer classification of the data.

J.M.S.
44 ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells and batteries; global sources of energy; fossil fuels; geothermal conversion; hydropower; wind power.

For related information see also 07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 85 Urban Technology and Transportation.

N80-10594* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SOME TECHNIQUES FOR REDUCING THE TOWER SHADOW OF THE DOE/NASA MOD-0 WIND TURBINE TOWER Final Report


Wind speed profile measurements to measure the effect of a wind turbine tower on the wind velocity are presented. Measurements were made in the wake of scale models of the tower and in the wake of certain full scale components to determine the magnitude of the speed reduction (tower shadow). Shadow abatement techniques tested on the towers included the removal of diagonals, replacement of diagonals and horizontals with round cross section members, installation of elliptical shapes on horizontal members, installation of airfoils on vertical members, and application of surface roughness to vertical members. A.W.H.

N80-10595* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

NASA-LEWIS CLOSSED-CYCLE MAGNETOHYDRODYNAMICS PLANT ANALYSIS


A brief review of preliminary analyses of coal fired closed cycle MHD power plants is presented. The performance of three power plants with differing combustion systems were compared. The combustion systems considered were (1) a direct coal-fired combustor, (2) a coal gasifier with in-bed desulfurization and (3) a coal gasifier requiring external fuel gas cleanup. Power plant efficiencies (auxiliary power excluded) were 44.5, 43, and 41 percent for the three plants, respectively. R.E.S.

N80-12652* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

A PHOTOVOLTAIC POWER SYSTEM IN THE REMOTE AFRICAN VILLAGE OF TANGAYE, UPPER VOLTA

William J. Bifano, Anthony F. Rateljczak, and James E. Martz 1979 17 p ref. UNURAR Conf. on Long-Term Energy Resources, Montreal, 26 Nov. - 7 Dec 1979 Sponsored in part by AID. (NASA-TM-79318; E-274) Avail: NTIS HC A02/MF A01 CSCL 10B

A photovoltaic (PV) system powering a grain mill and a water pump was installed in the remote West African village of Tangaye, Upper Volta. Village characteristics as well as system design, hardware, installation and operation to date are described. The PV system cost is discussed. A baseline socio-economic study performed and a follow-up study is planned to determine the impact of the system on the villagers. R.E.S.
described. Experiments were run to determine the corrosivity effects of trace metal contaminants (and potential fuel additives) on gas turbine materials and these results were correlated in a corrosion-life prediction model. Actual fuels were burned in a burner rig hot corrosion test to verify the model. A deposition prediction model was assembled and compared with results of actual coal-derived fuel deposition tests. Thermal barrier coatings were tested to determine their potential for protecting gas turbine hardware from the corrosive contaminants. Several coatings were identified with significantly improved spallation-resistance (and, hence, corrosion resistance).

A.R.H.

**N80-15554**

**National Aeronautics and Space Administration.**

**Lewis Research Center, Cleveland, Ohio.**

**SPACE SOLAR CELLS: HIGH EFFICIENCY AND RADIATION DAMAGE**


The progress and status of efforts to increase the end-of-life efficiency of solar cells for space use is assessed. High efficiency silicon solar cells, silicon solar cell radiation damage, GaAs solar cell performance and radiation damage and 30 percent devices are discussed. R.E.S.

**N80-15555**

**National Aeronautics and Space Administration.**

**Lewis Research Center, Cleveland, Ohio.**

**OPEN-CIRCUIT VOLTAGE IMPROVEMENTS IN LOW RESISTIVITY SOLAR CELLS**


Improvements in the open circuit voltage of 0.1 ohm-cm silicon solar cells were achieved using a multistep diffusion technique. Experimental details are given along with the results of an analysis that indicate that anomalous behavior of the electron mobility in the cell base limits attainment of higher voltages.

Author

**N80-15556**

**National Aeronautics and Space Administration.**

**Lewis Research Center, Cleveland, Ohio.**

**BACK SURFACE REFLECTORS FOR SOLAR CELLS**

An-Ti Chai Chai 1980 10 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE (NASA-TM-81390; E-300) Avail NTIS HC A02/MF A01 CSDL 10A

Sample solar cells were fabricated to study the effects of various back surface reflectors on the device performance. They are typical 50 micrometers thick, space quality, silicon solar cells except for variations of the back contact configuration. The back surfaces of the sample cells are polished to a mirror like finish, and have either conventional full contacts or grid finger contacts. Measurements and evaluation of various metallic back surface reflectors, as well as cells with total internal reflection, are presented. Results indicate that back surface reflectors formed using a grid finger back contact are more effective reflectors than cells with full back metallization and that Au, Ag, or Cu are better back surface reflector metals than Al. R.C.T.

**N80-15557**

**National Aeronautics and Space Administration.**

**Lewis Research Center, Cleveland, Ohio.**

**RADIATION DAMAGE IN LITHIUM-COUNTERDOPED N/P SILICON SOLAR CELLS**


Lithium counterdoped n/p silicon solar cells were irradiated with 1 MV electrons and their post irradiation performance and low temperature annealing properties were compared to that of the 0.35 ohm-cm control cells. Cells fabricated from float zone and Czochralski grown silicon were investigated. It was found that the float zone cells exhibited superior radiation resistance compared to the control cells, while no improvement was noted for the Czochralski grown cells. Room temperature and 60°C annealing studies were conducted. The annealing was found to be a combination of first and second order kinetics for short times. It was suggested that this annealing was migration of lithium to a radiation induced defect with subsequent neutralization of the defect by combination with lithium. The effects of base lithium gradient were investigated. It was found that cells with negative base lithium gradients exhibited poor radiation resistance and performance compared to those with positive or no lithium gradients, the latter being preferred for overall performance and radiation resistance. M.G.

**N80-15558**

**National Aeronautics and Space Administration.**

**Lewis Research Center, Cleveland, Ohio.**

**RADIATION DAMAGE ANNEALING MECHANISMS AND POSSIBLE LOW TEMPERATURE ANNEALING IN SILICON SOLAR CELLS**


The defect responsible for reverse annealing in 2 ohm-cm ntype silicon solar cells was identified. This defect, with energy level at e sub V = 0.30 eV was tentatively identified as a boron oxygen-vacancy complex. Results indicate that its removal could result in significant annealing for 2 ohm-cm and lower resistivity cells at temperatures as low as 200°C. These results were obtained by use of an expression derived from the Shockley-Read-Hall recombination theory which relates measured diffusion length ratios to relative defect concentrations and electron capture cross sections. The relative defect concentrations and one of the required capture cross sections are obtained from Deep Level Transient Spectroscopy. Four additional capture cross sections are obtained using diffusion length data and data from temperature dependent lifetime studies. These calculated results are in reasonable agreement with experimental data. M.G.

**N80-15560**

**National Aeronautics and Space Administration.**

**Lewis Research Center, Cleveland, Ohio.**

**CANDIDATE THERMAL ENERGY STORAGE TECHNOLOGIES FOR SOLAR INDUSTRIAL PROCESS HEAT APPLICATIONS**


A number of candidate thermal energy storage system elements were identified as having the potential for the successful application of solar industrial process heat. These elements which include storage media, containment and heat exchange are shown. R.C.T.

**N80-15561**

**National Aeronautics and Space Administration.**

**Lewis Research Center, Cleveland, Ohio.**

**GLOBAL CALIBRATION OF TERRESTRIAL REFERENCE CELLS AND ERRORS INVOLVED IN USING DIFFERENT IRRADIANCE MONITORING TECHNIQUES**


The feasibility of global calibration of terrestrial reference...
cells is discussed. A simple, accurate secondary calibration technique based on ratios of test to reference cell currents measured in natural sunlight is described. Different techniques for monitoring incident irradiance during solar cell performance measurements are also examined and assessed, including the techniques of black body detectors, calibrated reference cells, and the convolution of spectral response with solar irradiance. M.G.

N80-16453* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
LARGE WIND TURBINE DESIGN CHARACTERISTICS AND R AND D REQUIREMENTS
Detailed technical presentations on large wind turbine research and development activities sponsored by public and private organizations are presented. Both horizontal and vertical axis machines are considered with emphasis on their structural design. For individual titles see N80-16454 through N80-16482.

N80-16455* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
DESIGN EVOLUTION OF LARGE WIND TURBINE GENERATORS
David A. Spera In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 25-33 refs (For primary document see N80-16455 07:44) Avail NTIS HC A20/MF A01 CSCL 10B
During the past five years, the goals of economy and reliability have led to a significant evolution in the basic design—both external and internal—of large wind turbine systems. To show the scope and nature of recent changes in wind turbine designs, development of three types are described (1) system configuration developments; (2) computer code developments; and (3) blade technology developments. R.E.S.

N80-16469* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
STRUCTURAL ANALYSIS CONSIDERATIONS FOR WIND TURBINE BLADES
David A. Spera In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 211-224 refs (For primary document see N80-16453 07:44) Avail NTIS HC A20/MF A01 CSCL 10B
Approaches to the structural analysis of wind turbine blade designs are reviewed. Specifications and materials data are discussed along with the analysis of vibrations, loads, stresses, and failure modes. K.L.

N80-16470* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
BLADE DESIGN AND OPERATING EXPERIENCE ON THE MOD-0A 200 kw WIND TURBINE AT CLAYTON, NEW MEXICO
Bradford S. Linscott and Richard K. Shaltens In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 225-238 refs (For primary document see N80-16453 07:44) Avail NTIS HC A20/MF A01 CSCL 10B
Two 60 foot long aluminum wind turbine blades were operated for over 3000 hours on the MOD-0A wind turbine. The first signs of blade structural damage were observed after 400 hours of operation. Details of the blade design, loads, cost, structural damage, and repair are discussed. K.L.

N80-16472* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
DESIGN, FABRICATION, AND TEST OF A STEEL SPAR WIND TURBINE BLADE
Timothy L. Sullivan, Paul J. Sirowy, Jr., and Larry A. Viterna In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 267-284 refs (For primary document see N80-16453 07:44) Avail NTIS HC A20/MF A01 CSCL 10B
The design and fabrication of wind turbine blades based on 60 foot steel spars are described. Performance and blade load information is given and compared to analytical prediction. In addition, performance is compared to that of the original MOD-0 aluminum blades. Costs for building the two blades are given, and a projection is made for the cost in mass production. Design improvements to reduce weight and improve fatigue life are suggested. K.L.

N80-16480* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
SIMULATION STUDIES OF MULTIPLE LARGE WIND TURBINE GENERATORS ON A UTILITY NETWORK
Leonard J. Gilbert and David M. Triendlberg (Purdue Univ.) In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 375-384 refs (For primary document see N80-16453 07:44) Avail NTIS HC A20/MF A01 CSCL 10B
The potential electrical problems that may be inherent in the inertia of clusters of wind turbine generators and an electric utility network were investigated Preliminary and limited results of an analog simulation of two MOD-2 wind generators tied to an infinite bus indicate little interaction between the generators and between the generators and the bus. The system demonstrated transient stability for the conditions considered. A.R.H.

N80-16490* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
POTENTIAL PERFORMANCE ENHANCEMENT USING A REACTING GAS (NITROGEN TETROXIDE) AS THE WORKING FLUID IN A CLOSED BRAYTON CYCLE
The results of an analytic study to estimate the performance that could be obtained by using a chemically reacting gas (nitrogen tetroxide) as the working fluid in a closed Brayton cycle are presented. Compared with data for helium as the working fluid, these results indicate efficiency improvements from 4 to 90 percent, depending on turbine inlet temperature, pressures, and gas residence time in heat transfer equipment. Author

N80-16494* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
PRELIMINARY ANALYSIS OF PERFORMANCE AND LOADS DATA FROM THE 2 MEGAWATT MOD-1 WIND TURBINE GENERATOR
Preliminary test data on output power, wind speed, rotor blade load, system dynamic behavior, and start-stop characteristics on the Mod-1 wind turbine generator are presented. These data were analyzed statistically and are compared with design predictions of system performance and loads. To date, the Mod-1 wind turbine generator has produced up to 1.5 MW of power, with a measured power versus wind speed curve which agrees closely with design. Blade loads were measured at wind speeds up to 14 m/s and also during rapid shut downs. Peak transient loads during the most severe shutdowns are less than the design limit loads. On the inboard blade sections, fatigue loads are approximately equal to the design cyclic loads. On the outboard blade sections, however, measured cyclic loads
cells is discussed. A simple, accurate "secondary" calibration technique based on ratios of test to reference cell currents measured in natural sunlight is described. Different techniques for monitoring incident irradiance during solar cell performance measurements are also examined and assessed, including the techniques of black-body detectors, calibrated reference cells, and the convolution of spectral response with solar irradiance.

M.G.

N80-16453* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

LARGE WIND-TURBINE DESIGN CHARACTERISTICS AND R AND D REQUIREMENTS

Seymour Lieblein, ed. (Technical Report Services, Rocky River, Ohio) Dec. 1979 459 p refs Conf. held at Cleveland, 24-26 Apr. 1979, sponsored in part by DOE
(NASA-CP-2106; CONF-7904111) Avail. NTIS HC A20/MF A01 CSCL 10B

Detailed technical presentations on large wind turbine research and development activities sponsored by public and private organizations are presented. Both horizontal and vertical axis machines are considered with emphasis on their structural design. For individual titles, see N80-16454 through N80-16482.

N80-16455* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

DESIGN EVOLUTION OF LARGE WIND TURBINE GENERATORS

David A. Spera In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 25-33 ref (For primary document see N80-16453 07-44) Avail. NTIS HC A20/MF A01 CSCL 10B

During the past five years, the goals of economy and reliability have led to a significant evolution in the basic design—both external and internal—of large wind turbine systems. To show the scope and nature of recent changes in wind turbine designs, development of three types are described: (1) system configuration developments; (2) computer code developments; and (3) blade technology developments. R.E.S.

N80-16469* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

STRUCTURAL ANALYSIS CONSIDERATIONS FOR WIND TURBINE BLADES

David A. Spera In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 211-224 refs (For primary document see N80-16453 07-44) Avail. NTIS HC A20/MF A01 CSCL 10B

Approaches to the structural analysis of wind turbine blade designs are reviewed. Specifications and materials data are discussed along with the analysis of vibrations, loads, stresses, and failure modes. K.L.

N80-16470* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

BLADE DESIGN AND OPERATING EXPERIENCE ON THE MOD-0A 200 kW WIND TURBINE AT CLAYTON, NEW MEXICO

Bradford S. Linscott and Richard K. Shaltens In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 229-238 refs (For primary document see N80-16453 07-44) Avail. NTIS HC A20/MF A01 CSCL 10B

Two 60 foot long aluminum wind turbine blades were operated for over 3000 hours on the MOD-0A wind turbine. The first signs of blade structural damage were observed after 400 hours of operation. Details of the blade design, loads, cost, structural damage, and repair are discussed. K.L.

N80-16472* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

DESIGN, FABRICATION, AND TEST OF A STEEL SPAR WIND TURBINE BLADE

Timothy L. Sullivan, Paul J. Sroczynski, Jr., and Larry A. Viterna In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 267-284 refs (For primary document see N80-16453 07-44) Avail. NTIS HC A20/MF A01 CSCL 10B

The design and fabrication of wind turbine blades based on 60 foot steel spars are discussed. Performance and blade load information is given and compared to analytical prediction. In addition, performance is compared to that of the original MOD-0 aluminum blades. Costs for building the two blades are given, and a projection is made for the cost in mass production. Design improvements to reduce weight and improve fatigue life are suggested. K.L.

N80-16480* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

SIMULATION STUDIES OF MULTIPLE LARGE WIND TURBINE GENERATORS ON A UTILITY NETWORK

Leonard J. Gilbert and David M. Tribeberg (Purdue Univ.) In Its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 375-384 refs (For primary document see N80-16453 07-44) Avail. NTIS HC A20/MF A01 CSCL 10B

The potential electrical problems that may be inherent in the inertia of clusters of wind turbine generators and an electric utility network were investigated. Preliminary and limited results of an analog simulation of two MOD-2 wind generators tied to an infinite bus indicate little interaction between the generators and between the generators and the bus. The system demonstrated transient stability for the conditions considered. A.R.H.

N80-16490* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

POSSIBLE PERFORMANCE IMPROVEMENT USING A REACTING GAS (NITROGEN TETROXIDE) AS THE WORKING FLUID IN A CLOSED BRAYTON CYCLE


The results of an analysis to estimate the performance that could be obtained by using a chemically reacting gas (nitrogen tetroxide) as the working fluid in a closed Brayton cycle are presented. Compared with data for helium as the working fluid, these results indicate efficiency improvements from 4 to 90 percent, depending on turbine inlet temperature, pressures, and gas residence time in heat transfer equipment. Author

N80-16494* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PRELIMINARY ANALYSIS OF PERFORMANCE AND LOADS DATA FROM THE 2-MEGAWATT MOD-1 WIND TURBINE GENERATOR


Preliminary test data on output power versus wind speed, rotor blade loads, system dynamic behavior, and start-stop characteristics on the Mod-1 wind turbine generator are presented. These data were analyzed statistically and are compared with design predictions of system performance and loads. To date, the Mod-1 wind turbine generator has produced up to 1.5 MW of power, with a measured power versus wind speed curve which agrees closely with design. Blade loads were measured at wind speeds up to 14 m/s and also during rapid shutdowns. Peak transient loads during the most severe shutdowns are less than the design limit loads. On the inboard blade sections, fatigue loads are approximately equal to the design cyclic loads. On the outboard blade sections, however, measured cyclic loads...
are significantly larger than design values, but they do not appear to exceed fatigue allowable loads as yet.

R.E.S.

N80-18554f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

OVERVIEW OF A STIRLING ENGINE TEST PROJECT

Tests were conducted on three Stirling engines ranging in size from 1.33 to 53 horsepower (1 to 40 kW). The tests were directed toward developing alternative, backup component concepts to improve engine efficiency and performance or to reduce costs. Some of the activities included investigating attractive concepts and materials for cooler-regenerator units, installing a jet impingement device on a Stirling engine to determine its potential for improved engine performance, and presenting performance maps for initial characterization of Stirling engines. The experiment results of the tests are presented along with predictions of the results of future tests to be conducted on the Stirling engines.

R.E.S.

N80-18555f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

FLEXIBLE FORMULATED PLASTIC SEPARATORS FOR ALKALINE BATTERIES Patent Application

A flexible separator for alkaline batteries is disclosed. The separator is comprised of a coating which is applied to a nonwoven porous substrate such as sheets or mats of asbestos or other materials which are inert with respect to the alkaline electrolyte of the battery. The coating material comprises a polyphenylene oxide polymer, an organic additive and inorganic and organic fillers which comprise 55% by volume or less of the coating material. Preferably, at least one inorganic filler material which is reactive with the electrolyte is included to produce desirable pores in the coating. The organic additive is a polymeric polyester material which is hydrolyzed by the alkaline electrolyte to improve conductivity of the coating.

R.E.S.

N80-18556f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

FLEXIBLE FORMULATED PLASTIC SEPARATORS FOR ALKALINE BATTERIES Patent Application

A flexible separator for alkaline batteries is disclosed. The separator is comprised of a coating which is applied to a nonwoven porous substrate such as sheets or mats of asbestos or other materials which are inert with respect to the alkaline electrolyte of the battery. The coating material is comprised of a polyphenylene oxide polymer, an organic additive and inorganic, and organic fillers which comprise 55% by volume or less of the coating material. Preferably, at least one inorganic filler material which is reactive with the electrolyte is included to produce desirable pores in the coating. The organic additive is a polymeric polyester material which is hydrolyzed by the alkaline electrolyte to improve conductivity of the coating.

R.E.S.

N80-18557f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

CATALYST SURFACES FOR THE CHROMOUS/CHROMIC REDOX COUPLE Patent Application

An electricity producing cell of the reduction-oxidation type is disclosed. The cell is divided into two compartments by a membrane and each compartment contains a solid inert electrode. A ferrous/ferric couple in a chloride solution serves as a cathode fluid which is circulated through one of the compartments to produce a positive electric potential disposed therein. A chromic/chromous couple in a chloride solution serves as an anode fluid which is circulated through the second compartment to produce a negative potential on an electrode disposed therein. The electrode is an electrically conductive, inert material plated with copper, silver or gold. A thin layer of lead plates onto the copper, silver or gold layer when the cell is being charged, the lead ions being available from lead chloride which has been added to the anode fluid. If the REDOX cell is then discharged, the current flows between the electrodes causing the lead to depilate from the negative electrode and the metal coating on the electrode will act as a catalyst to increase current density. NASA

N80-18563f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ENGINEERING EVALUATION OF A SODIUM HYDROXIDE THERMAL ENERGY STORAGE MODULE Final Report

An engineering evaluation of thermal energy storage prototypes was performed in order to assess the development status of latent heat storage media. The testing and the evaluation of a prototype sodium hydroxide module is described. This module stored off-peak electrical energy as heat for later conversion to domestic hot water needs.

R.E.S.

N80-19613f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

TEETERED, TIP-CONTROLLED ROTOR: PRELIMINARY TEST RESULTS FROM MOD-0 100-kW EXPERIMENTAL WIND TURBINE

Results of tests conducted using the MOD-0 100 kW experimental wind turbine are evaluated. The teetered rotor significantly decreased loads on the yaw drive mechanism and reduced blade cyclic flapwise bending moments by 25 percent at the 20 percent span location when compared to the rigid hub rotor. The teetered hub performed well, but impacted the teeter stops on occasion as wind speed and/or direction varied rapidly. The tip-controlled rotor performed satisfactorily with some expected loss of control when compared to the full span pitchable blade. The performance results indicate that a review of techniques used to calculate rotor power is in order.

K.L.

N80-19614f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

INSTALLATION AND CHECKOUT OF THE DOE/NASA MOD-1 2000-kW WIND TURBINE GENERATOR

The Mod-1 machine was assembled without the blades, tested, and sent to the site at Boone, North Carolina for erection. The blades were transported directly to the site. A series of
checkout tests were then conducted to evaluate performance and loads. The results of these tests compared well with the design data.

NBO-19626*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTA). VOLUME 1: SUMMARY
Gerald J. Bama, Raymond K. Burns, and Gary D. Sagerman
Jan. 1980 89 p
(Contract EC-77-A-31-1062)
(NASA-TM-81400; DOE/NASA/1062-80/4; E-312) Avail: NTIS HC A05/MF A01 CSCL 10B
Various advanced energy conversion systems that can use coal or coal-derived fuels for industrial cogeneration applications were compared to provide information needed by DOE to establish research and development funding priorities for advanced-technology systems that could significantly advance the use of coal or coal-derived fuels in industrial cogeneration. Steam turbines, diesel engines, open-cycle gas turbines, combined cycles, closed-cycle gas turbines, Stirling engines, phosphoric acid fuel cells, molten carbonate fuel cells, and thermionics were studied with technology advancements appropriate for the 1985-2000 time period. The various advanced systems were compared and evaluated for wide diversity of representative industrial plants on the basis of fuel energy savings, annual energy cost savings, emissions savings, and rate of return on investment as compared with purchasing electricity from a utility and providing process heat with an on-site boiler. Also included in the comparisons and evaluations are results extrapolated to the national level.
F.O.S.

NBO-21837*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
FLAME TESTS: PARAMETRIC STUDIES FOR CONTROL OF FUEL BOUND NITROGEN USING RICH-LEAN TWO-STAGE COMBUSTION
Donald F. Schultz and Gary Wolfbrandt 1980 25 p refs
Presented at Western States Sect., Inst. of Spring Meeting, Irvine, Calif., 21-22 April, 1980
(Contract EF-77-A-01-2593)
(NASA-TM-81472; DOE/NASA/2593-80/15; E-405) Avail: NTIS HC A02/MF A01 CSCL 21B
An experimental parametric study of rich-lean two-stage combustion in a flame tube is described and approaches for minimizing the conversion of fuel-bound nitrogen to nitrogen oxides in a premixed, homogeneous combustion system are evaluated. Air at 672 K and 0.48 MPa was premixed with fuel blends of propylene, toluene, and pyridine at primary equivalence ratios ranging from 0.5 to 2.0 and secondary equivalence ratios of 0.5 to 0.7. Distillates of SRC-II, a coal syncrude, were also tested. The hydrogen fuels were pyrolyzed to vary fuel hydrogen composition from 9.0 to 18.3 weight percent and fuel nitrogen composition from zero to 1.5 weight percent. Rich-lean combustion proved effective in reducing fuel nitrogen to NO sub x conversion: conversion rates up to 10 times lower than those normally produced by single-stage combustion were achieved. The optimum primary equivalence ratio, where the least NO sub x was produced, was found to range from 1.4 to 1.7 with changes in fuel nitrogen content and fuel hydrogen content. Increasing levels of fuel nitrogen content lowered the conversion rate, but not enough to avoid higher NO sub x emissions as fuel nitrogen increased. M.G.

NBO-22776*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
LITERATURE SURVEY OF PROPERTIES OF SYN FUELS DERIVED FROM COAL Interm Report
Theine W. Reynolds, Richard W. Niedzwiecki, and John S. Clark
Feb. 1980 162 p
(Contract EF-77-A-01-2593)
(NASA-TM-79243; DOE/NASA/2593-79/8; E-150) Avail: NTIS HC A08/MF A01 CSCL 21D
A literature survey of the properties of synfuels for ground-based gas turbine applications is presented. Four major concepts for converting coal into liquid fuels are described: solvent extraction, catalytic liquefaction, pyrolysis, and indirect liquefaction. Data on full range syncrudes, various distillate cuts, and upgraded products are presented for fuels derived from various processes, including H-coal, synfuel, solvent-refined coal, donor solvent, zinc chloride hydrotreatment, co-steam, and flash pyrolysis. Some typical ranges of data for coal-derived low Btu gases are also presented.
R.E.S.

NBO-22777*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
ADVANCED SCREENING OF ELECTRODE COUPLES
J. Giner and K. Cahill Feb. 1980 56 p refs
(Contract NAS3-20794; EC-77-A-31-1002)
(NASA-CR-159738; DOE/NASA/0794-80/1) Avail: NTIS HC A04/MF A01 CSCL 10B
The chromium (Cr3+ /Cr2+ ) redox couple (electrolyte and electrode) was investigated to determine its suitability as negative electrode for the iron (Fe3+ /Fe2+ )/chromium (Cr3+ /Cr2+ ) redox flow battery. Literature search and laboratory investigation established that the solubility and stability of aqueous acidic solutions of chromium(3) chloride and chromium(2) chloride are sufficient for redox battery application. Four categories of electrode materials were tested: metals, metals and metalloid materials (elements and compounds), alloys, plated materials, and Teflon-bonded materials. In all, the relative performance of 26 candidate electrode materials was evaluated on the basis of slow scan rate linear sweep voltammetry in stirred solution. No single material tested gave both acceptable anodic and acceptable cathodic performance. However, the identification of lead as a good cathodic electrocatalyst and gold as a good anodic electrocatalyst led to the invention of the lead/gold combination electrocatalyst. This type of catalyst can be fabricated in several ways and appears to offer the advantages of each metal without the disadvantages associated with their use as single materials. This lead/gold electrocatalyst was tested by NASA-Lewis Research Center in complete, flowing, redox batteries comprising a stack of several cells. A large improvement in the battery's coulombic and energy efficiency was observed.
F.O.S.

NBO-22788*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
THERMAL ENERGY STORAGE: FOURTH ANNUAL REVIEW MEETING
The development of low cost thermal energy storage technologies is discussed in terms of near term oil savings, solar energy applications, and dispersed energy systems for energy conservation policies. Program definition and assessment and research and technology development are considered along with industrial storage, solar thermal power storage, building heating and cooling, and seasonal thermal storage. A bibliography on seasonal thermal energy storage, emphasizing aquifer thermal energy is included. For individual titles, see NBO-22779 through NBO-22829.

NBO-22790*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
PROGRAM DEFINITION AND ASSESSMENT OVERVIEW
The implementation of a program level assessment of thermal energy storage technology thrusts for the near and far term to assure overall coherent energy storage program is considered. The identification and definition of potential thermal energy storage applications, definition of technology requirements, and appropriate market sectors are discussed along with the necessary coordination, planning, and preparation associated with program reviews, workshops, multi-year plans and annual operating plans for the major laboratory tasks.
J.M.S.
INDUSTRIAL STORAGE APPLICATIONS OVERVIEW

Rudolph A. Dusch In its Thermal Energy Storage Mar. 1980 p 85-94 refs (For primary document see N80-22788 13-44)
Avail NTIS HC A99/MF A01 CSCL 10B

The implementation of a technology demonstration for the food processing industry, development and technology demonstrations for selected near-term, in-plant applications and advanced industrial applications of thermal energy storage are overviewed. R.E.S.

N80-22795# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COMBINED CYCLE MHD-POWER PLANT APPLICATIONS

HC A02/MF A01 CSCL 10B

Some of the design approaches being employed during a current supported study directed at developing an impromptu separation process for the production of oxygen enriched air for magnetohydrodynamics (MHD) combustion are outlined. The ultimate objective is to design separation plants, optimized for minimum specific power consumption and capital investment costs, for integration with MHD combined cycle power plants. R.E.S.

N80-22797# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COLLECTION AND DISSEMINATION OF TES SYSTEM INFORMATION FOR THE PAPER AND PULP INDUSTRY

M W Dietrich and Howard Eede (Eddie) (Howard), Inc., Bellevue, Wash.) In its Thermal Energy Storage Mar. 1980 p 105-111
(For primary document see N80-22786 13-44)
Avail NTIS HC A99/MF A01 CSCL 10B

A survey of U.S. and international paper and pulp mills using thermal energy storage (TES) systems as a part of their production processes was conducted to obtain sufficient operating data to conduct a benefits analysis encompassing: (1) an energy conservation assessment, (2) an economic benefits analysis, and (3) an environmental impact assessment. An informed dissemination plan was then proposed to effectively present the benefits of TES to the U.S. paper and pulp industry. R.E.S.

N80-22769# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

D Q Hoover, Jr. Apr. 1980 87 p
(Contracts DEN3-161; DE-A103-76ET-11272)
(NASA CR-159875; DOE/NASA 01612-2; QR-2) Avail: NTIS HC A05/MF A01 CSCL 10A

Stack: tests indicate that the discrepancies between calculated and measured temperature profiles are due to reactant cross-over and a lower than expected thermal conductivity of cells. Preliminary results indicate that acceptable contact resistance between cooling plane halves can be achieved without the use of paper. The preliminary design of the enclosure, definition of required labor and equipment for manufacturing repeating components, and the assembly procedures for the benchwork design were developed. Fabrication of components for a second 5-cell stack of the MK-2 design and a second 23-cell stack of the MK-1 design was started. The definition of water and fuel for the reforming subsystem was developed along with a preliminary definition of the control system for the subsystem. The construction and shakedown of the differential catalytic reactor was completed and testing of the first catalyst initiated. R.E.S.

N80-23777# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

REDOX STORAGE SYSTEMS FOR SOLAR APPLICATIONS

(Contract EF-77-A-31-244)
(NASA-TM-81510; DOE/NASA 02874-80/60; E-409) Avail: NTIS HC A02/MF A01 CSCL 10B

The NASA Redox energy storage system is described. The system is based on soluble aqueous iron and chromium chloride redox couples. The needed technology advances in the two elements (electrodes and membranes) key to its technological feasibility have been achieved and system development has begun. The design, construction, and test of a 1 kilowatt system integrated with a solar photovoltaic array is discussed. R.E.S.

N80-2378*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

THE OPTIMIZATION AIR SEPARATION PLANTS FOR

Lewis Research Center, Cleveland, Ohio.

THE OPTIMIZATION AIR SEPARATION PLANTS FOR
controllers with series traction motors resulted in a significant increase in vehicle performance and cost savings compared to the baseline propulsion system. The conclusions reached are that propulsion system technology advances can result in a major reduction of the sticker price of an electric vehicle and a smaller, but significant, reduction in overall cost of ownership.

R.E.S.
The use of various advanced energy conversion systems was compared with each other and with current technology systems for their savings in fuel energy, cost, and emissions. The study includes a description of the computer program used in calculating and analyzing the results.

For Vol 1, see N80-24797

R E S
Open cycle MHD is one of the major R&D efforts in the Department of Energy's program to meet the national goal of reducing U.S. dependence on oil through increased utilization of coal. MHD offers an effective way to use coal to produce electric power at low cost in a highly efficient and environmentally acceptable manner. Open cycle MHD plants are categorized by the MHD combustor oxidizer, its temperature and the method of preheat. The paper discusses MHD baseline plant design, open cycle MHD plant in the Energy Conversion Alternatives Study (ECAS), early commercial MHD plants, conceptual studies of the engineering test facility, retrofit (addition of an MHD topping cycle to an existing steam plant), and other potential applications and concepts. Emphasis is placed on a survey of both completed and ongoing studies to define both commercial and pilot plant design, cost, and performance.


The air flow through a propeller-type wind turbine rotor is characterized by three-dimensional rotating cascade effects about the inner portions of the rotor blades and compressibility effects about the tip region of the blades. In the case of large rotor diameter and/or increased rotor angular speed, the existence of small supersonic zones terminated by weak shocks is possible. An exact nonlinear mathematical model (called a steady Full Potential Equation - FPE) that accounts for the above phenomena has been rederived. An artificially time dependent version of FPE was iteratively solved by a finite volume technique involving an artificial viscosity and a three-level consecutive mesh refinement. The exact boundary conditions were applied by generating a boundary conforming periodic computation mesh.


The paper describes the DOE/NASA Mod-1 wind turbine generator, its assembly and testing, and its installation at Boone, North Carolina. The paper concludes with performance data taken during the Initial tests conducted on the machine. The successful installation and initial operation of the Mod-1 wind turbine generator has had the following results: (1) megawatt-size wind turbines can be operated satisfactorily on utility grids; (2) the structural loads can be predicted by existing codes; (3) assembly of the machine on top of the tower presents no major problem; (4) large blades 100 ft long can be transported long distances and over mountain roads; and (5) large blades 100 ft long can be transported long distances and over mountain roads; and (6) operating experience and performance data will contribute substantially to the design of future low-cost wind turbines.


A series of tests is currently being conducted using the DOE/NASA 100 kW Experimental Wind Turbine with a two-bladed, teetered rotor with 30% span tip control. Preliminary evaluation test results indicate that the teetered rotor significantly decreases loads on the yaw drive mechanism and reduces blade cyclic flapwise bending moments by 25% at the 20% span location when compared to rigid hub rotor. The teetered hub performed well but did impact the teeter stops on occasion as wind speed and/or direction varied rapidly. The tip-controlled rotor performed satisfactorily with some expected loss of control when compared to the full span pitchable blade. The performance results indicate that a review of techniques used to calculate rotor power in order.


It is noted that in 1976, 17 candidate sites were identified for detailed evaluation as potential sites for installation of large, horizontal axis Wind Turbines (WT). Attention is given to the Mod-OA, a 200 kW WT located in Clayton, New Mexico. The discussion covers the meteorological data collected, some of the analyses based on these wind data as well as additional areas currently being investigated in relation to these data.


The paper deals with a 4000-hr small turbine test in the effluent of a pressurized fluidized bed (PFB) at an average temperature of 770 C, an average relative gas velocity of 300 m/sec, and average solid loadings of 200 ppm. Consideration is given to combustion parameters and operating procedure as well as to the turbine system and turbine test operating procedures. Emphasis is placed on erosion/corrosion results.

A80-39642 # Comments on TEC trends. J. F. Morris (NASA, Lewis Research Center, Cleveland, Ohio), Institute of Electrical and Electronics Engineers, International Conference on Plasma Science, Montreal, Canada, June 4-6, 1979, Paper, p. 25 p. 54 refs.

The paper comments on published and projected thermionic-energy-conversion (TEC) performance trends. This commentary includes graphs and an appendix relating TEC performance parameter plots, predictions and actual TEC trends, a figure relating projected cost of electricity to overall efficiency for TEC topping, and a discussion of the implications of these relationships.


This paper describes the Safety, Reliability and Quality Assurance (SR&QA) approach developed for the first large wind turbine generator project, MOD-OA. The SR&QA approach to be used had to assure that the machine would not be hazardous, would operate unattended on a utility grid, would demonstrate reliable operation, and would help establish the quality assurance and maintainability requirements for wind turbine projects. The final approach consisted of a modified Failure Modes and Effects Analysis (FMEA) during the design phase, minimal hardware inspections during parts fabrication, and three documents to control activities during machine construction and operation.

This paper describes an example of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photovoltaic power systems. This particular application was for a solar cell power system demonstration project in Tangeyne, Upper Volta, Africa. The techniques involve a definition of the power system natural and operating environment, use of design criteria and analysis techniques, an awareness of potential problems via the inherent reliability and FMEA methods, and use of a fail-safe and planned spare parts engineering philosophy. (Author)

Spectral effects on direct-insolation absorptance of five collector coatings. G. B. Hotchkiss (Texas Instruments, Inc., Dallas, Texas), F. F. Simon (NASA, Lewis Research Center, Cleveland, Ohio), and L. C. Burmeister (Kansas University, Lawrence, Kan.). American Society of Mechanical Engineers and American Institute of Chemical Engineers, Joint National Heat Transfer Conference, 18th, San Diego, Calif., Aug. 5-8, 1979, ASME Paper 79-HT-12, 7 p. 16 refs. Memmbers, $1.50; nonmembers, $3.00. Grant No. NQ-G-3087.

Absorptances for direct insolation of black chrome, black nickel, copper oxide, and two black zinc conversion selective coatings were calculated for a number of typical solar spectrums. Measured spectral reflectances were used while the effects of atmospheric ozone density, turbidity, and air mass were incorporated in calculated direct solar spectrums. Absorbtance variation for direct insolation was found to be of the order of 1 percent for a typical range of clear-sky atmospheric conditions. (Author)


The data analysis of cycles to failure of silver-zinc electrochemical cells with competing failure modes is presented. The test ran 129 cycles through charge-discharge cycles until failure; preliminary data analysis consisted of response surface estimate of life. Batteries fail through low voltage condition and an internal shorting condition; a competing failure modes analysis was made using maximum likelihood estimation for the extreme value life distribution. Extensive residual plotting and probability plotting were used to verify data quality and selection of model.


The paper describes the designs, hardware, and installations of NASA photovoltaic power systems in the village of Schuchull in Arizona and Tangeyne in Upper Volta, Africa. The projects were designed to demonstrate that current photovoltaic system technology can provide electrical power for domestic services for small, remote communities. The Schuchull system has a 3.5 kW peak solar array which provides power for water pumping, a refrigerator for each family, lights, and community washing and sewing machines. The 1.8 kW Tangeyne system provides power for pumping, flour milling, and lights in the milling building. Both are stand-alone systems operated by local personnel, and they are monitored by NASA to measure design adequacy and refine future designs. A.T.
NASA/DOE photovoltaic test facility. The system includes four substacks of 39 cells each (1/3 sq ft active area) which are connected hydraulically in parallel and electrically in series. An open circuit voltage cell and a set of rebalance cells are used to continuously monitor the system state of charge and automatically maintain the anode and cathode reactants electrochemically in balance. Technological advances in membranes and electrodes and results of multiecell stack tests are reviewed.

V.L.

N80-12851*
ANTON PERMSELECTIVE MEMBRANE
Samuel S. Alexander, Russell R. Hodgdon, and Warren A. Waite
Mar. 1979 52 p Sponsored by NASA
(Contract DEN3-1)
(DOE/NASA/0001-79/1) Avail: NTIS
HC A04/MF A01 C8CL 10A
Experimental composite membranes were synthesized on a lab scale consisting of a thin layer of anion permselective resin supported by and bonded to a porous physically strong and conductive substrate film. These showed good selectivity and also substantially lower electrical resistivities than the homogenous candidate membranes optimized for the previous contract. A wide range of resin porosities were examined for three candidate membrane systems, CDIL, CP4L, and A3L to identify the formulation giving the best overall redox cell performance. Candidate anion membranes showed large increases in resistivity after a short time of immersion in concentrated FeCl3/HCl solution. Largely on the basis of stability resistance the CDIL formulation was selected as prime candidate and about thirty-five membranes (one foot square) were produced for experimental static and dynamic evaluation.

R.S.

N80-12852*
General Electric Co., Schenectady, N. Y.
CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR-TERM ELECTRIC UTILITY APPLICATIONS: VOLUME 2: APPENDIXES, SCREENING OF CONCEPTS
W. H. H. Hauss, B. J. Berkowitz, and R. C. Hare
April 1979 151 p Refs
(DOE/NASA/0067-79-2; QR-3) Avail: NTIS
HC A04/MF A01 C8CL 10A
A technique for producing an acid inventory control monitor by spraying FEP onto a partially screened carbon paper backing is discussed. Theoretical analysis of the acid management indicates that the vapor composition of 103% H3PO4 is approximately 1.0 ppm P4O10. An SEM evaluation of corrosion resistance of phenolic resins and graphite/phenolic resin composites in H3PO4 at 185°C shows specific surface etching.

K.L.

N80-12853*
Technical Report Services, Rocky River, Ohio.
EVALUATION OF FEASIBILITY OF PRESTRESSED CONCRETE FOR USE IN WIND TURBINE BLADES
Seymour Leiblin, D. S. Londahl, Donn B. Furlong, and Mark E. Drier
Sep. 1979 119 p Refs
(Contract NAS3-30052)
(NASA-CR-159598; DOE/NASA/0001-79/1) Avail: NTIS
HC A04/MF A01 C8CL 10B
The feasibility for implementation of a concept for direct ac/dc multikilowatt power conversion with bidirectional transfer of energy was investigated. A 10 kHz carrier was derived directly from a common 60 Hz three phase power system. The carrier was modulated to a 36 kHz triangle, inherent in the three phase power supply and then demodulated and processed by a high frequency filter. The resulting dc power was then supplied to a load. The process was implemented without the use of low frequency transformers and filters. This power conversion process was reversible and can operate in the four quadrants as viewed from any of the two of the converter’s ports. Areas of application include: power systems on air and spacecraft; terrestrial traction: integration of solar and wind powered systems with utility networks; HVDC asynchronous coupling of polyphase networks; heat treatment; industrial machine drives; and power supplies for any use including instrumentation.

R.C.T.

N80-12854*
Solarox Corp., Rockville, Md.
ECONOMICAL SPACE POWER SYSTEMS
Joel H. Burkholder
Jan. 1980 161 p Refs
(Contract NAS3-21353)
(NASA-CR-159690) Avail: NTIS
HC A04/MF A01 C8CL 10B
A preliminary evaluation of the feasibility of the use of prestressed concrete as a material for low cost blades for wind turbines was conducted. A baseline blade design was achieved for an experimental wind turbine that met aerodynamic and structural requirements. Significant cost reductions were indicated for volume production. Casting of a model blade section showed no fabrication problems. Coupled dynamic analysis revealed that adverse rotor tower interactions can be significant with heavy rotor blades.

R.C.T.
A commercial approach to design and fabrication of an economical space power system is investigated. Cost projections are based on a 2 kW space power system conceptual design taking into consideration the capability for serviceability, constraints of operation in space, and commercial production engineering approaches. A breakdown of the system design, documentation, fabrication, and reliability and quality assurance estimated costs are detailed.

N80-16483* Energy Technology, Inc., Cleveland, Ohio
STUDY OF ADVANCED RADIAL OUTFLOW TURBINE FOR SOLAR STEAM RANKINE ENGINES
Cecil Martin and Terry Kolenc Dec. 1979 74 p refs (Contract DEN3-B6) (NASA-CA-15966; DOE/NASA/0086-79/1; ETI-1279) Avail; NTIS HC A04/MF A01 CSCL 10B

The performance characteristics of various steam Rankine engine configurations for solar electric power generation were investigated. A radial outflow steam turbine was investigated to determine: (1) a method for predicting performance from experimental data, (2) the flexibility of a single design with regard to power output and pressure ratio, and (3) the effect of varying the number of turbine stages. All turbine designs were restricted to be compatible with commercially available gearboxes and generators. The development of several design methods and control schemes for the steam Rankine engine shows that from an efficiency and control complexity standpoint, the best approach is to hold turbine inlet temperature constant, vary turbine inlet pressure to match load, and allow condenser temperature to float maintaining constant heat rejection load. A.R.H.

A 15kW (NOMINAL) SOLAR THERMAL ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKINE REHEAT RECIPROCATOR SYSTEM Final Report

An evaluation was made of the potential of a steam Rankine reheat reciprocator engine to operate at high efficiency in a point-focused distributed receiver solar thermal-electric power system. The scope of the study included the engine system and electric generator, not included was the solar collector/mirror or the steam Rankine or reciprocator/receiver plant. A parametric analysis of predictive conditions was completed leading to the selection of 973 K (121.1 MPa) as the steam temperature/pressure for a conceptual design. A conceptual design was completed for a two cylinder opposed engine directly coupled to a commercially available induction generator. A unique part of the expander design is the use of a carbon/graphite piston rings to eliminate the use of upper cylinder lubricant. The evaluation included a system weight estimate of 230 kg at the mirror focal point with the condenser mounted separately on the ground. The estimated cost of the overall system is $1932 or $30/kW for the maximum 26 kW output. R.E.S.

N80-16493* Sundstrand Corp., Rockford, Ill.
THE 15 kW SUB-NOMINAL SOLAR THERMAL ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKINE TURBINE SYSTEM Final Report

A study to define the performance and cost characteristics of a solar powered, steam Rankine turbine system evaluated at the focal point of a solar concentrator is presented. A two-stage re-entry turbine system, each stage of which has an efficiency of 27% at a turbine inlet temperature of 732 C was used. System efficiency was defined at 60 Hertz electrical output divided by absorbed thermal input in the working fluid. Mass production costs were found to be approximately $384 dollars/kW. R.E.S.

DOE/NASA WIND TURBINE DATA ACQUISITION. PART 1: EQUIPMENT

Large quantities of data were collected stored, and analyzed in connection with research and development programs on wind turbines. The hardware configuration of the wind energy resource data acquisition system is described along with its use on the NASA/DOE Wind Energy Program. R.C.T.

N80-17547* Institute of Gas Technology, Chicago, Ill.

The results of comparative screening studies of candidate molten carbonate salts as phase change materials (PCM) for advanced solar thermal energy storage applications at 540 to 870 C (1004 to 1600 F) and steam Rankine electric generation at 400 to 540 C (752 to 1004 F) are presented. Alkali carbonates are attractive as latent heat storage materials because of their relatively high storage capacity and thermal conductivity, low corrosivity, moderate cost, and safe and simple handling requirements. Salts were tested in 0.1 kwh lab scale modules and evaluated on the basis of discharge heat flux, solidification temperature range, thermal cycling stability, and compatibility with containment materials. The feasibility of using a distributed network of high conductivity material to increase the heat flux through the layer of solidified salt was evaluated. The thermal performance of an 8 kWhr thermal energy storage (TES) module containing LiKCO3 remained very stable throughout 5650 hours and 130 charge/discharge cycles at 480 to 535 C (896 to 995 F). A TES utilization concept of an electrical generation peaking subsystem composed of a multistage condensing steam turbine and a TES subsystem with a separate power conversion loop was defined. Conceptual designs for a 100 MW sub TES peaking system providing steam at 316 C, 427 C, and 545 C (600 F, 800 F, and 1000 F) at 3.79 million Pa (650 psia) were developed and evaluated. Areas requiring further investigation have also been identified. Author

N80-17548* Kaman Aerospace Corp., Bloomfield, Conn.
DESIGN, FABRICATION, TEST, AND EVALUATION OF A PROTOTYPE 160-FOOT LONG COMPOSITE WIND TURBINE BLADE Final Report
Herbert W. Gewehr Sep. 1979 135 p refs (Contracts NAS3-20600; EX-76-01-1028) (NASA-CR-159775; DOE/NASA/0060-79/1; R-1575) Avail; NTIS HC A07/MF A01 CSCL 10B

The design, fabrication, testing, and evaluation of a prototype 150 foot long composite wind turbine blade is described. The design approach and material selection, compatible with low cost fabrication methods and objectives, are highlighted. The operating characteristics of the blade during rotating and nonrotating conditions are presented. The tensile, compression, and shear properties of the blade are reported. The blade fabrication, tooling, and quality assurance are discussed. A.W.H.
was then used to fabricate a number of cells for evaluation and study, as well as to establish the validity of the process sequence. While a number of cells exhibiting relatively good conversion efficiencies were produced, nearly all had low I-V curve factors for the level of efficiencies attained. Cells with conversion efficiencies of more than 15 percent (air mass zero and 25 C) had fill factors of only 0.76. Evidence as to the cause of this has not been conclusive, but is most probably linked to isolation failure in the wraparound dielectric and associated shunting problems.

Author

NBO-185859® Avco Corp., Wilmington, Mass.
PARAMETRIC STUDY OF POTENTIAL EARLY COM-
MERCIAL MHD POWER PLANTS Final Report
Finn A Hals Dec. 1979 246 p refs
(Contracts DEN3-51, EF-77-A-01-2674)
(NASA-CR-159833, DOE/NASA/0051-79/1) Avail: NTIS
HC A11/MF AO1 CSCL 10B

Three different reference power plant configurations were
considered with parametric variations of the various design
parameters for each plant. Two of the reference plant designs
were based on the use of high temperature regenerative air
preheaters separately fired by a low Btu gas produced from a
coal gasifier which was integrated with the power plant. The
third reference plant design was based on the use of oxygen
enriched combustion air preheated to a more moderate tempera-
ture in a tubular type metallic recuperative heat exchanger which
was part of the bottoming plant heat recovery system. Compara-
tive information was developed on plant performance and
economics. The highest net plant efficiency of about 45 percent
was attained by the reference plant design with the use of a
high temperature air preheater separately fired with the advan-
taced entrained bed gasifier. The use of oxygen enrichment of
the combustion air yielded the lowest cost of generating electricity
at a slightly lower plant efficiency. Both of these two reference
plant designs are identified as potentially attractive for early MHD
power plant applications.

R.E.S.

NBO-185862® Grumman Aerospace Corp., Bethpage, N.Y.
ACTIVE HEAT EXCHANGE SYSTEM DEVELOPMENT FOR
LATENT HEAT THERMAL ENERGY STORAGE Topical
Joseph Alario, Robert Kosson, and Robert Haslett Jan. 1980
73 p refs
(Contracts DEN3-39, EC-77-A-31-1034)
(NASA-CR-159726, DOE/NASA/0039-79/1; GAC-TR-1681-09) Avail: NTIS
HC A04/MF A01 CSCL 10A

Various active heat exchange concepts were identified from
among three generic categories: scrappers, ejectors/vibrators and
slurries. The most practical ones were given a more detailed
technical evaluation and an economic comparison with a passive
tube-shell design for a reference application (300 MW sub t
storage for 6 hours). Two concepts were selected for hardware
development: (1) a direct contact heat exchanger in which
moltan salt droplets are injected into a cooler countercflowing
stream of liquid metal carrier fluid, and (2) a rotating drum
scrapers in which molten salt is sprayed onto the circumference
of a rotating drum. This concept contains the fluid heat sink in an internal annulus near the surface. A fixed
scrapers blade removes the solidified salt from the surface which
was nickel plated to decrease adhesion forces. In addition to
improving performance by providing a nearly constant transfer
rate during discharge, these active heat exchanger concepts were
estimated to cost at least 25% less than the passive tube-shell
design.

R.E.S.

Div.
APPENDIX: MOD-1 WIND TURBINE GENERATOR
ANALYSIS AND DESIGN REPORT, VOLUME 2 Final
Report
May 1979 425 p
(Contracts NAS3-20058; EX-77-A-29-1010)
(NASA-CR-159486; DOE/NASA/0058-79/2-Vol-2-App) Avail:

NTIS HC A18/MF A01 CSCL 10B

The MOD-1 detail design is appended. The supporting
analyses presented include a parametric system trade study, a
verification of the computer codes used for rotor loads analysis,
a metal blade study, and a definition of the design loads at
each principal wind turbine generator interface for critical loading
conditions. Shipping and assembly requirements, composite blade
development, and electrical stability are also discussed.

K.L.

A 15 kW (NOMINAL) SOLAR THERMAL-ELECTRIC POWER
CONVERSION: CONCEPT DEFINITION STUDY: STEAM
RANKIN RECIPROCATOR SYSTEM Final Report
(Contracts DEN3-63, EX-78-A-29-1060)
(NASA-CR-159591; DOE/NASA/0063-79/1) Avail: NTIS
HC A03/MF A01 CSCL 10B

A conceptual design of a 3600 rpm reciprocation expander
was developed for maximum thermal input power of 80 kW.
The conceptual design covered two engine configurations, a single
cylinder design for simple cycle operation and a two cylinder
design for reheat cycle operation. The reheat expander contains
a high pressure cylinder and a low pressure cylinder with steam
being reheated to the initial inlet temperature after expansion in
the high pressure cylinder. Power generation is accomplished
with a three-phase induction motor coupled directly to the
expander and connected electrically to the public utility power
grid. The expander, generator, water pump and control system
weigh 297 kg and are dish mounted. The steam condenser,
water tank and accessory pumps are ground based. Maximum
heat engine efficiency is 33 percent maximum power conversion
efficiency is 30 percent. Total cost is $3,307 or $138 per kW
of maximum output power.

R.E.S.

NBO-19815® United Technologies Corp., South Windsor, Conn.
Power Systems Div.
ADVANCED TECHNOLOGY LIGHT WEIGHT FUEL CELL
R. E. Martin 1979 52 p refs
(Contract NAS3-21257)
(NASA-CR-159807; FCR-1657) Avail: NTIS
HC A04/MF A01 CSCL 10A

The development of a long life, high performance, high
efficiency, hydrogen oxygen alkaline fuel cell configuration for
application to a NASA orbiting space vehicle is documented.
Seven full-size 0.25 ft active area single cells were constructed
and tested at cell temperatures between 140 F and 200 F,
current densities out to 500 ASF, and reactant pressures up to
30 psis. Cells incorporating platinum-supported-on-carbon catalyst
anodes demonstrated 8.086 cell-hours of endurance operation
with virtually no change in performance and 2,995 cell-hours of
operation to a cyclical load profiles with no apparent loss in
cathode performance due to high voltage operation. Cell edge
frame materials and heat treated polybenzimidazole (PBI) matrix
samples were corrosion tested in 42 wt % aqueous potassium
hydroxide at 250 F. Based upon available test data, PBI appears
unsuitable for use as a fuel cell matrix material. Five semiconduc-
ting oxides were evaluated as cathode catalysts and as cathode
catalyst supports. The candidate supports LaMnO3 and LaNiO3
appear to have development potential and merit further study.

K.L.

NBO-19832® Jet Propulsion Lab., California Inst. of Tech.,
Pasadena.
ANNUAL TECHNICAL REPORT, FISCAL YEAR 1979,
VOLUME 1: EXECUTIVE SUMMARY Annual Report
John W. Lucas 15 Jan. 1980 46 p Sponsored in part by
DOE
(Contract NAS7-100)
HC A03/MF A01 CSCL 10A

Accomplishments of the Point-Focusing Distributed Receiver
Technology project are presented. The following aspects of the
project are discussed: information dissemination, concentrator
development, receiver and heat transport network development,
power conversion, manufacturing, systems engineering, and tests and evaluations


MOD 1 WIND TURBINE GENERATOR FAILURE MODES AND EFFECTS ANALYSIS
Feb. 1979 5 p refs (Contracts NAS3-20058, EX-77-A-29-1010)
Avail: NTIS HC A08/MF A01 CSCL 10B

A failure modes analysis (FMEA) was directed primarily at identifying those critical failure modes that would be hazardous to life or would result in major damage to the system. Each mode was broken down to successive lower levels where it appeared that the criticality of the failure mode warranted more detail analysis. The results were reviewed by specialists from outside the Mod 1 program, and corrective action taken wherever recommended.

A.R.H.


STUDY PROGRAM TO IMPROVE THE OPEN-CIRCUIT VOLTAGE OF LOW RESISTIVITY SINGLE CRYSTAL SILICON SOLAR CELLS
J A Minuccio and K W Matthei 7 Feb. 1980 119 p refs (Contracts NAS3-20823)
Avail: NTIS HC A06/MF A01 CSCL 10A

The results of a 14 month program to improve the open circuit voltage of low resistivity silicon solar cells are described. The approach was based on ion implantation in 0.1- to 1.0-dm-cm float-zone silicon. As a result of the contract effort, open circuit voltages as high as 645 mV (AMO 25) were attained by high dose phosphorus implantation followed by furnace annealing and simultaneous SiO2 growth. One key element was the use of pipeline gas, tap water and recovered water and definition of equipment required for treatment was initiated. An innovative approach was used to improve implant parameters, selection of furnace annealing techniques, and elimination of flash anneamal beam annealing to minimize thermal process-induced defects in the completed solar cells.

F.O.S


Avail: NTIS HC A06/MF A01 CSCL 10B

Three first-generation Brayton cycle engine types were studied for solar applications: a near-term open cycle (configuration A), a near-term closed cycle (configuration B), and a longer-term open cycle (configuration C). A parametric performance analysis was carried out to select engine designs for the three configurations. The interface requirements for the Brayton cycle engine/generator and solar receivers were determined. A technology assessment was then carried out to define production costs, durability, and growth potential for the selected engine types.

R.E.S

N80-2284* General Electric Co., Schenectady, N. Y.

CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR-TERM ELECTRIC UTILITY APPLICATIONS Final Report
E. W. Hall, W. Hausz, R. Anand, N. LaMarche, J. Oplinger, and M. Kazer Nov. 1979 524 p refs (Contracts DENG-161; DE-10057-79-79/2-Vol-1) Avail: NTIS HC A14/MF A01 CSCL 10A

The activities leading to the completion of detail design of the MOD-1 wind turbine generator are described. Emphasis is placed on the description of the design as it finally evolved. However, the steps through which the design progressed are also traced in order to understand the major design decisions.

R.E.S

N80-2378* Westinghouse Research and Development Center, Pittsburgh, Pa.

CELL MODULE AND FUEL CONDITIONER DEVELOPMENT
Avail: NTIS HC A04/MF A01

Components for the first 5 cell stack (no cooling plates) of the MK-2 design were fabricated. Preliminary specifications and designs for the components of a 23 cell MK-1 stack with four DIGAS cooling plates were developed. The MK-2 was selected as a bench mark engine and a preliminary design of the facilities required for high rate manufacture of fuel cell modules was developed. Two stands for testing 5 cell stacks were built and design work for modifying existing stands and building new stands for 23 and 80 cell stacks was initiated. Design and procurement of components and materials for the catalyst test stand were completed and construction initiated. Work on the specifications of pipeline gas, tap water and recovered water and definition of equipment required for treatment was initiated. An innovative geometry for the reformer was conceived and modifications of the computer program to be used in its design were stated.

R.E.S.

The durability of CATCOM catalysts and catalyst supports was experimentally demonstrated in a combustion environment under simulated gas turbine engine combustor operating conditions. A test of 1000 hours duration was completed with one catalyst using no. 2 diesel fuel and operating at catalytically supported thermal combustion conditions. The performance of the catalyst was determined by monitoring emissions throughout the test, and by examining the physical condition of the catalyst at the conclusion of the test. Tests were performed periodically to determine changes in catalytic activity of the catalyst core. Detailed parametric studies were also run at the beginning and end of the durability test, using no. 2 fuel oil. Initial and final emissions for the 1000 hours test respectively were: unburned hydrocarbons (C3 vppm): 0.146, carbon monoxide (vppm): 30, nitrogen oxides (vppm): 5.7, 5.6. R.E.S.

DISTRIBUTED RECEIVER TECHNOLOGY PROJECT, power and process heat in single energy conversion systems VOLUME 2: DETAILED REPORT: FOCUSING Large savings can be made in industry by cogenerating electric power and process heat in single energy conversion systems rather than separately in utility plants and in process boilers. About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidates which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesel, thermonics, stirling, closed-cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum-based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules for determining performance and cost in individual plants and on a national level. It was found that: (1) atmospheric and pressurized fluidized bed steam turbine systems were the most attractive of the direct coal-fired systems; and (2) open-cycle gas turbines with heat recovery steam generators and combined-cycles with NOx emission reduction and moderately increased firing temperatures were the most attractive of the coal-derived liquid-fired systems. R.E.S.
Data and information in the area of advanced energy conversion systems for industrial cogeneration applications in the 1985-2000 time period was studied. Six current and thirty-one advanced energy conversion systems were defined and combined with appropriate balance-of-plant equipment. Twenty-six industrial processes were selected from among the high energy consuming industries to serve as a framework for the study. Each conversion system was analyzed as a cogenerator with each industrial plant. Fuel consumption, costs, and environmental intrusions were evaluated and compared to corresponding traditional values. Various cogeneration strategies were analyzed and both topping and bottoming (using industrial by-product heat) applications were included. The advanced energy conversion technologies indicated reduced fuel consumption, costs, and emissions. Typically fuel energy savings of 10 to 25 percent were predicted compared to traditional on-site furnaces and utility electricity. With the variety of industrial requirements, each advanced technology had attractive applications. Overall, fuel cells indicated the greatest fuel energy savings and emission reductions. Gas turbines and combined cycles indicated overall annual cost savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesel units were most efficient. The advanced technologies used coal-derived fuels, or coal with advanced fluid bed combustion or on-site gasification systems.


Data and information in the area of advanced energy conversion systems for industrial cogeneration applications in the 1985-2000 time period was studied. Six current and thirty-one advanced energy conversion systems were defined and combined with appropriate balance-of-plant equipment. Twenty-six industrial processes were selected from among the high energy consuming industries to serve as a framework for the study. Each conversion system was analyzed as a cogenerator with each industrial plant. Fuel consumption, costs, and environmental intrusions were evaluated and compared to corresponding traditional values. Various cogeneration strategies were analyzed and both topping and bottoming (using industrial by-product heat) applications were included. The advanced energy conversion technologies indicated reduced fuel consumption, costs, and emissions. Typically fuel energy savings of 10 to 25 percent were predicted compared to traditional on-site furnaces and utility electricity. With the variety of industrial requirements, each advanced technology had attractive applications. Overall, fuel cells indicated the greatest fuel energy savings and emission reductions. Gas turbines and combined cycles indicated overall annual cost savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesel units were most efficient. The advanced technologies used coal-derived fuels, or coal with advanced fluid bed combustion or on-site gasification systems.


Information and data for 26 industrial processes are presented. The following information is given for each process: (1) a description of the process including the annual energy consumption and product production and plant capacity; (2) the energy requirements of the process for each unit of production and the detailed data concerning electrical energy requirements and also hot water, steam, and direct fired thermal requirements; (3) anticipated trends affecting energy requirements with new process or production technologies; and (4) representative plant data including capacity and projected requirements through the year 2000.


The potential technical capabilities of energy conversion systems in the 1985-2000 time period were defined with emphasis on systems using coal, coal-derived fuels or alternate fuels. Industrial process data developed for the large energy consuming industries serve as a framework for the cogeneration applications. Ground rules for the study were established and other necessary equipment (balance-of-plant) was defined. This combination of technical information, energy conversion system data ground rules, industrial process information and balance-of-plant characteristics was analyzed to evaluate energy consumption, capital and operating costs and emissions. Data in the form of computer printouts developed for 3000 energy conversion system-industrial process combinations are presented.


The second-degree nonlinear equations of motion for a flexible, twisted, nonuniform, horizontal axis wind turbine blade were developed using Hamilton's principle. A mathematical ordering scheme which was consistent with the assumption of a slender beam was used to discard some higher-order elastic and inertial terms in the second-degree nonlinear equations. The blade aerodynamic loading which was employed accounted for both wind shear and tower shadow and was obtained from strip theory based on a quasi-steady approximation of two-dimensional, incompressible, unsteady, airfoil theory. The resulting equations had periodic coefficients and were suitable for determining the aeroelastic stability and response of large horizontal-axis wind turbine blades.

N80-26776* Boeing Engineering and Construction, Seattle, Wash. MOD-2 WIND TURBINE SYSTEM CONCEPT AND PRELIMINARY DESIGN REPORT. VOLUME 2: DETAILED REPORT Jul. 1979 269 p (Contracts DEN3-2; DE-A101-793T-20305) (NASA-CR-159609; DOE/NASA/0002-B0/2) Avail: NTIS HC A12/MF A01 CSCL 10A

The configuration development of the MOD-2 wind turbine system (WTS) is documented. The MOD-2 WTS project is a continuation of DOE programs to develop and achieve early commercialization of wind energy. The MOD-2 is design optimized for commercial production rates which, in multiunit installations, will be integrated into a utility power grid and achieve a cost of electricity at less than four cents per kilowatt hour.
The performance and cost of moderate technology coal-fired open cycle MHD/steam power plant designs which can be expected to require a shorter development time and have a lower development cost than previously considered mature COMHD/steam plants were determined. Three base cases were considered: an indirectly-fired high temperature air heater (HTAH) subsystem delivering air at 2700°F, fired by a state of the art atmospheric pressure gasifier, and the HTAH subsystem was delayed and oxygen enrichment was used to obtain requisite MHD combustion temperature. Coal was bus bar efficiencies in base case 1 ranged from 41.4% to 42.9%, and cost of electricity (COE) was highest of the three base cases. For base case 2 the efficiency range was 42.0% to 45.6%, and COE was lowest. For base case 3 the efficiency range was 42.9% to 44.4%, and COE was intermediate. The best parametric cases in bases cases 2 and 3 are recommended for conceptual design. Eventual choice between these approaches is dependent on further evaluation of the tradeoffs among HTAH development risk, O2 plant integration, and further refinements of comparative costs.

NBO-27803# Wichita State Univ., Kans.

The feasibility of using aileron or spoiler controls as alternates to pitch control for large horizontal axis wind turbines was studied. The NASA Mod-0 100 kw machine was used as the basis for the study. Specific performance studies were conducted for 20% chord ailerons over the outboard 30% span, and for 10% chord spoilers over the same portion of the span. Both control systems utilized control deflections up to 60 deg. Results of the study show that either ailerons or spoilers can provide the control necessary to limit turbine power in high wind conditions. The aileron system, as designed, provides overspeed protection at hurricane wind speeds, low wind speed starting torque of 778 N-m (574 ft. lb) at 3.6 m/sec, and a 1.3 to 1.5% increase in annual energy compared to a fixed pitch rotor. The aileron control system preliminary design study includes aileron loads analysis and the design of a fail-safe flyweight actuator for overspeed protection in the event of a hydraulic system failure.

NBO-27808# Spectrolab, Inc., Sylmar, Calif.

The process for producing space qualified solar cells in both the conventional and wraparound configuration using screen printing techniques was investigated. Process modifications were chosen that could be easily automated or mechanized. Work was accomplished to optimize the tradeoffs associated with gridline spacing, gridline definition and junction depth. An extensive search for possible front contact metallization was completed. The back surface field structures along with the screen printed back contacts were optimized to produce open circuit voltages of at least an average of 600 millivolts. After all intended modifications on the process sequence were accomplished, the cells were exhaustively tested. Electrical tests at AMO and 28°C were made before and after boiling water immersion, thermal shock, and shock under conditions of high temperature and high humidity.

NBO-28880# Spectrolab, Inc., Sylmar, Calif.
COPLANAR BACK CONTACTS FOR THIN SILICON SOLAR


A process for fabricating 2 to 3 mil wraparound solar cells was formulated. Sample thin wraparound cells were fabricated using this process. The process used a reinforced perimeter construction to reduce the breakage that occurs during handling of the wafers. A retracting piston post was designed and fabricated to help minimize the breakage that occurs during the screen printing process. Two alternative methods of applying the aluminum back surface field were investigated. In addition to the standard screen printed back surface field, both spin-on and evaporated aluminum techniques were researched. Neither spin-on nor evaporated aluminum made any noticeable improvement over the screen printing technique. A fine screen mesh was chosen for the application of the aluminum paste back surface field. The optimum time and temperature for firing the aluminum turned out to be thirty seconds at 850° C. The development work on the dielectric included looking at three dielectrics for the wraparound application. Transene 1000, Thick Film Systems 1126CR8 and an in house formulation 61-2-2A were all tested. Cells with pre-dielectric thickness of 3.00-0.35 mils using Transene 1000 as the wraparound dielectric and the procedure outlined above showed an average efficiency of 10.7 percent. Thinner cells were fabricated, but had an unacceptable yield and efficiency.

NBO-28886# General Dynamics/Convair, San Diego, Calif.

The preliminary requirements and technology advances required for cost effective space power management systems for multi-100 kilowatt requirements were identified. System requirements were defined by establishing a baseline space platform in the 250 KE kW/s range and examining typical user loads and interfaces. The most critical design parameters identified for detailed analysis include: increased distribution voltages and space plasma losses, the choice between ac and dc distribution systems, shuttle servicing effects on reliability, life cycle costs, and frequency impacts to power management system and payload systems for AC transmission. The first choice for a power management system for this kind of application and size range is a hybrid ac/dc combination with the following major features: modular design and construction-sized minimum weight/life cycle cost; high voltage transmission (100 Vac RMS); medium voltage array < or = 440 Vdc); resonant inverter; transformer rotary joint; high frequency power transmission line < or = 20 KHz); energy storage on array side or rotary joint; fully redundant, and 10 year life with minimal replacement and repair.

N80-28886# Midwest Research Inst., Kansas City, Mo.

A rotary cement kiln and an electric arc furnace were chosen for evaluation to determine the applicability of a fluid bed heat exchanger (FBHX) for thermal energy storage (TES). Multistage shallow bed FBHIX's operating with high temperature differences were identified as the most suitable for TES applications. Analysis of the two selected conceptual systems included establishing a plant process flow configuration, an operational scenario, a preliminary FBHX/TES design, and parametric analysis. A computer model was developed to determine the effects of the number of stages, gas flow, bed materials, charge and discharge time, and parasitic power required for operation. The maximum national energy conservation potential
of the cement plant application with TES is 15.4 million barrels of oil or 3.9 million tons of coal per year. For the electric arc furnace application the maximum national conservation potential with TES is 4.5 million barrels of oil or 1.1 million tons of coal per year. Present time of day utility rates are near the breakeven point required for the TES system. Escalation of on-peak energy due to critical fuel shortages could make the FBHX/TES applications economically attractive in the future.

E.D.K.


Mid to late 1980’s power management technology needs to support development of a general purpose space platform, capable of supplying 100 to 250 KWe to a variety of users in low Earth orbit are examined. A typical, shuttle assembled and supplied space platform is illustrated, along with a group of payloads which might reasonably be expected to use such a facility. Examination of platform and user power needs yields a set of power requirements used to evaluate power management options for life cycle cost effectiveness. The most cost effective ac/dc and dc systems are evaluated, specifically to develop system details which lead to technology goals, including: array and transmission voltages, best frequency for ac power transmission, and advantages and disadvantages of ac and dc systems for the application. System and component requirements are compared with the state-of-the-art to identify areas where technological development is required.

Author


Silicon solar cells were fabricated to verify the predictions that: (1) thin n`-p`-p`-n` cells can provide high values of open circuit voltage even when high resistivity base material (> 1000 omega-cm) is used; (2) cells with good p`-n`-p`-n` back contacts will display an increase in open circuit voltage with decreasing cell thickness; and (3) high quality, thin, high resistivity, solar cells can be made using processing compatible with conventional practice. Analysis of I-V and spectral response measurements of these cells confirmed theoretical predictions and thereby pointed to voltages beyond the near 600 mV obtained in this study.

Author


Five tasks to select, design, fabricate, test and evaluate candidate active heat exchange modules for future applications to solar and conventional utility power plants were discussed. Experimental mechanisms of active heat exchange concepts were analyzed for use with high temperature phase change materials (PCMs) in the temperature range of 250 to 350 C. Twenty-six heat exchange concepts were reviewed, and eight were selected for detailed assessment. Two candidates were selected for small-scale experimentation: a coated tube and shell heat exchanger and a direct contact reflux boiler. A dilute eutectic mixture of sodium nitrate and sodium hydroxide was selected as the PCM from over 50 candidate inorganic salt mixtures.

Based on a salt screening process, eight major component salts were selected initially for further evaluation. The most attractive major components in the temperature range of 250 to 250 C appeared to be NaNO3, Na2NO2, and NaOH. Sketches of the two active heat exchange concepts selected for test are given.

R.K.G.


The technical and economic potential for high temperature (343 C, 850 F) thermal energy storage in hollow steel ingots, pipes embedded in concrete, and for pipes buried in sand was evaluated. Because it was determined that concrete separate from pipes due to thermal stresses, concrete was replaced by sand, which is free from thermal stresses. Variations of the steel ingot concept were not cost effective compared to the sand-pipe approach, therefore, the sand-pipe thermal storage unit (TSU) was evaluated in depth to assess the approximate tube spacing requirements consistent with different system performance characteristics and also attendant system costs. For large TSUs which do not require fast response times, the sand-pipe approach offers attractive possibilities. A pipe diameter about 9 cm (3.5 in) and pipe spacing of approximately 25 cm (10 in), with sand filling the interspaces, appears appropriate. Such a TSU system designed for 8 hours charge/dischage cycle has an energy unit storage cost (CE) of $2.63/kW-hr and a power unit storage cost (CP) of $42/kW (in 1977 dollars).

A.R.H.


About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermoclines, stirling, closed cycle and steam injected gas turbines and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. Computer generated reports of the fuels consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (CEC's) heat and power matched to the individual industrial processes are presented. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented. Two nocogeneration base cases are included: coal fired and residual fired process boilers.

T.M.

CSCL 108

About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (ECS's) heat and power matched to the individual industrial processes are presented. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented. Two nocogeneration base cases are included: coal fired and residual fired process boilers. T.M.

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS), VOLUME 3: INDUSTRIAL PROCESSES Final Report

W. F. Knightly May 1980 296 p
(Contract DEN3-31)
(NASA-CR-159770-PI-2: DOE/NASA/0031-80/6-Vol-6-PI-2;
GEB0ET0105-Vol-6-PI-2) Avail: NTIS HC A13/MF A01 CSCL 108

About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (ECS's) heat and power matched to the individual industrial processes are presented. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented. Two nocogeneration base cases are included: coal fired and residual fired process boilers. T.M.

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS), VOLUME 3: ENERGY CONVERSION SYSTEM CHARACTERISTICS Final Report
Jan, 1980 283 p refs
(Contracts DEN3-30; EC-77-A-31-1062)
(NASA-CR-159761; DOE/NASA/0030-80/3-Vol-3;
UTC-FCR-1333-Vol-3) Avail: NTIS HC A13/MF A01 CSCL 108

Six current and thirty-six advanced energy conversion systems were defined and combined with appropriate balance of plant equipment. Twenty-six industrial processes were selected from among the high energy consuming industries to serve as a frame work for the study. Each conversion system was analyzed as a cogenerator with each industrial plant. Fuel consumption, costs, and environmental intrusion were evaluated and compared to corresponding traditional values. The advanced energy conversion technologies indicated reduced fuel consumption, costs, and emissions. Fuel energy savings of 10 to 25 percent were predicted compared to traditional on site furnaces and utility electricity. With the variety of industrial requirements, each advanced technology had attractive applications. Fuel cells indicated the greatest fuel energy savings and emission reductions. Gas turbines and combined cycles indicated higher overall annual savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesels were most efficient. The advanced

N80-31882f Westinghouse Research and Development Center, Pittsburgh, Pa.
CELL MODULE AND FUEL CONDITIONER Quarterly Report.
Apr. - Jun, 1980
D. Q. Hoover, Jr. Jul. 1980 75 p
(Contracts DEN3-161; DE-At 03-78ET-11722)
(NASA-CR-159888; DOE/NASA/0161-4;
Rep7-80-960-MARED-R3; QR3) Avail: NTIS
HC A04/MF A01 CSCL 108

The computer code for the detailed analytical model of the MK-2 stacks is described. An ERG proprietary matrix is incorporated in the stacks. The mechanical behavior of the stack during thermal cycles under compression was determined. A 5 cell stack of the MK-2 design was fabricated and tested. Designs for the next three stacks were selected and component fabrication initiated. A 3 cell stack which verified the use of wet assembly and a new acid fill procedure were fabricated and tested. Components for the 2 kW test facility were received or fabricated and construction of the facility is underway. The definition of fuel and water is used in a study of the fuel conditioning subsystem. Kinetic data on several catalysts, both crushed and pellets, was obtained in the differential reactor. A preliminary definition of the equipment requirements for treating tap and recovered water was developed. S.J.

N80-33980f General Electric Co., Schenectady, N. Y.
(Contract DEN3-31)
(NASA-CR-159768; GEB0ET0103-Vol-4;
DOE/NASA/0031-80/4-Vol-4) Avail: NTIS
HC A09/MF A01 CSCL 108

Cogenerating electric power and process heat in single energy conversion systems rather than separately in utility plants and in process boilers is examined with respect to cost savings. The use of various advanced energy conversion systems is examined and compared with each other and with current technology systems for their savings in fuel energy, costs, and emissions in individual plants and on a national level. About fifty industrial processes from the target energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules specified by NASA for determining performance and cost. Data and narrative descriptions of the industrial processes are given. R.K.G.
Industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed-cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum-based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules specified by NASA for determining performance and cost. The advanced and commercially available cogeneration energy conversion systems studied in CTAS are lined together with their performance, capital costs, and the research and developments required to bring them to this level of performance.

Author


COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 6: COMPUTER DATA. PART 1: COAL-FIRED NOCOGENERATION PROCESS BOILER. SECTION A Final Report


(Contract DEN3-31)

(NASA-CR-159770-Pt-1, GEBOET0105-Vol-6-Pt-1; DOE/NASA/0031-80/6) Avail: NTIS HC A21/MF AO1 CSCL 108

Various advanced energy conversion systems (ECS) are compared with each other and with current technology systems for their savings in fuel energy, costs, and emissions in individual plants and on a national level. About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidates which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed-cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum-based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of residual fired process boilers are presented. Performance parameters included fuel consumption and savings, capital costs, economics, and emissions of residual fired process boilers.

Author


COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 6: COMPUTER DATA. PART 2: RESIDUAL-FIRED NOCOGENERATION PROCESS BOILER. Final Report

W. F. Knightly May 1980 287 p refs

(Contract DEN3-31)

(NASA-CR-159770-Pt-2: GEB0ET0105-Vol-6-Pt-2; DOE/NASA/0031-80/6-Vol-6-Pt-2) Avail: NTIS HC A13/MF AO1 CSCL 108

Computer generated data on the performance of the energy conversion system is presented. Performance parameters included fuel consumption and savings, capital costs, economics, and emissions of residual fired process boilers.

Author

N80-33862\# National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

MOD-2 WIND TURBINE FARM STABILITY STUDY Final Report

E. N. Hinrichsen Jun. 1980 170 p refs

(Contracts DEN3-134: DE-AIO1-79ET-20305)


A parametric study of the performance of the MHD generator and combustor components of potential early commercial open-cycle MHD/steam power plants is presented. Consideration is given to the effects of air heater system concept, MHD combustor type, coal type, thermal input power, oxygen enrichment of the combustion, subsonic and supersonic generator flow and magnetic field strength on coupled generator and combustor performance. The best performance is found to be attained with a 3000 F, indirectly fired air heater, 80% oxygen enrichment, Illinois no. 6 coal, a two-stage cyclone combustor with 85% slag rejection, a subsonic generator, and a magnetic field configuration yielding a constant transverse electric field of 4 kV/m. Results indicate that optimum net MHD generator power is generally developed in a machine dynamics differ very little from single machine dynamics.

T.M.
**45 ENVIRONMENT POLLUTION**

Includes air, noise, thermal and water pollution; environment monitoring; and contamination control.

**N80-13721**

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

**AN ANALYTICAL STUDY OF NITROGEN OXIDES AND CARBON MONOXIDE EMISSIONS IN HYDROCARBON COMBUSTION WITH ADDED NITROGEN. PRELIMINARY RESULTS.**


The effect of combustor operating conditions on the conversion of fuel-bound nitrogen (FBN) to nitrogen oxides NO sub x was analytically determined. The effect of FBN and of operating conditions on carbon monoxide (CO) formation was also studied.

For these computations, the combustor was assumed to be a two stage, adiabatic, perfectly-stirred reactor. Propane-air was used as the combustible mixture and fuel-bound nitrogen was simulated by adding nitrogen atoms to the mixture. The oxidation of propane and formation of NO sub x and CO were modeled by a fifty-seven-reaction chemical mechanism. The results for NO sub x and CO formation are given as functions of primary and secondary stage equivalence ratios and residence time.

R.E.S.

**N80-14881**

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

**SULFATE AND NITRATE COLLECTED BY FILTER SAMPLING NEAR THE TROPOPAUSE**

Francis M. Humenik, Erwin A. Lezberg, and Dumas A. Ottersen Jan. 1980 30 p refs (NASA-TP-1587; E-073) Avail. NTIS HC A02/MF A01 CSCL 13B

Filter samples collected near the tropopause with an F-106 aircraft and two Boeing 747 aircraft were analyzed for sulfate and nitrate ion content. Within the range of routine commercial flight altitudes (at or below 12.5 km), stratospheric mass mixing ratios for the winter-spring group averaged 0.26 ppm for sulfate and 0.35 ppm for nitrate. For the summer-fall group, stratospheric mixing ratios averaged 0.13 ppm and 0.25 ppm for sulfate and nitrate, respectively. Winter-spring group tropospheric mass mixing ratios averaged 0.08 ppm for sulfate and 0.10 ppm for nitrate, while summer-fall group tropospheric mixing ratios averaged 0.05 ppm for sulfate and 0.08 ppm for nitrate. Correlations of the filter data with available ozone data suggest that the sulfate and nitrate are transported from the stratosphere to the troposphere.

K.L.

**N80-21892**

National Aeronautics and Space Administration.


J. D. Holdeman, Thomas J. Dudziak, and Marvin W. Tiefermann

Mar. 1979 63 p refs (NASA-TM-81462; E-393) Avail. NTIS HC A04/MF A01 CSCL 13B

In situ measurements of atmospheric ozone, carbon monoxide, clouds, and related meteorological and flight information obtained during 1122 flights of aircraft VH-5B and N65PA from January 10 through October 2, 1979 are reported. In addition, tropopause pressures obtained from time and space interpolation of achieved data for the dates of the flights are included.

R.E.S.

**N80-23875**

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

**ASSESSMENT OF POTENTIAL EXPOSURE TO FRAMIBLE INSULATION MATERIALS CONTAINING ASBESTOS.**


Asbestos and the procedures for assessing potential exposure hazards are discussed. Assessment includes testing a bulk sample of the suspected material for the presence of asbestos, and monitoring the air, if necessary. Based on field inspections and laboratory analyses, the health hazard is evaluated, and abatement measures are taken if a potential hazard exists. Throughout the assessment and abatement program, all applicable regulations are administered as specified by the Environmental Protection Agency and the Occupational Safety and Health Administration.

R.E.S.

**N80-27832**

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

**COORDINATED AIRCRAFT AND SHIP SURVEYS for DETERMINING IMPACT OF RIVER INPUTS ON GREAT LAKES WATERS. REMOTE SENSING RESULTS**


The remote sensing results of aircraft and ship surveys for determining the impact of river discharges on Great Lakes waters are presented. Aircraft multi-spectral scanner data were acquired throughout the spring and early summer of 1976 at five locations: the West Basin of Lake Erie, Genesee River - Lake Ontario, Menomonie River - Lake Michigan, Grand River - Lake Michigan, and Nemadji River - Lake Superior. Multispectral scanner data and ship surface sample data are correlated resulting in 40 contour plots showing large-scale distribution of parameters such as total suspended solids, turbidity, Secchi depth, nutrients, salts, and dissolved oxygen. The imagery and data analysis are used to determine the transport and dispersion of materials from the river discharges, especially during spring runoff events, and to evaluate the relative effects of river input, resuspension, and shore erosion. Twenty-five LANDSAT satellite images of the study sites are also included in the analysis. Examples of the use of remote sensing data in quantitative estimating total particulate loading in determining water types, in assessing transport across international boundaries, and in supporting numerical current modeling are included. The importance of coordination of aircraft and ship lake surveys is discussed, including the use of telecommunications for the transmission of imagery.

J.M.S.
Performance deficiencies in aerial liquid and dry dispersal systems are identified. Five control system concepts are explored: (1) end of field on/off control, (2) manual control of particle size and application rate from the aircraft; (3) manual control of deposit rate on the field; (4) automatic alarm and shut-off control; and (5) fully automatic control. Operational aspects of the concepts and specifications for improved control configurations are discussed in detail. A research plan to provide the technology needed to develop the proposed improvements is presented along with a flight program to verify the benefits achieved. K.L.
47 METEOROLOGY AND CLIMATOLOGY
Includes weather forecasting and modification.


In an investigation of windpower plant siting, equations are presented and evaluated for a wind profile model which incorporates both roughness and wind speed effects, while retaining the basic simplicity of the Hellman power law. These equations recognize the statistical nature of wind profiles and are compatible with existing analytical models and recent wind profile data. Predictions of energy output based on the proposed profile equations are 10% to 20% higher than those made with the 1/7 power law. In addition, correlation between calculated and observed blade loads is significantly better at higher wind speeds when the proposed wind profile model is used than when a constant power model is used. B.J.

A group of 30 patients with adenocarcinoma of the pancreas including some patients with very advanced disease, were treated with the so-called mixed beam modality employing photon treatments three times per week and neutron treatments twice a week. Two hundred Rods or equivalent Rads (RBE 3.3) were given in daily fractions aiming at a total dose of 6000 Rods in 6 to 8 weeks. The treatments were well tolerated and significant palliation was achieved in 28 to 30 cases. Twelve months survival was 33 percent with a median survival of 7 months or 210 days. Treatment techniques and localization procedures are discussed.

R.E.S.
AEROSPACE MEDICINE

Includes physiological factors, biological effects of radiation, and weightlessness.

INTRA-OCULAR PRESSURE NORMALIZATION TECHNIQUE

A method and apparatus is described for safely reducing abnormally high intraocular pressure in an eye during a predetermined time interval. This allows maintenance of normal intraocular pressure during glaucoma surgery. A pressure regulator of the spring-biased diaphragm type is provided with additional bias by a column of liquid. A hypodermic needle can be safely inserted into the anterior chamber of the eye. Liquid is then bled out of the column to reduce the bias on the diaphragm of the pressure regulator and, consequently, the output pressure of the regulator. This lowering pressure of the regulator also occurs in the eye by means of a small second bleed path provided between the pressure regulator and the hypodermic needle.

Official Gazette of the U.S. Patent and Trademark Office
A computer program was developed to aid assembly language programmers of minicomputers and micro computers in solving the man machine communications problems that exist when scaled integers are involved. In addition to producing displays of quasi-steady state values, INFORM provides an interactive mode for debugging programs, making program patches, and modifying the displays. Auxiliary routines SAMPLE and DATAO add dynamic data acquisition and high speed dynamic display capability to the program. Programming information and flow charts to aid in implementing INFORM on various machines together with descriptions of all supportive software are provided. Program modifications to satisfy the individual user's needs are considered.

R C T
NONANALYTIC FUNCTION GENERATION ROUTINES FOR 
16-BIT MICROPROCESSORS
James F Soeder and Marynta Shaufl Washington Sep 1980
66 p refs (NASA-TM-81586, E-565) Avail NTIS HC A04/MF A01 CSCL 098

Interpolation techniques for three types (univariate, bivariate, and map) of nonanalytic functions are described. These interpolation techniques are then implemented in scaled fraction arithmetic on a representative 16 bit microprocessor. A FORTRAN program is described that facilitates the scaling, documentation, and organization of data for use by these routines. Listings of all these programs are included in an appendix. L.F.M.

ALGORITHM FOR CALCULATING TURBINE COOLING FLOW AND THE RESULTING DECREASE IN TURBINE EFFICIENCY
James W. Gantner Feb, 1980 23 p refs (NASA-TM-81453; E-384) Avail NTIS HC A02/MF A01 CSCL 098

An algorithm is presented for calculating both the quantity of compressor bleed flow required to cool the turbine and the decrease in turbine efficiency caused by the injection of cooling air into the gas stream. The algorithm, which is intended for an axial flow, air routine in a properly written thermodynamic cycle code. Ten different cooling configurations are available for each row of cooled airfoils in the turbine. Results from the algorithm are substantiated by comparison with flows predicted by major engine manufacturers for given bulk metal temperatures and given cooling configurations. A list of definitions for the terms in the subroutine is presented. K.L.
65 STATISTICS AND PROBABILITY
Includes data sampling and smoothing, Monte Carlo method, and stochastic processes.

N80-28088
National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CYCLES TILL FAILURE OF SILVER-ZINC CELLS WITH COMPLETING FAILURES MODES: PRELIMINARY DATA ANALYSIS
Steven M. Sidik, Harold F. Leiback, and John M. Bozek 1980
(NASA-TM-81556; E-517) Available NTIS HC A03/MF A01 C/SCL 14D
One hundred and twenty nine cells were run through charge-discharge cycles until failure. The experiment design was
a variant of a central composite factorial in five factors. Preliminary data analysis consisted of response surface estimation of life.
Batteries fail under two basic modes: a low voltage condition
and an internal shorting condition. A competing failure modes
analysis using maximum likelihood estimation for the extreme
value life distribution was performed. Extensive diagnostics such
as residual plotting and probability plotting were employed to
verify data quality and choice of model.

A80-40764
As many as three iterated statistical model deletion procedures
are considered for an experiment. Population model coefficients
were chosen to simulate a saturated factorial experiment having an
unfavorable distribution of parameter values. Using random number
studies, three model selection strategies were developed, namely, (1)
a strategy to be used in anticipation of large coefficients of variation
(neighborhood of 65 percent), (2) strategy to be used in anticipation
of small coefficients of variation (4 percent or less), and (3) a
security regret strategy to be used in the absence of such prior
knowledge. (Author)
66 Systems Analysis

Includes mathematical modeling; network analysis; and operations research.

N80-16824*// National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

AN AVERAGING BATTERY MODEL FOR A LEAD-ACID BATTERY OPERATING IN AN ELECTRIC CAR Final Report
John M. Bozek Dec 1979 19 p refs (Contract EC-77-A-31-1044)
(NASA-TM-79321, DOE/NASA/1044-79/5, E-277) Avail NTIS HC A02/MF A01 CSCL 128

A battery model is developed based on time averaging the current or power, and is shown to be an effective means of predicting the performance of a lead acid battery. The effectiveness of this battery model was tested on battery discharge profiles expected during the operation of an electric vehicle following the various SAE J227a driving schedules. The averaging model predicts the performance of a battery that is periodically charged (regenerated) if the regeneration energy is assumed to be converted to retrievable electrochemical energy on a one-to-one basis.


The paper describes the computational techniques employed in determining the optimal propulsion systems for future aircraft applications and to identify system tradeoffs and technology requirements. The computer programs used to perform calculations for all the factors that enter into the selection process of determining the optimum combinations of airplanes and engines are examined. Attention is given to the description of the computer codes including NNEP, WATE, LIFCYC, INSTAL, and POD DRG. A process is illustrated by which turbine engines can be evaluated as to fuel consumption, engine weight, cost and installation effects. Examples are shown as to the benefits of variable geometry and of the tradeoff between fuel burned and engine weights. Future plans for further improvements in the analytical modeling of engine systems are also described.

C.F.W.
Approximate expressions were developed for the noise radiation from the aft duct. The results of approximate aft radiation equation compare favorably to more exact Wiener-Hopf radiation results. Refraction as well as convective effects in the multiple flow streams is considered. The peak in the radiation pattern, which occurs nearly at engine sideline, is composed of modes with relatively large cut-off ratios. This implies that aft fan radiation will be inherently more difficult to suppress than the fan inlet noise. The theoretical multimodal radiation pattern is compared to experimental data for the first two harmonics of blade passage frequency for three full scale fans at two speeds. The agreement between theory and experiment is quite good. A.R.H.
TIME-DEPENDENT DIFFERENCE THEORY FOR NOISE PROPAGATION IN A TWO-DIMENSIONAL DUCT
(NASA-TM-79329; E-248; AIAA-Paper-80-0098) Avail: NTIS HC A02/MF A01 CSCL 20A
A time dependent numerical formulation was derived for sound propagation in a two dimensional straight soft-walled duct in the absence of mean flow. The time dependent governing acoustic-difference equations and boundary conditions were developed along with the maximum stable time increment. Example calculations were presented for sound attenuation in hard and soft wall ducts. The time dependent analysis were found to be superior to the conventional steady numerical analysis because of much shorter solution times and the elimination of matrix storage requirements. R.C.T.

TIME-DEPENDENT DIFFERENCE THEORY FOR SOUND PROPAGATION IN DUCTS WITH FLOW
K. J. Baumeister 1979 38 p refs Presented at 98th Meeting of the Acoustical Soc. of Am., Salt Lake City, Utah, 26-30 Nov. 1979
(NASA-TM-79302; E-254) Avail: NTIS HC A03/MF A01 CSCL 20A
A time dependent numerical solution of the linearized continuity and momentum equation was developed for sound propagation in a two dimensional straight hard or soft wall duct with a sheared mean flow. The time dependent governing acoustic difference equations and boundary conditions were developed along with a numerical determination of the maximum stable time increments. A harmonic noise source radiating into a quiescent duct was analyzed. This explicit iteration method then calculated stepwise in real time to obtain the transient as well as the steady state solution of the acoustic field. Example calculations were presented for sound propagation in hard and soft wall ducts, with no flow and plug flow. Although the problem with sheared flow was formulated and programmed, sample calculations were not examined. The time dependent finite difference analysis was found to be superior to the steady state finite difference and finite element techniques because of shorter solution times and the elimination of large matrix storage requirements. R.C.T.

RECIPIROCITY PRINCIPLE IN DUCT ACOUSTICS
(NASA-TM-79030; E-250) Avail: NTIS HC A02/MF A01 CSCL 20A
Various reciprocity relations in duct acoustics have been derived on the basis of the spatial reciprocity principle implied in Green's functions for linear waves. The derivation includes the reciprocity relations between mode conversion coefficients for reflection and transmission in nonuniform ducts, and the relation between the radiation of a mode from an arbitrarily terminated duct and the absorption of an externally incident plane wave by the duct. Such relations are well defined as long as the systems remain linear, regardless of acoustic properties of duct nonuniformities which cause the mode conversions. Author

APPLICATION OF COHERENCE IN FAN NOISE STUDIES
Joseph R. Balombini Feb. 1980 26 p refs
(NASA-TP-1630; E-157) Avail: NTIS HC A03/MF A01 CSCL 20A
A study of fan noise was made by using the coherence function to obtain far field spectra that were coherent with the
fan rotational rate. Choosing fan rotational rate as one of the two variables yielded new information about the far field noise generated during static fan testing. As a result of this coherent data processing, the inlet fan-tone noise present in static testing was determined to be mostly random when the rotor-alone and rotor-stator interaction tones were cut off. After the rotor-alone sound field was cut on, the sound pressure became coherent, and the angular extent of high coherence increased as fan speed was increased. In addition, the sound field was organized as a pattern of lobes whose amplitude varied slowly with time. Additional fan test results indicate that operating the fan with an inflow control device can partially reduce the fan-tone noise levels to those produced by coherent processing.

A method which shows that increasing the annulus width of a conventional coaxial nozzle with constant bypass velocity will lower the noise level is described. The method entails modifying a concentric coaxial nozzle to provide an eccentric outer stream annulus while maintaining approximately the same through flow as that for the original concentric bypass nozzle. Acoustical tests to determine the noise generating characteristics of the nozzle over a range of flow conditions are described. The tests involved sequentially analyzing the noise signals and digitally recording the 1/3 octave band sound pressure levels. The measurements were made in a plane passing through the minimum and maximum annulus width points, as well as at 90 degrees in this plane, by rotating the outer nozzle about its axis. Representative measured spectral data in the flyover plane for the concentric nozzle obtained at model scale are discussed. Representative spectra for several engine cycles are presented for both the eccentric and concentric nozzles at engine size.

A method which shows that increasing the annulus width


A semi-empirical model for predicting the noise generated by jets exhausting from circular nozzles is presented and compared with small-scale static and simulated-flight data. The present method is an updated version of that part of the original NASA aircraft noise prediction program relating to circular jet noise. The earlier method agreed reasonably well with experimental static and flight data for jet velocities up to approximately 520 m/sec. The poorer agreement at higher jet velocities appeared to be due primarily to the manner in which supersonic convection effects were formulated. The purely empirical supersonic convection formulation is replaced in the present method by one based on theoretical considerations. Other improvements of an empirical nature were included based on model-jet/free-jet simulated-flight tests. The effects of nozzle size, jet velocity, jet temperature, and flight angle are included.

Author: A.W.H.
A liquid fuel, ducted, combustion noise test facility are analyzed Measurements made over a range of air and fuel flows are discussed Measured spectra are compared with spectra calculated using a simple analytical model.

**Effect of Inflow Control on Inlet Noise of a Cut-On Fan**


The control of turbulence and other inflow disturbances in anechoic chambers for static turbulent noise studies was studied A cut-on, high tip speed fan stage was acoustically tested with three configurations of an inflow control device in an anechoic chamber Although this was a cut-on design, rotor inflow interaction appeared to be a much stronger source of blade passing tone radiated from the inlet than rotor stator interaction for the 1.6 mean rotor chord separation As external suction applied to the area where the inflow control device joined the inlet produced a further reduction in blade passing tone, suggesting that disturbances in the forward flow on the outside of the inlet were superimposed on the inlet boundary layer and were a significant source of tone noise.

**Forward Acoustic Performance of a Shock, Swallowing High-Tip-Speed Fan (GF-13)**


Forward noise and overall aerodynamic performance data are presented for a high-tip-speed fan having rotor blade airfoils designed to alter the conventional leading-edge bow shocks to weak, oblique shocks which are swallowed within the interblade channels It was anticipated that the swallowed shocks would minimize the generation of multiple-frequency tone noise In the speed range where the shocks presumably were swallowed, the multiple-tone noise was lowered only about 3 decibels Comparison with several high-speed fans on a thrust-corrected basis indicates that the present fan was the quietest in total forward noise at low speeds but offered no advantage at high speeds.

**Higher Order Mode Propagation in Nonuniform Circular Ducts**


Higher order mode propagation in a nonuniform circular duct without mean flow was investigated An approximate wave equation is derived on the assumptions that the duct cross section varies slowly and that mode conversion is negligible Exact closed form solutions are obtained for a particular class of converging-diverging circular duct which referred to as 'Circular cowl duct' Numerical results are presented in terms of the transmission loss for the various duct shapes and frequencies The results are applicable to multimodal propagation, single mode propagation, and sound radiation from certain types of contoured inlet ducts, or of sound propagation in a converging-diverging duct of somewhat different shape from a cowl duct.

**An Exploratory Survey of Noise Levels Associated With a 100kW Wind Turbine**


Noise measurements of a 125-foot diameter, 100 kW wind turbine are presented The data include measurements as functions of distance from the turbine and directivity angle and cover a frequency range from 1 Hz to several kHz Potential community impact is discussed in terms of A-weighted noise levels relative to background levels, and the intrasonic spectral content Finally, the change in the sound power spectrum associated with a change in the rotor speed in described The acoustic impact of this size wind turbine is judged to be minimal.

**A Comparison Between an Existing Propeller Noise Theory and Wind Tunnel Data**

James H. Dittmar May 1980 41 p refs (NASA-TM-81519; E-464) Avail: NTIS HC A03/MF A01 CSCL 20A

The noise of three supersonic helical tip speed propellers was compared with the noise predicted by an existing noise theory Comparisons of the peak blade passage tones showed fairly good agreement between theory and experiment at the lowest helical tip Mach numbers tested, 0.86 and 1.00, while at higher numbers, the theory predicted higher noise levels than measured When the differences among the propellers were considered the theory and measurement showed fairly good agreement Directivity measurements in general showed that the measured blade passage tone data peaked further downstream than the theory predicted At the noise design condition the harmonics appeared to fall off faster in the data than the theory indicated.

**Measured and Predicted Impingement Noise for a Model-Scale Under the Wing Externally BLOWn FLAP CONFIGURATION WITH a QCSEE TYPE NOZZLE**


Jet/flare interaction noise was measured and predicted for a small-scale model two-flap, under-the-wing, externally blown flap configuration equipped with and without noise suppression devices The devices consisted of short spanwise fairings centered in relationship to the jet axis and positioned in the slots between the wing and flaps The nozzle approximated that of the Quiet Clean Short-haul Experimental Engine (QCSEE) Takeoff noise reductions of 6 dB in the flyover and 5 dB in the sideline plane were obtained over a wide range of radiation angles Approach noise reductions of about 5 dB were obtained only in the forward quadrant of the flyover plane, no reductions were obtained in the sideline plane, Models of several noise sources were combined analytically to form an overall noise prediction, the results from which were compared favorably with the measured data The aerodynamic performance characteristics for these configurations were substantially the same in the takeoff attitude However, in the approach attitude, the suppressed configuration produced a 6 percent reduction in the flow turning efficiency.

**Prediction of Unsuppressed Jet Engine Exhaust Noise in Flight from Static Data**


A methodology developed for predicting in-flight exhaust noise from static data is presented and compared with experimental
data for several unsuppressed turbojet engines. For each engine, static data over a range of jet velocities are compared with the predicted jet mixing noise and shock-cell noise. The static engine noise over and above the jet and shock noises is identified as excess noise. The excess noise data are then empirically correlated to smooth the spectral and directivity relations and account for variations in test conditions. This excess noise is then projected to flight based on the assumption that the only effects of flight are a Doppler frequency shift and a level change given by 40 log (1 + m sub 0 cos theta), where m sub 0 is the flight Mach number and theta is the observer angle relative to the jet axis.


A time-dependent numerical formulation is derived for sound propagation in a two-dimensional straight soft-walled duct with flow, as might be found in a typical turbojet engine duct, muffler, or industrial ventilation system, are reviewed. Both steady-state and transient theories are discussed. Emphasis is placed on the advantages and limitations associated with the various numerical techniques. Examples of practical problems are given for which the numerical techniques have been applied.


This paper presents the initial quantitative comparison of inlet suppressor far-field directivity suppression with that predicted using an approximate linear design and evaluation method based upon cutoff ratio. The experimental data was obtained using a series of cylindrical point-reacting inlet liners on an Avco-Lycoming YF102 engine. The theoretical prediction program is based upon simplified sound-propagation concepts derived from exact calculations. These results indicate that all of the controlling phenomenon can be approximately correlated with mode cutoff ratio which itself is intimately related to the angles of propagation within the duct. The objective of the theory-data comparisons is to point out possible deficiencies in the approximate theory which may be corrected. After all theoretical
refinements have been made, then empirical corrections can be applied.

(Author)


Insight into the inflight acoustic characteristics of high-speed jet noise suppressor nozzles for supersonic cruise aircraft (SCA) is provided. Although the suppression of jet noise over the entire range of directivity angles is of interest, the suppression of the peak noise level in the rear quadrant is frequently of the most interest. Consequently, the paper is directed primarily to the inflight effects at the peak noise level. Both single and inverted-velocity-profile multimodal suppressor nozzles are considered. The importance of static spectral shape on the noise reduction due to inflight effects is stressed.

(Author)

A80-35496 * # Spectral structure of pressure measurements made in a combustion duct. J. H. Miles (NASA, Lewis Research Center, Cleveland, Ohio) and D. D. Raftopoulos (Toledo University, Toledo, Ohio). Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper. 44 p. 43 refs.

The spectral structure of pressure measurements made in a ducted combustion test facility are studied. Dispersion and attenuation of acoustic plane waves may occur in the duct at low frequencies due to combustor emissions and affect the spectral structure. A model that considers the propagation of plane waves through a cloud of particles in a flowing gas and which includes heat transfer between soot particles and the gas is described. Experimental results are compared with theory.

(Author)


Previous studies have shown that increasing the annulus width of a conventional coaxial nozzle with constant bypass velocity will lower the noise level. In the present model-scale study, the annulus was shaped by an eccentric mounting of the annular nozzle with respect to the conical core nozzle. Acoustic measurements were made in the flyover plane below the widest portion of the annulus and at 90 deg and 180 deg from this point. The model-scale spectra are scaled up to engine size (1.07 m diameter) and the perceived noise levels for the eccentric and concentric coaxial nozzles are compared over a limited range of operating conditions. The implications of the acoustic benefits derived from the eccentric nozzle to practical applications are discussed.

(Author)


Previous studies have shown that an inverted-velocity-profile coaxial nozzle for use with supersonic cruise aircraft produces less jet noise than an equivalent conical nozzle. Furthermore, decreasing the annulus height (increasing radius ratio with constant flow) results in further noise reduction benefits. In the present model-scale study, the annulus shape, that is, height, was varied by an eccentric mounting of the annular nozzle with respect to a conical core nozzle. Acoustic measurements were made in the flyover plane below the narrowest portion of the annulus and at 90 deg and 180 deg from this point. The model-scale spectra are scaled up to engine size (1.07 m diameter) and the perceived noise levels for the eccentric and baseline concentric inverted-velocity-profile coaxial nozzles are compared over a range of operating conditions. The implications of the acoustic benefits derived with the eccentric nozzle to practical applications are discussed.

(Author)


During performance tests of a 125-foot diameter, 100 kW wind turbine at the NASA Plum Brook Station near Sandusky, Ohio, the opportunity arose to make exploratory noise measurements and results of those surveys are presented. The data include measurements as functions of distance from the turbine, and directivity angle, and cover a frequency range from 1 Hz to several kHz. Potential community impact is discussed in terms of A-weighted noise levels relative to background levels, and the infrasonic spectral content. Finally, the change in the sound power spectrum associated with a change in the rotor speed is described. The acoustic impact of this size wind turbine is judged to be minimal.

(Author)


This paper presents an analytical investigation of higher order mode propagation in a nonuniform circular duct without mean flow. An approximate wave equation is derived on the assumptions that the duct cross section varies slowly and that mode conversion is negligible. Exact closed form solutions are obtained for a particular class of converging-diverging circular duct which is here referred to as 'circular cosh duct'. Numerical results are presented in terms of the transmission loss for the various duct shapes and frequencies. The results are applicable to studies of multimodal propagation as well as single mode propagation. The results are also applicable to studies of sound radiation from certain types of contoured inlet ducts, or of sound propagation in a converging-diverging duct of somewhat different shape from a cosh duct.

(Author)


A cut-on, high tip speed fan stage was acoustically tested with three configurations of an inflow control device in the NASA Lewis annular chamber. Although this was a cut-on design, rotor-stator interaction appeared to be a much stronger source of blade passing tone radiated from the inlet than rotor-stator interaction for the 1.6 mean rotor chord separation. Aft external suction applied to the area where the inflow control device joined the inlet produced a further reduction in blade passing tone suggesting that disturbances in the forward flow on the outside of the inlet were superimposed on the inlet boundary layer and were a significant source of tone noise.

(Author)


A rigorous treatment is presented of sound radiation from circular ducts with either a hyperbolic horn or an infinite plane baffle. In the analysis hyperboloidal wave functions are used, which are defined here, for the first time, as a class of eigensolutions of the wave equation for oblate spheroidal co-ordinates. The numerical results include the complex conversion (or reflection) coefficients and the radiation directivity for various incident wave modes.

171
spinning modes as well as axisymmetric modes. The solutions are valid for the whole frequency range, including frequencies above and below the cut-off frequencies of the duct modes involved. (Author)


Summaries of current understandings, technological tools and remaining controversies in the field of aeroacoustics are presented, with attention also given to developments in means of noise suppression to comply with proposed regulations. Topics include jet noise mechanisms and their suppression; aerofoil noise, including noise sources, noise prediction by the model approach and experimental methods; duct acoustics, with discussion of sound attenuation and propagation, the application of finite element methods, and the radiation of sound from inlets; helicopter rotor, airplane propeller and V/STOL noise; aircraft interior noise; and general acoustics, atmospheric propagation and the sonic boom. A.L.W.

NBO-1870# Lockheed-Georgia Co., Marietta.
STUDIES OF THE ACOUSTIC TRANSMISSION CHARACTERISTICS OF COAXIAL NOZZLES WITH INVERTED VELOCITY PROFILES, VOLUME 1. Final Report

The efficiency of internal noise radiation through coannular exhaust nozzle with an inverted velocity profile was studied. A preliminary investigation was first undertaken to (1) define the test parameters which influence the internal noise radiation; (2) develop a test methodology which could realistically be used to examine the effects of the test parameters; and (3) to validate this methodology. The result was the choice of an acoustic impulse as the internal noise source in the jet nozzles. Noise transmission characteristics of a nozzle system were then investigated. In particular, the effects of fan nozzle convergence angle, core extension length to annulus height ratio, and flow Mach number and temperatures were studied. The results are presented as normalized directivity plots. R.C.T.

NBO-13882# Hamilton Standard, Windsor Locks, Conn.
ADVANCED TURBO-PROP AIRPLANE INTERIOR NOISE REDUCTION-SOURCE DEFINITION Final Report
B. Magliozzi and Bennett M. Brooks Oct. 1979 90 p refs (Contract NAS3-20614) NASA-CR-159668) Avail: NTIS HC A05/MF A01 CSCL 20A

Acoustic pressure amplitudes and phases were measured in model scale on the surface of a rigid semicylinder mounted in an acoustically treated wind tunnel near a prop-fan (an advanced turboprop with many swept blades) model. Operating conditions during the test simulated those of a prop-fan at 0.8 Mach number cruise. Acoustic pressure amplitude and phase contours were defined on the semicylinder surface. Measurements obtained without the semicylinder in place were used to establish the magnitude of pressure doubling for an aircraft fuselage located near a prop-fan. Pressure doubling effects were found to be 68 dB at 90 deg incidence decreasing to no effect at grazing incidence. Comparisons of measurements with predictions made using a recently developed prop-fan noise prediction theory which includes linear and non-linear source terms showed good agreement in phase and in peak noise amplitude. Predictions of noise amplitudes and phase contours, including pressure doubling effects derived from test, are included for a full scale prop-fan installation. Author

A STUDY OF THE TRANSMISSION CHARACTERISTICS OF SUPPRESSOR NOZZLES

The internal noise radiation characteristics for a single stream 12-108 24 tube suppressor nozzle, and for a dual stream 36 chute suppressor nozzle were investigated. An equivalent single round conical nozzle and an equivalent coannular nozzle system were also tested to provide a reference to the internal noise source within the test duct which permitted separation of the incident, reflected and transmitted signals in the time domain. These signals were then Fourier transformed to obtain the nozzle transmission coefficient and the power transfer function. These transmission parameters for the 12-108, 24 tube suppressor nozzle and the reference conical nozzle are presented as a function of jet Mach number, duct Mach number, polar angle and temperature. Effects of simultaneous forward flight are also considered for this nozzle. For the dual stream, 36 chute suppressor, the transmission parameters are presented as a function of velocity ratios and temperature ratios. Possible data for the equivalent coaxial nozzle is also presented. Jet noise suppression by these nozzles is also discussed. A.R.H.


A semiempirical model of the acoustic behavior of fibrosely constructed bulk materials of Hersh and Walker (1978) is generalized to take into account the filtration or removal of particles by fibrous mats and heat conduction between the material fibers and the surrounding fluid. Equations governing the propagation and attenuation of sound waves in a fibrous material are derived on the basis of a solution of the Navier Stokes equation for momentum conservation and a one-dimensional model of heat transfer between the sound field and the fibers. A comparison of the two propagation constants and material impedance specified by the model and experimental measurements for Kevlar 29 indicates the accuracy of the model over a wide range of sound frequencies, material porosities and specimen thickness. It is also found that heat transfer effects are relatively unimportant, while the attenuation constants and material characteristic impedance are a function of fiber orientation relative to sound field propagation direction. A.R.H.


Acoustic pressure amplitude and phase distributions on the surface of a simulated fuselage (a rigid semi-cylinder) installed in an acoustically treated wind tunnel near a Prop-Fan model were measured. The test conditions simulated the relative tip Mach number and blade loading of a full scale Prop-Fan at high altitude 0.8 Mach number cruise. Measurements were also made at equivalent microphone locations without the semi-cylinder to establish the effects of the presence of a fuselage on the sound pressure amplitudes. These effects were found to be 6 dB at 90 degrees incidence, decreasing to no effect at grazing incidence. Comparison of measurements and calculations using a Hamilton Standard Prop-Fan noise calculation computer program showed good agreement in peak level and in phase distribution. Continuous recordings were also made of a Prop-Fan RPM sweep at constant simulated flight speed and a simulated flight speed sweep at constant Prop-Fan RPM. These showed smooth variations in noise level over the tip Mach number range 0.878 to 1.143. (Author)

Nozzle transmission coefficient (NTC) for a 12-lobe, 24-tube suppressor nozzle and a reference round convergent nozzle of equal area are obtained by an impulse test technique. This technique utilizes a high voltage spark discharge as a noise source within the test duct. Effects of nozzle geometry, jet Mach number, jet temperature and flight velocity on the radiation characteristics of the two nozzles are presented. Likewise, the jet mixing noise measured in the absence of internal noise for both nozzles at static and also simulated flight conditions are discussed. (Author)


An experimental and analytical program has been carried out to evaluate sound suppression techniques in ducts that produce refraction effects due to axial velocity gradients. The analytical program employs a computer code based on the method of multiple scales to calculate the influence of axial variations due to slow changes in the cross-sectional area as well as transverse gradients due to the wall boundary layers. Detailed comparisons between the analytical predictions and the experimental measurements have been made. The circumferential variations of pressure amplitudes and phases at several axial positions have been examined in straight and variable area ducts, with hard walls and lined sections, and with and without a mean flow. Reasonable agreement between the theoretical and experimental results has been found. (Author)
HYDROGEN HOLLOW CATHODE ION SOURCE Patent

An invention is disclosed which provides a source of hydrogen ions. The source includes a chamber having at one end a cathode which provides electrons and through which hydrogen gas flows into the chamber. Screen and accelerator grids are provided at the other end of the chamber. A baffle plate is disposed between the cathode and the grids and a cylindrical baffle is disposed coaxially with the cathode at the one end of the chamber. The cylindrical baffle is of greater diameter than the baffle plate to provide discharge impedance and also to protect the cathode from ion flux. An anode electrode draws the electrons away from the cathode. The hollow cathode includes a tubular insert of tungsten impregnated with a low work function material to provide ample electrons. A heater is provided around the hollow cathode to initiate electron emission from the low work function material.

Official Gazette of the U.S. Patent and Trademark Office

174
75 PLASMA PHYSICS
Includes magnetohydrodynamics and plasma fusion.
For inorganic plasmas see 46 Geochemistry. For space plasmas see 59 Astrophysics.

N80-12881* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
RESULTS OF DUCT AREA RATIO CHANGES IN THE NASA LEWIS H2O2 COMBUSTION MHD EXPERIMENT.
(NASA-TM-79308; E-264) Avail. NTIS HC A02/MF A01 CSCL 201

MHD power generation experiments utilizing a cesium-seeded H2-O2 working fluid were carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments were conducted in a high field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, generator loading, B-field strength, and electrode breakdown voltage were investigated. The effects of area ratio, multiple loading of the duct, and duct location within the magnetic field are considered.

N80-14822* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
EFFECT OF VELOCITY OVERSHOOT ON THE PERFORMANCE OF MAGNETOHYDRODYNAMIC SUBSONIC DIFFUSERS.
(Contract EF-77-A•01.2674) (NASA-TM-79305; DOE/NASA/2674-70/6; E-257) Avail. NTIS HC A03/MF A01 CSCL 201

The evolution of an overshoot velocity distribution was studied in a plane two-dimensional diffuser as a function of diffuser divergence angle. The diffuser performance for velocity overshoot was compared to that for a fully developed inlet velocity profile. Results indicate that the ratio of peak to center line velocity increases along the diffuser for a diffuser half angle greater than some critical value. It was also found that irrespective of the accompanying inlet temperature distribution, the wall shear stress and the wall heat flux is substantially larger when the inlet velocity profile has an overshoot than that for a fully developed inlet velocity profile.

N80-16885* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
COMMENTS ON TEC TRENDS.
(NASA-TM-79317; E-273) Avail. NTIS HC A03/MF A01 CSCL 201

A technology assessment of thermionic energy conversion research and technology is presented.

N80-18886* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
EXPERIMENTS ON H2-O2 MHD POWER GENERATION.
(NASA-TM-81424) Avail. NTIS HC A02/MF A01 CSCL 201

Magnetohydrodynamic power generation experiments utilizing a cesium-seeded H2-O2 working fluid were carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments were conducted in a high-field strength cryomagnet facility at field strengths up to 6 tesla. The effects of power takeoff location, axial duct location within the magnetic field, generator loading, B-field strength, and electrode breakdown voltage were investigated. For the operating conditions of these experiments, it is found that the power output increases with the square of the B-field and can be limited by choking of the channel or interelectrode voltage breakdown which occurs at Hall fields greater than 50 volts/insulator. Peak power densities of greater than 100 MW/cu M were achieved.

N80-18946* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL RESULTS ON PLASMA INTERACTIONS WITH LARGE SURFACES AT HIGH VOLTAGES.
(NASA-TM-81423, E-348) Avail. NTIS HC A02/MF A01 CSCL 201

Multikilowatt power levels for future payloads can be more efficiently generated using solar arrays operating in the kilowatt range. This implies that large areas of the array at high operating voltages will be exposed to the space plasma environment. The resulting interactions of these high voltage surfaces with space plasma environments can seriously limit the performance of the satellite system. The plasma surface interaction phenomena were studied in tests performed in two separate vacuum chambers, a 64 m diameter by 19.2 long chamber and a 200 m diameter by 27.4 m long chamber. The generated plasma density was approximately 1x10^6 to the 4th power/cm^2. Ten solar array panels, each with areas of 1400 sq cm were used in the tests. Nine of the solar panels were tested as a composite unit in the form of a 3x3 solar panel matrix. The results from all the tests confirmed small sample tests results insulators were found to enhance the plasma coupling current for high positive bias and arcing was found to occur at high negative bias.

N80-22063* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
FACILITIES OF TEC TOPPING: A SIMPLIFIED VIEW OF PARAMETRIC EFFECTS.
(Contract EC-77-A•31.1062) (NASA-TM-81468; DOE/NASA/1062-80/5; E-399) Avail. NTIS HC A02/MF A01 CSCL 10A

An examination of the benefits of thermionic-energy-conversion (TEC)-topped power plants and methods of increasing conversion efficiency are discussed. Reductions in the cost of TEC modules yield direct decreases in the cost of electricity (COE) from TEC-topped central station power plants. Simplified COE, overall-efficiency charts presented illustrate this trend. Additional capital-cost distribution results from designing more compact furnaces with considerably increased heat transfer rates allowable and desirable for high temperature TEC and heat pipes. Such improvements can evolve from the protection of hot corrosion and slag as well as the thermal expansion compatibilities offered by silicon-carbide clads on TEC-heating surfaces. Greater efficiencies and far fewer modules are possible with high-temperature, high-power-density TEC. This decreases capital and fuel costs much more and substantially increases electric power outputs for fixed fuel inputs. In addition to more electricity, less pollution, and lower costs, TEC topping used directly in coal-combustion products contributes balance-of-payment gains.

N80-33221* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
OPTIMAL THERMIONIC ENERGY CONVERSION WITH ESTABLISHED ELECTRODES FOR HIGH-TEMPERATURE TOPPING AND PROCESS HEATING.
Final Report.
(Contract EC-77-A•31.1062) (NASA-TM-81555; DOE/NASA/1062-6; E-614) Avail. NTIS HC A03/MF A01 CSCL 201

Applied research-and-technology (ART) work reveals that optimal thermionic energy conversion (TEC) with approximately

175
1000 K to approximately 1100 K collectors is possible using well-established tungsten electrodes. Such TEC with 1800 K emitters could approach 26% efficiency at 27.4 W/sq cm with approximately 1000 K collectors and 21.7% at 22.6 W/sq cm with approximately 1100 K collectors. These performances result in S and 1.7 eV collector work functions (not the 1 eV ultimate) with nearly negligible interelectrode losses. Such collectors correspond to tungsten electrode systems in approximately 0.5 torr cesium at approximately 1000 K to 1800 K collectors. Because higher heat-rejection temperatures for TEC allow greater collector work functions, interelectrode losses become an increasingly important target for applications aimed at elevated temperatures. Studies of intragap modifications and new electrodes that will allow better electron emission and collection with lower cesium pressures are among the TEC ART approaches to reduced interelectrode losses. These solutions will provide very effective TEC to serve directly in coal-combustion products for high-temperature topping and process heating. In turn, this will help to use coal and to use it well.


An experimental and analytical study of a Blumlein-type transverse fast discharge operating with He and Xe is presented. An electrostatic voltage probe was used to measure the discharge voltage, and the measured voltages were in agreement with the computed voltages. The analytical model was used to predict the dependence of the discharge efficiency for producing metastable ions on the important plasma and external circuit parameters. In He the ion efficiency is greater than the metastable efficiency, while in Xe it is the opposite; the He ion efficiencies are much larger than in Xe, while Xe metastable efficiencies are much larger than in He. These differences between Xe and He are accounted for by the large associated recombinant rate of Xe compared with He.


MHD power generation experiments utilizing a cesium-seeded H2-O2 working fluid have been carried out using a diverging-area Hall duct having an entrance Mach number of 2. The experiments are conducted in a high-field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, axial duct location within the magnetic field, generator loading, B-field strength, and electrode breakdown voltage were investigated. For the operating conditions of these experiments it is found that the power output increases with the square of the B field and can be limited by Ar choking of the channel or interelectrode voltage breakdown which occurs at Hall fields greater than 50 volts/insulator. (Author)


Hot-ion plasma experiments were conducted in the NASA Lewis SUMMA facility. A steady-state modified Penning discharge was formed by applying a radially inward dc electric field of several kilovolts near the magnetic mirror maxima. Results are reported for a hydrogen plasma covering a wide range in midplane magnetic flux densities from 0.5 to 3.37 T. Input power greater than 45 kW was obtained with water-cooled cathodes. Steady-state plasmas with ion kinetic temperatures from 15 to 830 eV were produced and measured spectroscopically. These ion temperatures were correlated with current, voltage, and magnetic flux density as the independent variables. Electron density measurements were made using an unusually sensitive Thomson scattering apparatus. The measured electron density ranges from 2.1 x 10 to the 11th to 6.8 x 10 to the 12th per cu cm. (Author)

A80-12880 * State Univ. of New York at Buffalo Lab for Power and Environmental Studies


David T. Shaw Apr 1979 41 p refs (Grant NsG-7071)

(NASA-CR-159611: LAFES-79-003) Avail: NTIS HC A03/MA AO1 CSCL 201

The possibility of using N2 as a gas additive for the development of thermionic topping generators was investigated. The experiment is described and observations are discussed. The potential of applying microwave power in the interelectrode spacing of the converter as an ion generation source was also assessed. (A.R. H.)

A80-14823 * Colorado State Univ., Fort Collins, Dept. of Physics

INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA Annual Report

Harold R. Kaufman and Raymond S. Robinson May 1979 81 p refs (Grant NsG-3196)

(NASA-CR-159731) Avail NTIS HC A05/MA AO1 CSCL 201

Tests were conducted using plasma densities of approximately 10 to the 5th power - 10 to the 6th power/cu cm. Insulating materials tested were polyimide (Dapton), mica and glass. Surface-area effects were found to be substantially reduced from those previously reported at lower plasma densities. The difference in typical plasma density was felt to be the major cause of this change, although a saturation effect may also be involved. At the 10 to the 5th power/cu cm plasma density range, surface effects on collection current appear limited to roughly 1 cm from the hole. A factor of several reduction of collected current was obtained with both surface scribing and a 2 x 2 cm conducting mesh. It appears possible that the effects of surface treatment might be more significant at lower plasma densities. Effects of repeated tests were also noted, with current collection decreasing with successive tests. Depending on the materials involved, the effect appeared due to either the smoothing of the inside of the insulator hole or the sputtering of insulator on the exposed conductor. A general conclusion was made from a variety of
observations, that the generation of vapor is a major factor in the enhancement of collected current, A.R.H.

NBO-26161*† Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.

An experimental investigation of the physical processes governing ion extraction from a plasma is presented. The screen hole plasma sheath of a multiaperture ion accelerator system is defined by equipotential plots for a variety of accelerator system geometries and operating conditions. A sheath thickness of at least fifteen Debye lengths is shown to be typical. The electron density variation within the sheath satisfies a Maxwell-Boltzmann density distribution at an effective electron temperature dependent on the discharge plasma primary to Maxwellian electron density ratio. Plasma ion flow up to and through the sheath is predominantly one dimensional and the ions enter the sheath with a modified Bohm velocity. Low values of the screen grid thickness to screen hole diameter ratio give good ion focusing and high extracted ion currents because of the effect of screen webbing on ion focusing.

Author

PLASMA PHYSICS ANALYSIS OF SERT-2 OPERATION

An analysis of the major plasma processes involved in the SERT 2 spacecraft experiments was conducted to aid in the interpretation of recent data. A plume penetration model was developed for neutralization electron conduction to the ion beam and showed qualitative agreement with flight data. In the SERT 2 configuration conduction of neutralization electrons between thrusters was experimentally demonstrated in space. The analysis of this configuration suggests that the relative orientation of the two magnetic fields was an important factor in the observed results. Specifically, the opposed field orientation appeared to provide a high conductivity channel between thrusters and a barrier to the ambient low energy electrons in space. The SERT 2 neutralizer currents with negative neutralizer biases were up to about twice the theoretical prediction for electron collection by the ground screen. An experimental value higher than the theoretical prediction was found to be possible conductive path from the neutralizer plume to a nearby part of the ground screen. Plasma probe measurements of SERT 2 gave the clearest indication of plasma electron temperature, with normal operation being near 5 eV and discharge only operation near 2 eV.

E.D.K.

INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA Annual Report

High voltage solar arrays provide spacecraft power while optimizing mass and power efficiency. Operating such arrays in the space plasma environment can result in anomalously large currents being collected through insulation defects. Two thicknesses of the insulating material were tested, with no effect found due to insulator thickness. In these tests the polyimide thickness was always much less than the pinhole diameter. The pinhole area was varied over an area range of more than 30:1. It was found that the current collected was independent of the pinhole area for hole diameters from 0.35 to 2.0 mm. Two types of adhesives were tried in two different configurations. The adhesives were chosen for their extreme difference in vacuum qualifications. Neither adhesive types nor configuration made a significant difference in current collection. The temperature of the insulating material was also varied. It was found that current collection decreased with increasing temperature. Tests were conducted to see if pinhole current collection decreased with time, as was indicated by the effects of several short tests. Current was collected for over four hours while the conductor potential was held constant at 1000 volts. A smooth decrease with time was not observed, but rather a roughly constant current collection with brief surges to high values. Tests were also conducted with the simulated solar cell biased negative. The current was found to be proportional to pinhole area.

R.K.G.

The planar multijunction (PMJ) cell is being developed. The new cells combine the attractive features of planar cells with conventional or interdigitated back contacts and the vertical multijunction (VMJ) solar cell. The PMJ solar cell is internally divided into many voltage-generating regions, called unit cells, which are internally connected in series. The key to obtaining reasonable performance from this device was the separation of top surface field regions over each active unit cell area. Using existing solar cell fabricating methods, output voltages in excess of 20 volts per linear centimeter are possible. Analysis of the new device is complex, and numerous geometries are being studied which should provide substantial benefits in both normal sunlight usage as well as with concentrators.

Author


The planar multijunction (PMJ) cell is being developed. The new cells combine the attractive features of planar cells with conventional or interdigitated back contacts and the vertical multijunction (VMJ) solar cell. The PMJ solar cell is internally divided into many voltage-generating regions, called unit cells, which are internally connected in series. The key to obtaining reasonable performance from this device was the separation of top surface field regions over each active unit cell area. Using existing solar cell fabricating methods, output voltages in excess of 20 volts per linear centimeter are possible. Analysis of the new device is complex, and numerous geometries are being studied which should provide substantial benefits in both normal sunlight usage as well as with concentrators.

Author
homogeneous alignment. Extinction ratios were very high, and twist and tilt-bias angles were very small. The SEM results indicate a parallel oriented surface structure on the ion beam etched surfaces which may determine alignment.


The paper considers critical currents in A-15 structure Nb3Al converted from a cold-worked bcc structure. Nb3Al prepared in the ductile phase by quenching and mechanical working followed by conversion to the A-15 structure could carry currents above 10 to the 9th power A/sq m in fields near 20 T. These critical currents are comparable to those of Nb3Ge and V3Ga which are closest competing materials for use in high fields; further enhancement of the critical current is possible if thermal treatments are optimized.


Three high open-circuit voltage cell designs based on 0.1 ohm-cm p-type silicon were irradiated with 1 MeV electrons and their performance determined to fluences as high as 10 to the 15th/sq cm. Of the three cell designs, radiation induced degradation was greatest in the high-low emitter (HLE) cell. The diffused and ion implanted cells degraded approximately equally but less than the HLE cell. Degradation was greatest in an HLE cell exposed to X-rays before electron irradiation. The cell regions controlling both short-circuit current and open-circuit voltage degradation were defined in all three cell types. An increase in front surface recombination velocity accompanied time dependent degradation of a HLE cell after X-irradiation. It was speculated that this was indirectly due to a decrease in positive charge at the silicon-oxide interface. Modifications aimed at reducing radiation induced degradation are proposed for all three cell types.


A computational model is developed which describes the evolution and propagation of an ionizing front (negative streamer) in solid materials. The ionization front consists of drifting avalanching electrons moving self-consistently under the influence of their own space-charge field together with an applied external field. The required input information for the model consists of the functional dependence of the macroscopic transport coefficients on the local electric field, the initial conditions for beginning the calculation, and the strength of the applied field. A computational approach for specifying the transport coefficients and initial conditions is also described. The approach has been implemented by constructing three computer codes which sequentially interface, beginning with single electron scattering, and ending with streamer development. Computational results are presented for model calculations in Teflon. The overall model is perceived to provide a picture of the initial phase of a propagating discharge in electron-irradiated dielectrics.
THERMODYNAMICS AND STATISTICAL PHYSICS

Includes quantum mechanics, and Bose and Fermi statistics.

For related information see also 25 Inorganic and Physical Chemistry and 34 Fluid Mechanics and Heat Transfer.


Specific examples are cited herein to illustrate the universal needs and demands for thermophysical property data. Applications of the principles of similarity in fluid mechanics and heat transfer and extensions of the principle to fluid mixtures are discussed. It becomes quite clear that no matter how eloquent theories or experiments in fluid mechanics or heat transfer are, the results of their application can be no more accurate than the thermophysical properties required to transform these theories into practice, or in the case of an experiment, to reduce the data. Present-day projects take place on such a scale that the need for international standards and mutual cooperation is evident. (Author)
The matrix management approach to program management is an organized effort for attaining program objectives by defining and structuring all elements so as to form a single system whose parts are united by interaction. The objective of the systems approach is uncompromisingly complete coverage of the program management endeavor. Starting with an analysis of the functions necessary to carry out a given program, a model must be defined; a matrix of responsibility assignment must be prepared; and each operational process must be examined to establish how it is to be carried out and how it relates to all other processes.
COST EFFECTIVE TECHNOLOGY ADVANCEMENT DIRECTIONS FOR ELECTRIC PROPULSION TRANSPORTATION SYSTEMS IN EARTH-ORBITAL MISSIONS


(NASA-TM-79289) Avail NTIS HC A02/MF A01 CSCL 05C

The directions that electric propulsion technology should take to meet the primary propulsion requirements for earth-orbital missions in the most cost effective manner are determined. The mission set requirements, state of the art electric propulsion technology and the baseline system characterized by it, adequacy of the baseline system to meet the mission set requirements, cost optimum electric propulsion system characteristics for the mission set, and sensitivities of mission costs and design points to system level electric propulsion parameters are discussed. The impact on overall costs than specific masses or costs of propulsion and power systems is evaluated.

A.W.H.
85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation.

For related information see 03 Air Transportation and Safety, 16 Space Transportation, and 44 Energy Production and Conversion.

N80-21200* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SUPPORT FOR TECHNICAL AND ENGINEERING DEVELOPMENT FOR AUTOMOTIVE STIRLING ENGINE DEVELOPMENT


The technology advancement topics described are a part of the supporting research and technology (SRT) program conducted to support the major Stirling engine development program. This support focuses on developing alternatives or backups to the engine development in critical areas. These areas are materials, seals control, combustors and system analysis. Specific objectives and planned milestone schedules for future activities as now envisioned are described. These planned SRT activities are related to the timeline of the engine development program that they must support.

Author

N80-21201* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FUEL ECONOMY SCREENING STUDY OF ADVANCED AUTOMOTIVE GAS TURBINE ENGINES


Fuel economy potentials were calculated and compared among ten turbomachinery configurations. All gas turbine engines were evaluated with a continuously variable transmission in a 1978 compact car. A reference fuel economy was calculated for the car with its conventional spark ignition piston engine and three speed automatic transmission. Two promising engine/transmission combinations, using gasolene, had 56 to 60 percent gains over the reference fuel economy. Fuel economy sensitivities to engine design parameter changes were also calculated for these two combinations.

Author

N80-28264* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY RESULTS OF STEADY STATE CHARACTERIZATION OF NEAR TERM ELECTRIC VEHICLE BREADBOARD PROPULSION SYSTEM


The steady state test results on a breadboard version of the General Electric Motorized Vehicle (GEMV-1) are discussed. The breadboard was built using exact duplicate vehicle propulsion system components with few exceptions. Full instrumentation was provided to measure individual component efficiencies. Tests were conducted on a 50 hp dynamometer in a road load simulator facility. Characterization of the propulsion system over the lower half of the speed-torque operating range has shown the system efficiency to be composed of a predominant motor loss plus a speed dependent transaxle loss. At the lower speeds with normal road loads the armature chopper loss is also a significant factor. At the conditions corresponding to a cycle for which the vehicle system was specifically designed, the efficiencies are near optimum.

M.G.

N80-30239* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A LABORATORY FACILITY FOR ELECTRIC VEHICLE PROPULSION SYSTEM TESTING


The road load simulator facility located at the NASA Lewis Research Center enables a propulsion system or any of its components to be evaluated under a realistic vehicle scenario and road loads. The load is applied to the system under test according to the road load equation: $F_{\text{road}} = K_1 F + K_2 F^2 + K_3 F^3$. The coefficient of each term in the equation can be varied to yield a wide range of vehicle inertial representative of vehicles up to 7500 pounds simulated by means of flywheels. The required torque is applied by the flywheel, a hydroviscous absorber and clutch, and a drive motor integrated by a closed loop control system to produce a smooth continuous load up to 150 horsepow.

A.H.R.


The paper presents a traffic control design technique for application to large traffic networks with signalized intersections. It is shown that the design method adopts a macroscopic viewpoint to establish a new traffic modelling procedure in which vehicle platoons are subdivided into main stream queues and turning queues. Optimization of the signal splits minimizes queue lengths in the steady state condition and improves traffic flow conditions, from the viewpoint of the traveling public. Finally, an application of the design method to a traffic network with thirty-three signalized intersections is used to demonstrate the effectiveness of the proposed technique.

M.E.P.


ASSESSMENT OF THE STATE OF TECHNOLOGY OF AUTOMOTIVE STIRLING ENGINES


The current status of automotive Stirling engine technology is considered. The energy is described and the history of its evolution is reviewed. Overall engine, component, subsystem, and material problem areas are identified and recommendations are made for further development and testing. Potential improvements are also identified. Projected Stirling engine/vehicle performance is compared to that of vehicles using current internal combustion engines in terms of performance, fuel consumption, multifuel capability, emissions, and noise level. It is concluded that the potential for achieving 1984 program goals is clearly discernible. The program goals require at least a 30 percent reduction in fuel consumption, acceptable emissions, and the capability of satisfactorily operating with a variety of alternate fuels.

A.R.H.

N80-17916* Garrett Corp., Torrance, Calif.

ADVANCED ELECTRIC PROPULSION SYSTEM CONCEPT FOR ELECTRIC VEHICLES

Seventeen propulsion system concepts for electric vehicles were compared to determine the differences in components and battery pack to achieve the basic performance level. Design tradeoffs were made for selected configurations to find the optimum component characteristics required to meet all performance goals. The anticipated performance when using nickel-zinc batteries rather than the standard lead-acid batteries was also evaluated. The two systems selected for the final conceptual design studies included a system with a flywheel energy storage unit and a basic system that did not have a flywheel. The flywheel system meets the range requirement with either lead-acid or nickel-zinc batteries and also the acceleration of zero to 89 km/hr in 15 s. The basic system can also meet the required performance with a fully charged battery, but, when the battery approaches 20 to 30 percent depth of discharge, maximum acceleration capability gradually degrades. The flywheel system has an estimated life-cycle cost of $0.041/km using lead-acid batteries and also the acceleration of zero to 89 km/hr. Nickel-zinc batteries rather than the standard lead-acid batteries was also evaluated. The anticipated performance when using nickel-zinc batteries was high degrees of discharge. Both electrical and mechanical means of transfer of energy to and from the flywheel appear attractive; however, development work is required to establish the safe limits of speed and energy storage for advanced flywheel designs and to achieve the optimum efficiency of energy transfer. Brushless traction motor designs using either electronic commutation schemes or dc-to-ac inverters appear to provide a practical approach to a mass producible motor, with excellent efficiency and light weight. No comparison were made with advanced system concepts which do not incorporate a flywheel.
application in several different vehicle sizes. A conceptual design was prepared for the most promising configuration. Various system configurations were parametrically evaluated and compared. Design tradeoffs were performed, and a conceptual design produced. Fifteen vehicle propulsion system concepts were parametrically evaluated to select two systems and one vehicle for detailed design tradeoff studies. A single hybrid propulsion system concept and vehicle (five passenger family sedan) were selected for optimization based on the results of the tradeoff studies. The final propulsion system consists of a 65 kW spark-ignition heat engine, a mechanical continuously variable traction transmission, a 20 kW permanent magnet axial-gap traction motor, a variable frequency inverter, a 386 kg lead-acid improved state-of-the-art battery, and a transaxle. The system was configured with a parallel power path between the heat engine and battery. It has two automatic operational modes: electric mode and heat engine mode. Power is always shared between the heat engine and battery during acceleration periods. In both modes, regenerative braking energy is absorbed by the battery.

Author

N80-28255* Eaton Engineering and Research Center, Southfield, Mich.

SMALL PASSENGER CAR TRANSMISSION TEST- CHEVROLET 200 TRANSMISSION Final Report

The small passenger car transmission was tested to supply electric vehicle manufacturers with technical information regarding the performance of commercially available transmissions which would enable them to design a more energy efficient vehicle. With this information the manufacturers could estimate vehicle driving range as well as speed and torque requirements for specific road load performance characteristics. A 1979 Chevrolet Model 200 automatic transmission was tested per a passenger car automatic transmission test code (SAE J95.1h) which required drive performance, coast performance, and no load test conditions. The transmission attained maximum efficiencies in the mid-eighty percent range for both drive performance tests and coast performance tests. Torque, speed and efficiency curves map the complete performance characteristics for Chevrolet Model 200 transmission.

Author


REGENERATOR MATRIX PHYSICAL PROPERTY DATA

Among several cellular ceramic structures manufactured by various suppliers for regenerator application in a gas turbine engine, three have the best potential for achieving durability and performance objectives for use in gas turbines, Stirling engines, and waste heat recovery systems: (1) an aluminum-silicate sinusoidal flow passage made from a corrugated wate paper process; (2) an extruded isosceles triangle flow passage; and (3) a second generation matrix incorporating a square flow passage formed by an embossing process. Key physical and thermal property data for these configurations presented include: heat transfer and pressure drop characteristics, compressive strength, tensile strength and elasticity, thermal expansion characteristics, chemical attack, and thermal stability.

A.R.H.

N80-32298* Battelle Columbus Labs, Ohio

DESIGN STUDY OF STEEL V-BELT CVT FOR ELECTRIC VEHICLES Final Report

A continuously variable transmission (CVT) design layout was completed. The intended application was for coupling the flywheel to the driveline of a flywheel battery hybrid electric vehicle. The requirements were that the CVT accommodate flywheel speeds from 14,000 to 28,000 rpm and driveline speeds of 850 to 5000 rpm without slipping. Below 850 rpm a slipping clutch was used between the CVT and the driveline. The CVT was required to accommodate 330 ft-lb maximum torque and 100 hp maximum transient. The weighted average power was 22 hp. The maximum allowable full range shift time was 2 seconds and the required lift was 2800 hours. The resulting design utilized two steel V-belts in series to accommodate the required wide speed ratio. The size of the CVT, including the slipping clutch, was 20.6 inches long, 9.6 inches high and 13.8 inches wide. The estimated weight was 165 lb. An overall potential efficiency of 85 percent was projected for the average power condition.

Author
### SUBJECT INDEX

#### Typical Subject Index Listing

<table>
<thead>
<tr>
<th>SUBJECT HEADING</th>
<th>TITLE</th>
<th>REPORT NUMBER</th>
<th>PAGE NUMBER</th>
<th>NASA ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABRASION</td>
<td>Abradable compressor and turbine seals, volume 1</td>
<td>p0123 180-15411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABRASION</td>
<td>Abradable compressor and turbine seals, volume 2</td>
<td>p0083 180-12435</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABRASION RESISTANCE</td>
<td>An investigation into the role of adhesion in the erosion of ductile metals</td>
<td>p0070 180-21469</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACCELERATION STRESSES (PHYSIOLOGY)</td>
<td>Experimental evaluation of a spinning-mode acoustic-treatment design concept for aircraft inlets</td>
<td>p0170 180-20956</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACCELERATION STRESSES (PHYSIOLOGY)</td>
<td>Spectral structure of pressure measurements made in a combustion duct</td>
<td>p0167 180-23097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACCELERATION STRESSES (PHYSIOLOGY)</td>
<td>Higher order mode propagation in nonuniform circular ducts</td>
<td>p0171 180-35496</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACCELERATION STRESSES (PHYSIOLOGY)</td>
<td>Rigorous solutions for sound radiation from circular ducts with hyperbolic horns or infinite plane baffles</td>
<td>p0170 180-37985</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABSORBERS (MATERIALS)</td>
<td>Reciprocity principle in duct acoustics</td>
<td>p0170 180-20956</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABSORPTION</td>
<td>Spectral structure of pressure measurements made in a combustion duct</td>
<td>p0167 180-23097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACIDS</td>
<td>Higher order mode propagation in nonuniform circular ducts</td>
<td>p0171 180-35496</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Rigorous solutions for sound radiation from circular ducts with hyperbolic horns or infinite plane baffles</td>
<td>p0170 180-37985</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Reciprocity principle in duct acoustics</td>
<td>p0170 180-20956</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Spectral structure of pressure measurements made in a combustion duct</td>
<td>p0167 180-23097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Higher order mode propagation in nonuniform circular ducts</td>
<td>p0171 180-35496</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Rigorous solutions for sound radiation from circular ducts with hyperbolic horns or infinite plane baffles</td>
<td>p0170 180-37985</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Reciprocity principle in duct acoustics</td>
<td>p0170 180-20956</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Spectral structure of pressure measurements made in a combustion duct</td>
<td>p0167 180-23097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Higher order mode propagation in nonuniform circular ducts</td>
<td>p0171 180-35496</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Rigorous solutions for sound radiation from circular ducts with hyperbolic horns or infinite plane baffles</td>
<td>p0170 180-37985</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Reciprocity principle in duct acoustics</td>
<td>p0170 180-20956</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Spectral structure of pressure measurements made in a combustion duct</td>
<td>p0167 180-23097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACOUSTIC DUCTS</td>
<td>Higher order mode propagation in nonuniform circular ducts</td>
<td>p0171 180-35496</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, a title extension is added, separated from the title by three hyphens. The title is also included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is included in the access number to assist the user in locating the abstract. The title and accession numbers are located beneath and to the right of each entry to assist the user in locating the abstract in the abstract section.
ACOUSTIC PROPAGATION

- Quiet Clean Short-haul Experimental Engine (QCSEE)
- Under-The-Wing (UTW) composite nacelle test report, Volume 2: Acoustic performance
  - NASA-CR-159742
  - p0044 80-0-29297

ACOUSTIC PROPAGATION

- Higher order mode propagation in nonuniform circular ducts
  - NASA-TN-4011
  - p0169 80-0-23101

ACOUSTIC IMPEDANCE

- Higher order mode propagation in nonuniform circular ducts
  - AIAA PAPER 80-1018
  - p0171 80-0-25794

ACOUSTIC VELOCITY

- Acoustic considerations of flight effects on jet noise suppressor nozzles
  - NASA-TN-4087
  - p0167 80-0-18943

ACOUSTIC RADIATION

- Quiet Clean Short-haul Experimental Engine (QCSEE)
- Acoustic treatment development and design
  - NASA-CR-135266
  - p0033 80-0-15122

ACOUSTIC VELOCITY

- Studies of the acoustic propagation characteristics of coaxial nozzles with inverted velocity profiles, volume 1 -- jet engine noise radiation through annular exhaust nozzles
  - NASA-CR-159598
  - p0172 80-0-11870

ACOUSTIC ACOUSTICS

- Acoustic behavior of fibrous bulk materials
  - AIAA PAPER 80-0016
  - p0172 80-0-35591

- Quiet Clean Short-haul Experimental Engine (QCSEE)
  - Over-The-Wing (OTW) propulsion systems test report, Volume 4: Acoustic performance
    - NASA-CR-135326
    - p0032 80-0-15118

- Core noise investigation of the CF6-50 turbofan engine
  - NASA-CR-159598
  - p0036 80-0-16061

- Core noise investigation of the CF6-50 turbofan engine
  - NASA-CR-159749
  - p0036 80-0-16062

- Application of coherence in fan noise studies
  - NASA-TF-1630
  - p0167 80-0-18862

ACQUISITION

- Quiet Clean Short-haul Experimental Engine (QCSEE)
  - Ball spline pitch change mechanism design report
    - NASA-CR-134873
    - p0030 80-0-15101

- Quiet Clean Short-haul Experimental Engine (QCSEE)
  - Ball spline pitch change mechanism design report
    - NASA-CR-135073
    - p0030 80-0-15101

- Quiet Clean Short-haul Experimental Engine (QCSEE)
  - Ear test of cas/harmonic pitch change actuation system
    - NASA-CR-135140
    - p0032 80-0-15117

- Durability tests of seal wedges for digital actuators
  - NASA-TF-01522
  - p0020 80-0-26299

- Single-stage electroadhydraulics actuator system for actuating on airflow with frequencies to 500 hertz
  - NASA-TF-1670
  - p0046 80-0-29369

ADAPTIVE CONTROL

- Identification and dual adaptive control of a turbojet engine
  - NASA-0-10033
  - p0023 80-0-28167

- An adaptive-control switching buck regulator -- implementation, analysis, and design
  - NASA-0-28167
  - p0103 80-0-28167

ADAPTIVE CONTROL SYSTEMS

- Quiet Clean Short-haul Experimental Engine (QCSEE)
- Adaptive control system

ADAPTIVE BOUNDARY LAYERS

- Effect of interfacial species on shear strength of metal-sapphire contacts
  - NASA-0-22400

- Investigation into the effect of plasma pretreatment on the adhesion of parylene to various substrates
  - NASA-CR-13473

- Improved bond coatings for use with thermal barrier coatings
  - NASA-CR-135073

ADAPTIVE BOUNDARY LAYERS ON VARIOUS SURFACES

- Phase change in liquid face seals, II -- Isothermal and adiabatic bounds with real fluid values
  - NASA-0-14739

ADAPTIVE BOUNDARY LAYERS ON VARIOUS SURFACES

- Assessment at full scale of exhaust nozzle-to-wing size on STOL-OTW acoustic characteristics
  - NASA-CR-159749

- Acoustic considerations of flight effects on jet noise suppressor nozzles
  - AIAA PAPER 80-0164

- Effect of temperature on surface noise
  - NASA-TF-1630

- Effect of inflow control on inlet noise of a cut-on fan
  - AIAA PAPER 80-1049

- Workshop report for the AIAA 5th Aeroacoustics Conference
  - NASA-0-1156

- Assessment at full scale of exhaust nozzle-to-wing size on STOL-OTW acoustic characteristics
  - NASA-0-13881

- High-speed-propeller wind-tunnel aeroacoustic results
  - NASA-0-23997

- Pressure spectra and cromm spectra at an area contraction in a ducted combustion exaume
  - NASA-TF-18477

- Quiet Clean Short-haul Experimental Engine (QCSEE)
  - Under-The-Wing (UTW) composite nacelle test report, Volume 2: Acoustic performance
    - NASA-CR-135073
    - p0044 80-0-29297

- Acoustic performance of a 50.8-cm (20-inch) diameter variable-pitch fan and inlet
  - NASA-CR-135140

ADAPTIVE CHARACTERISTICS

- Quiet Clean Short-haul Experimental Engine (QCSEE)
- Adaptive control system

ADAPTIVE CHARACTERISTICS

- NASA-TF-01522

ADAPTIVE CHARACTERISTICS

- NASA-0-10033

ADAPTIVE CHARACTERISTICS

- NASA-0-28167

ADAPTIVE CHARACTERISTICS

- NASA-0-28167

ADAPTIVE CHARACTERISTICS

- NASA-0-28167

<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
<th>AEROSPACE ENGINEERING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale model performance test investigation of exhaust system minora for an Energy Efficient Engine (NASA-PAP 80-0229)</td>
<td>p0024 A80-20968</td>
</tr>
<tr>
<td>Numerical calculation of steady incompressible full potential compressible flow around wind turbine blades</td>
<td>p0165 A80-28804</td>
</tr>
<tr>
<td>Zero-length, slotted-lip inlet for supersonic military aircraft</td>
<td>p0004 A80-61203</td>
</tr>
<tr>
<td>Prediction method for two-dimensional aerodynamic loss of cooled vanes using integral boundary-layer parameters</td>
<td>p0156 A80-17030</td>
</tr>
<tr>
<td>Core compressor exit stage study: 1. Aerodynamic and mechanical design</td>
<td>p0027 A80-15374</td>
</tr>
<tr>
<td>Advanced propeller aerodynamic analysis</td>
<td>p0018 A80-22345</td>
</tr>
<tr>
<td>Forward acoustic performance of a shock-swallowing high-tip-speed fan (QF-13)</td>
<td>p0163 B80-23100</td>
</tr>
<tr>
<td>CF6 jet engine performance improvement program: High pressure turbine aerodynamic performance improvement</td>
<td>p0040 A80-26502</td>
</tr>
<tr>
<td>AERODYNAMIC CONFIGURATIONS</td>
<td>AEROSPACE ENGINEERING</td>
</tr>
<tr>
<td>NT WING MACHETE CONFIGURATIONS</td>
<td>NT AERODYNAMIC STABILITY</td>
</tr>
<tr>
<td>Quiet Clean Short-haul Experimental Engine (QCSEE): The aerodynamic and mechanical design of the QCSEE wing-body fan</td>
<td>p0031 A80-15109</td>
</tr>
<tr>
<td>An analytical and experimental study of a short N-shaped subsonic diffuser of a supersonic inlet</td>
<td>p0015 A80-95124</td>
</tr>
<tr>
<td>High-speed-propeller wind-tunnel aeroacoustic results</td>
<td>p0108 A80-22344</td>
</tr>
<tr>
<td>Measured and predicted impingement noise for a model-scale aero-engine nacelle-blow, fan configuration with a QCSE type nozzle</td>
<td>p0016 A80-95115</td>
</tr>
<tr>
<td>AERODYNAMIC DRAG</td>
<td>AERODYNAMIC LOADS</td>
</tr>
<tr>
<td>Dynamic behavior of a beam drag-force accelerometer</td>
<td>p0110 A80-24595</td>
</tr>
<tr>
<td>NT AERODYNAMIC DRAG</td>
<td>NT AERODYNAMIC LOADS</td>
</tr>
<tr>
<td>Effect of time dependent flight loads on JT29D-7 performance deterioration</td>
<td>p0134 A80-10515</td>
</tr>
<tr>
<td>Expanded study of feasibility of measuring in-flight JT29D loads, performance, clearance, and thermal data</td>
<td>p0036 A80-16063</td>
</tr>
<tr>
<td>NT AERODYNAMIC LOADS</td>
<td>NT AERODYNAMIC MACHETE</td>
</tr>
<tr>
<td>Workshop report for the AIAA 5th Aeroacoustics Conference</td>
<td>p0172 A80-81156</td>
</tr>
<tr>
<td>AERODYNAMIC STABILITY</td>
<td>AERODYNAMIC MACHETE</td>
</tr>
<tr>
<td>Measuring unsteady pressure on rotating compressor blades -- with semiconductor strain gages under gas turbine engine operating conditions</td>
<td>p0110 A80-12630</td>
</tr>
<tr>
<td>Examination of the flap-lag stability of rigid airfoil blade sections</td>
<td>p0110 A80-15123</td>
</tr>
<tr>
<td>Dynamic response of a Mach 2.5 axisymmetric inlet and turbojet engine with a power- or fuel-controlled inlet stability bypass system when subjected to internal and external size flow transients</td>
<td>p0014 A80-10143</td>
</tr>
<tr>
<td>AERODYNAMIC MACHETE</td>
<td>AERODYNAMIC STABILITY</td>
</tr>
<tr>
<td>A phenomenological model of the dynamic stall of a helicopter blade profile</td>
<td>p0006 A80-20086</td>
</tr>
<tr>
<td>NT AERODYNAMICS</td>
<td>NT AEROTHERMODYNAMICS</td>
</tr>
<tr>
<td>Modification of axial compressor streamline program for analysis of engine test data</td>
<td>p0001 A80-94051</td>
</tr>
</tbody>
</table>
subject index

aircraft compartments

measurements of cabin and ambient ozone on 747 airplanes

p0110 N80-18368

simultaneous cabin and ambient ozone measurements on two Boeing 747 airplanes, volume I


aircraft construction materials

p0130 N80-20653

plane test method for graphite fiber reinforced plastics

p0270 N80-31169

hybrid composites that retain graphite fibers on burning

p0273 N80-32064

endurance and failure characteristics of modified vanco X-2, CUS 600 and AIE 5310 stage gases --- aircraft construction materials


aircraft design

MT HELICOPTER DESIGN

computer simulation of engine systems----for aircraft design

p0024 N80-10253

high-flying-point fuel studies

p0043 N80-25329

aircraft engines

MT T-63 ENGINE

p0165 N80-10035

thermal barrier coatings for aircraft gas turbines

p0024 N80-17737

engine component improvement program - performance improvement

p0024 N80-19300

heat of wall materials used in aircraft propulsion systems

p0121 N80-26010

aircraft propelling for a new era in energy and the environment

p0165 N80-10035

aircraft to satellite data computations

p0130 N80-20653

fuselage and nacelle design

p0165 N80-10035
SUBJECT INDEX

Noise reduction
Material and structures technology
Turbomachinery technology
Mechanical components
Effect of time dependent flight loads on JT9D-7 performance deterioration
[NASA-CR-159681]
Engine component improvement program: Performance improvement -- fuel consumption
[NASA-TN-79304]
Exhaust emission reduction for intermittent combustion aircraft engines
[NASA-Ca-159767]
Quiet Clean Subsonic Experimental Engine (Q3SE)
Double-annular clean combustor technology development report
[NASA-CP-2126]
Compressor simulation of engine systems
[NASA-WL-792920]
Air pollution from aircraft
[NASA-Cr-159711]
Some considerations of "A" performance of eco b. accp. gas turbine engine system
[NASA-TK-63199]
Aeropropulsion in year 2000
[NASA-WL-16016]
A 150 and 300 kw lightweight diesel aircraft engine design study
[NASA-CR-21.50]
JT9D-7A (1F) jet engine performance deterioration trend
[NASA-WL-16009]
Computerized systems analysis and optimization of aircraft engine performance, weight, and life cycle costs
[NASA-WL-21071]
Study/States performance of JBS-21 compressor at 100 percent of design speed with and without interstage intake blockage
[NASA-WL-16019]
Application of superalloy powder metallurgy jet engine aircraft engine
[NASA-Cr-16006]
Two-dimensional finite-element analyses of simulated rotor-stator impact against rings and bores compared with experiments
[NASA-Ch-159645]
Performance deterioration based on existing (historical) data: JT9D jet engine diagnostic program
[NASA-Ch-153448]
Design study: A 196 kw lightweight diesel aircraft engine
[NASA-Cr-1261]
General Aviation Propulsion
[NASA-Cr-2126]
An overview of NASA research on positive displacement general-aviation engines
[NASA-Ch-159657]
Positive displacement type general-aviation engines: Summary and concluding remarks
[NASA-Ch-22324]
Preliminary study of advanced turboprop and turboshaft engines for light aircraft -- cost effectiveness
[NASA-TM-81667]
Advanced component technologies for energy-efficient turbofan engines
[NASA-TM-81507]
Engine component improvement: Performance improvement, JT9D-7 3.6 kN fan
[NASA-Cr-159866]
Cold-air investigation of a 1/2 stage turbine with stage-loading factor of 4.66 and high specific work output: 2: Stage group performance
[NASA-TM-16080]
Performance deterioration based on in-service engine data: JT9D jet engine diagnostic program
[NASA-Ch-159552]
CF6 jet engine performance improvement program: High pressure turbine aerodynamic performance improvement

[NASA-CR-159632]
Performance, emissions, and physical characterization of rotating combustion aircraft engine, supplement A
[NASA-Cr-135119]
Fuel/engine/airframe tradeoff study, phase 1
[NASA-TM-20092]
Combustion technology overview - the use of broadened property aircraft fuels
[NASA-TM-20091]
Experimental combustor study program
[NASA-TM-20092]
Air Force fuel supply and turbine effects program
[NASA-TM-20092]
Investigation of performance deterioration of the CF6-5/3S, high-bypass ratio turbofan engines
[NASA-TM-21522]
Some advantages of methane in an aircraft gas turbine
[NASA-TM-21555]
Reentry thrust performance of the QC758 variable pitch turbine engine
[NASA-TM-21555]

EXPERIMENTAL EQUIPMENT

AIRCRAFT FUELS

Analytical and experimental evaluation of the effect of broad property fuels on combustion for commercial aircraft gas turbine engines
[NASA-CR-159845]
Temperature and flow measurements on near-freezing aviation fuels in a wing-tank model
[NASA-CP-21553]
NASA Broad-Specification Fuels Combustion Technology Program - Status and Progress
[NASA-CP-21146]
Alternative jet aircraft fuels
[NASA-TM-16029]
Temperature and flow measurements on near-freezing aviation fuels in a wing-tank model
[NASA-TM-16029]
Initial characterization of an Experimental Referee Broadened-Specification (ERBS) aviation turbine fuel
[NASA-TM-81440]
Advanced fuel system technology for utilizing broadened property aircraft fuels
[NASA-TM-81538]
Aircraft Research and Development for Future Fuels
[NASA-CT-2146]
Future aviation fuels overview
[NASA-CT-2146]
Future aviation fuels overview
[NASA-CT-2146]
Outlook for alternative energy sources --- aviation fuels
[NASA-CT-2146]
Current jet fuel trends
[NASA-CT-2146]
Aviation fuels outlook
[NASA-CT-2146]
A methodology for long-range prediction of air transportation fuel demand
[NASA-CT-2146]
Effect of refining variables on the properties and composition of JP-5
[NASA-CT-2146]
Fuel/engine/airframe tradeoff study, phase 1
[NASA-TM-20092]
Military jet fuel from shale oil
[NASA-TM-20092]
Aircraft fuel system technology overview
[NASA-TM-20092]
[1] pp0152 N80-26779

Report on MHD electric power plants [NASA-TM-81554].
[1] pp0144 N80-23962

Cogeneration Technology Alternatives Study (CTAS), Volume 6: Computer data. Part 1: Coal-fired cogeneration process boiler, section A
[1] pp0152 N80-30888

Cogeneration Technology Alternatives Study (CTAS), Volume 6: Computer data. Part 1: Coal-fired cogeneration process boiler, section B
[1] pp0154 N80-30889

Cogeneration Technology Alternatives Study (CTAS), Volume 6: Computer data. Part 2: Residual-fired cogeneration process boiler
[1] pp0155 N80-30890

Cogeneration Technology Alternatives Study (CTAS), Volume 6: Computer data. Part 3: Reaction bonded silicon nitride boiler
[1] pp0156 N80-33061

BONDING
MT ADHESIVE BONDING
MT METAL BONDING
MT FRACTION BONDING

Boron bonded silicon nitride prepared from wet attrition-milled silicon
[1] pp0085 N80-32628

Mechanisms of lubrication and wear of a bonded solid lubricant film
[1] pp0085 N80-16165

Reaction bonded silicon nitride prepared from wet attrition-milled silicon --- fractography
[1] pp0086 N80-18181

Effects of yttrium, aluminium and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers
[1] pp0079 N80-22460

BORON
MT BORON FIBERS

Boron fibers
[1] pp0071 A80-44236

Dynamic modulus and damping of boron, silicon carbide, and alumina fibers
[1] pp006 N80-20313

Calculation of residual principal stresses in CVD boron on carbon filaments
[1] pp0069 N80-20314

Predicting the time-temperature dependent axial failure of B/Al composites
[1] pp0069 N80-21452

BORON REINFORCED MATERIALS
Calculation of residual principal stresses in CVD boron on carbon filaments
[1] pp0072 A80-44237

Diffusion bonded boron/alumina spar-shell fan blade
[1] pp0072 N80-25382

BOUNDARIES
MT GRAIN BOUNDARIES

BOUNDARY LAYER CONTROL
Griffith diffusers
[1] pp0006 A80-20748

Static and transient performance of Yf-102 engine with up to 14 percent core airbleed for the quiet short-haul research aircraft
[1] pp0020 N80-25339

BOUNDARY LAYER FLOW
MT BOUNDARY LAYERS SEPARATION
MT SECONDARY FLOW
MT SEPARATE FLOW

BOUNDARY LAYER NOISE
U AERODYNAMIC NOISE
U BOUNDARY LAYERS

BOUNDARY LAYER SEPARATION
The effect of finite turbulence spatial scale on the amplification of turbulence by a contracting stream
[1] pp0004 A80-44682

BOUNDARY LAYERS
Prediction method for two-dimensional aerodynamic losses of cooled vanes using integral boundary-layer parameters
[1] pp0002 N80-17030

Three-dimensional mean flow and turbulence characteristics of the near wake of a compressor rotor blade
[1] pp0004 A80-16133

C-15 AIRCRAFT
quiet powered-lift propulsion
[1] pp0015 N80-15127

BOAT MACHINES
Measurements of cabin and ambient ozone on 747 airpplanes
[1] pp0010 A80-28853
Reduced bleed air extraction for DC-10 cabin air conditioning

[IAA PAPER 80-1197]  p0010 A00-41194

CADMIUM Hypoclinic magnetic field at Ca impurity site in L2/1 Heusler alloys Rh2MnSe and Rh2MnPb by TOFAC technique --- Time Differential Perturbed Angular Correlation

p0170 A00-16043

CALCIUM COMPOUNDS MT CALCIUM FLUORIDES MT CALCIUM SILICATES MT CALCIUM CARBONATES CALCIUM FLUORIDES Friction and wear of plasma-sprayed coatings containing cobalt alloys from 25 deg to 65 deg in air

[MTA-M-79951]  p0085 N00-14249

CALCIUM SILICATES Analysis of the response of a thermal barrier coating to sodium and vanadium doped combustion gases

[MTA-M-799205]  p0076 N00-10344

Reactions of calcium orthosilicate and calcium zirconate with oxides and sulfates of various elements

[MTA-M-799272]  p0085 N00-13256

CALCULUS Prediction of fiber composite mechanical behavior made simple --- using a rocket calculator

[MTA-M-81940]  p0068 N00-16107

CALCULUS MT POWER SERIES CALCULATING Wind-tunnel investigation of the flow correction for a model-mounted angle of attack sensor at angles of attack from -10 deg to 110 deg --- Langley 12-foot low speed wind tunnel test

[MTA-M-80189]  p0011 N00-14110

Global calibration of terrestrial reference cells and errors involved in using different irradiance monitoring techniques

[MTA-M-81393]  p0130 N00-15561

CANCER Preliminary results of fast neutron treatments in carcinomas of the pancreas

[MTA-M-81514]  p0160 N00-24983

CANTILEVER BEAMS Dynamic behavior of a beam drag-force anemometer

[MTA-M-81577]  p0110 A00-24955

CANTILEVER BEAMS MT CANTILEVER BEAMS CAPILLARY CIRCULATION U CAPILLARY FLOW CAPILLARY FLOW Capillary acquisition devices for high-performance vehicles: Executive summary --- evaluation of cryogenic propellant management techniques using the cantilever launch vehicle

[MTA-CR-159656]  p0062 N00-19185

CAPILLARY TUNNELS Capillary acquisition devices for high-performance vehicles: Executive summary --- evaluation of cryogenic propellant management techniques using the cantilever launch vehicle

[MTA-CR-159658]  p0062 N00-19185

CAPTIVE TESTS MT STATIC FIBERS MT STATIC TESTS CARBIDES MT SILICON CARBIDES MT TITANIUM CARBIDES MT TUNGSTEN CARBIDES Improved adhesion of sputtered refractory carbides to metal substrates

p0081 A00-25274

An investigation of the initiation stage of hot corrosion in Ni-base alloys

[MTA-CR-159718]  p0083 N00-15233

CARBON Combustion of solid carbon rods in zero and normal gravity

p0074 A00-20955

Combustion of solid carbon rods in zero and normal gravity

[MTA-M-799303]  p0104 N00-13404

CARBON COMPOUNDS MT CARBIDES MT FLUOROPOLYMERS MT SILICON CARBIDES

MT TITANIUM CARBIDES MT TUNGSTEN CARBIDES CARBON DIOXIDE LASERS A cesium TELEC experiment at Lowes Research Center

[MTA-CR-159729]  p0170 N00-14368

CARBON FIBER REINFORCED PLASTICS Fire test method for graphite fiber reinforced plastics

p0070 A00-31169

Burning characteristics and fiber retention of graphite/epoxy matrix composites

p0070 A00-32062

Hybrid composites that retain graphite fibers on burning

p0073 A00-32064

Improved fiber retention by the use of fillers in graphite fiber/epoxy matrix composites

p0071 A00-32066

Burning characteristics and fiber retention of graphite/epoxy matrix composites

p0067 N00-14196

Fire test method for graphite fiber reinforced plastics

[MTA-M-81467]  p0068 N00-18010

Circumferential shaft seal

p0119 N00-26711

CARBON FIBERS Fiber release characteristics of graphite fiber hybrid composites

p0073 A00-32063

High char amid-modified epoxy matrix resins

p0071 A00-34799

Calculation of residual principal stresses in CVD boron on carbon filaments

p0072 A00-42327

Calculation of residual principal stresses in CVD boron on carbon filaments

[MTA-M-81456]  p0068 N00-20314

Potential release of fibers from burning carbon composites --- aircraft fires

[MTA-M-80214]  p0069 N00-29431

Statistical aspects of carbon fiber risk assessment modeling --- fire accidents involving aircraft

[MTA-CR-159318]  p0073 N00-29432

CARBON MONOXIDE Comments on 'Experimental evidence for interhemispheric transport from airborne carbon monoxide measurements'

p0159 A00-32520

An analytical study of nitrogen oxides and carbon monoxide emissions in hydrocarbon combustion with added nitrogen - Preliminary results

[ASME PAPER 80-GT-60]  p0074 A00-42190

An analytical study of nitrogen oxides and carbon monoxide emissions in hydrocarbon combustion with added nitrogen, Preliminary results

[MTA-M-79296]  p0157 N00-13721

CARBON STEELS Manufacure of low carbon baseball bat steel shapes by hot isostatic pressing. Volume 2, Project 1

[ASME-CASE-AM-12119-1]  p0037 N00-21329

CARBON-CONTAINING SUBSTANCES MT COAL CARCINOMA U CANCER CARGO AIRCRAFT U KC-14 AIRCRAFT CARTRIDGE ACTUATED DEVICES U ACTUATORS CARTRIDGES Dynamic properties of elastomer cartridge specimens under a rotating load

p0121 A00-24002

CASCADE FLOW An experimental investigation of endwall profiling in a turbine cascade

[IAA PAPER 80-1089]  p0004 A00-38904

Streakline flow visualization study of a horsehoe vortex in a large-scale, two-dimensional turbine stator cascade

[ASME PAPER 80-GT-49]  p0004 A00-42145

An implicit finite-difference code for inviscid and viscous cascade flow

[IAA PAPER 80-1427]  p0007 A00-44128

Aerodynamic analysis of a supersonic cascade vibrating in a complex mode

p0007 A00-45841
Streakline flow visualization study of a horseshoe vortex in a large-scale, two-dimensional turbine stator cascade  
[NASA-TM-79274]  
p0104 800-11376
Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torque mode cascade  
[NASA-CR-159931]  
p0040 800-25335
A calculation procedure for viscous flow in turbomachines, volume 3 -- computer programs  
[NASA-CR-159864]  
p0055 800-26274
CASCAD: FORTRAN program for nonrotating blade-to-blade, steady, potential transonic cascade flows  
[NASA-TP-1705]  
p0003 800-27284
CASTINGS (FLUID DYNAMICS)  
U FLUID DYNAMICS  
CAST ALLOYS  
Development of exothermically cast single-crystal Mar-M 247 and derivative alloys  
[AERORESEARCH-21-3669]  
p0004 800-45825
Preparation of cast aluminum alloy-mica particle composites  
p0071 800-32632
Adherence of ion beam sputter deposited metal films on H-13 steel  
[NASA-TM-81565]  
p0079 800-31527
CASTINGS  
U METAL OXIDES  
Catalytic high temperature refractory materials  
[NASA-CASE-LEW-13000-1]  
p0086 800-29496
Catalysts  
Advanced catalytic combustors for low pollutant emissions, phase 1  
[NASA-CR-159535]  
p0026 800-13048
Diesel engine catalytic combustor system -- turbocharging  
[NASA-CASE-LEW-12995-1]  
p0116 800-26659
Catalysts  
U ELECTROCATALYSTS  
Durability testing of advanced catalysts and catalyst supports for gas turbine engine combustors  
p0074 800-35801
The effect of catalyst length and downstream reactor distance on catalytic combustor performance  
[NASA-TM-81475]  
p0142 800-23779
Durability testing at 5 atmosphere of advanced catalysts and catalyst supports or gas turbine engine combustors  
[NASA-CR-159839]  
p0151 800-24748
Gas phase oxidation downstream of a catalytic combustor  
[NASA-TM-81551]  
p0144 800-29863
Catalytic Action  
CATCON catalyst 5 at 1000 hour aging study using No. 2 fuel oil  
p0075 800-35900
Cathodes  
U METAL CATHODES  
U METAL ALLOYS  
Life test studies on tungsten impregnated cathodes  
[NASA-TM-81441]  
p0103 800-45122
Thermonic cathode life test studies  
[NASA-TM-81441]  
p0101 800-18302
Cavitation  
Cavitation Flow  
Marangoni bubble motion in zero gravity  
p1017 800-20958
Observation of pressure variation in the cavitation region of submerged journal bearings  
[NASA-TM-81582]  
p120 800-31798
Cell Cathodes  
Decay of the zincate concentration gradient at an alkaline zinc cathode after charging  
p0074 800-13070
Centaur Launch Vehicle  
Capsule acquisition devices for high-performance vehicles: Executive summary -- evaluation of cryogenic propellant management techniques using the centaur launch vehicle  
[NASA-CR-159658]  
p0062 800-19105
Central Launch Vehicle  
U CENTAUR LAUNCH VEHICLE  
CENTRIFUGAL COMPRESSORS  
Field verification of lateral-torsional coupling  
Effects on rotor instabilities in centrifugal compressors  
p0125 800-29700
Analysis and identification of subsonic oscillations for high pressure parallel flow centrifugal compressor  
p0125 800-29700
Subsonic instability of a geared centrifugal compressor of overhung design  
p0125 800-29710
Asynchronous vibration problem of centrifugal compressor  
p0125 800-29711
Effect of fluid forces on rotor stability of centrifugal compressors and pumps  
p0126 800-29720
Experimental results concerning centrifugal impeller excitations  
p0127 800-29727
Centrifugal Pumps  
Hydraulic forces caused by annular pressure seals in centrifugal pumps  
p0126 800-29718
A test program to measure fluid mechanical whirl-excitation forces in centrifugal pumps  
p0126 800-29719
Effect of fluid forces on rotor stability of centrifugal compressors and pumps  
p0126 800-29720
Fluid forces on rotating centrifugal impeller with whirling motion  
p0127 800-29724
Centrifugal Stress  
Buckling of rotating beams  
p0133 800-20149
Ceramic Protective Coatings  
U PROTECTIVE COATINGS  
Ceramic Coatings  
Thick ceramic coating development for industrial gas turbines -- A program plan  
[SA79-A-4702-05]  
p0091 800-10042
Thermal barrier coatings for aircraft gas turbines  
[AIAA PAPER 80-6302]  
p0089 800-16303
Preliminary study of a solar selective coating system using black cobalt oxide for high temperature solar collectors  
p0082 800-35500
Effect of thermal cycling on ZrO2-Y2O3 thermal barrier coatings  
p0082 800-35500
Effects of yttrium, aluminum and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers  
p0083 800-35500
Development of improved-durability plasma sprayed ceramic coatings for gas turbine engines  
[AIAA PAPER 80-1913]  
p0083 800-39963
Similarity tests of turbine vanes - Effects of ceramic thermal barrier coatings  
[CASCHE PAPER 80-10-U-T-24]  
p0027 800-40013
Plasma-sprayed dual density ceramic turbine seal system  
[NASA-CR-159739]  
p0123 800-15411
Similarity tests of turbine vanes, effects of ceramic thermal barrier coatings  
[NASA-CR-159739]  
p0105 800-21066
Significance of thermal contact resistance in two-layer thermal-barrier-coated turbine vanes  
[NASA-TM-81483]  
p0116 800-23310
Development of improved-durability plasma sprayed ceramic coatings for gas turbine engines  
[NASA-TM-81512]  
p0116 800-23310
Extension of similarity test procedures to cooled engine components with insulating ceramic coatings  
[NASA-TP-1615]  
p0105 800-24777
Composite wall concept for high temperature turbine shrouds: Heat transfer analysis  
[NASA-TP-1615]  
p0105 800-24777
Effect on combined cycle efficiency of stack gas temperature constraints to avoid acid corrosion  
[NASA-TM-81511]  
p0143 800-27804
Ceramics  
State-of-the-art of SiAlON materials  
p0009 800-13066
3500-hour durability testing of ceramic materials  
[AERORESEARCH-31-3542]  
p0092 800-35575
Significance of thermal contact resistance in two-layer, thermal-barrier-coated turbine vanes  
[AIRFOILCON-79-207]  
p0125 800-29700
Factors affecting cleanup of exhaust gases from a pressurized, fluidized-bed coal combustor [NASA-TM-81439]

Improved PFR operations: 400-hour turbine test results -- coal combustion products and hot corrosion in gas turbines [NASA-TM-81511]


Optimal thermionic energy conversion with established electrodes for high-temperature topping and process heating -- coal combustion product environments [NASA-TM-81555]

Preliminary study of a solar selective coating [NASA-CP-159767]

Volume 4: Energy conversion systems [NASA-CR-159768]

Adhesion and friction of iron-base binary alloys in contact with silicon carbide in vacuum [NASA-TP-192]

Tribological properties of sputtered Au5 and 2 films in relation to film morphology [NASA-TM-81465]

The rusting of turbine engine rotors to comparison of Pt [NASA-TM-81510]

ANTIREFLECTION SPRAYED COATINGS [NASA-TP-1F104] p0076 N80-15234

Optimal thermionic energy conversion with established electrodes for high-temperature topping and process heating -- coal combustion product environments [NASA-TM-81555]

Preliminary study of a solar selective coating [NASA-CP-159767]

Volume 4: Energy conversion systems [NASA-CR-159768]

Adhesion and friction of iron-base binary alloys in contact with silicon carbide in vacuum [NASA-TP-192]

Tribological properties of sputtered Au5 and 2 films in relation to film morphology [NASA-TM-81465]

The rusting of turbine engine rotors to comparison of Pt [NASA-TM-81510]
COLLISIONS
MT BIRD-AIRCRAFT COLLISIONS
MT PARTICLE COLLISIONS
COLLISIONS (PROCESS ENGINEERING)
The optimization of air separation plants for combined cycle H2/P20 power plant applications
[NASA-TP-61510] p0142 N00-23778

COMBUSTIBILITY
U FLAMMABILITY
COMBUSTIBLE FUEL
Dispersion of sound in a combustion duct by fuel droplets and soot particles
p0170 A80-20953

COMBUSTION
MT FUEL COMBUSTION
MT HYDROCARBON COMBUSTION
Burning characteristics and fiber retention of graphite/resin matrix composites
p0070 A80-32062
Investigation of critical burning of fuel droplets
[NASA-TP-159597] p0150 N80-12142
Combustion of solid carbon rods in zero and normal gravity
[NASA-TP-79303] p0104 N80-13404
Gas phase oxidation downstream of a catalytic combustor
[NASA-TP-159511] p0144 N80-29863

COMBUSTION CHAMBERS
Coupled generator and combustor performance calculations for potential early commercial H2 power plants
p0156 A80-25099
Durability testing of advanced catalysts and catalyst supports for gas turbine engine combustors
p0074 A80-35861
Cooling of high pressure rocket thrust chambers with liquid oxygen
[AZAA PAPER 80-1260] p0060 A80-38992
Analytical and experimental evaluation of the effect of broad property fuels on combustors for commercial aircraft gas turbine engines
[AZAA PAPER 80-1204] p0094 A80-41516
Performance of annular prediffuser-combustor systems
Characterization of swirl combustor modules with swirl blad fuel injectors
[ASME PAPER 80-07] p0026 A80-42164
Low NOX/NOx heavy fuel combustor program
[AIAA PAPER 80-01] p0026 A80-82199
Advanced catalytic combustors for low pollutant emissions, phase 1
[NASA-CH-159520] p0028 N80-13048
Stability analysis of a liquid fuel annular combustion chamber
[NASA-CH-159720] p0061 N80-13165
Effect of degree of fuel vaporization upon emissions for a premixed partially vaporized combustion system --- for gas turbine engines
[NASA-TP-1562] p0014 N80-14125
Quiet Clean Short-burn Experimental Engine (QCSEE), Double-annular clean combustor technology development report
[NASA-CH-159482] p0032 N80-15121
Core noise investigation of the CF6-50 turbofan engine
[NASA-CH-159598] p0036 N80-16061
Core noise investigation of the CF6-50 turbofan engine
[NASA-CH-159579] p0036 N80-16062
Study of research and development requirements of small gas-turbine combustors
[NASA-CH-159796] p0036 N80-16063
Factors affecting cleanup of exhaust gases from a pressurized, fluidized-bed coal combustor
[NASA-TP-81439] p0105 N80-20532
The effect of catalyst length and downstream reactor distance on catalytic combustor performance
[NASA-TP-15875] p0142 N80-23779
Durability testing at 5 atmospheres of advanced catalysts and catalyst supports for gas turbine engine combustors
[NASA-CH-159839] p0151 N80-24748
Analytical and experimental evaluation of the effect of broad property fuels on combustors for commercial aircraft gas turbine engines
[NASA-TP-81496] p0093 N80-25549

COMBUSTION PRODUCTS

Diesel engine catalytic combustor system --- turbocharging
[NASA-CASE-LEW-12955-1] p0110 N80-26659
Experimental combustor study program
p0042 N80-29311
NASA broadened-specification fuels combustion technology program
p0021 N80-29313
The broadened-specification fuels combustion technology program at Pratt and Whitney Aircraft
p0042 N80-29315
Fuel property effects in stirred combustors
p0143 N80-29321
Preliminary studies of combustor sensitivity to alternative fuels
p0021 N80-29323
Low-pressure performance of annular, high-pressure (40 at) high-temperature (2400 K) combustion system
[NASA-TP-1713] p0023 N80-32396
Energy efficient engine
p0045 N80-33408

COMBUSTION CONTROL
Float tube parametric studies for control of fuel bound nitrogen using rich-lean two-stage combustion
[NASA-TP-15972] p0041 N80-21837

COMBUSTION EFFICIENCY
Results of duct area ratio changes in the NASA Lewis H2-02 combustion H2D experiment
[NASA-TP-79308] p0075 N80-12801
Design and evaluation of high performance rocket engine injectors for use with hydrocarbon fuels
[NASA-TP-159319] p0056 N80-15163
Fuel quality combustion analysis
[NASA-CH-159721] p0094 N80-159284
The broadened-specification fuels combustion technology program at Pratt and Whitney Aircraft
p0042 N80-29315
NASA/General Electric broad-specification fuels combustion technology program, phase 1
p0042 N80-29316
Fuel research: Combustion effects overview
p0021 N80-29317
Fuel property effects in stirred combustors
p0043 N80-29321
Performance deterioration of commercial high-bypass ratio turbofan engines
[NASA-TP-81552-REV] p0023 N80-32399
The energy efficient engine project
p0023 N80-32395

COMBUSTION HEAT
U HEAT OF COMBUSTION

COMBUSTION INSTABILITY
U COMBUSTION STABILITY

COMBUSTION PHYSICS
p0075 A80-11754
Combustion of solid carbon rods in zero and normal gravity
p0074 A80-20955
CATCON catalyst 5 atm 1000 hour aging study using No. 2 fuel oil
p0075 A80-15908

COMBUSTION PRODUCTS
CO2
The chemistry of sodium chloride involvement in processes related to hot corrosion
p0074 A80-10041
Combustion of solid carbon rods in zero and normal gravity
p0074 A80-20955
An analytical study of nitrogen oxides and carbon monoxide emissions in hydrocarbon combustion with added nitrogen --- Preliminary results
[ASME PAPER 80-02-62] p0048 N80-42190
Effect of fuel molecular structure on soot formation in gas turbine engines
[ASME PAPER 80-02-62] p0095 N80-42192
Burning characteristics and fiber retention of graphite/resin matrix composites
[NASA-TP-79314] p0067 N80-14196
Quiet Clean Short-burn Experimental Engine (QCSEE)
clean combustor test report
p0067 N80-14196
Theory of deposition of condensible impurities on graphite/epoxy composites
[NASA-CH-159516] p0033 N80-15130
COMMUNICATION NETWORKS

COMMUNICATION EQUIPMENT

COMMUNICATION NETWORKS

COMMUNICATION SYSTEMS
Efficient laser anemometer for intra-rotor flow
mapping in turbomachinery

Three-dimensional mean flow and turbulence
characteristics of the near wake of a compressor
rotor blade

Evaluation of the cyclic behavior of aircraft
turbine disks, Part 2

Akradable compressor and turbine seals, Volume 1
for gas turbine engines

Program to develop sprayed, plastically deformable
compressor shroud seal materials

Study of blade aspect ratio on a compressor front
stage

Composite seal for turbomachinery

Evaluation of instability forces of labyrinth
seals in turbines or compressors

Application of the principle of similarity fluid
mechanics

Computation of three-dimensional flow in turbosan
aircraft and comparison with experimental data

Comparison of three-dimensional viscous
supercritical flow in inlets

Numerical calculation of steady inviscid full
potential compressible flow about wind turbine
blades

A three-dimensional turbulent compressible
subsonic duct flow analysis for use with
cosntructed coordinate systems

An implicit finite-difference code for inviscid
and viscous cascade flow

Numerical calculation of transonic axial
turbomachinery flows

Computational fluid mechanics of internal flow

COMPUTER GRAPHICS

INFORM: An interactive data collection and
display program with debugging capability

MODEL: An interactive modular design for computerized
photometry in spectrochemical analysis

COMPUTER TECHNIQUES

Modeling and analysis of Power Processing Systems

Computer code for estimating installed performance
of aircraft gas turbine engines. Volume 1:
Final report

Computer code for estimating installed performance
of aircraft gas turbine engines. Volume 2:
Users manual

Modification of axial compressor streamline
program for analysis of engine test data

Development of a three-dimensional supersonic
inlet flow analysis

Computer program for generating input for analysis
of impingement-cooled, axial-flow turbine blades

A calculation procedure for viscous flow in
compressors, Volume 1 --- computer programs

CAS2D: FORTRAN program for nonrotating
cascade flows

Calculation of water drop trajectories to and
about arbitrary three-dimensional bodies in
potential airflow

High-frenging-point fuel studies

Development of flexible rotor balancing criteria

Nonanalytic function generation routines for
16-bit microprocessors

WIND: Computer program for calculation of three
dimensional potential compressible flow about
wind turbine rotor blades

COMPUTER SIMULATION

U COMPUTERIZED SIMULATION

COMPUTER STORAGE DEVICES

U MAGNETIC CORES

COMPUTER SYSTEMS DESIGN

An interactive modular design for computerized
photometry in spectrochemical analysis

COMPUTER SYSTEMS PROGRAMS

INFORM: An interactive data collection and
display program with debugging capability

COMPUTER TECHNIQUES

Modeling and analysis of Power Processing Systems

Computer code for estimating installed performance
of aircraft gas turbine engines. Volume 1:
Final report

Computer code for estimating installed performance
of aircraft gas turbine engines. Volume 2:
Users manual

Computerized systems analysis and optimization of
aircraft engine performance, Weight, and life
cycle costs

COMPUTER CONTROL

U NUMERICAL CONTROL

COMPUTER AIDED DESIGN

Computerized systems analysis and optimization of
aircraft engine performance, Weight, and life
cycle costs
Computer simulation of engine systems --- for aircraft design

Numerical simulation of supersonic inlets using a three-dimensional viscous flow analysis

Capillary device refilling --- liquid rocket propellant

Simulation of transducer-couplant effects on broadband ultrasonic signals --- in nondestructive flaw evaluation and materials tests

A three-dimensional spacecraft-charging computer code

Quiet Clean Short-haul Experimental Engine (QCSEE) under the-wing engine simulation report

Computer simulation of engine systems

Numerical simulation of supersonic inlets using a three-dimensional viscous flow analysis

Effects of secondary yield parameter variation on predicted equilibrium potential of an object in a charging environment --- using computerized simulation

Advanced electric propulsion system concept for electric vehicles

NASA CAP modelling computations on large optics spacecraft in geosynchronous environments

Simulation of transducer-couplant effects on broadband ultrasonic signals

An alternative approach to the numerical simulation of steady inviscid flow

Thermal energy storage system using fluidized bed heat exchangers

Simulation and visualization of face seal motion stability by means of computer generated movies

Modelling of environmentally induced discharges in geosynchronous satellites

Computers

Microcomputers

Data processors

Concentration (composition)

Atmospheric moisture

Moisture content

Conductors

Evaluation of feasibility of precast concrete for use in wind turbine blades

Synthesis of improved polyester resins

Adiabatic conditions

Nonadiabatic conditions

Superconductors

Conference proceedings


Aeropropulsion 1979 --- conferences

Quiet powered-lift propulsion

General Aviation Propulsion

Thermal Energy Storage: Fourth Annual Review Meeting

Aircraft Research and Technology for Future Fuels

Rotoaerodynamic Instability Problems in high-performance turbomachinery

Low Space System/Low-Thrust Propulsion Technology

Synchronous Energy Technology

Conical nozzles

Acoustic considerations of flight effects on jet noise suppressor nozzles

Vehicle energy conservation

Constraints

Geophysical parameters

Spacecraft (spacecraft)

Propellant storage

Working fluids

Consumption

Fuel consumption

Contact resistance

Significance of thermal contact resistance in two-layer thermal-barrier-coated turbine vanes

Contacts (electric)

Electric contacts

Combustion

Fuel combustion

Spacecraft combustion

Mechanical impact tests of materials in oxygen effects of contamination --- Teflon, stainless steel, and aluminum

CONTROLLERS

North America

Control devices

Control equipment

Control equipment

Pressure regulators

Comparison of several inflow control devices for flight simulation of fan tone noise using a JT9D-1 engine

Electrical applications dispersal systems control requirements study --- agriculture

Quiet Clean Short-haul Experimental Engine (QCSEE) over-the-wing engine and control simulation results

Quiet Clean Short-haul Experimental Engine (QCSEE) under-the-wing engine simulation report

Effect of temperature on surface noise

Tested, tip-controlled rotor - Preliminary test results from Mod-0 100-kW experimental wind turbine

Control theory

A new traffic control design method for large networks with signalized intersections

Controlled atmospheres

Control engines

Performance of 22.4-kW nonlaminated-framed dc series motor with chopper controller --- a dc to ac converter
COOLANTS

Coolant tube curvature effects on film cooling as detected by infrared imagery

Influence of coolant tube curvature on film cooling effectiveness as detected by infrared imagery

[NASA-TP-1546] p0013 80-11087

Heat pipe cooled power magnetics

[NASA-CP-159659] p0013 80-13362

Scanning-electron-microscope study of normal-impingement erosion of ductile metals

[ASM-PAPER-80-01-6] p0025 80-42147

COOLED

Copper

Strengthening of tough-iron-12% nickel-reactive metal alloys at 77 K by copper additions

[ASME-80-15353] p0093 80-27509

Scanning-electron-microscope study of normal-impingement erosion of ductile metals

[ASM-PAPER-80-01-6] p0025 80-42147

Cores

MT MAGNETIC CORES

COPPER CORES

Anodic polarization behavior of austenitic stainless steel alloys with lower chromium content

[ASME-PAPER-80-GT-150] p0048 80-19501

Evaluation of present-day thermal barrier coatings for industrial/utility applications

[NASA-TP-79289] p0041 80-27364

Corrosion resistant thermal barrier coating for gas turbines and other gas turbine parts

[NASA-CASE-LMW-13088-1] p0067 80-11142

Mechanical properties and oxidation and corrosion resistance of reduced-chromium 304 stainless steel alloys

[NASA-TP-1557] p0076 80-11160

Corrosion resistance of sodium sulfate coated cobalt-chromium-aluminum alloys at 500 °C, 1000 °C, and 1100 °C

[NASA-TP-7931] p0076 80-14234

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7930] p0076 80-15235

Stress corrosion cracking evaluation of martensitic precipitation-hardening stainless steels

[NASA-TP-78257] p0056 80-16142

Method of making bearing material

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion tests

An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys

[ASTM-PAPER-80-01-6] p0039 80-24262

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7931] p0076 80-14234

Hot corrosion of superalloys

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion resistant thermal barrier coating for gas turbines and other gas turbine parts

[NASA-CASE-LMW-13088-1] p0067 80-11142

Mechanical properties and oxidation and corrosion resistance of reduced-chromium 304 stainless steel alloys

[NASA-TP-1557] p0076 80-11160

Corrosion resistance of sodium sulfate coated cobalt-chromium-aluminum alloys at 500 °C, 1000 °C, and 1100 °C

[NASA-TP-7931] p0076 80-14234

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7930] p0076 80-15235

Stress corrosion cracking evaluation of martensitic precipitation-hardening stainless steels

[NASA-TP-78257] p0056 80-16142

Method of making bearing material

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion tests

An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys

[ASTM-PAPER-80-01-6] p0039 80-24262

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7931] p0076 80-14234

Hot corrosion of superalloys

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion resistant thermal barrier coating for gas turbines and other gas turbine parts

[NASA-CASE-LMW-13088-1] p0067 80-11142

Mechanical properties and oxidation and corrosion resistance of reduced-chromium 304 stainless steel alloys

[NASA-TP-1557] p0076 80-11160

Corrosion resistance of sodium sulfate coated cobalt-chromium-aluminum alloys at 500 °C, 1000 °C, and 1100 °C

[NASA-TP-7931] p0076 80-14234

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7930] p0076 80-15235

Stress corrosion cracking evaluation of martensitic precipitation-hardening stainless steels

[NASA-TP-78257] p0056 80-16142

Method of making bearing material

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion tests

An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys

[ASTM-PAPER-80-01-6] p0039 80-24262

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7931] p0076 80-14234

Hot corrosion of superalloys

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion resistant thermal barrier coating for gas turbines and other gas turbine parts

[NASA-CASE-LMW-13088-1] p0067 80-11142

Mechanical properties and oxidation and corrosion resistance of reduced-chromium 304 stainless steel alloys

[NASA-TP-1557] p0076 80-11160

Corrosion resistance of sodium sulfate coated cobalt-chromium-aluminum alloys at 500 °C, 1000 °C, and 1100 °C

[NASA-TP-7931] p0076 80-14234

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7930] p0076 80-15235

Stress corrosion cracking evaluation of martensitic precipitation-hardening stainless steels

[NASA-TP-78257] p0056 80-16142

Method of making bearing material

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion tests

An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys

[ASTM-PAPER-80-01-6] p0039 80-24262

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7931] p0076 80-14234

Hot corrosion of superalloys

[NASA-CASE-LMW-11930-3] p0070 80-33402

Corrosion resistant thermal barrier coating for gas turbines and other gas turbine parts

[NASA-CASE-LMW-13088-1] p0067 80-11142

Mechanical properties and oxidation and corrosion resistance of reduced-chromium 304 stainless steel alloys

[NASA-TP-1557] p0076 80-11160

Corrosion resistance of sodium sulfate coated cobalt-chromium-aluminum alloys at 500 °C, 1000 °C, and 1100 °C

[NASA-TP-7931] p0076 80-14234

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, U-700, In-792, and Mar M-509 --- coal-derived liquid fuel combustion in turbines

[NASA-TP-7930] p0076 80-15235

Stress corrosion cracking evaluation of martensitic precipitation-hardening stainless steels

[NASA-TP-78257] p0056 80-16142

Method of making bearing material

[NASA-CASE-LMW-11930-3] p0070 80-33402
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
<th>CURRENT DENSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRACK INITIATION</td>
<td>CHORUS OIL</td>
</tr>
<tr>
<td>Practical implementation of the double linear damage rule and damage curve</td>
<td>Low KO/x/ heavy fuel combusted program (ASME PAPER 80-GT-69) p0026 A80-42199</td>
</tr>
<tr>
<td>approach for treating cumulative fatigue damage</td>
<td>Alternative jet aircraft fuels p0112 A80-16209</td>
</tr>
<tr>
<td>[NASA-TR-81517]</td>
<td>CHRONIC EQUIPMENT</td>
</tr>
<tr>
<td>Simple spline-function equations for fracture mechanics calculations</td>
<td>CHRONIC PLOIDY</td>
</tr>
<tr>
<td>p0113 A80-10032</td>
<td>MY LIQUID HYDROGEN</td>
</tr>
<tr>
<td>Characterization and properties of controlled nucleation thermomechanical</td>
<td>Comparative thermal analysis of alternate cryogenic Fluid Management Experiment (CFME) p0048 A80-32412</td>
</tr>
<tr>
<td>deposition /C/rib/ silicon carbide</td>
<td>CHRONIC MAGNETS</td>
</tr>
<tr>
<td>p0089 A80-13063</td>
<td>Experiments on H2-02 MHD power generation p0176 A80-44239</td>
</tr>
<tr>
<td>Fracture toughness determination of Al203 using four-point-bend specimens</td>
<td>CHRONIC ROCKET PROPULSION</td>
</tr>
<tr>
<td>with straight-through and chevron notches</td>
<td>LeRC reduced gravity fluid management technology p0051 A80-20304</td>
</tr>
<tr>
<td>Performance of Chevron-notch short bar specimens in determining the fracture</td>
<td>CHRONIC RESISTING</td>
</tr>
<tr>
<td>toughness of silicon nitride and alumina oxide</td>
<td>Oxygen-enriched air for MHD power plants p0096 A80-25096</td>
</tr>
<tr>
<td>p0090 A80-42085</td>
<td>High toughness-high strength iron alloy p0079 A80-32404</td>
</tr>
<tr>
<td>Comparison tests and experimental compliance calibration of the proposed</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>standard round compact plane strain fracture toughness specimen</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>[NASA-TR-81293]</td>
<td>CHORUS OIL</td>
</tr>
<tr>
<td>Sudden bending of cracked laminates</td>
<td>Low KO/x/ heavy fuel combusted program (ASME PAPER 80-GT-69) p0026 A80-42199</td>
</tr>
<tr>
<td>p0132 A80-13513</td>
<td>Alternative jet aircraft fuels p0112 A80-16209</td>
</tr>
<tr>
<td>Long-time creep behavior of the tantalum alloy</td>
<td>CHORUS OIL</td>
</tr>
<tr>
<td>Antar 811C --- as a function of stress, temperature, and grain size</td>
<td>Low KO/x/ heavy fuel combusted program (ASME PAPER 80-GT-69) p0026 A80-42199</td>
</tr>
<tr>
<td>p0080 A80-32489</td>
<td>Alternative jet aircraft fuels p0112 A80-16209</td>
</tr>
<tr>
<td>CHRONIC PROPERTIES</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>Long-time creep behavior of the niobium alloy C-103</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>p0080 A80-33555</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>CHRONIC RESISTANCE</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>CHRONIC RESISTANCE</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>CHRONIC SUSTAIN STRENGTH</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>A quarter-century of progress in the development of correlation and</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>extrapolation methods for creep rupture data</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>p0133 A80-38142</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>Anisotropy of nickel-base superalloy single crystals</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>p0083 A80-51573</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>Improving the stress rupture and creep of silicon nitride -- turbine</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>materials</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>[NASA-CH-159585]</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>p0072 A80-10318</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>Creep-rupture behavior of seven iron-base alloys after long term aging at</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>760 deg in low pressure hydrogen</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>[NASA-TR-81534]</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>p0080 A80-32480</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>CHRONIC SUSTAIN STRENGTH</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>Elevated temperature flow strength, creep resistance and diffusion</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>welding characteristics of Ti-6Al-2Nb-1Ta-0.8Mo</td>
<td>CHRONIC SUSTAIN STRENGTH</td>
</tr>
<tr>
<td>p0081 A80-13277</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>CHRONIC TESTS</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>Strainrange partitioning life predictions of the long time metal properties</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>council creep-fatigue tests</td>
<td>CHRONIC TIPING</td>
</tr>
<tr>
<td>p0133 A80-27958</td>
<td>Atomic hydrogen storage -- cryotrapping and magnetic field strength p0039 A80-20404</td>
</tr>
<tr>
<td>CRISSTATIONS</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>D TRAVELLING WAVE TUBES</td>
<td>...</td>
</tr>
<tr>
<td>CRIVIES</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>U CRACKS</td>
<td>...</td>
</tr>
<tr>
<td>CRITERIA</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>WT STRUCTURAL DESIGN CRITERIA</td>
<td>...</td>
</tr>
<tr>
<td>Development of flexible rotor balancing criteria</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>[NASA-CH-159585]</td>
<td>...</td>
</tr>
<tr>
<td>CRITICAL REYNOLDS NUMBER</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>U REYNOLDS NUMBER</td>
<td>...</td>
</tr>
<tr>
<td>CROP DUSTING</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>Aerial applications dispersal systems control</td>
<td>...</td>
</tr>
<tr>
<td>requirements study --- agriculture</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>[NASA-CH-159781]</td>
<td>...</td>
</tr>
<tr>
<td>CROSSLINKING</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>Method of cross-linking polyvinyl alcohol and other water soluble resins</td>
<td>...</td>
</tr>
<tr>
<td>[NASA-CASE-LEW-13103-1]</td>
<td>...</td>
</tr>
<tr>
<td>p0088 A80-32516</td>
<td>CRISSTATIONS</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

A-23
Comparison of elastic and elastic-plastic behavior: The performance and efficiency of four motor/controller/battery systems for the simpler electric vehicles

[ NASA-CR-159776] Impact of propulsion system R and D on electric vehicle performance and cost
[ NASA-TM-81540] Small passenger car transmission test: Chevrolet
[ NASA-CR-159001] Small passenger car transmission test: Toyota
[ NASA-CR-159002] Small passenger car transmission test: Chevrolet

ELECTRIC BATTERIES
MT ALKALINE BATTERIES
MT LEAD ACID BATTERIES
MT NICKEL HYDROGEN BATTERIES
MT NICKEL ZINC BATTERIES
MT SILVER ZINC BATTERIES
MT STORAGE BATTERIES

Advanced screening of electrode couples
[ NASA-CR-159738] Toroidal cell and battery --- energy storage for high-speed applications or power cells for electric vehicles
[ NASA-CASE-LEW-12916-1] Toroidal cell and battery --- energy storage for high-speed applications or power cells for electric vehicles

ELECTRIC CHARGERS
MT SPACE CHARGE
Configuration effects on satellite charging response
[ NASA-CR-159792]

ELECTRIC CIRCUITS
MT DIRECT CURRENT
MT GROUNDING CIRCUITS
MT GLOW DISCHARGES

Development of procedures for calculating stiffness and damping of elastomers in engineering applications, part 6
[ NASA-CR-159568] Use of elastomeric elements in control of rotor instability
[ NASA-CR-159570] Use of elastomeric elements in control of rotor instability

ELECTRIC CURRENTS
MT DIRECT CURRENT
MT GROUNDING CIRCUITS
MT GLOW DISCHARGES
MT SPACE CHARGE

Development of procedures for calculating stiffness and damping of elastomers in engineering applications, part 6
[ NASA-CR-159568] Use of elastomeric elements in control of rotor instability
[ NASA-CR-159570] Use of elastomeric elements in control of rotor instability

ELECTRIC ENERGY STORAGE
Maintenance and scale-up of the NASA AEC storage system
[ NASA-CR-159756] Maintenance and scale-up of the NASA AEC storage system

Assessment and preliminary design of an energy buffer for regenerative braking in electric vehicles
[ NASA-CR-159756] Maintenance and scale-up of the NASA AEC storage system

ELECTRIC GENERATORS
MT ALKALINE BATTERIES
MT FUEL CELLS
MT HYDROGEN OXYGEN FUEL CELLS
MT MAGNETOHYDRODYNAMIC GENERATORS
MT NICKEL ZINC BATTERIES
MT SOLAR CELLS
MT SOLAR GENERATORS
MT THERMOCOUPLED GENERATORS
MT THERMOELECTRIC GENERATORS
MT TURBINE GENERATORS

Bi-directional four quadrant (BDQ) power converter development
[ NASA-CR-159660] Bi-directional four quadrant (BDQ) power converter development
[ NASA-CR-159660] Bi-directional four quadrant (BDQ) power converter development

Large Wind Turbine Design Characteristics and System Requirements
[ NASA-CR-159660] Large Wind Turbine Design Characteristics and System Requirements
[ NASA-CR-159660] Large Wind Turbine Design Characteristics and System Requirements

Simulation studies of multiple large wind turbines for a utility network
[ NASA-CR-159660] Simulation studies of multiple large wind turbines for a utility network
[ NASA-CR-159660] Simulation studies of multiple large wind turbines for a utility network

Engineering test facility design definition
[ NASA-CR-159660] Engineering test facility design definition
[ NASA-CR-159660] Engineering test facility design definition

A-28
SUBJECT INDEX


ELECTRIC HYBRID VEHICLES
Advanced propulsion system for hybrid vehicles [NASA-CR-159771] p0104 880-26212
A laboratory facility for electric vehicle propulsion system testing [NASA-DE-81576] p0103 880-30229
Small passenger car transmission test; Ford C4 transmission [NASA-CR-159881] p0128 880-31795
Small passenger car transmission test; Chevrolet LUV transmission [NASA-CR-159886] p0128 880-31796

ELECTRIC IMPULSES
U ELECTRIC PULSES
ELECTRIC MOTOR VEHICLES
Performance of 22.4-kW nonlaminated-frame dc series motor with chopper controller --- a dc to dc voltage converter [NASA-TM-79252] p0101 880-13361
An averaging battery model for a lead-acid battery operating in an electric car [NASA-TM-79321] p0165 880-16824
Advanced electric propulsion system concept for electric vehicles [NASA-CR-159651] p0183 880-17916
Design study of flat belt CVT for electric vehicles [NASA-CR-159767] p0188 880-22702
Assessment and preliminary design of an energy buffer for regenerative braking in electric vehicles [NASA-CR-159756] p0184 880-23216
An electric vehicle propulsion system's impact on battery performance: An overview [NASA-TM-81515] p0143 880-24756
Progress charging of lead-acid traction cells [NASA-TM-81513] p0143 880-25780
Impact of propulsion system B and D on electric vehicle performance and cost [NASA-TM-81546] p0143 880-27805
Preliminary results of steady state characterization of near-term electric vehicle propulsion system [NASA-CR-159767] p0103 880-28254
A laboratory facility for electric vehicle propulsion system testing [NASA-CR-159803] p0128 880-25661
Toroidal cell and battery --- energy storage for orbital space applications or power cells for electric vehicles [NASA-CASE-18218-1] p0144 880-33857

ELECTRIC MOTORS
Study of advanced electric propulsion system concept using a flywheel for electric vehicles [NASA-CR-159600] p0184 880-18991
Preliminary results of steady state characterization of near-term electric vehicle propulsion system [NASA-TM-81546] p0183 880-28254

ELECTRIC REGNERS
Simulation study of multiple large wind turbine generators on a utility network

ELECTRIC POTENTIAL
Study of a rare-gas transverse fast discharge [AIAA PAPER 79-2103] p0064 880-13311
Initial comparison of STRA ground test results and flight data to transient simulations of a satellite Surface Potential Monitor NASA Charging Analyzer Program [NASA-CH-159720] p0034 880-29751
Open-circuit voltage improvements in low resistivity solar cells [NASA-TM-81380] p0138 880-15555
Study program to improve the open-circuit voltage of low resistivity single crystal silicon solar cells [NASA-CR-159833] p0150 880-22775

ELECTRIC POWER CONVERSION
U ELECTRIC GENERATORS
ELECTRIC POWER PLANTS
Parametric study of potential early commercial MHD power plants [NASA-TM-81556] p0150 880-25099
Concept definition study of small Brayton cycle engines for dispersed solar electric power systems [NASA-CR-159592] p0150 880-22778
The optimization air separation plants for combined cycle MHD-power plant applications [NASA-TM-81510] p0142 880-23778
Summary and evaluation of the parametric study of potential early commercial MHD power plants [PSPEC] [NASA-TM-81497] p0142 880-23778

ELECTRIC SPACECRAFT POWER SUPPLIES
Cycles till failure of silver-zinc cells with competing failure modes - Preliminary data analysis [NASA-CE-159767] p0156 880-1414
Electronic devices and magnetic interactions

- Electron Radiations
- Electron Beams
- Electron Temperatures
- Electron Energy
- Electron Trajectories
  - Analytical prediction and experimental verification of WIM and depressed collector performance using multidimensional computer programs
- Electron Tubes
  - Microwave Tubes
  - Traveling Wave Tubes
- Electronic Components
  - Improved traveling wave tubes --- for BGR systems
- Electronic Equipment
  - Photovoltaic Cells
  - Solar State Devices
- Electronic Levels
  - Electron Energy
  - Electronic Switches
  - Switching Circuits
- Electrons
  - Potential Consequences
- Electromagnetics
  - Electro Optics
  - Electro-Optics
- Electromagnetic Force
  - Flexible formulated plastic separators for alkali batteries
- Electromagnetic Radiation
  - X-Ray Waves
  - Electromagnetic Wave Transmission
  - Microwave Transmission
- Electromagnetics
  - Superconducting Magnets
- Electromotive Forces
  - Flexible formulated plastic separators for alkaline batteries
- Electromagnetic Paper
  - Negative streamer development in PEP teflon
- Electron Drains
  - 90- to 93-percent efficient collector for operation of a dual-mode traveling-wave tube in the linear region
  - Coupled cavity traveling wave tube with velocity tapering
  - Multistage depressed collector with efficiency of 90 to 94 percent for operation of a dual-mode traveling wave tube in the linear region
  - Baffle aperture design study of hollow cathode equipped ion thrusters
- Electron Compounds
  - Intermetallics
  - Electron Density (Concentration)
  - Parametric dependence of ion temperature and electron density in the SUNMA hot-ion plasma using laser light scattering and emission spectroscopy
- Electron Diffusion
  - Baffle aperture design study of hollow cathode equipped ion thrusters
- Electron Emission
  - Multistage depressed collector with efficiency of 90 to 94 percent for operation of a dual-mode traveling wave tube in the linear region
  - Improved traveling wave tubes
- Electron Ignition
  - Active control of spacecraft charging
- Electron Instability
  - Multistage depressed collector with efficiency of 90 to 94 percent for operation of a dual-mode traveling wave tube in the linear region
- Electron Ionization
  - Radiation damage in high voltage silicon solar cells
  - Radiation damage in high voltage silicon solar cells
- Electron Microscopy
  - Some TEM observations of Al203 scales formed on nicar alloys
  - Scanning-electron-microscope study of normal-lapision erosion of ductile metals
- Electron Optics
  - 90- to 93-percent efficient collector for operation of a dual-mode traveling-wave tube in the linear region
- Electron Paths
  - Electron Trajectories
- Energy Conversion
  - Electron Radiation
  - Electron Beams
  - Electron Temperatures
  - Electron Energy
  - Electron Trajectories
    - Analytical prediction and experimental verification of WIM and depressed collector performance using multidimensional computer programs
  - Electron Tubes
    - Microwave Tubes
    - Traveling Wave Tubes
  - Electronic Components
    - Improved traveling wave tubes --- for BGR systems
  - Electronic Equipment
    - Photovoltaic Cells
    - Solar State Devices
  - Electronic Levels
    - Electron Energy
    - Electronic Switches
    - Switching Circuits
  - Electrons
    - Potential Consequences
  - Electromagnetics
    - Electro Optics
    - Electro-Optics
  - Electromagnetic Force
    - Flexible formulated plastic separators for alkaline batteries
  - Electromagnetic Radiation
    - X-Ray Waves
    - Electromagnetic Wave Transmission
    - Microwave Transmission
  - Electromagnetics
    - Superconducting Magnets
  - Electromotive Forces
    - Flexible formulated plastic separators for alkaline batteries
  - Electromagnetic Paper
    - Negative streamer development in PEP teflon
  - Electron Drains
    - 90- to 93-percent efficient collector for operation of a dual-mode traveling-wave tube in the linear region
    - Coupled cavity traveling wave tube with velocity tapering
    - Multistage depressed collector with efficiency of 90 to 94 percent for operation of a dual-mode traveling wave tube in the linear region
    - Baffle aperture design study of hollow cathode equipped ion thrusters
  - Electron Compounds
    - Intermetallics
    - Electron Density (Concentration)
      - Parametric dependence of ion temperature and electron density in the SUNMA hot-ion plasma using laser light scattering and emission spectroscopy
    - Electron Diffusion
      - Baffle aperture design study of hollow cathode equipped ion thrusters
    - Electron Emission
      - Multistage depressed collector with efficiency of 90 to 94 percent for operation of a dual-mode traveling wave tube in the linear region
      - Improved traveling wave tubes
    - Electron Ignition
      - Active control of spacecraft charging
    - Electron Instability
      - Multistage depressed collector with efficiency of 90 to 94 percent for operation of a dual-mode traveling wave tube in the linear region
    - Electron Ionization
      - Radiation damage in high voltage silicon solar cells
      - Radiation damage in high voltage silicon solar cells
    - Electron Microscopy
      - Some TEM observations of Al203 scales formed on nicar alloys
      - Scanning-electron-microscope study of normal-lapision erosion of ductile metals
    - Electron Optics
      - 90- to 93-percent efficient collector for operation of a dual-mode traveling-wave tube in the linear region
  - Energy Conversion
    - Electron Radiation
    - Electron Beams
    - Electron Temperatures
    - Electron Energy
    - Electron Trajectories
      - Analytical prediction and experimental verification of WIM and depressed collector performance using multidimensional computer programs
    - Electron Tubes
      - Microwave Tubes
      - Traveling Wave Tubes
Impact of propulsion system A and D on electric vehicle performance and cost

Small passenger car transmission test-Chevrolet

Cogeneration Technology Alternatives Study (CTAS), Volume 2: Analytical approach

Outlook for alternative energy sources --- aviation fuels

Small passenger car transmission test; Ford C4 transmission

Large wind turbines: A utility option for the generation of electricity

Optimal thermionic energy conversion with established electrodes for high-temperature topping and process heating --- coal combustion product environments

Cogeneration Technology Alternatives Study (CTAS), Volume 6: Computer data. Part 1: Coal-fired cogeneration process boiler, section A.

Cogeneration Technology Alternatives Study (CTAS), Volume 6: Computer data. Part 2: Liquified-fueled cogeneration process boiler

Large wind turbines: A utility option for the generation of electricity

Optimal thermionic energy conversion with established electroded for high-temperature topping and process heating --- coal combustion product environments

Catalyst surfaces for the chromous/chromic redox couple

Study of advanced electric propulsion system concept using a hybrid for electric vehicles

Design study of flat belt CVT for electric vehicles

Advanced screening of electrode couples

Advanced screening of electrode couples

Advanced screening of electrode couples

Study of the DOE/NASA critical gas turbine research and technology project

Candidate thermal energy storage technologies for solar industrial process heat applications

Largo Wind Turbine Design Characteristics and B-and-D Report

Structural analysis considerations for wind turbine blades

Blade design and operating experience on the 200-kW wind turbine at Clayton, New Mexico

Design, fabrication, and test of a steel spar wind turbine blade

Preliminary analysis of performance and loads data from the 2-MW (60 x 100) wind turbine generator

Experiments on a 1-MW wind turbine power generator

Parametric study of potential early commercial HED power plants

Appendix: NOx-1 wind turbine generator analysis and design report, Volume 2

Advanced technology light weight fuel cell program --- orbiting space vehicle long-life hydrogen fuel cell

Cogeneration Technology Alternatives Study (CTAS), Volume 1: Summary

Thermal Energy Storage: Fourth Annual Review Meeting

The effect of catalyst length and downstream reactor distance on catalytic combustor performance

An electric vehicle propulsion system's impact on battery performance: An overview

Cogeneration Technology Alternatives Study (CTAS), Volume 1: Summary report

Thermal energy storage

Rapporvoir report: HED electric power plants

Synchronous energy transfer technology program

Experimenteral and theoretical investigation for the suppression of the planar arc drop in the thermionic converter

Engine Analyses

Computer code for estimating installed performance of aircraft gas turbine engines

Final report

Computer code for estimating installed performance of aircraft gas turbine engines

Users manual

Engine Control

Identification and dual adaptive control of a turbojet engine

Control technology

Quiet Clean Short-haul Experimental Engine (QCSEE) under-the-wing engine digital control system design report

Quiet Clean Short-haul Experimental Engine (QCSEE) under-the-wing engine simulation report

Quiet Clean Short-haul Experimental Engine (QCSEE) over-the-wing control system design report

Data analysis of & sub T/F sub S nozzle probe testing on F100 engine 060072 at NASA Lewis Research Center

Engine Design

Jet Rocket Engine Design

Computerized analysis and optimization of aircraft engine performance, weight, and life cycle costs

Preparing aircraft propulsion for a new era in energy and the environment

Computer simulation of engine systems --- for aircraft design

Advanced component technologies for energy-efficient turbomachinery

Multifuel rotary aircraft engine

SUNJNCT INDEX
ENGINE INLETS
Zero-length, slotted-lip inlet for subsonic aircraft
[ AIAA PAPER 80-1245 ]
An efficient user-oriented method for calculating compressible flow in an about three-dimensional inlets --- panel method
[ NASA-TR-81386 ]
Comparison of inlet suppressor data with approximate theory based on cutoff ratio
[ NASA-9486 ]
Distribution analysis for P100(3) engine
[ NASA-CR-159754 ]
Optimum subsonic, high-angle-of-attack nacelles
[ NASA-TR-81491 ]
Experimental evaluation of a spinning-mode acoustic-treatment design concept for aircraft inlets --- suppression of YF-102 engine fan noise
[ NASA-TP-11624 ]
ENGINE MOUNTING INSTRUMENTS
Fatigue strength testing employed for evaluation and acceptance of jet-engine instrumentation probes
[ NASA-TR-81402 ]
ENGINE NOISE
Comparison of inlet suppressor data with approximate theory based on cutoff ratio
[ AIAA PAPER 80-0100 ]
Acoustic measurements of three Prop-Fan models
[ AIAA PAPER 80-0956 ]
Acoustic pressures on a prop-fan aircraft fuselage surface
[ AIAA PAPER 80-1002 ]
Effect of inflow control on inlet noise of a cut-on fan
[ AIAA PAPER 80-1049 ]
Prediction of unsuppressed jet engine exhaust noise in flight from static data
[ AIAA PAPER 80-1008 ]
Noise reduction
[ NASA-TR-81402 ]
Quiet, Clean, Short-Haul, Experimental Engine (QCSEE) Under-The-Wing (UTW) engine acoustic design
[ NASA-TR-135568 ]
Quiet, Clean, Short-Haul Experimental Engine (QCSEE) Over-The-Wing (OTW) engine acoustic design
[ NASA-TR-135568 ]
Quiet Clean Short-Haul Experimental Engine (QCSEE). Core engine noise measurements
[ NASA-TR-135568 ]
Core noise investigation of the CF6-50 engine engine
[ NASA-TR-135568 ]
Core noise investigation of the CF6-50 turboshaft engine
[ NASA-TR-135568 ]
Spectral structure of pressure measurements made in a combustion duct --- jet engine noise
[ NASA-TR-81471 ]
Arco Lycoming quiet clean general aviation turboshaft engine
[ NASA-TR-81471 ]
Summary of NASA QCGAT program
[ NASA-TR-81471 ]
Prediction of unsuppressed jet engine exhaust noise in flight from static data
[ NASA-TR-81471 ]
[ NASA-TR-81471 ]
Acoustic performance of a 50.8-cm (20-inch) diameter variable-pitch fan and inlet. Volume 2: Acoustic data
[ NASA-TR-81471 ]
ENGINE PARTS
Engine component improvement program - Performance
[ NASA-TR-81471 ]
Summary of NASA QCGAT program
[ NASA-TR-81471 ]
Prediction of unsuppressed jet engine exhaust noise in flight from static data
[ NASA-TR-81471 ]
[ NASA-TR-81471 ]
Acoustic performance of a 50.8-cm (20-inch) diameter variable-pitch fan and inlet. Volume 2: Acoustic data
[ NASA-TR-81471 ]
ENGINE TESTS
Improvement
[ AIAA PAPER 80-0223 ]
Hydrogen thruster component testing
[ AIAA PAPER 79-7916 ]
Wear of seal materials used in aircraft propulsion systems
[ AIAA PAPER 80-1842 ]
Airbreathing propulsion component technologies
[ AIAA PAPER 80-3427 ]
Advanced component technologies for energy-efficient turbofan engines
[ AIAA PAPER 80-1086 ]
Materials and structures technology
[ NASA-9801 ]
Engine component improvement program: Performance improvement --- fuel consumption
[ NASA-79304 ]
Hydrogen thruster component testing
[ NASA-TR-79304 ]
Quiet Clean Short-Haul Experimental Engine (QCSEE) Under-The-Wing engine composite fan blade design report
[ NASA-TR-135046 ]
Gas path seal
[ NASA-TR-135046 ]
Development of improved high pressure turbine engine gas path seal components --- abradability and thermal cycling test results
[ NASA-TR-135046 ]
Quiet Clean Short-Haul Experimental Engine (QCSEE) Under-The-Wing engine composite fan blade design report
[ NASA-TR-135046 ]
Application of superalloy powder metallurgy for aircraft engine components
[ NASA-TR-81466 ]
Performance deterioration based on existing (historical) data; JT9D jet engine diagnostics program
[ NASA-TR-135046 ]
Extension of similarity test procedures to cooled engine components with insulating ceramic coatings
[ NASA-TR-135046 ]
Engine component improvement: Performance improvement, JT9D-7 3.8 AR fan
[ NASA-TR-135046 ]
Materials for advanced turbine engines. Volume 1: Power metallurgy B6 95 rotating turbine engine parts
[ NASA-TR-135046 ]
Improved components for engine fuel savings
[ NASA-TR-135046 ]
Energy efficient engine
[ NASA-TR-135046 ]
ENGINE STARTERS
An experimental evaluation of the performance deficit of an aircraft engine starter turbine
[ NASA-TR-81471 ]
ENGINE TESTS
AT COLD FLOW TESTS
AT SPACE ELECTRIC ROCKET TESTS
AT STATIC Firing
Turbine engine altitude chamber and flight testing with liquid hydrogen
[ AIAA PAPER 79-2103 ]
6-cm Engineering model Thruster technology - A review of recent developments
[ AIAA PAPER 79-2103 ]
Scale model performance test investigation of exhaust system mixers for an Energy Efficient Engine /3/ propulsion system
[ AIAA PAPER 80-0229 ]
Status of NASA full-scale engine aeroelasticity research
[ AIAA PAPER 80-0229 ]
The measuring and growing of advanced gas turbines
[ NASA-TR-81471 ]
Flutter spectral measurements using stationary pressure transducers
[ NASA-TR-81471 ]
Temperature and pressure measurement techniques for an advanced turbine test facility
[ NASA-TR-81471 ]
QCSEE UTW engine powered-lift acoustic performance --- Quiet Clean Short-Haul Experimental Engine Under 2to Wing
[ NASA-TR-81471 ]
Experimental evaluation of exhaust mixers for an Energy Efficient Engine
[ NASA-TR-81471 ]
CF6-50 Short Core Exhaust Nozzle
[ NASA-TR-81471 ]

Engineering Development

NASA Broad-Specification Fuels Combustion Technology Program - Status and description

[ASME paper 00-1A-3] p0024 88-0-42195

Results from tests on a high work transonic turbine for liquid rocket engine

[ASME paper 00-01-46] p0026 88-0-42228

CPE fan performance improvement

[ASME paper 00-06-176] p0026 88-0-42288

Fatigue strength testing employed for evaluation and acceptance of jet-engine instrumentation probes

J90-7A /SP/ jet engine performance deterioration trends

p0112 88-0-42291


[NSA CR-159691] p0028

Modification of axial compressor streamline program for analysis of engine test data

[NSA CR-157912] p0002 88-0-41011

Quiet Clean Short-Haul Experimental Engine (QCSEE) Over-The-Wing propulsion system test report. Volume 2: Aerodynamics and performance --- engine performance tests to define propulsion system performance on turbofan engines

[NSA CR-153524] p0029 88-0-14120

Quiet Clean Short-Haul Experimental Engine (QCSEE) Over-The-Wing (OTW) propulsion system test report. Volume 1: Summary report

[NSA CR-153523] p0033 88-0-15125

Expanded study of feasibility of measuring in-flight 747/757 loads, performance, clearance, and thermal data

[NSA CR-159717] p0036 88-0-16063

Experimental evaluation of a low emissions high performance duct burner for variable cycle engines

[NSA CR-159694] p0036 88-0-17074

Analytical investigation of two hydrogen oxygen rocket engine systems for low-thrust application

[NSA TM-81420] p0056 88-0-17138

Performance sensitivity analysis of Department of Energy-Chrysler upgraded automotive gas turbine engine, 5/M 5-4

[NSA TM-819242] p0115 88-0-17460

Overview of a stirling engine test project

[NSA TM-81442] p0140 88-0-16564

JT9D-7A (SP) jet engine performance deterioration trends

[NSA TM-815695] p0016 88-0-20278

CPE-60 engine short-term performance deterioration

[NSA CR-159690] p0039 88-0-23316

Engine component improvement: Performance improvement for a jet propulsion system

[NSA CR-159696] p0039 88-0-25332

Static and transient performance of YF-102 engine with up to 1 percent core bleed for the quiet short-haul research aircraft

[NSA TP-1692] p0020 88-0-25339

CPE jet engine performance improvement program: High pressure turbine aerodynamic performance improvement

[NSA CR-159832] p0040 88-0-26302

Inert gas ion thruster development

[NSA CR-159835] p0062 88-0-27424

Air Force fuel mixer/burner/turbine effect study

[NSA CR-159836] p0042 88-0-29343

Investigation of performance deterioration of the CPE/737D high-hypers ratio turbofan engines

[NSA TM-81552] p0022 88-0-29332

Description of the warm core turbine facility recently installed at NASA Lewis Research Center

[NSA TM-81652] p0022 88-0-29333

Performance deterioration of commercial high-hypers ratio turbofan engines

[NSA TM-81552-20v] p0023 88-0-32394

Engineering Development

U PRODUCT DEVELOPMENT

ENGINES

MT HYDROGEN OXYGEN ENGINES

MT INTERNAL COMBUSTION ENGINES

MT JET ENGINES

MT MERCURY ION ENGINES

MT NUCLEAR ENGINE FOR ROCKET VEHICLES

MT PRIMARY ENGINES

MT ROCKET ENGINES

MT SPACECRAFT ROCKET ENGINES

MT SUPERSONIC COMBUSTION RAMJET ENGINES

MT T-63 ENGINE

MT TURBINE ENGINES

MT TURBOFAN ENGINES

MT TURBOJET ENGINES

MT TURBOPROP ENGINES

MT UPPER STAGE ROCKET ENGINES

MT VARIABLE CYCLE ENGINES

MT WANKEL ENGINES

ENVIRONMENT EFFECTS

Engine environmental effects on composite behavior

[NSA TM-81508] p0069 88-0-23370

ENVIRONMENT POLLUTION

MT AIR POLLUTION

MT ENVIRONMENT PROTECTION

Preparing aircraft propulsion for a new era in energy and the environment

p0024 88-0-17377

Energy conservation and environmental benefits of thermal energy storage systems in the pulp and paper industry

p0146 88-0-46194

Aerial applications dispersal system: comparison study --- agriculture

[NSA CR-159761] p0158 88-0-16586

Performance of potential exposure to friable insulation materials containing asbestos

[NSA TM-81435] p0157 88-0-23875

ENVIRONMENT SIMULATION

MT ACOUSTIC SIMULATION

MT SPACE ENVIRONMENT SIMULATION

ENVIRONMENTAL MONITORING

Assessment of satellite and aircraft multispectral scanner data for strip-wise monitoring

p0136 88-0-20787

ENVIRONMENTAL QUALITY

MT AEROSPACE ENVIRONMENTS

MT AIR QUALITY

MT WIND ENVIRONMENT

ENVIRONMENTAL TESTS

MT COMBUSTION ENGINES

MT HIGH TEMPERATURE TESTS

MT ENGINE ENVIRONMENTAL EFFECTS ON COMPOSITE BEHAVIOR

MT HIGH TEMPERATURE ENVIROMENTS

MT TURBOFAN ENGINES

MT SPACECRAFT ENVIRONMENTS

EPOXY RESINS

Improved fiber retention by the use of fillers in graphite fiber/resin matrix composites

p0152 88-0-26774

High char inside-modified epoxy matrix resin composites

High char inside-modified epoxy matrix resin composites --- mechanical properties

p0024 88-0-35101

EQUATIONS OF MOTION

MT SPACECRAFT ENVIRONMENTS

MT AEROSPACE ENVIRONMENTS

MT HIGH TEMPERATURE ENVIROMENTS

MT SPACECRAFT ENVIRONMENTS

MT TURBOFAN ENGINES

MT SPACECRAFT ENVIRONMENTS

EQUATIONS OF MOTION

MT HELMHOLTZ VORTEX EQUATION

MT NONLINEAR ACOUSTIC EQUATIONS OF MOTION OF TWISTED, NONLINEAR, FLEXIBLE HORIZONTAL-AXIS WIND TURBINE BLADES

[NSA CR-159502] p0152 88-0-26774

EROSION

The erosion/corrosion of small superalloy turbine rotors operating in the effluent of a FPS coal combustion

p0050 88-0-10083

An investigation into the role of adhesion in the erosion of ductile metals

[ASLE PREDICT 80-AM-3E-3] p0122 88-0-43159

Scanning-electron-microscope study of surface morphology erosion of ductile metals

[NSA TE-1609] p0077 88-0-16411

An investigation into the role of adhesion in the erosion of ductile metals

[NSA TM-81450] p0078 88-0-21489

A-36
EXTRACTION
MET 70W EXTRACTION
EXTRAGALACTIC LIGHT
U EXTRAGalACTICAL RADIATION
EXTRAPOLATION
A quarter-century of progress in the development of correlation and extrapolation methods for creep rupture data

FAILURE MODES
Fracture modes of high modulus graphite/epoxy
angleplied laminates subjected to off-axis
tensile loads

PREDICTING THE TIME-TEMPERATURE DEPENDENT AXIAL
FAILURE OF T/A1 COMPOSITES

Cycles till failure of silver-zinc cells with competing failure modes - Preliminary data

Fracture modes of high modulus graphite/epoxy
angleplied laminates subjected to off-axis
tensile loads

Fracture modes of high modulus graphite/epoxy
angleplied laminates subjected to off-axis
tensile loads

Far-field radiation of aft turbofan noise

Endurance and failure characteristics of modified
Vasco I-2, CBS 600 and AISI 9310 spur gears --- suppression of YF-102 engine fan noise

Endurance and failure characteristics of modified
Vasco I-2, CBS 600 and AISI 9310 spur gears --- suppression of YF-102 engine fan noise

FABRICATION
Screen printing technology applied to silicon
cell fabrication

Fabrication and evaluation of low fiber content
alumina fiber/aluminum composites

Fabrication and evaluation of low fiber content
alumina fiber/aluminum composites

Fabrication and evaluation of low fiber content
alumina fiber/aluminum composites

Far-field radiation of aft turbofan noise

Fatigue strength testing employed for evaluation
and acceptance of jet-engine instrumentation
probes

Constrained fatigue life optimization of
a MASVITYS multiceroller traction drive

Endurance and failure characteristics of modified
Vasco I-2, CBS 600 and AISI 9310 spur gears ---
corrugated waveguide tubing

Simulated fatigue life analysis for traction
drive contacts

Simulated fatigue life analysis for traction
drive contacts

Constrained fatigue life optimization of a
MASVITYS multiceroller traction drive

Fatigue strength testing employed for evaluation
and acceptance of jet-engine instrumentation
probes

Analysis of wear debris from full-scale bearing
fatigue tests using the Ferrograph

A-38
Finite Difference Theory

Silicone modified resins for graphite fiber laminates
[HASA-79-159750]  p0072 880-22407
Engine environmental effects on composite behavior
[HASA-79-158580]  p0069 880-23370
Properties of PAN Polyimide composites made with
improved high strength graphite fibers
[HASA-79-158577]  p0069 880-28444
Characterization of PMR-15 polyamide composition
in thermo-oxidatively exposed graphite fiber
composites
[HASA-78-15655]  p0088 880-28524

Filter Optics
Optical sensors for aeronautics and space
[HASA-78-16097]  p010 880-17423
Fiber optic sensors for measuring angular position
and rotational speed --- air breathing engines
[HASA-78-16058]  p010 880-18368
Design, fabrication and testing of an optical
temperature sensor
[HASA-78-165135]  p0112 880-31777

Filter Orientation
Improved fiber retention by the use of fillers in
graphite fiber/resin matrix composites
[HASA-79-159757]  p0071 880-32066

Filterglass
U Glass fibers

Filter Tubes
MT Boron Fibers
MT Carbon Fibers
MT Glass Fibers
MT Reinforcing Fibers
Acoustic behavior of fibrous bulk materials
Fabrication and evaluation of low fiber content
silicon fiber/aluminum composites
[HASA-78-159517]  p0073 880-29430

Filter Tubes Materials
U Fiber

Fighter Aircraft
MT F-16 Aircraft
MT F-102 Aircraft
High-performance-vehicle technology --- fighter
aircraft propulsion
[HASA-TM-81515]  p0073 880-10219

Fillers
Improved fiber retention by the use of fillers in
graphite fiber/resin matrix composites
[HASA-78-159517]  p0071 880-32066
Improved fiber retention by the use of fillers in
graphite fiber/resin matrix composites
[HASA-78-159528]  p0057 880-13171

Filling
MT Refilling

Film Cooling
Coolant tube curvature effects on film cooling as
detected by infrared imagery
Full-coverage film cooling. I - Comparison of heat
transfer data for three injection angles
[AIAA Paper 80-6743]  p0108 880-42176
Full-coverage film cooling. II - Heat transfer
data and numerical simulation
[AIAA Paper 80-6744]  p0109 880-42177
Influence of coolant tube curvature on film
cooling effectiveness as detected by infrared
decals
[HASA-78-159564]  p0113 880-11067

Film Thickness
Elastohydrodynamic film thickness measurements of
artificially-produced nonsmooth surfaces
[ASLE Spine Print 79-01-1A-3]  p0102 880-14720
Mechanisms of lubrication and wear of a bonded
solid-lubricant film
[ASLE Spine Print 80-AM-32-1]  p0122 880-43163
Some limitations in applying classical HDH
film-thickness formulae to a high-speed bearing
[HASA-78-16431]  p0116 880-16409
Fully flooded elastohydrodynamic lubricated
elliptical contacts
[HASA-78-16543]  p0118 880-27698
Starved elastohydrodynamic lubricated elliptical
contacts
[HASA-78-16549]  p0110 880-27699
Film thickness for different regimes of fluid-film
lubrication
[HASA-78-15950]  p0119 880-29735

Finite Difference Theory
Time-dependent difference theory for noise
propagation in a two-dimensional duct

| AIAA PAPER 80-0096 | p0170 A80-18269 |

A time dependent difference theory for sound propagation in ducts with flow

| p0170 A80-20951 |

Summary of advanced methods for predicting high speed propulsive performance

| AIAA PAPER 80-0225 | p0003 A80-20966 |

An implicit finite-difference code for inviscid and viscous cascade flow

| AIAA PAPER 80-1427 | p0007 A80-44120 |

Time-dependent difference theory for noise propagation in a two-dimensional duct --- of a turbofan engine

| NASA-TM-79290 | p0167 A80-12622 |

A time dependent difference theory for sound propagation in ducts with flow --- characteristic of inlet and exhaust ducts of turbofan engines

| NASA-TM-79302 | p0167 A80-12623 |

Time dependent difference theory for sound propagation in axisymmetric ducts with plug flow

| NASA-TM-81501 | p0168 A80-23096 |

An alternative approach to the numerical simulation of steady inviscid flow

| NASA-TM-81542 | p0003 A80-27286 |

Influence of pressure driven secondary flows on the behavior of high speed forced mixers

| NASA-TM-81541 | p0105 A80-27632 |

Numerical techniques in linear duct acoustics --- finite difference and finite element analyses

| NASA-TM-81653 | p0170 A80-30154 |

**FLIGHT CHARACTERISTICS**

Analytical and experimental spur gear tooth temperature as affected by operating variables

| p0123 A80-46412 |

A three-dimensional spacecraft-charging computer code

| p0055 A80-46691 |

Modelling of crack tip deformation with finite element method and its applications

| p0130 A80-13503 |

Two-dimensional finite-element analyses of simulated rotor-fragment impacts against rings and beams compared with experiments

| NASA-CR-15646 | p0038 A80-22323 |

Nonlinear, three-dimensional finite-element analysis of air-cooled gas turbine blades

| NASA-TP-16669 | p0132 A80-22734 |

Three dimensional finite-element elastic analysis of a totally cycled double-edge wedge geometry specimen --- nickel alloy turbine parts

| NASA-TM-80980 | p0079 A80-26433 |

Finite-strain large-deflection elastic-viscoplastic finite-element transient response analysis of structures

| NASA-CR-15614 | p0134 A80-29762 |

Numerical techniques in linear duct acoustics --- finite difference and finite element analyses

| NASA-TM-81553 | p0170 A80-30154 |

**FIRE DAMAGE**

Fiber release characteristics of graphite hybrid composites

| p0073 A80-32063 |

**FIRE PREVENTION**

Hybrid composites that retain graphite fibers on burning

| p0073 A80-32064 |

**FIRE**

Fire test method for graphite fiber reinforced plastic

| NASA-TM-81436 | p0068 A80-10107 |

Potential release of fibers from burning carbon composites --- aircraft fires

| NASA-TM-9026 | p0069 A80-29431 |

Statistical aspects of carbon fiber risk assessment modeling --- fire accidents involving aircraft

| NASA-CR-15918 | p0073 A80-29432 |

**FIRE PROTECTION**

U FLAME PROPAGATION

U CHEMICAL REACTIONS

U FLAME PROPAGATION

U FLAME PROPAGATION

Combustion of solid carbon rods in zero and normal gravity
FLOW SEPARATION
FLOW STABILITY
FLOW PATTERNS
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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FLOW GEOMETRY
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APPLICATIONS
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APPLICATIONS
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FLOW EQUATIONS
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APPLICATIONS
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FLOW MEASUREMENTS
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APPLICATIONS
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APPLICATIONS
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FLOW EQUATIONS
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FLOW MEASUREMENTS
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FLOW REGIME
APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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APPLICATIONS
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FLOW REGIME
APPLICATIONS
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APPLICATIONS
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FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
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FLOW VELOCITY
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FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
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FLOW EQUATIONS
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FLOW REGIME
APPLICATIONS
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APPLICATIONS
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FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISUALIZATION
FLOW VELOCITY
FLOW DISTRIBUTION
FLOW EQUATIONS
FLOW GEOMETRY
FLOW MEASUREMENTS
FLOW RESISTANCE
FLOW REGIME
APPLICATIONS
FLOW VISU
Temperature and flow measurements on near-freezing aviation fuels in a wing-tank model

[ASME PAPER 00-07-63] p0009 A80-42193

FUEL INJECTION

Design and evaluation of high performance rocket engine injectors for use with hydrocarbon fuels
[ASME PAPER 00-20957] p0059 A80-20957

Atmospheric characteristics of swirl can combustor modules with swirl blast fuel injectors
[ASME PAPER 00-20957] p0059 A80-20957

Atmospheric characteristics of swirl can combustor modules with swirl blast fuel injectors -- in terms of NOX emission rate
[ASME PAPER 00-20957] p0059 A80-20957

Analytical and experimental evaluations of the effect of broad property fuels on combustors for commercial aircraft gas turbine engines
[ASME PAPER 00-20957] p0059 A80-20957

Low-pressure performance of annular, high-pressure (90 atm) high-temperature (2400 K) combustion system
[ASME PAPER 00-20957] p0059 A80-20957

FUEL OXIDS

CACTOS catalyst 5 atm 1000 hour aging study using No. 2 fuel oil
[ASME PAPER 00-20957] p0059 A80-20957

Current jet fuel trends
[ASME PAPER 00-20957] p0059 A80-20957

Aviation fuels outlook
[ASME PAPER 00-20957] p0059 A80-20957

Effect of refining variables on the properties and composition of JP-5
[ASME PAPER 00-20957] p0059 A80-20957

Military jet fuel from shale oil
[ASME PAPER 00-20957] p0059 A80-20957

FUEL SPRAYS

Atmospheric characteristics of swirl can combustor modules with swirl blast fuel injectors
[ASME PAPER 00-20957] p0059 A80-20957

FUEL SYSTEMS

MO AIRCRAFT FUEL SYSTEMS

Analytical and experimental evaluations of the effect of broad property fuels on combustors for commercial aircraft gas turbine engines
[ASME PAPER 00-20957] p0059 A80-20957

FUEL TANK PRESSURIZATION

External fuel vaporization study, phase 1
[ASME PAPER 00-20957] p0059 A80-20957

FUEL TANKS

MO WING TANKS

Temperature and flow measurements on near-freezing aviation fuels in a wing-tank model
[ASME PAPER 00-20957] p0059 A80-20957

FUEL TESTS

Effect of fuel molecular structure on soot formation in gas turbine engine
[ASME PAPER 00-20957] p0059 A80-20957

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of IN-100, U-700, IN-792, and MAR-N-5041
[ASME PAPER 00-20957] p0059 A80-20957

FUEL AIR RATIO

Effect of degree of fuel vaporization upon emissions for a premixed partially vaporized combustion system --- for gas turbine engines
[ASME PAPER 00-20957] p0059 A80-20957
GAS TURBINES

[ASME PAPER 00-GT-4] p0048 A80-21425

Experimental study of low aspect ratio compressor blading

Performance of annular prefluer-combustor system

An analytical study of nitrogen oxides and carbon monoxide emissions in hydrocarbon combustion with added nitrogen - Preliminary results

Effect of fuel molecular structure on heat transfer in gas turbine engines

NASA Broad-Specification Fuels Combustion Technology Program - Status and description

Low NOx/CO heavy fuel combustor program

Evaluating a high performance fixed-ratio traction drive

Similarity tests of turbine vane - Effects of ceramic thermal barrier coatings

Control technology

Analysis of the response of a thermal barrier coating to molasses and vanadium doped combustion gases

Computer code for estimating performance of aircraft gas turbine engine - Volume 1

Computer code for estimating performance of aircraft gas turbine engine - Volume 2

Advanced catalytic combustors for low pollutant emissions, phase 1

Effect of degree of fuel vaporization upon emissions for a premixed partially vaporized combustion system - For gas turbine engines

NASA broad-specification fuels combustion technology program: Status and description

Laser-optical blade tip clearance measurement system

Temperature and pressure measurement technique for an advanced turbine test facility

Theory of deposition of condensible impurities on surfaces immersed in combustion gases

Experimental studies of the formation/deposition of sodium sulfate in/for combustion gases --- hot corrosion of gas turbine engine components

Impact of new instrumentation on advanced turbine research

Sintered silicon nitride recuperator fabrication

Plasma-sprayed dual density ceramic turbine seal system

Air pollution from aircraft

Some considerations of the performance of two honeycomb gas path seal materials

Performance sensitivity analysis of Department of Energy-Chrysler upgraded automotive gas turbine engine, 5/8 5-4

Materials review for improved automotive gas turbine engine --- superalloys, refractory alloys, and ceramic matrix

Study of research and development requirements of small gas-turbine combustors

Effect of water injection and off scheduling of variable inlet guide vane, gas generator speed and power turbine nozzle angle on the performance of an automotive gas turbine engine

Composite wall concept for high temperature turbine_shafts: Survey of low modulus strain isolator materials

Fuel economy screening study of advanced automotive gas turbine engines

Operating characteristics of high-speed, jacket-driven 35 kilowatt-hour ball bearing with a single-outlet land-guided engine

NASA TM-14973

Parametric tests of a traction drive retrofitted to an automotive gas turbine

Development of improved-durability plasma sprayed ceramic coatings for gas turbine engines

Extension of similarity test procedures to cooled engine components with insulating ceramic coatings

NASA TM 1615

Dowel automotive gas turbine engine development program

Conceptual design study of an improved automotive gas turbine powertrain

Durability testing at 5 atmospheres of advanced catalysts and catalyst supports for gas turbine engine combustors

NASA TM 15939

External fuel vaporization study, phase 1

Analytical and experimental evaluation of the effect of broad property fuels on combustors for commercial aircraft gas turbine engines

A silicon-mullite/aluminate coating - protects aircraft and land-based gas turbine engines

High temperature self-lubricating coatings for air lubricated foil bearings for the automotive gas turbine engine

A市区-may 1994

C90-50 engine performance deterioration

Loe model for off-design performance analysis of radial turbines with pivoting-vane, variable-area stators

NASA TM-61532

Air force fuel system/turbine effects program

Atomization of broad specification aircraft fuels

Effect of fuel molecular structure on smoke formation in gas turbine combustion

State-of-the-art SiAlON materials

Some advantages of methane in an aircraft gas turbine

NASA TM-61559

The 3500 hour durability testing of commercial ceramic materials

NASA TM-159785

Upgraded automotive gas turbine engine design and development program, volume 2

NASA TM-15971

GAS TURBINES

Thick ceramic coating development for industrial gas turbines - A program plan

The measuring and growing of advanced gas turbines

Improved PPB operation - 400-hour turbine test results - Premature fluidized bed

Results from tests on a high work transonic turbine for an energy efficient engine

Development of silicon nitride of improved toughness

Corrosion resistant thermal barrier coating - protecting gas turbines and other heat engine parts

Feasibility of SiC composite structures for 1644 deg gas turbine seal applications

NASA TM-15959

A-46
Analytical and experimental spur gear tooth temperature as affected by operating variables
[NASA-TM-80-10403] p0115 A80-10403
Ideal spiral bevel gears: A new approach to surface geometry

Gear research and its probable effect on rotorcraft transmission design
Effect of geometry and operating conditions on spur gear system power loss
Quiet Clean Short-haul Experimental Engine (QCSEE)
Main reduction gears test program
[NASA-CE-134669] p0030 A80-15103
Quiet Clean Short-haul Experimental Engine (QCSEE)
Main reduction gears bearing development program
[NASA-CE-134890] p0030 A80-15105
Quiet Clean Short-haul Experimental Engine (QCSEE)
Main reduction gears detailed design report
[NASA-CE-134872] p0030 A80-15106
Spur-gear-system efficiency at part and full load
Endurance and failure characteristics of modified Vanco X-2, CES 600 and AISI 9310 spur gears ---
oircraft construction materials
[NASA-TM-81421] p0116 A80-18045
Effect of geometry and operating conditions on spur gear system power loss
Ideal spiral bevel gears: A new approach to surface geometry
Anisotropy of nickel-base superalloy single crystal

Materials and structures technology

Effect of thermally induced porosity on an as-HP powder metallurgy superalloy

[NASA-TM-79263]
p0076 N80-11189

Characterization of an oxide dispersion strengthened superalloy, MA-6000E, for turbine blade applications --- turbine blade

[NASA-GT-15949A]
p0083 N80-13210

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of In-100, In-791, and Hastelloy --- coal-derived liquid fuel combustion in turbines

[NASA-TM-79309]
p0076 N80-15235

Chemical processes involved in the initiation of hot corrosion of In-100 and NASA-TRW VIA


Anisotropy of nickel-base superalloy single crystal

[NASA-TM-81437]
p0077 N80-17200

Study of the effects of gaseous environments on the hot corrosion of superalloy materials

[NASA-GT-159747]
p0083 N80-18155

Effects of impingement in coal-derived liquids on accelerated hot corrosion of superalloys

[NASA-TM-81438]
p0077 N80-18157

An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys

[NASA-TM-81455]
p0076 N80-202370

Application of superalloy powder metallurgy for aircraft engines

[NASA-TM-81466]
p0076 N80-21488

Pitting and the inhibition of salt corrosion --- hot corrosion of superalloys

[NASA-TM-81469]
p0076 N80-21492

Effects of fluoride on the fatigue behavior of a powder metallurgy superalloy

[NASA-TM-81448]
p0076 N80-21493

Performance of two-layer thermal barrier systems on directionally solidified Ni-Al-Mo and comparative effects of alloy thermal expansion on system

[NASA-TM-81604]
p0080 N80-32487

Heat Transfer Coefficients:

Full-coverge film cooling, I --- comparison of heat transfer data for three injection angles

[ASME PAPER 80-GT-143] p0120 N80-42176

Heat Transfer

A reduced volumetric expansion factor plot

[ASME PAPER 79-AH/HT-17] p0107 A80-10038

Thermophysical property data -- Who needs them --- similarity principle applications in fluid mechanics and heat transfer

[ASME PAPER 79-AH/HT-17] p0105 A80-16630

Full-coverage film cooling, II -- Heat transfer data and numerical simulation

[ASME PAPER 80-GT-64] p0109 A80-42177

Impact of new instrumentation on advanced turbine research


Comparison of predicted and experimental performance of large-bore roller bearing operating to 2.0 million DN


Prediction method for two-dimensional aerodynamic lames of cooled vanes using integral boundary-layer parameters

[NASA-TM-81623] p0002 N80-17030

Analytical and experimental spur gear tooth temperature as affected by operating variables


Engineering evaluation of a sodium hydroxide thermal energy storage module


Performance tests of turbine vanes, effects of ceramic thermal barrier coatings


Significance of thermal contact resistance in two-layer thermal-barrier-coated turbine vanes


Two-phase working fluids for the temperature range of 80 to 350 deg, phase 2


Extension of similarity test procedures to cooled engine components with laminating ceramic coatings

[NASA-TP-1615] p0105 N80-24577

Conceptual design of two-phase fluid mechanics and heat transfer facility for space lab

[NASA-CR-159810] p0049 N80-27403

Heat Transmission

Full-coverge film cooling, I --- comparison of heat transfer data for three injection angles

[ASME PAPER 80-GT-143] p0120 A80-42176

Heat Treatment

MT HEAT TREATMENT

MT HEATING EQUIPMENT

MT ROTARY KINGS

MT HELICOPTER TAIL ROTORS

MT HELICOPTER ROTORS

MT HELICOPTER TREATMENT A reduced volumetric expansion factor plot

[ASME PAPER 79-AH/HT-17] p0107 A80-10038

Thermophysical property data -- Who needs them --- similarity principle applications in fluid mechanics and heat transfer

[ASME PAPER 79-AH/HT-17] p0105 A80-16630

Full-coverge film cooling, II -- Heat transfer data and numerical simulation

[ASME PAPER 80-GT-64] p0109 A80-42177

Impact of new instrumentation on advanced turbine research


Comparison of predicted and experimental performance of large-bore roller bearing operating to 2.0 million DN


Prediction method for two-dimensional aerodynamic lames of cooled vanes using integral boundary-layer parameters

[NASA-TM-81623] p0002 N80-17030

Analytical and experimental spur gear tooth temperature as affected by operating variables


Engineering evaluation of a sodium hydroxide thermal energy storage module


Performance tests of turbine vanes, effects of ceramic thermal barrier coatings


Significance of thermal contact resistance in two-layer thermal-barrier-coated turbine vanes


Two-phase working fluids for the temperature range of 80 to 350 deg, phase 2


Extension of similarity test procedures to cooled engine components with laminating ceramic coatings

[NASA-TP-1615] p0105 N80-24577

Conceptual design of two-phase fluid mechanics and heat transfer facility for space lab

[NASA-CR-159810] p0049 N80-27403

Heat Transmission

Full-coverge film cooling, I --- comparison of heat transfer data for three injection angles

[ASME PAPER 80-GT-143] p0120 A80-42176

Heat Treatment

Characterization and properties of controlled nucleation thermoechemical deposited (CND) silicon carbide


HEATING

MT SOLAR HEATING

MT HEATING EQUIPMENT

MT ROTARY KINGS

MT HELICOPTER TAIL ROTORS

MT HELICOPTER ROTORS

MT HELICOPTER TREATMENT

A reduced volumetric expansion factor plot

[ASME PAPER 79-AH/HT-17] p0107 A80-10038

Thermophysical property data -- Who needs them --- similarity principle applications in fluid mechanics and heat transfer

[ASME PAPER 79-AH/HT-17] p0105 A80-16630

Full-coverge film cooling, II -- Heat transfer data and numerical simulation

[ASME PAPER 80-GT-64] p0109 A80-42177

Impact of new instrumentation on advanced turbine research


Comparison of predicted and experimental performance of large-bore roller bearing operating to 2.0 million DN


Prediction method for two-dimensional aerodynamic lames of cooled vanes using integral boundary-layer parameters

[NASA-TM-81623] p0002 N80-17030

Analytical and experimental spur gear tooth temperature as affected by operating variables


Engineering evaluation of a sodium hydroxide thermal energy storage module


Performance tests of turbine vanes, effects of ceramic thermal barrier coatings


Significance of thermal contact resistance in two-layer thermal-barrier-coated turbine vanes


Two-phase working fluids for the temperature range of 80 to 350 deg, phase 2


Extension of similarity test procedures to cooled engine components with laminating ceramic coatings

[NASA-TP-1615] p0105 N80-24577

Conceptual design of two-phase fluid mechanics and heat transfer facility for space lab

[NASA-CR-159810] p0049 N80-27403

Heat Transfer Coefficients:

Full-coverge film cooling, I --- comparison of heat transfer data for three injection angles

[ASME PAPER 80-GT-143] p0120 A80-42176
An efficient user-oriented method for calculating compressible flow in an about three-dimensional inlet [NASA-CR-159579]

Computational fluid mechanics of internal flow [NASA-CR-159576]

An analytical and experimental study of a short m-shaped subsonic diffuser of a supersonic inlet [NASA-CR-159576]

Distribution analysis for P100 (3) engine [NASA-CR-159574]

Comparison of several inflow control devices for flight simulation of fan tone noise using a JT8D-1 engine [NASA-TM-815105]

Critical mass flux through short Borda type inlets [NASA-TM-815105]

Comparison of various cross sections of the inlet [NASA-TM-815105]

Free jet phenomena in a 90 deg-sharp edge geometry [NASA-TM-815105]

Low-pressure performance of annular, high-pressure (40 atm) high-temperature (2480 K) combustion system [NASA-TP-17113]

Installation and checkout of the DOE/NASA Mod-1 wind turbine generator [NASA-TM-815105]

Flight tests of navigation and guidance sensor errors measured on STG approaches [NASA-TM-815105]

Assessment of potential exposure to friable insulation materials containing asbestos [NASA-TM-815105]

Low speed test of the inlet designed for a tandem fan V/STOL nacelle [NASA-TM-815105]

Application of coherence in fan noise studies [NASA-TM-815105]


Cell module and fuel conditioner development [NASA-CR-159828]

Cell module and fuel conditioner [NASA-CR-159828]

Interactive Graphics [NASA-CR-159828]

U-Computer Graphics

Intrusion Aircraft [NASA-CR-159828]

U-Fighter Aircraft

Influence of interfacial tension on the performance of aircraft engines [NASA-CR-159828]

Integration of noncontacting face seals [NASA-TM-79294]

Dynamic analysis of noncontacting face seals [NASA-TM-79294]

Evaluation of interпланetary propulsion interactions studies [NASA-CR-159828]

Interplanetary propulsion interactions studies [NASA-CR-159828]

ION BEAMS

ION BEAMS

ION BEAMS

ION BEAMS

ION BEAMS
JET EXHAUST

Engine bleed air reduction in DC-10
[NASA CR-159546] p0010 N80-32370

JET EXHAUST
Prediction of unsuppressed jet engine exhaust noise in flight from static data
[IAA PAPER 80-1008] AE; pollution from aircraft
[NASA CR-159712] p0010 N80-16600

JET FAMES
U FLAMES
U JET FLOW
U JET FLYON
U JET AIRCRAFT

JET EXHAUST Effect of temperature on surface noise
p0107 A80-20619

JET FUELS
U JET ENGINE FUELS

JET IMPELLMENT
Analytical and experimental spur gear tooth temperature as affected by operating variables
p0123 A80-66412

Computer program for generating input for analysis of impingement-cooled, axial-flow turbine blade
[NASA TV 1601] p0104 N80-15361

Measured and predicted impingement noise for a model-scale under the wing externally blows flap configuration with a QCSE nozzle
[NASA TM 01494] p0169 N80-26115

JET MIXING FLOW
Scale model performance test investigation of exhaust system mixers for an Energy Efficient Engine / E3/ propulsion system
[IAA PAPER 80-0229] p0024 A80-20698

JET NOISE
U JET AIRCRAFT NOISE

JET THRUST
Method and apparatus for rapid thrust increases in a turboprop engine
[NASA CASE LW 12971-1] p0016 N80-18039

JET VANES
Significance of thermal contact resistance in two-layer, thermal-barrier-coated turbine vanes
p0024 A80-39625

JET VENTS
U GUIDE VANES
JET VANES
U VIBRATION

JOURNAL Bearings
Observation of pressure variation in the cavitation region of submerged journal bearings
[NASA TM-15802] p0120 N80-31798

JOURNALS (SHAFTS)
U SHAFTS (MACHINE ELEMENTS)

Jp-5JET FUEL
Effect of refining variables on the properties and composition of Jp-5
p0041 N80-29306

K

K BAND
U EXTREMELY HIGH FREQUENCIES

K BAND
U EXTREMELY HIGH FREQUENCIES

KENTUCKY
Assessment of satellite and aircraft multispectral scanner data for strip-mine monitoring
[NASA TM 79268] p0136 N80-20787

KEROSENE
Antisizing kerosene — reduced flammability during aircraft accident circumstances
p0021 N80-29319

KEVAU (TRADEMARK)
Acoustic behavior of fibrous bulk materials
[IAA PAPER 60-0966] p0172 A80-25515

Development of a Kevlar/PMB-15 reduced drag airfoil
[IAA PAPER 60-1194] p0010 A80-21193

Feasibility of Kevlar 49/PMR-15 polyimide for high temperature applications
[NASA TM 61560] p0069 N80-27429

KINEMATICS
Kinemetic correction for roller skewing
[IAA PAPER 60-1564] p0119 880-20716

KINETIC EQUATIONS
U HELMOLTZ VORTICITY EQUATION

KINETIC FLOW
U SLIDING FRICTION

L

L BAND
U ULTRAHIGH FREQUENCIES

L BAND
U ULTRAHIGH FREQUENCIES

LAMINATES
Mechanical property characterization of intraply hybrid composites
p0070 A80-20954

Dynamic response of damaged angleplied fiber composites
p0070 A80-27982

Failure characteristics and fiber retention of graphite/resin matrix composites
p0070 A80-32062

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
p0071 A80-32069

Micromechanics of intraply hybrid composites
p0071 A80-32069

Thermal and environmental testing
[NASA TM 79253] p0067 N80-11143

Dynamic response of damaged angleplied fiber composites
[NASA TM 79281] p0067 N80-11145

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
[NASA TM 819405] p0068 N80-16102

Silicone modified resins for graphite fiber laminates
[NASA CR 159750] p0072 N80-22407

Smooth bending of cracked laminates
[NASA CR 159860] p0073 N80-25303

Feasibility of Kevlar 49/PMR-15 polyimide for high temperature applications
[NASA TM 81560] p0069 N80-27429

LAMINATIONS
U LAMINATES

LAMINATES
Mechanical property characterization of intraply hybrid composites
p0070 A80-20954

Dynamic response of damaged angleplied fiber composites
p0070 A80-27982

Failure characteristics and fiber retention of graphite/resin matrix composites
p0070 A80-32062

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
p0071 A80-32069

Micromechanics of intraply hybrid composites
p0071 A80-32069

Thermal and environmental testing
[NASA TM 79253] p0067 N80-11143

Dynamic response of damaged angleplied fiber composites
[NASA TM 79281] p0067 N80-11145

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
[NASA TM 819405] p0068 N80-16102

Silicone modified resins for graphite fiber laminates
[NASA CR 159750] p0072 N80-22407

Smooth bending of cracked laminates
[NASA CR 159860] p0073 N80-25303

Feasibility of Kevlar 49/PMR-15 polyimide for high temperature applications
[NASA TM 81560] p0069 N80-27429

LAMINATIONS
U LAMINATES

LAMINATES
Mechanical property characterization of intraply hybrid composites
p0070 A80-20954

Dynamic response of damaged angleplied fiber composites
p0070 A80-27982

Failure characteristics and fiber retention of graphite/resin matrix composites
p0070 A80-32062

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
p0071 A80-32069

Micromechanics of intraply hybrid composites
p0071 A80-32069

Thermal and environmental testing
[NASA TM 79253] p0067 N80-11143

Dynamic response of damaged angleplied fiber composites
[NASA TM 79281] p0067 N80-11145

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
[NASA TM 819405] p0068 N80-16102

Silicone modified resins for graphite fiber laminates
[NASA CR 159750] p0072 N80-22407

Smooth bending of cracked laminates
[NASA CR 159860] p0073 N80-25303

Feasibility of Kevlar 49/PMR-15 polyimide for high temperature applications
[NASA TM 81560] p0069 N80-27429

LAMINATIONS
U LAMINATES

LAMINATES
Mechanical property characterization of intraply hybrid composites
p0070 A80-20954

Dynamic response of damaged angleplied fiber composites
p0070 A80-27982

Failure characteristics and fiber retention of graphite/resin matrix composites
p0070 A80-32062

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
p0071 A80-32069

Micromechanics of intraply hybrid composites
p0071 A80-32069

Thermal and environmental testing
[NASA TM 79253] p0067 N80-11143

Dynamic response of damaged angleplied fiber composites
[NASA TM 79281] p0067 N80-11145

Fracture models of high modulus graphite/oxygung angleplied laminates subjected to off-axis tensile loads
[NASA TM 819405] p0068 N80-16102

Silicone modified resins for graphite fiber laminates
[NASA CR 159750] p0072 N80-22407

Smooth bending of cracked laminates
[NASA CR 159860] p0073 N80-25303

Feasibility of Kevlar 49/PMR-15 polyimide for high temperature applications
[NASA TM 81560] p0069 N80-27429

LAMINATIONS
U LAMINATES
Initial comparison of SSPM ground test results and flight data to NASCAP simulations --- Satellite Surface Potential Monitor NASA Charging Analyzer Program
[ASME PAPER 79-LUB-34] p0129 A80-14760

Modified power law equations for vertical wind profiles --- in investigation of windpower plant siting
[ASME PAPER 80-GT-162] p0054 A80-29751

'Chain pooling' model selection for two-level fixed effects factorial experiments
[ASME PAPER 79-LUB-34] p0164 A80-40764

Analysis of combustion instability in liquid fuel rocket motors
[ASME CR-159733] p0061 A80-13164

Modeling of crack tip deformation with finite element method and its applications
[CAS2D: FORTRAN program for nonrotating blade-to-blade, steady, potential transonic cascade flows
[ASME TP-1705] p0003 A80-27204

Statistical aspects of carbon fiber risk assessment modeling --- fire accidents involving aircraft
[ASME CR-159318] p0073 A80-29432

MATRICES (MATHEMATICS)
A matrix solution for the simulation of magnetic fields with ideal current loops
p0102 A80-13903

MATRIX ANALYSIS
H MATRICES (MATHEMATICS)

MATRIX METHODS
Feasibility of kevlar 49/TM-15 polyamide for high temperature applications
[ASME TP-81560] p0069 A80-27429

MATRIX STRESS CALCULATION
H MAVEX METHODS

MAXIMUM LIKELIHOOD ESTIMATES
Cycles till failure of silver-zinc cells with competing failure modes: Preliminary data analysis
[ASME TP-81556] p0164 A80-29088

MCDONELL AIRCRAFT
MT DC 10 AIRCRAFT
MCDONELL DOUGLAS AIRCRAFT
MT DC 10 AIRCRAFT
MT DC 9 AIRCRAFT
MT SIMULATION AND INTEGRATION
MT NUMERICAL INTEGRATION
MEASURING INSTRUMENTS
W ENGINE ANALYZERS
W ENGINE MONITORING INSTRUMENTS
W FLIGHT LOAD RECORDERS
W HOT-WIRE FLOWMETERS
W LASER ANEMOMETERS
W LASER DOPPLER VELOCIMETERS
W MICRODENSITOMETERS
W OPTICAL MEASURING INSTRUMENTS
W RADIO ALTIMETERS
W TEMPERATURE MEASURING INSTRUMENTS
W WEIGHERS
W WATTMETERS
The measuring and growing of advanced gas turbines
p0111 A80-36127

Instrumentation technology
p0013 A80-10214

MECHANICAL DRIVES
MT TRANSMISSIONS (MACHINE ELEMENTS)
Load support system analysis high speed input pinion configuration
[ASME PAPER 79-LUB-34] p0129 A80-14760

Balancing of a power-transmission shaft with the application of axial torque
[ASME PAPER 80-GT-143] p0121 A80-42256

Elastomer drive performance -- A comparison with a squeeeze film for a supercritical power transmission shaft
[ASME PAPER 80-GT-162] p0121 A80-42272

Constrained fatigue life optimization of a NASVYTIS multicolor traction drive
[ASME PAPER 80-GT-162] p0121 A80-42272

Effect of geometry and operating conditions on spur gear system power loss
[ASME PAPER 80-GT-162] p0122 A80-46407

Evaluation of a high performance fixed-ratio traction drive
[ASME PAPER 80-GT-162] p0122 A80-46409

Mechanical property characterization of intraply hybrid composites
p0070 A80-20956

Effects of thermally induced porosity on an as-HIP powder metallurgy superalloy
p0082 A80-20990

Improved fiber retention by the use of fillers in graphite fiber/resin matrix composites
p0071 A80-30606

Strengthening of tough iron-12% nickel-precise metal alloys at 77 K by copper additions
p0174 A80-34099

A review of issues and strategies in nondestructive evaluation of fiber reinforced structural composites
p0071 A80-34764

Engine environmental effects on composite behavior --- moisture and temperature effects on mechanical properties
[ASME 80-0655] p0024 A80-25101

Application of superalloy powder metallurgy for aircraft engines
p0122 A80-46440

Concepts and techniques for ultrasonic evaluation of material mechanical properties.

MECHANICAL RESONANCE

Effect of thermally induced porosity on an as-HIP powder metallurgy superalloy

Mechanical property characterization of intraparticle hybrid composite
[NASA-TM-79306] p0067 N80-12120

Characterization of an oxide dispersion strengthened superalloy, MA-6000E, for turbine blade applications --- turbine blade

Synthesis of improved phononic resins

Concepts and techniques for ultrasonic evaluation of metallic mechanical properties

Quantitative ultrasonic evaluation of engineering properties of metals, composites and ceramics

Influence of excess diameter on properties of PM polyamide --- tensile and flexural property data
[NASA-CR-159806] p0185 N80-30228

Regenerator matrix physical property data

MECHANICAL EQUIPMENT

U RESONANT VIBRATION

MEDICAL EQUIPMENT

Intra-ocular pressure normalization technique and equipment
[NASA-CASE-LW-12723-1] p0135 N80-18690

MEETINGS

U CONFERENCES

MEMBRANE ANALOGY

MEMBRANE THEORY

MEMBRANES

Aton perme-selective membrane
[NASA-CR-159599] p0147 N80-12551

RECURRENT ION ENGINES

Spattering in mercury ion thrusters
[AIAP PAPER 79-2061] p0058 A80-10394

Preliminary results of the mission profile life test of a 30-cm Hy bombarding thruster
[AIAP PAPER 79-2078] p0083 A80-10391

Reduced power processor requirements for the 30-cm Hy ion thruster
[AIAP PAPER 79-2081] p0059 A80-10392

Evaluation of particle transport for the 30-cm spacecraft --- mercury ion thruster and spacecraft surfaces interactive effects
[AIAP PAPER 79-2047] p0055 A80-13301

Hy ion thruster component testing
[AIAP PAPER 79-2116] p0059 A80-20959

A model for predicting the wearout lifetime of the LEH/C Hughes 30-cm Mercury ion thruster
[AIAP PAPER 79-2079] p0064 A80-20962

Specific spacecraft evaluation: Special report --- charged-particle transport in a mercury ion thruster to spacecraft surfaces
[NASA-CR-159204] p0060 N80-11137

Hy ion thruster component testing
[NASA-TM-79627] p0056 N80-13159

Physical phenomena in mercury ion thrusters
[NASA-CR-159784] p0061 N80-17137

METAL BONDING

Effects of yttrium, aluminum and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers
[NASA-CR-159204] p0062 A80-10392

Heat exchanger and method of making --- rocket liner

METAL COATINGS

PT ALUMINUM COATINGS

PT NICKEL COATINGS

Spectral effects on direct-insolation absorptance of five collector coatings
[ASLE PREPRINT 80-AM-3E-2] p0122 A80-10036

Effect of thermal cycling on 2R02-2Y03 thermal barrier coatings
[NASA-TM-79480] p0180 N80-22349

Adherence of ion beam sputter deposited metal films on H-13 steel
[NASA-CR-159565] p0079 N80-31527

METAL CORROSION

U CORROSI ON

METAL CRYSTALS

Development of exothermically cast single-crystal

METAL FILMS

Tribological properties of sputtered Mo sub 2 film in relation to film morphology

METAL FLUIDS

NT CALCIUM FLUORIDES

NT CALCIUM FLUORIDES

NT CALCIUM FLUORIDES

NT CALCIUM FLUORIDES

NT CALCIUM FLUORIDES

RESISTANCE TIME

NT SODIUM CHLORIDES

METAL MATRIX COMPOSITES

Fatigue behavior of SiC reinforced titanium composites

Preparation of cast aluminum alloy-microparticle composites
[ASLE PREPRINT 80-AM-3E-2] p0122 A80-10036

A review of issues and strategies in nondestructive evaluation of fiber reinforced structural composites
[NASA-CR-159599] p0058 A80-10394

Tensile and flexural strength of non-graphitic superhydrophobic composites: Predictions and comparisons

Predicting the time-temperature dependent axial fatigue of H/Al composites
[NASA-TM-81474] p0069 N80-24573

Heat exchanger and method of making --- rocket lining

Ductile bonded boron/aluminum spar-blade fan blade
[NASA-CR-159571] p0072 N80-25362

Cost analysis of composite fan blade manufacturing processes
[NASA-CR-159676] p0044 N80-31396

METAL OXIDES

NT ALUMINUM OXIDES

NT CESIUM OXIDES

NT COBALT OXIDES

NT MAGNESIUM OXIDES

NT NAPHTHALENE

NT TITANIUM OXIDES

NT ZINC OXIDES

NT ZIRCONIUM OXIDES

Characterization of an oxide dispersion strengthened superalloy, MA-6000E, for turbine blade applications --- turbine blade

Performance of two-layer thermal barrier systems on directionally solidified Ni-All-As and comparative effects of alloy thermal expansion on system life

METAL PARTICLES

NT METAL POWDER

An investigation into the role of adhesion in the erosion of ductile metals
[ASLE PREPRINT 80-AM-3E-2] p0122 A80-43159

Analysis of wear debris from full-scale bearing fatigue tests using the Ferrograph
[ASLE PREPRINT 80-AM-3E-2] p0122 A80-43159

METAL PLATES

NT ROLLER PLATE

METAL POWders

Development of a high strength hot isostatically pressed Ni/Ni/ disk alloy, ARRL 76

SUBJECT INDEX

Mas-2 C47 and derivative alloys
[AIARESEARCH-21-3469] p0084 A80-45825

METAL FATigue

Staircase partitioning life predictions of the long time Metal Properties Council creep-fatigue tests

Effects of fine porosity on the fatigue behavior of a powder metallurgy superalloy

Constrained fatigue life optimization of a NASMIS multicolor tractive drive

Effects of fine porosity on the fatigue behavior of a powder metallurgy superalloy

Practical implementation of the double linear damage rule and damage curve approach for treating cumulative fatigue damage
[NASA-CR-159177] p0132 N80-23684

A review of issues and strategies in nondestructive evaluation of fiber reinforced structural composites

Tensile and flexural strength of non-graphitic superhydrophobic composites: Predictions and comparisons

Predicting the time-temperature dependent axial fatigue of H/Al composites
[NASA-TM-81474] p0069 N80-24573

Heat exchanger and method of making --- rocket lining

Ductile bonded boron/aluminum spar-blade fan blade
[NASA-CR-159571] p0072 N80-25362

Cost analysis of composite fan blade manufacturing processes
[NASA-CR-159676] p0044 N80-31396

Characterization of an oxide dispersion strengthened superalloy, MA-6000E, for turbine blade applications --- turbine blade

Performance of two-layer thermal barrier systems on directionally solidified Ni-All-As and comparative effects of alloy thermal expansion on system life

An investigation into the role of adhesion in the erosion of ductile metals
[ASLE PREPRINT 80-AM-3E-2] p0122 A80-43159

Analysis of wear debris from full-scale bearing fatigue tests using the Ferrograph
[ASLE PREPRINT 80-AM-3E-2] p0122 A80-43159

Development of a high strength hot isostatically pressed Ni/Ni/ disk alloy, ARRL 76
Influence of pressure driven secondary flows on the behavior of tubofoam forced mixers [AIAA PAPER 88-0196].
p0025 A80-41515

Influence of pressure driven secondary flows on the behavior of tubofoam forced mixers [NASA-TP-81541].
p0105 980-27632

MIXTURES

PT COMPOUNDING
PT TURBULENT MIXING

Computation of three-dimensional flow in tubofoam mixers and comparison with experimental data [AIAA PAPER 88-0227].
p0003 980-20967

MOISTURES

PT ACIDOUS SOLUTIONS
PT EUTECTIC ALLOYS
PT GAS MIXTURES
PT METAL WAXER COMPOSITES
PT SOLID SOLUTIONS

MODULUS

PT IONIC MOBILITY

MODE OF VIBRATION

U VIBRATION MODE

MODELS

PT AIRCRAFT MODELS
PT ANALOG SIMULATION
PT DIGITAL SIMULATION
PT DYNAMIC MODELS
PT MATHEMATICAL MODELS
PT SCALE MODELS

Acoustic test and analyses of three advanced turboprop models [NASA-CS-159667].
p0039 980-23311

MODES

PT FAILURE MODES
PT PROPAGATION MODES
PT VIBRATION MODE

MODULATION

PT VELOCITY MODULATION

MOLD OF ELASTICITY

PT DYNAMIC MODULUS OF ELASTICITY

Compliance and stress intensity coefficients for short bar specimens with chevron notches.

p033 980-46032

Composite wall concept for high temperature turbine shrouds; Survey of low modulus strain isolator materials [NASA-TM-81443].
p0086 980-20398

Fully plasma-sprayed compliant backed ceramic turbine seal [NASA-CASE-LW-13268-1].
p0117 980-24619

Fully flooded elastohydrodynamic lubricated elliptical contacts [NASA-TM-81543].
p0118 980-27698

Starved elastohydrodynamic lubricated elliptical contacts [NASA-TM-81549].
p0118 980-27699

MOBB CIRCLES

U FRACTURE REHEATING

MOISTURE CONTENT

PT ATMOSPHERIC MOISTURE

Engine environmental effects on composite behavior --- moisture and temperature effects on mechanical properties [NASA-88-0065].
p0024 980-35101

Analyzes of moisture in polymers and composites [NASA-CS-159745].
p0091 980-15264

MOLECULAR STRUCTURE

Effect of fuel molecular structure on soot formation in gas turbine engines [AIAA PAPER 88-06-62].
p0095 980-42192

Effect of fuel molecular structure on soot formation in gas turbine combustion.
p0043 980-29322

MOLECULAR WEIGHT

Influence of excess diamine on properties of PMR polyamide resin and composites [NASA-TM-81580].
p0069 980-29433

MOLTEN SALTS

High-temperature molten salt thermal energy storage systems [NASA-CS-159663].
p0148 980-17547

Active heat exchange system development for latent heat thermal energy storage [NASA-CS-159637].
p0149 980-18562

MOLYBDENUM COMPOUNDS

PT MOLYBDENUM DISULFIDES

p0078 980-21490

MOLYBDENUM DISULFIDES

Triboehological properties of sputtered MoS2 films in relation to film morphology.
NICKEL HYDROGEN BATTERIES
Status of nickel-hydrogen cell technology

NICKEL STEELS
Comparison tests and experimental compliance calibration of the proposed standard round compact plane strain fracture toughness specimen

NICKEL ZINC BATTERIES
Effect of positive pulse charge waveform on cycle life of nickel-zinc cells

NITRIDES
Mechanism of nitrogen heterocycle influence on turbine fuel stability
[p0043 N80-29327

NITROGEN OXIDES
An analytical study of nitrogen oxides and carbon monoxide emissions in hydrocarbon combustion with added nitrogen - Preliminary results
[ASME PAPER 80-GT-60] p0014 A80-42190

NITRATES
Sulfate and nitrate collected by filter sampling near the tropopause
[NASA-TP-1567] p0157 N80-14501

NITRIC OXIDE
Plane tube parametric studies for control of fuel combustion using rich-lean two-stage

NOISE (SOUND)
Comparison of several inflow control devices for flight simulation of fan tone noise using a JT15D-1 engine
[NASA-TM-81506] p0166 N80-24129

NOISE REDUCTION
Comparison of inlet suppressor data with approximate theory based on cutoff ratio
[ASA PAPER 80-0100] N80-20964

NOISE PREDICTION (AIRCRAFT)
Acoustic considerations of flight effects on jet noise suppression nozzles
[NASA-TP-81519] p0171 A80-20691

NOISE PROPAGATION
Time-dependent difference theory for noise propagation in a two-dimensional duct
[ASA PAPER 80-0098] p0170 A80-16269

NOISE MEASUREMENT
Acoustic pressure on a prop-fan aircraft fuselage surface
[ASA PAPER 80-1002] p0172 A80-35565

Quiet Clean Short-haul Experimental Engine (QCSHE) Core program noise measurements

An exploratory survey of noise levels associated with a 100 kW wind turbine

Acoustic test and analyses of three advanced turboprop models
[NASA-CR-159667] p0039 A80-23111

A comparison between an existing propeller noise theory and wind tunnel data
[NASA-TM-81519] p0169 N80-25101

NOISE REJECTION
Comparison of several inflow control devices for flight simulation of fan tone noise using a JT15D-1 engine

Acoustic considerations of flight effects on jet noise suppression nozzles
[ASA PAPER 80-0100] N80-20964

Noise suppression due to annulus shaping of a conventional coaxial nozzle
[ASA PAPER 80-0164] p0171 A80-20965

Noise suppression due to annulus shaping of an inverted-velocity-profile coaxial nozzle
[p0171 A80-35497

Acoustic measurements of three Prop-Fan models
[ASA PAPER 80-0098] p0171 A80-35498

Effect of inflow control on inlet noise of a cut-on fan
[ASA PAPER 80-1049] p0171 A80-35593

NOISE INTENSITY
An exploratory survey of noise levels associated with a 100 kW wind turbine
[ASA PAPER 80-1049] p0171 A80-35599

A-68
A comparison of experiment and theory for sound propagation in variable area ducts

An acoustic sensitivity study of general aviation propellers

A review of issues and strategies in nondestructive evaluation of fiber reinforced structural composites

Quantitative ultrasonic evaluation of engineering properties in metals, composites, and ceramics

Simulation of transducer-couplant effects on broadband ultrasonic signals

A review of issues and strategies in nondestructive evaluation of material mechanical properties

A review of issues and strategies in nondestructive evaluation of material mechanical properties
SUBJECT INDEX


OPTIMIZATION

OPTIMAL CONTROL
Performance of computer-optimized tapered-roller bearings to 2.4 million ON [NASA-TP-81414] p0114 ABO-16342

OPTIMUM CONTAINAL

OPTIMAL CONTROL
Orbit transfer vehicles Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures [NASA PAPER 80-1223] p0060 ABO-28975

Orbital transfer of large space structures with nuclear electric rockets [NASA PAPER 80-695] p0058 ABO-81697
An analytical investigation of two hydrogen-oxygen rocket engine systems for low-thrust application - for orbital transfer p0057 ABO-30382

LEO-to-GEO low thrust chemical propulsion p0063 ABO-30384
Upper stage utilizing electric propulsion p0057 ABO-30386
Low-thrust vehicles concept studies p0063 ABO-31456
Low-thrust vehicle concept studies p0058 ABO-31457
Low-thrust chemical orbit to orbit propulsion system propellant management study p0064 ABO-31469
Solar rocket system concept analysis p0064 ABO-31470

ORBITAL SPACE STATIONS
Power management for multi-100 KWe space systems p0060 ABO-40357

ORBITAL TRANSFER
W TRANSFER ORBITS
Orbits NW EARTH ORBITS NW GEOSYNCHRONOUS ORBITS NW SATELLITE ORBITS NW TRANSFER ORBITS ORGANIC COMPOUNDS NW FLUOROCARBONS ORIFICE FLOW Free jet phenomena in a 90 deg-sharp edge inlet geometry p0106 ABO-10037

OSCILLATION DAMPERS Off-design correlation for losses due to part-span dampers on transonic rotors [NASA-TD-16693] p0020 ABO-28352

OSCILLATIONS
W PRESSURE OSCILLATIONS OSCILLATIONS W MICROWAVE TUBES OTF W ORBIT TRANSFER VEHICLES OSCILLATION FLOW Laser anemometer measurements at the exit of a T63 combustor p0085 ABO-27737

OUTLINES
W VENTS OUTPUT W LASER OUTPUTS

OXIDATION
Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a Si3N4-6 Wt% Y203 ceramic p0090 ABO-46100
Combustion of solid carbon rods in zero and normal gravity [NASA-TP-79303] p0104 ABO-15404
Chemical processes involved in the initiation of hot corrosion of K-1900 and NASA-TRE VIA [NASA-TP-81399] p0077 ABO-17199
Thermal fatigue and oxidation data for directionally solidified MAR-M 246 turbine blades [NASA-CH-159790] p0037 ABO-21330

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a Si3N4-6 Wt% Y203 ceramic [NASA-TP-81396] p0088 ABO-27944

Determination of jet fuel thermal deposit rate using a modified JFTOT p0043 ABO-29326
Gas phase oxidation downstream of a catalytic combustor [NASA-TP-81551] p0144 ABO-29663

Oxidation Resistance
Boundary lubrication, thermal and oxidative stability of a fluoroelastomer and a perfluoroelastomer triazine [NASA-TM-79-AM-12-1] p0048 ABO-12089
Hot corrosion of four superalloys - HA-188, In-501, In-617, and TD-WnicrAl p0091 ABO-18445

The effect of zirconium on the isothermal oxidation of nominal Ni-14Cr-2NaAl alloys p0082 ABO-23466

Effect of W and WC on the oxidation resistance of yttria-doped silicon nitride p0090 ABO-6089
Study of the effects of gaseous environments on the hot corrosion of superalloy materials [NASA-CH-15977] p0088 ABO-10155
Effect of W and WC on the oxidation resistance of yttria-doped silicon nitride [NASA-TP-81529] p0087 ABO-27483

Oxidation-Reduction Reactions
Catalyst surfaces for the chromate/chromic redox couple [NASA-CASE-LW-13148-1] p0101 ABO-20467
Redox storage systems for solar applications [NASA-PB-81463] p0142 ABO-23777

Oxide Films
Homogeneous alignment of nematic liquid crystals by ion beam etched surfaces p0178 ABO-26007
Effects of yttrium, aluminum and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers p0082 ABO-35900
Adherence of ion beam sputter deposited metal films on H-13 steel [NASA-TP-81505] p0079 ABO-31527

Oxides
W ALUMINUM OXIDES W CARBON MONOXIDE W CHLORIDE OXIDES W HYDROCHLORIC OXIDE W MAGNESIUM OXIDES W METAL OXIDES W NITRIC OXIDE W NITROGEN OXIDES W NITROSYL OXIDES W OXIDES W ZIRCONIUM OXIDES Stability of several oxide dispersion strengthened alloys and a directionally solidified gamma/gamma prime-alpha eutectic alloy in a thermal gradient p0082 ABO-40962

Reactions of calcium orthophosphate and barium zirconate with oxides and sulfates of various elements [NASA-TP-79272] p0085 ABO-13256

Oxidizers
W LIQUID OXYGEN

Oxygen
W HIGH PRESSURE OXGEN W LIQUID OZONE W OZONE Oxygen-enriched air for HDD power plants p0096 ABO-25966

Results of duct area ratio changes in the NASA Lewis M2-2 combustion HED experiment [NASA-TP-79308] p0175 ABO-12801
Performance, emissions, and physical characteristics of a rotating combustion aircraft engine, supplement A  
[NASA-CR-125119]  p0041 80-27361
Small panasonic car transmission test-Chevrolet  
[NASA-TM-81552]  p0165 80-26855
Fuel character affects on the J79 and F101 engine  
[NASA-CR-159835]  p0185 80-26855
Small panasonic car transmission test-Chevrolet  
[NASA-TM-81521]  p0074 80-24366
Photoreceptors  
[NASA-CH-159787]  p0105 80-33410
Photocells  
[NASA-CH-159821]  p0023 80-32719
Nitrogen response to peritoneal implants  
[NASA-CR-159017]  p0066 80-32478
Photoneutron  
[NASA-CE-1596991]  p0039 80-23309
Performance deterioration of commercial high-bypass ratio turbofan engines  
[NASA-TM-81552]  p0022 80-29332
Photoreceptors  
[NASA-CH-159671]  p0128 80-27361
Performance deterioration of commercial high-bypass ratio turbofan engines  
Uranium photoconducting membrane  
[NASA-CR-159599]  p0167 80-12551
Photoreceptors  
[NASA-CH-1597871]  p0151 80-24759
Performance deterioration of commercial high-bypass ratio turbofan engines  
Photoreceptors  
[NASA-CH-159787]  p0029 80-14182
Phase transformation  
[NASA-CE-1596681]  p0049 80-12551
Phase transformation  
[NASA-CR-159724]  p0091 80-17221
Phase transformation  
[NASA-CR-159724]  p0151 80-24759
Phase transformation  
[NASA-CE-1596681]  p0049 80-12551
Phase transformation  
[NASA-CR-159724]  p0091 80-17221
Phase transformation  
[NASA-CR-159724]  p0151 80-24759
Phase transformation  
[NASA-CE-1596681]  p0049 80-12551
Phase transformation  
[NASA-CR-159724]  p0091 80-17221
Phase transformation  
[NASA-CR-159724]  p0151 80-24759
Phase transformation  
[NASA-CE-1596681]  p0049 80-12551
Phase transformation  
[NASA-CR-159724]  p0091 80-17221
Phase transformation  
[NASA-CR-159724]  p0151 80-24759
Phase transformation  
[NASA-CE-1596681]  p0049 80-12551
Phase transformation  
[NASA-CR-159724]  p0091 80-17221
Phase transformation  
[NASA-CR-159724]  p0151 80-24759
Phase transformation  
[NASA-CE-1596681]  p0049 80-12551
Phase transformation  
[NASA-CR-159724]  p0091 80-17221
Phase transformation  
[NASA-CR-159724]  p0151 80-24759
A photovoltaic power system in the remote African village of Tangaye, Upper Volta [NASA-TM-793619] p0137 NO-12552
Evaluation of cleaners for photovoltaic modules exposed in an outdoor environment [NASA-TM-792860] p0096 NO-13317
Economic analysis of the design and fabrication of a space qualified power system [NASA-TM-80-018] p0056 NO-10098
Photovoltaic technology development for synchronous orbit [NASA-CR-159980] p0065 NO-33470
TOPHOTOVOLTAIC CONVERSION PHOTOVOLTAIC CONVERSION PHOTOVOLTAIC SYSTEM RELIABILITY CONSIDERATIONS Description of photovoltaic village power systems in the United States and Africa [NASA-CR-159921] p0146 NO-46776
Photovoltaic power system reliability considerations [NASA-CR-159921] p0130 NO-15242
PHONIC OSCILLATIONS u PITCH (INCCLINATION) PHYSICICAL EFFECTS MF PHYSIOLOGICAL RESPONSES PHYSIOLOGICAL RESPONSES Please compare to peritoneal implants [NASA-CR-159917] p0066 NO-33470
PNEUMES Interaction of high voltage surfaces with the space plasma [NASA-CR-160131] p0177 NO-32223
TUESCoolant tube curvature effects on film cooling as detected by infrared imagery [AIAA PAPER 79-WA-PTR-7] p0107 NO-18636
High temperature thermal energy storage in steel and nano [NASA-CR-159708] p0154 NO-29860
PISTON ENGINES NT DIESEL ENGINES Exhaust emission reduction for intermittent combustion aircraft engines [NASA-CR-159978] p0029 NO-14130
Overview of a stirling engine test project [NASA-TM-80-1442] p0140 NO-18564
A 15 kwe (nominal) solar thermal-electric power conversion concept definition study: Stena Rankin reciprocator system [NASA-CR-159991] p0149 NO-19612
Design study of a 15 kW free-piston Stirling engine-linear alternator for dispersed solar electric power systems [NASA-CR-159987] p0150 NO-22797
PISTONEN Preliminary results from a four-work space, double-acting piston, Stirling engine controls model [NASA-TM-80-1656] p0106 N°-29624
Free-piston regenerative hot gas hydraulic engine [NASA-CASE-LEN-12274-1] p0119 NO-31790
PITCH (INCCLINATION) Quiet Clean Short-haul Experimental Engine (QCESE) - Ball spline pitch change mechanism design report [NASA-CR-134673] p0030 NO-15101
Quiet Clean Short-haul Experimental Engine (QCESE) - Ball spline pitch change mechanism design report [NASA-CR-134673] p0030 NO-15101
PITCH ANGLES U PITCH (INCCLINATION) PLANAR STRUCTURES The planar multijunction cell - A new solar cell for earth and space Planar multijunction high voltage solar cells [NASA-TM-80-18138] p0146 NO-48205
[NASA-TM-80-16514] p0178 NO-16514
PLANFORMS NT RECTANGULAR PLATES PLANNING NT MANAGEMENT PLANNING NT MISSION PLANNING NT PROJECT PLANNING PLASMA ANGS U PLASMA JETS
FLASMA CONFURTNTion "U PLASMA CONTROL PLASMA CONTROL The effect of a weak vertical magnetic field on fluctuation-induced transport in a Bumpy-Torus plasma [NASA-CASE-LEN-12274] p0176 NO-25476
PLASMA DIAGNOSTICS Study of a rare-gas transverse fast discharge [NASA-CASE-LEN-12274] p0176 NO-11366
PLASMA DIFFUSION The effect of a weak vertical magnetic field on fluctuation-induced transport in a Bumpy-Torus plasma [NASA-CASE-LEN-12274] p0176 NO-25476
PLASMA DISCHARGES NT PLASMA JETS NT PLASMA DIFFUSION NT PLASMA INSTABILITY NT MAGNETOHYDRODYNAMIC STABILITY NT PLASMA INTERACTIONS NT PLASMA-ELECTROMAGNETIC INTERACTION Toppling and electrostatic deformation of the solar sail [NASA-CASE-LEN-12274] p0066 NO-46776
PLASMA JETS Experimental and theoretical investigation for the suppression of the planar arc drop in the thermonic converter [NASA-CASE-LEN-12274] p0176 NO-12880
PLASMA POTENTIALS Neutralization tests on the SERT I. spacecraft --- of ion beams [AIAA PAPER 79-2044] p0059 AE-10387
Active control of spacecraft charging [NASA-CS-159789] p0055 AE-46890
PLASMA PROPELLENT A model for predicting the wearout lifetime of the LowC heat 30-cm mercury ion thruster [AIAA PAPER 79-2079] p0064 NO-20962
Inert gas thrusters [NASA-CR-159895] p0062 NO-24362
PLASMA RINGS NT TIDAL PLASMAS PLASMA SHEATHS Plasma collection by high voltage spacecraft at low earth orbit [AIAA PAPER 80-0042] p0055 AE-18249
Physical plasma in mercury ion thrusters [NASA-CS-159789] p0061 NO-17137
PLASMA SPRAYING Investigation into the effect of plasma pretreatment on the adhesion of pyrolytic to various substrates Development of improved-durability plasma sprayed ceramic coatings for gas turbine engines [NASA-CS-159789] p0092 NO-13962
Evaluation of present-day thermal barrier coatings for industrial/utility applications [NASA-CS-159789] p0092 NO-39637
Friction and wear of plasma-sprayed coatings containing cobalt alloys from 25 deg to 650 deg in air [NASA-CS-159789] p0122 NO-43176
Improved refractory coatings and method of producing them [NASA-CS-159789] p0076 NO-14232
Friction and wear of plasma-sprayed coatings containing cobalt alloys from 25 deg to 650 deg in air [NASA-CS-159789] p0122 NO-43176
Flapper spectral measurements using stationary pressure transducers p011 A80-36147
Steady-state performance of J05-21 compressor at 100 percent design speed with and without interstage nacelle blockage [NASA-TM-61451] p0017 N80-21333
Data analysis of p[sub P] in sub P pressure vessel testing on P100 engine P680072 at NASA Lewis Research Center [NASA-CE-159725] p0147 N80-15553
PRESTRESSING u PRESSURE VESSELS
Prediction of fragment velocities and trajectories p0096 N80-16210
PRESSURE WELDING
u DIFFUSION WELDING
u FUEL TANK PRESSURIZATION
u PRESTRESSING
u PRESSURE SENSORS
u PRESSURE TRANSDUCERS
u PRESSURE TRANSDUCERS
u PRESSURE TRANSDUCERS
u PRESSURE TRANSDUCERS
PRETREATMENT u PRESSURIZATION
u PRESTRESSING
u PREVENTION
u PRESERVATION
u PREVENTION
u PROBABILITY
u PROBABILITY THEORY
Statistical aspects of carbon fiber reinforced composite material modeling including fire accidents involving aircraft [NASA-CR-159345] p0073 N80-29432
PRODUCT DEVELOPMENT
u FINITE ELEMENT METHOD
u FINITE ELEMENT METHOD
Design of ceramic coating development for industrial gas turbine engines - A program plan [SM-07-4-702-05] p0051 A80-18554
Characteristics of primary electric propulsion systems [AIAA Paper 79-2041] p0058 A80-18576
NASA gear research and its probable effect on rotocraft transmission design p0128 A80-19360
Advanced Gas Turbine Powertrain System Development Project p0129 A80-28574
Photovoltaic technology development for synchronous orbit p0058 N80-33470
PRODUCTION ENGINEERING
Screen printing technology applied to silicon solar cells fabrication [NASA-CR-15951] p0153 N80-27088
Coplanar back contacts for thin silicon solar cells [NASA-CR-15951] p0153 N80-28411
u PRODUCTION ENGINEERING
u PROGRAM MANAGEMENT
u PROJECT MANAGEMENT
u PROGRAMS
u DEPARTMENT OF DEFENSE PROGRAMS
u GLOBAL ATMOSPHERIC RESEARCH PROGRAM
u NASA PROGRAMS
u QUIET ENGINE PROGRAMS
u STABILITY PROGRAM
u SUPersonic Cruise Aircraft Research Project
u PROGRAM MANAGEMENT
PROJECT PLANNING
Low NO(x) heavy fuel combustor program p0137 N80-13244
PROBABILITY (EXTENSION)
u CRACK PROPAGATION
u PLANE PROPAGATION
u PROPAGATION MODES
Reciprocity principle in duct acoustics p0070 A80-20556
Higher order mode propagation in nonuniform circular ducts with hyperbolic horns or infinite plane baffle p071 A80-37995
Comparison of inlet suppressor data with approximate theory based on cutoff ratio [NASA-TM-81386] p117 N80-16576
PROPELLANT STORAGE
Liquid reduced gravity fluid management technology program p0048 A80-35504
PROPELLANT TANKS
Capillary device refilling - liquid rocket propellant tank tests p0060 A80-38906
Liquid reduced gravity fluid management technology program p0057 N80-30383
PROPELLANT TRANSPORT
Comparative thermal analysis of alternate cryogenic Fluid Management Experiment (CFME) configurations [NASA-CR-165151] p0069 N80-32412
PROPELLANTS
u CYCLOTRON ROCKET PROPELLANTS
u LIQUID ROCKET PROPELLANTS
u ROCKET PROPELLANTS
u ROCKET PROPELLANTS
Propellant Blends
PROPELLER EFFICIENCY
High speed turboprops for executive aircraft, potential and recent test results [NASA-TM-81482] p0002 N80-21205
NASA propulsion technology program p0018 N80-22341
PROPELLER FANS
Acoustic measurements of three Prop-Fan models [AIAA Paper 80-08955] p0045 A80-35958
Acoustic pressures on a prop-fan aircraft fuselage surface [AIAA Paper 80-1002] p0172 A80-35965
PROPELLERS
u PROPELLER FANS
A theoretical and experimental investigation of propeller performance methodologies [AIAA Paper 80-1240] p0026 A80-38283
An acoustic sensitivity study of general aviation propellers
PROPELLER EFFICIENCY

Quiet Clean Short-Haul Experimental Engine (QCSEE) main reduction gears detailed design report
[NASA-CR-159972]
p0038 N80-15106
Quiet Clean Short-Haul Experimental Engine (QCSEE) Over-The-Wing (OTW) propulsion system test report, Volume 4: Summary report
[NASA-CR-135212]
p0033 N80-15125
Quiet Clean Short-Haul Experimental Engine (QCSEE) Over-The-Wing (OTW) propulsion system test report, Volume 3: Mechanical performance
[NASA-CR-135325]
p0033 N80-15126
Potential performance improvement using a reacting gas (nitrogen tetraoxide) as the working fluid in a closed Brayton cycle
[NASA-TR-79212]
p0130 N80-16490
Preliminary study of V/STOL aircraft with lift plus lift/cruise propulsion
[NASA-TM-81429]
p0016 N80-19110
J75-7A (SP) jet engine performance deterioration trends
[NASA-TM-81559]
p0016 N80-20274
The performance and efficiency of four motor/controlling laboratory systems for the simpler electric vehicles
[NASA-CR-159776]
p1023 N80-24550
Engine component improvement: Performance improvement, J79-7 3.8 Air fan
[NASA-CR-159806]
p0339 N80-25322
Preliminary results of steady state characterization of near term electric vehicle broadband propulsion system
[NASA-TM-81846]
p1983 N80-28254
A laboratory facility for electric vehicle propulsion system testing
[NASA-TM-81877]
p1983 N80-30229
Primary propulsion/large space system interactions
[NASA-TM-80348]
p0063 N80-31450
Advanced concepts --- specific impulse, mass drivers, electromagnetic launchers, and the rail gun

PROTECTIVE COATINGS

MT PROPELLER EFFICIENCY

Engine component improvement program - Performance improvement
[AIAA PAPER 80-0223]
p0024 A80-19300
Fuel conservation through active control of rotor clearances
[AIAA PAPER 80-1087]
p0045 A80-41506
[NASA-CR-135250]
p0028 N80-14116
LS5/propulsion interactions studies
[NASA-TM-81574]
p0063 N80-31450
Advanced concepts --- specific impulse, mass drivers, electromagnetic launchers, and the rail gun

PROTECTOR

MT COHESION PREVENTION

MT ENVIRONMENT PROTECTION

MT IONIZATION SHIELDING

MT THERMAL PROTECTION

PROTECTIVE COATINGS

MT CERAMIC COATINGS

An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys
[NASA PAPER 80-WT-24]
p0062 A80-35501
Similarity tests of turbine vanes - Effects of ceramic thermal barrier coatings
[NASA PAPER 80-8435]
p0062 A80-48013
Ceramics resistant thermal barrier coating --- protecting gas turbines and other high temperature parts
[NASA-CASE-LEW-13068-1]
p0067 N80-11142
Investigation into the effect of plasma pretreatments on the adhesion of paint to various substrates
[NASA-TM-79224]
p1014 N80-13473
Improved refractory coatings and method of producing the same
[NASA-CASE-LEW-13169-1]
p0076 N80-14232
Ceramics resistant of sodium sulfide-coated cobalt-chromium-aluminum alloys at 900 C, 1000 C, and 1100 C
[NASA-TM-79311]
p0076 N80-14234
Friction and wear of plasma-sprayed coatings containing cobalt alloys from 25 deg to 650 deg in air
[NASA-TM-79316]
p0085 N80-14249
Internal coating of air cooled gas turbine blades
[NASA-CR-159701]
p0036 N80-16041
Effect of thermal cycling on ZrO2-V2O3 thermal barrier coatings
[NASA-TM-81460]
p0108 N80-22349
A silicon-aluminide/aluminide coating --- protects aircraft and land-based gas turbine engines
[NASA-CASE-LEW-13393-1]
p0069 N80-26389
High temperature self-lubricating coatings for air lubricated foil bearings for the automotive gas turbine engine
[NASA-CR-159848]
p0091 N80-26448
Performance of two-layer thermal barrier systems on directionally solidified Al-Al2O3 and comparative effects of alloy thermal expansion on system life
[NASA-TM-81604]
p0080 N80-32467
Improved bond coatings for use with thermal barrier coatings
[NASA-TM-81567]
p0080 N80-33566
PUBLIC HEALTH

Assessment of potential exposure to friable insulation materials containing asbestos
[NASA-TM-81435]
p0157 N80-28275
FULLER'S

Design study of steel V-Belt CVT for electric vehicles
[NASA-CR-159845]
p0105 N80-32299
FUSILATION FLOW

UNSTEADY FLOW

FUSION COMMUNICATION

The 30/20 GHz mixed user architecture development study
[NASA-CR-159686]
p0097 N80-10415
The 30/20 GHz mixed user architecture development study: Executive summary
[NASA-CR-159687]
p0097 N80-10416
A digitally implemented communication experiment utilizing the communications technology satellite, Hermes
[NASA-TM-81452]
p0052 N80-21412
FUES

NY ELECTRIC FUSES

PUMP SEALS

Analysis and design of a uniform-clearance, pumping-cage rod seal for the Stirling engine
[NASA-CR-159643]
p1116 N80-18408
FUELS

NY CENTRIFUGAL PUMPS

NY TURBINE PUMPS

PYROPHYLALLOY

U COMPOSITE MATERIALS

ELECTROPERMATERIALS

PYROPHYLALLOY

U TEMPERATURE MEASUREMENT

QUALITY

MT AIR QUALITY

MT WATER QUALITY

QUALITY CONTROL

Modified aerospace RQA method for wind turbines
[p0145 A80-40335
Alternative jet aircraft fuels
[p0122 A80-10209
Fatigue strength testing employed for evaluation and acceptance of jet-engine instrumentation probes
[p0110 N80-17422
QUARKS

U MINES (EXCAVATIONS)

QUICK ENGINE PROGRAM

QCSEE UTW engine powered-lift acoustic performance --- Quiet Clean Short-Haul Experimental Engine Under The Wing
[AIAA PAPER 80-1065]
p0025 A80-38651
Quiet Clean Short-Haul Experimental Engine (QCSEE) Under-the-Wing (UTW) engine boilerplate Nacelle test report. Volume 1: Aerodynamics and performance
[NASA-CR-153254]
p0028 N80-14115
[NASA-CR-153256]
p0028 N80-14116
Quiet, Clean, Short-Haul, Experimental Engine (QCSEE) Under-The-Wing (UTW) engine acoustic
Quick powered-lift propulsion
[NASA-CP-20771] p0015 NBO-15127
Program for impact testing of spar-shell fan blades, test report
[NASA-CR-159593] p0037 NBO-23128
Aeromitch QCAT program --- quiet clean general aviation turbofan engines
[NASA-CR-159758] p0037 NBO-21331
Avco Lycoming quiet clean general aviation turbofan engine
Summary of NASA QCAT program
OCSEE fan exhaust bulk absorber treatment evaluation
[NASA-TH-01408] p0017 NBO-22334
OCSEE UTV engine powered-lift acoustic performance
[NASA-TH-01408] p0019 NBO-23314
Quiet Clean Short-haul Experimental Engine (QCSEE)
Quiet Clean Short-haul Experimental Engine (QCSEE)
under-the-wing engine composite fan blades; Preliminary design test report
[NASA-CR-159404] p0044 NBO-29298
Acoustic performance of a 50.8-cm (20-inch) diameter variable-pitch fan and inlet. Volume 2: Acoustic data
[NASA-CR-153116] p0044 NBO-29299
R
RADAR
RADAR AE乔GONE SURVEILLANCE RADAR
RADAR ALTIMETERS
U RADIO ALTIMETERS
RADIAL FLOW
Evolution of a rotating flow in the vicinity of a surface
Study of advanced radial outflow turbine for solar steam Rankine engines
[NASA-CR-159665] p0107 ABO-16460
Loss model for off-design performance analysis of radial turbines with pivoting-vane, variable-area stators
[NASA-TH-01532] p0020 NBO-27365
RADIANT FLOW DENSITY
U IRRADIANCE
RADIATION ABSORPTION
U THERMAL ABSORPTION
RADIATION DAMAGE
Origin of x-ray annealing in radiation-damaged silicon solar cells
[NASA-TH-01390] p0059 ABO-33550
Radiation damage in high voltage silicon solar cells
p0179 ABO-44234
Space solar cells: High efficiency and radiation damage
[NASA-TH-01367] p0138 ABO-15554
Radiation damage in lithium-counterdoped n/p silicon solar cells
[NASA-TH-01391] p0138 ABO-15554
Radiation damage annealing mechanisms and possible low temperature annealing in silicon solar cells
[NASA-TH-01392] p0138 ABO-15558
Radiation damage in high voltage silicon solar cells
[NASA-TH-01438] p0178 ABO-23180
Radiation damage in high voltage silicon solar cells
p0144 NBO-33389
RADIATION EFFECTS
U RADIATION DAMAGE
RADIATION MEASUREMENT
Global calibration of terrestrial reference cells and errors involved in using different irradiance monitoring techniques
[NASA-TH-01393] p0138 ABO-15551
RADIATION PRESSURE
U ION PRESSURE
RADIATION PROTECTION
U RADIATION SHIELDING
RADIATION RESISTANCE
U RADIATION TOLERANCE
RADIATION SHIELDING
Interaction of high voltage surfaces with the space plasma
RADIATION THERAPY
Preliminary results of fast neutron treatments in carcinoma of the pancreas
[NASA-TR-01515] p0160 NBO-24983
RADIATION TOLERANCE
Radiation damage in lithium-counterdoped n/p silicon solar cells
[NASA-TR-01391] p0138 ABO-15557
Thin n-i-p radiation-resistant solar cell feasibility study
RADIO ALTIMETERS
Solid-state X-band combiner study
RADIO COMMUNICATION
U TITAN DIVISION MULTIPLE ACCESS
The 30/20 GHz fixed communications systems service demand assessment. Volume 1: Executive summary
The 30/20 GHz fixed communications systems service demand assessment. Volume 2: Main report
The 30/20 GHz fixed communications systems service demand assessment. Volume 3: Annex
[NASA-CR-159621] p0099 NBO-18264
RADIO FREQUENCIES
U EXTREMELY HIGH FREQUENCIES
U ULTRA HIGH FREQUENCIES
U ULTRASONIC FREQUENCIES
RADIO RELAY SYSTEMS
U TIME DIVISION MULTIPLE ACCESS
RADIO TRANSMISSION
U MICROWAVE TRANSMISSION
RADIO WAVES
U MILLIMETER WAVES
RADIOSPECTROMETRY
U RADIATION TOLERANCE
RADIOTHERAPY
U RADIATION THERAPY
RAIN
Concepts for 18/30 GHz satellite communication system, volume 1
[NASA-155625-VOL-1] p0096 NBO-11277
Concepts for 18/30 GHz satellite communication system, volume 1A: Appendix
[NASA-155625-VOL-1A] p0096 NBO-11278
Concepts for 18/30 GHz satellite communication system study, Executive summary
[NASA-155680] p0096 NBO-11279
RAYNOLOGY
Calculation of water drop trajectories to and about arbitrary three-dimensional bodies in potential airflow
[NASA-CR-3291] p0005 NBO-26302
RAJET ENGINE
U SUPERSONIC CORROSION RAMEY ENGINES
RANKING CYCLE
Study of advanced radial outflow turbine for solar steam Rankine engines
A 15 kw (nominal) solar thermal-electric power conversion concepts definition study: Steam Rankine steam-electric Rankine cycle system, volume 1A: Appendix
[NASA-159590] p0146 NBO-16491
The 15 kw sub e (nominal) solar thermal-electric power conversion concepts definition study: Steam Rankine steam-steam Rankine cycle system
[NASA-155690] p0146 NBO-16493
A 15 kw (nominal) solar thermal-electric power conversion concept definition study: Steam Rankine steam-electric Rankine cycle system
RARE EARTH ELEMENTS
U EUROPE
U TITANIUM
RARE GASES
U ARGON
U KERON
U XENON
Inert gas thrusters
[NASA-CR-159613] p0062 NBO-24362
Inert gas ion thruster development
RARE METALS
U MEASURING INSTRUMENTS
RATES (PER TIME)
U ACOUSTIC VELOCITY
U ANGULAR VELOCITY
U BURNING RATE
U CURRENT DENSITY
U FLOW VELOCITY
A-62
REFILLING

Capillary device refilling --- liquid rocket propulsion tank tests
recently installed at NASA Lewis Research Center
[NASA-DE-61562] p0022 880-29333

RESEARCH MANAGEMENT
National Aeronautics and Space Administration
plans for space communication technology
[NASA-DE-61562] p0029 880-26795

NASA broacspecification fuels combustion
technology program: Status and description
[NASA-DE-61562] p0204 880-14126

Program definition and assessment overview ---
for thermal energy storage project management
[NASA-DE-61562] p0141 880-22790

RESIDUAL GAS
Cogenation Technology Alternatives Study (CTAS).
Volume 6: Computer data. Part 2:
Residual-fired cogeneration process boiler
[NASA-DE-61562] p0156 880-33861

RESIDUAL STRESS
Calculation of residual principal stresses in CVD
boron on carbon filaments
[NASA-DE-61562] p0072 880-44237

Calculation of residual principal stresses in CVD
boron on carbon filaments
[NASA-DE-61562] p0068 880-20314

RESIN MATRIX COMPOSITES
Cost analysis of composite fan blade manufacturing
processes
[NASA-DE-61562] p0044 880-31398

RESINS
MT EPOXY RESINS
MT KEVLAR (TRADEMARK)
MT PHENOLIC RESINS
MT POLYESTER RESINS
MT POLYIMIDE RESINS
MT SILICONE RESINS
MT THERMOSETTING RESINS

Burning characteristics and fiber retention of
graphite/resin matrix composites
[NASA-DE-61562] p0070 880-32062

RESISTIVITY
MT ELECTRICAL RESISTIVITY

RESONANCE
MT PARAMAGNETIC RESONANCE
MT RESONANT VIBRATION

RESONANT FREQUENCIES
Vibration and buckling of rectangular plates under
in-plane hydrostatic loading
[NASA-DE-61562] p0133 880-45364

RESONANT VIBRATION
Design of electromechanical dampers for a high-speed
flexible rotor
[ASME PAPER 79-DET-88] p0121 880-15736

RESONATORS
Effect of grazing flow on the nonlinear acoustic
behavior of helmholtz resonators
[NASA-DE-61562] p0095 880-31619

RESOURCES
MT COAL
MT CRUDE OIL
MT FOSSIL FUELS
MT GEOTHERMAL RESOURCES
MT ICEBERGS

RESOURCES MANAGEMENT
Fuels research: Fuel thermal stability overview
[NASA-DE-61562] p0021 880-29324

RESPONSES
MT DYNAMIC RESPONSE
MT PHYSIOLOGICAL RESPONSES
MT TRANSIENT RESPONSE

RETROFITTING
MT ACOUSTIC RETROFITTING

REUSABLE SPACECRAFT
MT SPACE SHUTTLES

RETROGRADE NUMBER
Amplification of Reynolds number dependent
processes by wave distortion --- liquid fuel
combustor stability
[NASA-DE-159732] p0075 880-13193

RHENIUM
Influence of excess diamine on properties of PAN
polymide resins and composites
[NASA-DE-61562] p0069 880-29433

RHODIUM ALLOYS
Hyperfine magnetic field at Cd impurity site in
Li2/3Ni2/3Ru2/3 oxides by neutron and X-ray
TOPAC technique --- Time Differential Perturbed
Angular Correlation
[NASA-DE-61562] p0178 880-16843
NOTARY

ROTATING ROBINS
Bonn WINGS
YT
MT FLYWHEELS
NT TILT ROTOR AIRCRAFT
HT ROTATING CYLINDERS
MT TANDEM ROTOR HELICOPTERS
MT ROTORS
MT HELICOPTER TAIL ROTORS
NT COMPRESSOR ROTORS
NT TURBINE ROTORS
MT 02LICOPT'ERS

Practical experience with unstable compressors
Field verification of lateral-torsional coupling effects on rotor instabilities in centrifugal compressors

Analysis and identification of subsynchronous vibration for a high pressure parallel flow centrifugal compressor
Subsynchronous instability of a geared centrifugal compressor of overhung design
The parameters and measurements of the destabilizing actions of rotating machines, and the assumptions of the 1950's
Asynchronous vibration problem of centrifugal compressor
Testing of turbulent seals for rotodynamic coefficients
Evaluation of instability forces of labyrinth seals in turbines or compressors
Damaging in ring seals for compressible fluids
Flow induced upg ing coefficients of labyrinth seals for application in rotor dynamics
A test program to measure fluid mechanical whirl-excitation forces in centrifugal pumps
Effect of fluid forces on rotor stability of centrifugal compressors and pumps
Non-synchronous whirling due to fluid-dynamic forces in axial turbo-machinery rotors
Self-excited rotor whirl due to tip-seal leakage forces
Fluid forces on rotating centrifugal impeller with whirl ing motion
Experimental results concerning centrifugal impeller excitations
Physical explanations of the destabilizing effect of damping in rotating parts
Parametric instabilities of rotor-support systems with application to industrial ventilators
Instability thresholds for flexible rotors in hydrodynamic bearings
Use of elastomeric elements in control of rotor instability
Feasibility of active feedback control of rotodynamic instability

ROTARY WING AIRCRAFT
MT HELICOPTERS
MT RIGID ROTOR HELICOPTERS
MT TANDER ROTOR HELICOPTERS
MT TILT ROTOR AIRCRAFT

EXAMINATION OF THE FLAP-LAG STABILITY OF RIGID ARTICULATED ROTOR BLADES

ROTATING BODIES
MT COMPRESSOR ROTORS
MT FLYWHEELS
MT HELICOPTER TAIL ROTORS
MT ROTARY WINGS
MT ROTATING CYLINDERS
MT ROTORS

MT TURBINE WHEELS
Temperature and pressure measurement techniques for an advanced turbine test facility
Dynamic response to rotating-seat runout in non-contacting face seals

NOTATING CYLINDERS
Calculated and experimental data for a 116-mm bore roller bearing to 3 million DM
KinetIc correction for roller skewing

ROTATING FLUIDS
Evolution of a rotating flow in the vicinity of a surface

ROTATING GENERATORS
MT TURBOGENERATORS

ROTATING SHAFTS
MT SHAFTS (MACHINE ELEMENTS)

MT TURBOSHAFTS
Balancing of a power-transmission shaft with the application of axial torque
Direct integration of transient rotor dynamics
Development of procedures for calculating stiffness and damping of elastomers in engineering applications, part 6

Circumferential shaft seal

A PHENOMENOLOGICAL MODEL OF THE DYNAMIC STALL OF A HELICOPTER BLADE PROFILE

AERODYNAMICS
A phenomenological model of the dynamic stall of a helicopter blade profile
Numerical calculation of steady in viscous full potential compressible flow about wind turbine blades
Comparison between optical measurements and a numerical solution of the flow field within a transonic axial-compressor rotor
Aerodynamic analysis of a supersonic cascade vibrating in a complex mode

AERODYNAMIC PERFORMANCES OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 Meters per second and pressure ratio of 1.54.
Experimental performance

Numerical calculation of steady in viscous full potential compressible flow about wind turbine blades
Forward acoustic performance of a shock-swallowing high-tip-speed fan (QF-13)
Development of flexible rotor balancing criteria

ROTORS BLADES
Teetered, tip-controlled rotor — Preliminary test results from NO-0 100-kW experimental wind turbine

KINEROS MACHINERY
The erosion/corrosion of small superalloy turbine rotors operating in the effluent of a FPP coal combustor

Instrumentation technology
Flutter spectral measurements using stationary pressure transducers
The response of turbine engine rotors to interference cubs
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
<th>SCALE MODELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility study of all-conductor and spoiler control systems for large</td>
<td>SABS High temperature thermal energy storage in steel</td>
</tr>
<tr>
<td>horizontal axis wind turbines</td>
<td>and sand</td>
</tr>
<tr>
<td>[NASA-CR-15956]</td>
<td>[NASA-CR-159700]</td>
</tr>
<tr>
<td>Off-design correlation for losses due to part-span damped centrifugal</td>
<td>SAPPHIRE Effect of interfacial species on shear strength of</td>
</tr>
<tr>
<td>rotor dynamics on transonic rotors</td>
<td>metal-nonmetal contacts</td>
</tr>
<tr>
<td>[NASA-TP-1633]</td>
<td>p0178 A80-22300</td>
</tr>
<tr>
<td>Effect of fluid forces on rotor stability of</td>
<td>SASEBORA</td>
</tr>
<tr>
<td>centrifugal compressors and pumps</td>
<td></td>
</tr>
<tr>
<td>p0126 A80-29720</td>
<td></td>
</tr>
<tr>
<td>Non-synchronous whirling due to fluid-dynamic forces in axial turbine-</td>
<td>SATELLITE ANTENNAS</td>
</tr>
<tr>
<td>rotors</td>
<td>p0009 A80-13064</td>
</tr>
<tr>
<td>p0126 A80-29721</td>
<td>Packet communications in satellites with</td>
</tr>
<tr>
<td>Self-excited rotor whirl due to tip-seal leakage forces</td>
<td>multiple-beam antenna and signal processing</td>
</tr>
<tr>
<td>p0127 A80-29723</td>
<td>p0099 A80-29574</td>
</tr>
<tr>
<td>Fluid forces on rotating centrifugal impeller with</td>
<td>Ka-band, multibeam, contiguous coverage satellite</td>
</tr>
<tr>
<td>whirling motion</td>
<td>systems for the USA</td>
</tr>
<tr>
<td>p0127 A80-29724</td>
<td>p0099 A80-29588</td>
</tr>
<tr>
<td>Physical explanations of the destabilizing effect of damping in rotating</td>
<td>SATELLITE CONFIGURATIONS</td>
</tr>
<tr>
<td>parts</td>
<td>Configuration effects on satellite charging response</td>
</tr>
<tr>
<td>p0127 A80-29726</td>
<td>p0053 A80-15200</td>
</tr>
<tr>
<td>Parametric instabilities of rotor-support systems with</td>
<td>SATELLITE DESIGN</td>
</tr>
<tr>
<td>application to industrial ventilators</td>
<td>An advanced mixed user domestic satellite system</td>
</tr>
<tr>
<td>p0127 A80-29729</td>
<td>[AIAA 80-0494]</td>
</tr>
<tr>
<td>Instability thresholds for flexible rotors in</td>
<td>A three-dimensional spacecraft-charging computer code</td>
</tr>
<tr>
<td>hydrodynamic bearings</td>
<td>p0055 A80-46691</td>
</tr>
<tr>
<td>p0126 A80-29730</td>
<td>SATELLITE NETWORKS</td>
</tr>
<tr>
<td>Stabilization of aerodynamically excited turbine machinery with</td>
<td>p0126 A80-13064</td>
</tr>
<tr>
<td>hydrodynamic journal bearings and supports</td>
<td>NASA's program in communication satellites</td>
</tr>
<tr>
<td>p0128 A80-29731</td>
<td>[AAS 79-247]</td>
</tr>
<tr>
<td>Use of elastomeric elements in control of rotor</td>
<td>p0099 A80-28712</td>
</tr>
<tr>
<td>instability</td>
<td>Concepts for 20/30 GHz satcom systems for</td>
</tr>
<tr>
<td>p0128 A80-29732</td>
<td>direct-to-user applications</td>
</tr>
<tr>
<td>Feasibility of active feedback control of rotodynamic instability</td>
<td>[AIAA 80-0502]</td>
</tr>
<tr>
<td>p0128 A80-29733</td>
<td>p0050 A80-35329</td>
</tr>
<tr>
<td>ROTOR DISKS</td>
<td>SATELLITE ORBITS</td>
</tr>
<tr>
<td>U TURBINE WHEELS</td>
<td>NT GEOEQUIV Synchronous Orbits</td>
</tr>
<tr>
<td>ROTOR HOBS</td>
<td>Plasma collection by high voltage spacecraft at</td>
</tr>
<tr>
<td>U ROTORS</td>
<td>low earth orbit</td>
</tr>
<tr>
<td>ROBOT SPEED</td>
<td>p0055 A80-16249</td>
</tr>
<tr>
<td>CF6 jet engine performance improvement: New fan</td>
<td>SATELLITE TRANSMISSION</td>
</tr>
<tr>
<td>[NASA-CR-159699]</td>
<td>The 30/20 GHz mixed user architecture development study</td>
</tr>
<tr>
<td>ROTORS</td>
<td>[NASA-CR-159686]</td>
</tr>
<tr>
<td>NT COMPRESSOR ROTORS</td>
<td>p0097 A80-10415</td>
</tr>
<tr>
<td>NT PLANE WHEELS</td>
<td>The 30/20 GHz mixed user architecture development study: Executive summary</td>
</tr>
<tr>
<td>NT HELICOPTER TAIL ROTORS</td>
<td>[NASA-CR-159667]</td>
</tr>
<tr>
<td>NT ROTARY WINGS</td>
<td>p0097 A80-10416</td>
</tr>
<tr>
<td>NT TURBINE WHEELS</td>
<td>Low sidelobe level low-cost earth station antennas for the 12 GHz</td>
</tr>
<tr>
<td>Design of elastomer damped for a high-speed flexible rotor</td>
<td>broadcasting satellite service</td>
</tr>
<tr>
<td>[AIAA PAPER 79-DEF-60]</td>
<td>[NASA-CR-159703]</td>
</tr>
<tr>
<td>Dynamic properties of elastomer cartridge specimens under a rotating load</td>
<td>p0096 A80-1225</td>
</tr>
<tr>
<td>p0121 A80-15736</td>
<td>A digitally implemented communications experiment utilizing the</td>
</tr>
<tr>
<td>Direct integration of transient rotor dynamics</td>
<td>communications technology</td>
</tr>
<tr>
<td>[NASA-TP-1597]</td>
<td>satellite, Hermes</td>
</tr>
<tr>
<td>[NASA-CASE-LTA-1227-3]</td>
<td>p0052 A80-21412</td>
</tr>
<tr>
<td>Liquid metal slip ring -- aerospace environments</td>
<td>On-board processing concepts for future satellite</td>
</tr>
<tr>
<td>p0095 A80-15120</td>
<td>communications systems</td>
</tr>
<tr>
<td>Tethered, tip-controlled rotor: Preliminary test results from Rod-0 100-kW</td>
<td>[NASA-CR-159683]</td>
</tr>
<tr>
<td>experimental wind turbine</td>
<td>p0099 A80-24514</td>
</tr>
<tr>
<td>[NASA-TR-01485]</td>
<td>Study of advanced communications satellite systems</td>
</tr>
<tr>
<td>The parameters and measurements of the destabilizing actions of rotating</td>
<td>based on ES-PHNA</td>
</tr>
<tr>
<td>machines, and the assumptions of the 1950's</td>
<td>[NASA-CR-159778]</td>
</tr>
<tr>
<td>p0125 A80-29712</td>
<td>p0050 A80-25357</td>
</tr>
<tr>
<td>ROUGHNESS</td>
<td>SATELLITES</td>
</tr>
<tr>
<td>NT SURFACE ROUGHNESS</td>
<td>NT ATS 5</td>
</tr>
<tr>
<td>ROBBER</td>
<td>NT ATS 6</td>
</tr>
<tr>
<td>NT ELASTOMERS</td>
<td>NT COMMUNICATION SATELLITES</td>
</tr>
<tr>
<td>S</td>
<td>NT COMMUNICATIONS TECHNOLOGY SATELLITES</td>
</tr>
<tr>
<td>S BAND</td>
<td>NT ORBITAL SPACE STATIONS</td>
</tr>
<tr>
<td>S SUPERHIGH FREQUENCIES</td>
<td>NT SCAIER SATELLITE</td>
</tr>
<tr>
<td>S ULTRASHORT FREQUENCIES</td>
<td>NT SYNCHRONOUS SATELLITES</td>
</tr>
<tr>
<td>S GLASS</td>
<td>SCALE (CORROSION)</td>
</tr>
<tr>
<td>Mechanical property characterization of isotropic hybrid composites</td>
<td>Song TIR observations of Al203 scales formed on</td>
</tr>
<tr>
<td>[NASA-TR-9306]</td>
<td>microalloyed alloys</td>
</tr>
<tr>
<td>SAFETY FACTORS</td>
<td>[AIAA PAPER 80-0229]</td>
</tr>
<tr>
<td>Photovoltaic power system reliability considerations</td>
<td>Acoustic measurements of three Prop-Fan models</td>
</tr>
<tr>
<td>p0046 A80-40336</td>
<td>[AIAA PAPER 80-0959]</td>
</tr>
<tr>
<td>SAILS</td>
<td>SCALE MODELS</td>
</tr>
<tr>
<td>NT SOLAR SAILS</td>
<td>Scale model performance test investigation of</td>
</tr>
<tr>
<td>SAMPLING</td>
<td>exhaust system mixers for an Energy Efficient</td>
</tr>
<tr>
<td>NT AIR SAMPLING</td>
<td>Engine/ES/propulsion system</td>
</tr>
<tr>
<td>p0024 A80-20968</td>
<td>[AIAA PAPER 80-0959]</td>
</tr>
<tr>
<td>p0045 A80-35556</td>
<td>Scale model performance test investigation of exhaust system mixers for an</td>
</tr>
</tbody>
</table>

A-87
Acoustic analysis of aft noise reduction

Quiet Clean Short-haul Experimental Engine (QCSEE).

Design report

Quiet Clean Short-haul Experimental Engine (QCSEE).

Ball spline pitch change mechanism design report

Quiet Clean Short-haul Experimental Engine (QCSEE).

Exhaust nozzle-to-ring interference rubber test report.

Ball spline pitch change mechanism whirligig test report.

Over-the-wing (OTW) composite nacelle subsystem test report.

Aircraft test report.

Volume 1

Channel VHF COM.

NASA-ES-134892

p0030 N80-15107

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine composite fan blade design report

NASA-ES-134691

p0030 N80-15102

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine composite fan blade design report

NASA-ES-134569

p0030 N80-15103

Quiet Clean Short-haul Experimental Engine (QCSEE). Over-the-wing fan conceptual fan frame design report

NASA-ES-134590

p0030 N80-15105

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine composite fan blade design report

NASA-ES-134576

p0031 N80-15110

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing fan conceptual design report

NASA-ES-134861

p0031 N80-15112

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine composite fan blade design report

NASA-ES-134860

p0031 N80-15113

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine conceptual design report

NASA-ES-134504

p0031 N80-15108

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine composite fan blade design report

NASA-ES-134591

p0030 N80-15104

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine composite fan blade design report

NASA-ES-134569

p0030 N80-15103

Quiet Clean Short-haul Experimental Engine (QCSEE). Ball spline pitch change mechanism design report

NASA-ES-134691

p0030 N80-15102

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine conceptual design report

NASA-ES-134569

p0030 N80-15103

Quiet Clean Short-haul Experimental Engine (QCSEE). Over-the-wing fan conceptual fan frame design report

NASA-ES-134590

p0030 N80-15105

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine conceptual design report

NASA-ES-134576

p0031 N80-15110

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine conceptual design report

NASA-ES-134861

p0031 N80-15112

Quiet Clean Short-haul Experimental Engine (QCSEE). Ball spline pitch change mechanism whirligig test report.

NASA-ES-134534

p0032 N80-15115


NASA-ES-134508

p0032 N80-15116

Quiet Clean Short-haul Experimental Engine (QCSEE). Ball spline pitch change mechanism whirligig test report.

NASA-ES-134534

p0032 N80-15115


NASA-ES-134520

p0032 N80-15119


NASA-ES-134520

p0032 N80-15119

Quiet Clean Short-haul Experimental Engine (QCSEE).

Design report

Quiet Clean Short-haul Experimental Engine (QCSEE).

Ball spline pitch change mechanism design report

Quiet Clean Short-haul Experimental Engine (QCSEE).

Over-the-wing (OTW) composite nacelle subsystem test report. Volume 4: Acoustic performance

NASA-ES-134520

p0032 N80-15119

Quiet Clean Short-haul Experimental Engine (QCSEE).

Design report

Quiet Clean Short-haul Experimental Engine (QCSEE).

Ball spline pitch change mechanism design report

Quiet Clean Short-haul Experimental Engine (QCSEE). Under-the-wing engine composite fan blade design report

NASA-ES-134846

p0044 N80-29298

Reverse thrust performance of the QCSEE variable pitch turbofan engine

NASA-ES-135558

p0022 N80-31399

SHORT TAKEOFF AIRCRAFT

CT-C-15 AIRCRAFT

Assessment at full scale of exhaust nozzle-to-wing size on STOL-OTW acoustical characteristics

NASA-ES-134677

p0190 N80-20952

Flight test of navigation and guidance sensor measurements on STOL approaches

NASA-ES-134891

p0028 N80-13041

Assessment at full scale of exhaust nozzle to wing size on STOL-OTW acoustical characteristics

NASA-ES-134891

p0170 N80-13681

SHORT WAVE RADIATION

MILLIMETER WAVES

Shining Turbines

Aerodynamic propulsor and turbine seals, volume 1

NASA-ES-134669

p0063 N80-14235

Gas path seal assessment

NASA-ES-134846

p0115 N80-18400

Composite seal for turbomachinery

NASA-ES-134846

p0115 N80-26668

Composite wall concept for high temperature turbine shroud: Design transfer analysis

NASA-ES-135199

p0020 N80-73762

The response of turbine engine rotors to interference rubs

NASA-ES-135199

p0118 N80-27656

Short Term

BYPASSES

Sidebar Reduction

Low sidelobe level low-cost earth station antennas for the 12 GHz broadcasting satellite service

NASA-ES-1357903

p0098 N80-12259

Signal Analysis

Simulation of transducer-couplact effects on broadband ultrasonic signals in nondestructive flaw evaluation and materials tests

NASA-ES-1357903

p0112 N80-42333

Signal Processing

Packet communications in satellites with multiple-beam antennas and signal processing

AIAA 80-0537

p0099 N80-29574

Multisatellite on-board signal processing

AIAA 80-0537

p0100 N80-29605

Application of coherence in fiber optics

NASA-ES-134891

p0170 N80-18682

On-board processing concepts for future satellite communications systems

NASA-ES-134891

p0099 N80-29514

Signal Transmission

MT DATA TRANSMISSION

MT FREQUENCY DIVISION MULTIPLE ACCESS

MT MICROWAVE TRANSMISSION

MT SATELLITE TRANSMISSION

MT TELEMETRY

MT SPECTRAL SIGNATURES

MT SILICATES

MT CALCIUM SILICATES

Silicon

Characterization of solar cells for space applications. Volume 10: Electrical characteristics of Spectrolab BFA, textured, 10
Effect of starting powder characteristics on density, microstructure, and low temperature oxidation behavior of a $\text{Si}_3\text{N}_4$ - w/o Y2O3 ceramic

Performance of Chevron-notch short bar specimens in determining the fracture toughness of silicon nitride and aluminum oxide

Formation of porous surface layers in reaction-bonded silicon nitride during processing

Improving the stress rupture and creep of silicon nitride --- turbine materials

Development of silicon nitride of improved toughness

Sintered silicon nitride coperator fabrication

Radiation damage in high voltage silicon solar cells

Improving the stress rupture and creep of silicon nitride --- turbine materials

Development of silicon nitride of improved toughness

Sintered silicon nitride coperator fabrication

Radiation damage in high voltage silicon solar cells

Effect of starting powder characteristics on density, microstructure, and low temperature oxidation behavior of a $\text{Si}_3\text{N}_4$ - w/o Y2O3 ceramic

Performance of Chevron-notch short bar specimens in determining the fracture toughness of silicon nitride and aluminum oxide

Formation of porous surface layers in reaction-bonded silicon nitride during processing

Effect of V and WC on the oxidation resistance of yttria-doped silicon nitride

Effect of W and WC on the oxidation resistance of yttria-doped silicon nitride

Effect of oxide additions and temperature on sinterability of silicon nitride

Formation of porous surface layers in reaction-bonded silicon nitride during processing

Effect of starting powder characteristics on density, microstructure, and low temperature oxidation behavior of a $\text{Si}_3\text{N}_4$-w/o Y2O3 ceramic

The 3500 hour durability testing of commercial ceramic materials

Effect of W and WC on the oxidation resistance of yttria-doped silicon nitride
SINGLE CRYSTALS

Preliminary results from a four-working space, double-acting piston, stirling engine controls model
[NASA-TR-61569] p0106 NO-29624
A laboratory facility for electric vehicle propulsion system testing
[NASA-TR-61574] p0163 NO-30229

SINGLE CRYSTALS

The friction and wear of metals and binary alloys in contact with an abrasive grit of single-crystal silicon carbide
[ASLE PREPRINT 79-JC-5C-1] p0120 AO-14734
Development of electrothermically cast single-crystal ZrC-247 and derivative alloys
[ASLE PR-RESEARCH 21-JC-4689] p0084 AO-45025
Anisotropy of nickel-base superalloy single crystals
[NASA-TR-61437] p0077 NO-17200

SKEWNESS

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a Si3N4 - 8 w/o Y2O3 ceramic
[NASA-TR-61464] p0056 NO-21532
Formation of porosity surfaces in reaction bonded silicon nitride during processing
[NASA-TR-61437] p0087 NO-23456

SITE DATA PROCESSORS

Modified power law equations for vertical wind profiles -- in investigation of windpower plant sifting
p0159 NO-35719

SKEWNESS

Kinematic correction for roller skewing
p0119 NO-28716

SKIN FRICTION

MT AERODYNAMIC DRA...
SOLAR COLLECTORS

MT SOLAR REFLECTORS

Preliminary study of a solar selective coating system using black carbon oxide for high temperature solar collectors

Spectral effects on direct-insolation absorption of five collector coatings


SOLAR CONVERTERS

SOLAR ELECTRIC PROPULSION

SERT II 1979 extended flight thruster system design report. Volume 2: Detailed report

SOLAR ENERGY

Photovoltaic power system reliability considerations

SOLAR ENERGY ABSORBERS

Spectral effects on direct-insolation absorption of five collector coatings

SOLAR ENERGY CONVERSION

A photovoltaic power system in the remote African village of Tangaye, Upper Volta

A 15 kW (nominal) solar thermal-electric power conversion concept definition study: Steam Rankine reheat reciprocator system

The 15 kW sub e (nominal) solar thermal electric power conversion concept definition study: Steam Rankine turbine system

A 15 kW (nominal) solar thermal-electric power conversion concept definition study: Steam Rankine reciprocator system


Biloxi storage systems for solar applications

Solar thermal power system point-focusing distributed receiver technology project. Volume 2: Detailed report

SOLAR HEATING

Candidate thermal energy storage technologies for solar industrial process heat applications

SOLAR POWER GENERATION

SOLAR POWER SOURCES

SOLAR PROPULSION

MT SOLAR ELECTRIC PROPULSION

Solar rocket system concept analysis

SOLAR REFLECTORS

Solar thermal power system point-focusing distributed receiver technology project. Volume 2: Detailed report

SOLAR SAILS

Torquing and electrostatic deformation of the sail sail

SOLNOID VALVES

Durability tests of solenoid valves for digital actuators

SOLID LUBRICANTS

Effect of thermal aging on the tribological properties of polyimide film and polyimide-bonded graphite fluoride films

Preparation of cast aluminum alloy-nickel particle composites

Mechanisms of lubrication and wear of a bonded solid-lubricant film

SOLID ROTATION

State-of-the-art of SIALON materials

SOLID SOLUTIONS

State-of-the-art of SILICON materials

SOLVENTS

MT PHOTOVOLTAIC CELLS

Solid-state x-band combiner study

SOLID- SOLID INTERFACES

Metal-dielectric interactions

Effect of interfacial species on shear strength of metal-sapphire contacts

Rolling-element bearings --- contact sliding friction study of solid bodies

SOLUTIONS

MT AQUEOUS SOLUTIONS

MT GAS MIXTURES

MT SOLID SOLUTIONS

SONIC FLOW

U TRANSonic FLOW

SONIC SPEED

U ACOUSTIC VELOCITY

SOOT

Dispersion of sound in a combustion duct by fuel droplets and soot particles

Effect of fuel molecular structure on soot formation in gas turbine engines

Laboratory measurements in a turbulent, swirling flow --- measurement of soot inside a flame-tube burner

Soot formation and burnout in flames

Effect of fuel molecular structure on soot formation in gas turbine combustion

SORTIE CAN

U SPACELAB

SORTIE LAB

U SPACELAB

SOUND

U ACOUSTICS

}{

Subject Index

Radiation damage in high voltage silicon solar cells

Solar thermal power systems point-focusing distributed receiver technology project. Volume 2: Detailed report

Solar heating Candidate thermal energy storage technologies for solar industrial process heat applications

Solar power generation U SOLAR GENERATORS

Solar power sources U SOLAR GENERATORS

Solar propulsion MT SOLAR ELECTRIC PROPULSION

Solar reflectors Solar thermal power system point-focusing distributed receiver technology project. Volume 2: Detailed report

Solar sails Torquing and electrostatic deformation of the sail sail

Solaroid valves Durability tests of solenoid valves for digital actuators

Solid lubricants Effect of thermal aging on the tribological properties of polyimide film and polyimide-bonded graphite fluoride films

Preparation of cast aluminum alloy-nickel particle composites

Mechanisms of lubrication and wear of a bonded solid-lubricant film

Solid rotation State-of-the-art of SIALON materials

Solid solutions State-of-the-art of SILICON materials

Solvent solutions State-of-the-art of SILICON materials

Solid-state devices MT PHOTOVOLTAIC CELLS Solid-state x-band combiner study

Solid-solid interfaces Metal-dielectric interactions

Effect of interfacial species on shear strength of metal-sapphire contacts

Rolling-element bearings --- contact sliding friction study of solid bodies

Solutions MT AQUEOUS SOLUTIONS MT GAS MIXTURES MT SOLID SOLUTIONS

Sonic flow U TRANSonic FLOW

Sonic speed U ACOUSTIC VELOCITY

Soot Dispersion of sound in a combustion duct by fuel droplets and soot particles

Effect of fuel molecular structure on soot formation in gas turbine engines

Laboratory measurements in a turbulent, swirling flow --- measurement of soot inside a flame-tube burner

Soot formation and burnout in flames

Effect of fuel molecular structure on soot formation in gas turbine combustion

SORTIE CAN U SPACELAB

SORTIE LAB U SPACELAB

Sound U ACOUSTICS

A-93
Computed voltage distribution around Solar Electric Propulsion spacecraft

Initial comparison of S5PM ground test results and flight data to NASCAP simulations --- Satellite Surface Potential Monitor NASA Charging Analyzer Program

NASA modelling computations on large optics spacecraft in geosynchronous substorms environments

Effects of secondary yield parameter variation on predicted equilibrium potential of an object in a charging environment --- for spacecraft

First results of material charging in the space environment

Active control of spacecraft charging

A three-dimensional spacecraft-charging computer code

Space environmental interactions with biased spacecraft surfaces

Torturing and electrostatic deformation of the solar sail

Specific spacecraft evaluation: Special report --- charged particle transport from a mercury ion thruster to spacecraft surfaces

Configuration effects on satellite charging response

Effects of secondary yield parameter variation on predicted equilibrium potential of an object in a charging environment --- using computerised simulation

Computed voltage distributions around solar electric propulsion spacecraft

NASA modelling computations on large optics spacecraft in geosynchronous substorms environments

Modelling of environmentally induced discharges in geosynchronous satellites

Spacecraft Communication

UHF coplanar-slot antenna for aircraft-to-satellite data communications

NASA’s program in communication satellites

Multigigabit satellite on-board signal processing

Application of advanced on-board processing concepts to future satellite communications systems

Application of advanced on-board processing concepts to future satellite communications systems: Bibliography

Study of advanced communications satellite systems

Spacecraft Configurations

NT Satellite Configurations

Primary propulsion/large space system interactions

Spacecraft Construction Materials

First results of material charging in the space environment

Spacecraft Compatibility

NASA modelling computations on large optics spacecraft in geosynchronous substorms environments

Spacecraft Design

NT Satellite Design

Computed voltage distribution around Solar Electric Propulsion spacecraft

Economical space power systems

Spacecraft Environments

Computed voltage distribution around Solar Electric Propulsion spacecraft
Power processing technology for spacecraft primary ion propulsion

An experimental investigation of endwall profiling in a turbine wake cascade

Effect of inflow control on inlet noise of a cut-off fan --- in an anechoic chamber

Static and transient performance of YF-102 engine with up to 14 percent core bleed for the Titan rocket research aircraft

An improved prediction method for the noise mind tunnel investigation of the Titan Forward Skirt compartment flow from a free-end-cusp nozzle of number of 0.80 to 1.96 --- conducted in the Lewis Research Center 0 by 6 foot supersonic wind tunnel

Effect of inflow control on inlet noise of a cut-off fan --- in an anechoic chamber

Liquid metal slip ring --- aerospace environments

The 15 kW sub a (nominal) solar thermal electric power conversion concept demonstration study: Steam Rankine turbine system

An alternative approach to the numerical simulation of steady inviscid flow

Development of procedures for calculating stiffness and damping of elastomers in engineering applications, part 7

Aircraft FUELS

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Comparison of the state of technology of automotive Stirling engines

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Steam Rankine engines

Stirling engine development

Aircraft FUELS

Testing of reciprocating seals for application in a Stirling cycle engine

Aircraft FUELS

Reciprocating seals for application in a Stirling cycle engine

Hydrogen Storage and propulsion systems

Technological aspects of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Exploitation of ion beam sputter deposited metal film on H-13 steel

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

Comparative data on H-13 steel

Supporting research and technology for automotive Stirling engine development

Testing and evaluation of recycled silicon nitride recuperator fabrication

The 15 kW sub a (nominal) solar thermal electric power conversion concept demonstration study: Steam Rankine turbine system

Aircraft FUELS

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade

Supporting research and technology for automotive Stirling engine development

Overview of a Stirling engine test project

Testing and evaluation of recycled silicon nitride recuperator fabrication

An analysis of carbon fiber risk assessment modeling --- fire accidents involving aircraft

An alternative approach to the numerical simulation of steady inviscid flow

Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torus cascade cascade
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SYNTHETIC FIBERS</strong></td>
</tr>
<tr>
<td><strong>SYNTHETIC RESINS</strong></td>
</tr>
<tr>
<td><strong>SYSTEM FAILURES</strong></td>
</tr>
<tr>
<td><strong>SYSTEMS ENGINEERING</strong></td>
</tr>
<tr>
<td><strong>SYSTMS ENGINEERING</strong></td>
</tr>
<tr>
<td><strong>TAPES</strong></td>
</tr>
<tr>
<td><strong>TECHNOLOGICAL FORECASTING</strong></td>
</tr>
<tr>
<td><strong>TECHNOLOGIES</strong></td>
</tr>
<tr>
<td><strong>TECHNOLOGY ASSESSMENT</strong></td>
</tr>
</tbody>
</table>

**SYNTHETIC FIBERS**
- MT GLASS FIBERS

**SYNTHETIC RESINS**
- Natural survey of properties of synthetic resins derived from coal
  - [NASA-TM-79243] p0141 880-22776
- Use of petroleum-based correlations and estimation methods for synthetic resins
  - [NASA-TM-81533] p0093 880-27509
- Synthetic resins
  - [NASA-CH-159752] p0037 880-18042
- Synthetic resins
  - [NASA-CH-159494] p0150 880-20864

**SYSTEM FAILURES**
- Mod 1 wind turbine generator failure modes and effects analysis
  - [NASA-CR-159494] p0150 880-20864

**SYSTEMS ENGINEERING**
- NASA advanced communications systems analysis
  - [NASA-CR-159494] p0093 880-27509
- Upper stages utilizing electric propulsion
  - [NASA-TM-81533] p0093 880-27509

**SYSTMS ENGINEERING**
- System analysis for millimeter-wave communication satellites
  - [NASA-CR-159494] p0150 880-20864

**TECHNOLOGICAL FORECASTING**
- Technological forecasting
  - [AIAA PAPER 80-0494] p0146 880-40338

**TECHNOLOGIES**
- Technology assessment
  - Selected data from a transonic flexible walled test section
    - [NASA-CS-159360] p0047 880-32404

**TAPES**
- Tapes (CONTAINERS)
  - [NASA-CS-159752] p0037 880-18042

**TECHNOLOGY ASSESSMENT**
- Cogeneration technology alternatives study
    - [NASA-CS-159770-PP-1-A] p0154 880-30899
  - Cogeneration technology alternatives study (CTAS).
    - Volume 6: Computer data. Part 1: Coal-fired cogeneration process boiler, section A
      - [NASA-CS-159770-PP-1-A] p0154 880-30899
TECHNOLOGY TRANSFER

VSCC technology definition study [NASA-CR-159730] p0027 A80-10222
Cost-effective technology advancement directions for electric propulsion transportation systems in earth-orbital missions [NASA-TN-97206] p0182 A80-11950
Assessment of the state of technology of automotive Stirling engines [NASA-CR-159631] p0163 A80-13509
Cladding technology [NASA-TN-97317] p0175 A80-16805
An overview of NASA research on positive displacement general-rotation engines [NASA-CR-159631] p0163 A80-13509
Assessment and preliminary design of an energy buffer for regenerative braking in electric vehicles [NASA-CR-159756] p0184 A80-23216
Advanced fuel cell system technology for utilizing broadband property aircraft fuel [NASA-CR-159756] p0184 A80-23216
Impact of propulsion system B and D on electric vehicle performance and cost [NASA-TN-81548] p0143 A80-27805
Synchronous energy technology program [NASA-CR-159756] p0184 A80-23216

TECHNOLOGY UTILIZATION

NASA communications technology research and development [NASA-CR-159730] p0027 A80-10222
Instrumentation technology [NASA-CR-159730] p0027 A80-10222
Industrial storage applications overview [NASA-CR-159730] p0027 A80-10222
Collection and dissemination of TES system information for the paper and pulp industry [NASA-CR-159730] p0027 A80-10222

TELEMETRY

Teetered, tip-controlled rotor: Preliminary test results from NAD-0 100-kW experimental wind turbine [NASA-TP-81845] p0140 A80-19613
Television (TRADEMARK) negative staggerer development in FEP teflon [NASA-TP-15717] p0179 A80-19776
Mechanical impact tests of materials in oxygen effects of precipitation -- Teflon, stainless steel, and aluminum [NASA-TP-15717] p0093 A80-21551

TELECOMMUNICATION

MT Data Links
MT Frequency Division Multiple Access
MT Pulse Communication
MT Radio Communication
MT Space Communication
MT Storage Communication
MT Telemetry
MT Time Division Multiple Access
MT Voice Communication
MT Wideband Communication
NASA advanced communications systems analysis [NASA-CR-159797] p0097 A80-25916

SUBJECT INDEX

Multigigabit satellite on-board signal processing [AIAA 80-0583] p0100 A80-29605
On-board processing concepts for future satellite communications systems [NASA-CR-159631] p0099 A80-24514
A quantitative analysis of inter-inland telephony traffic in the Specific Basic Region [NASA-TM-81587] p0097 A80-32610

TELEMETRY

U TELEMETRY

Telemetered telecommunication system for rotary instrumentation of tachometers, phase 1 [NASA-CR-159457] p0029 A80-14182

TEMPERATURE

NT HIGH TEMPERATURE
NT LOW TEMPERATURE
NT LOW DENSITY
NT SURFACE TEMPERATURE
NT WALL TEMPERATURE

TEMPERATURE DEPENDENCE

Predicting the time-temperature dependent axial failure of B/Ni composites [NASA-CR-159797] p0096 A80-32500
Predicting the time-temperature dependent axial failure of B-Ni composites [NASA-CR-159797] p0096 A80-32500
Long-time creep behavior of the tantalum alloy aster 8110 --- as a function of stress, temperature, and grain size [NASA-TP-1691] p0030 A80-32489

TEMPERATURE DISTRIBUTION

U TEMPERATURE GRADIENTS

U TEMPERATURE DISTRIBUTION

Computerized video densitometry method for rapid analysis of infrared photographic images --- temperature distribution across a turbine blade [NASA-TP-1691] p0110 A80-25735

TEMPERATURE EFFECTS

Elevated temperature flow strength, creep resistance and diffusion welding characteristics of Ti-6Al-2Nb-Ta-0.8Mo [NASA-TP-1691] p0261 A80-13227
The effects of strain and temperature on the dynamic properties of elastomers [AIAA 80-0583] p0071 A80-35494
Apparatus for trapping and thermal detection of atomic hydrogen in high magnetic fields at low temperatures [NASA-TP-1691] p0111 A80-38546
Engine environmental effects on composite behavior --- moisture and temperature effects on mechanical properties [AIAA 80-0583] p0012 A80-38546
Effect of thermal cycling on Fe02-Ty03 thermal barrier coatings [NASA-TP-1691] p0099 A80-35099
Effects of oxide additions and temperature on sinterability of milled silicon nitride [NASA-TP-1691] p0086 A80-21523
Fuel system technology overview [NASA-TP-1691] p0022 A80-25328
Long-time creep behavior of the niobium alloy C-103 [NASA-TP-1691] p0012 A80-38546

TEMPERATURE GRADIENTS

U TEMPERATURE DISTRIBUTION

Stability of several oxide dispersion strengthened alloys and a directionally solidified gamma/gamma prime-alpha eutectic alloy is a thermal gradient [NASA-CR-159797] p0082 A80-40562
Directional solidification at ultra-high thermal gradient [NASA-CR-159797] p0082 A80-40562

TEMPERATURE MEASUREMENT

Impact of new instrumentation on advanced turbine
SUBJECT INDEX

Research
Temperature and pressure measurement techniques for an advanced turbine test facility
[ASME PAPER 71-GT-28] p0114 A80-36515
Temperature and pressure measurements on near-freezing ablation fuels in a wing-tank model
[ASME PAPER 72-GT-1] p0094 A80-42193
Temperature and pressure measurement techniques for an advanced turbine test facility
[ASME PAPER 71-GT-28] p0110 A80-14374
TEMPERATURE MEASURING INSTRUMENTS
- Design, fabrication and testing of an optical temperature sensor
[ASME-PAPER-74-GT-152] p0112 A80-31777
TEST CHAMBERS
This film temperature sensor
[ASME-CU-15978] p0112 A80-17425
TEST EQUIPMENT
Mechanical properties and oxidation and corrosion resistance of reduced-chromium 304 stainless steel alloys
Creep-rupture behavior of seven iron-base alloys after long term aging at 760 deg in low pressure hydrogen gas
TEST ENVIRONMENTS
Tensile and flexural strength of non-graphitic superhybrid composites: Predictions and comparisons
[ASME-PAPER-79-TM-70726] p0074 A80-11144
TENSILE STRENGTH
Fracture modes of high modulus graphite/epoxy unidirectional laminates subjected to off-axis tensile loads
Anisotropy of nickel-base superalloy single crystals
Fracture modes of high modulus graphite/epoxy unidirectional laminates subjected to off-axis tensile loads
TEST IN ALLOYS
MC45550Y (TRADERS) Superfine magnetic field at C1 impurity site in L2/1/Heusler alloys Rh2Mg2 and Rh2Mn7 by TDPAC technique --- Time Differential Perturbed Angular Correlation
p0176 A80-16043
THERMAL ENERGY
Design and evaluation of high performance rocket engine injectors for use with hydrocarbon fuels
p0059 A80-20957
TESTS
U TEST EQUIPMENT
TESTING MACHINES
U TEST EQUIPMENT
TEXTURES
Mechanical and chemical effects of ion-texturing biomedical polymers
p009 A80-13065
Modification of the electrical and optical properties of polymers --- Ion irradiation to create texture
[NASA-REPORT-13027-1] p0087 A80-24437
THEORIES
U RECIPROCAL THEOREMS
U SIMILARITY THEOREMS
THERAPY
U RADIATION THERAPY
THERMAL INSULATION
U THERMAL ENERGY
THERMAL CONTROL COATINGS
Thermal barrier coatings for aircraft gas turbines
[ASAE PAPER 80-0302] p0069 A80-18303
Effects of yttria, alumina and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers
p0062 A80-35900
Evaluation of present-day thermal barrier coatings for industrial/utility applications
p0092 A80-39637
Similarity tests of turbine vanes - Effects of ceramic thermal barrier coatings
[ASME PAPER 80-07-24] p0027 A80-48013
Effects of a ceramic coating on metal temperatures of an air-cooled turbine vane
An experimental, low-cost, silicon-aluminide high-temperature coating for superalloys
Similarity tests of turbine vanes, effects of ceramic thermal barrier coatings
Effects of yttria, alumina and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers
Development of improved-durability plasma sprayed ceramic coatings for gas turbine engines
THERMAL CYCLING TESTS
Hot corrosion of four superalloys - HA-188, S-57, IN-617, and TO-Nicroal
3500-hour durability testing of ceramic materials for automotive gas turbine engines
Effect of thermal cycling on Zr02-5203 thermal barrier coatings
Development of improved high pressure turbine outer gas path seal components --- Abrasability and thermal cycling test results
[ASME-PAPER-79-TM-871564] p0038 A80-21332
Three dimensional finite-element elastic analysis of a thermally cycled double-edge wedge geometry specimen --- Nickel alloy turbine part
The 3500 hour durability testing of commercial ceramic materials
THERMAL DECAY
Effect of thermal aging on the tribological properties of polyimide films and polyimide-bonded graphite fluoride films
[ASME-PAPER-79-A5-3B] p0068 A80-12094
Evaluation of present-day thermal barrier coatings for industrial/utility applications
p0092 A80-35637
Life test studies on tungsten impregnated cathodes
p0103 A80-45122
THERMAL EFFECTS
U TEMPERATURE EFFECTS
THERMAL EFFICIENCY
U THERMODYNAMIC EFFICIENCY
THERMAL ENERGY
Energy conservation and environmental benefits of thermal energy storage systems in the pulp and
TRANSPORTATION TECHNOLOGY

TRANSPORTATION TECHNOLOGY is a field that focuses on the development and application of technology for transportation systems, including vehicles, infrastructure, and logistics. This technology plays a crucial role in the movement of people and goods, impacting economic development, environmental sustainability, and social mobility.

Some key areas within transportation technology include:
- **Automotive Technology**: This encompasses the design, development, and production of vehicles for personal and commercial use. It includes advancements in vehicle efficiency, safety, and connectivity.
- **Aerospace Engineering**: This involves the design and development of aircraft, spacecraft, and related equipment. Advances in aerospace technology have led to improvements in flight safety, speed, and fuel efficiency.
- **Railway Engineering**: This field focuses on the design, construction, and operation of railway systems. It includes innovations in high-speed trains, freight trains, and urban transit systems.
- **Maritime Technology**: This involves the development of ships and other marine vehicles, as well as port infrastructure. It includes advancements in ship design, propulsion, and safety.
- **Transportation Systems**: This includes the study of how vehicles are integrated into transportation networks, including traffic management, public transport systems, and logistics.

In recent years, transportation technology has seen significant advancements, particularly in the areas of electric and autonomous vehicles, as well as in the development of more efficient and sustainable transportation systems.

**Further Reading**

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**Example**: The development of electric vehicles has been a significant advancement in transportation technology, offering improved efficiency and reduced environmental impact compared to traditional gasoline-powered vehicles.
TRIBOLOGY
TRAVELING WAVES
TRAPPING
TRANSPORT
TRANSPORT COEFFICIENTS
TRANSPORT PROPERTIES
TRANSPORTATION
TRANSPIRATION COOLING
TRANSPIRATION COOLING
TRANSPIRATION COOLING
TRANSPIRATION COOLING
TRANSPIRATION COOLING
TRANSPIRATION COOLING
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TRANSPIRATION COOLING
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TRANSPIRATION COO
**SUBJECT INDEX**

**TURBINE ENGINES**

- Internal coating of air cooled gas turbine blades
- Turbomachinery testing of steady inviscid full potential compressible flow about wind turbine blades
  - [NASA-TM-81938] p0136 N80-18497
- Analysis of uncertainties in turbine metal temperature predictions
  - [NASA-TF-15933] p0017 N80-21326
- Program for impact testing of spar-shell fan blades, test report
  - [NASA-CR-159393] p0037 N80-21326
- Thermal fatigue and oxidation data for directionally solidified MAR-M 246 turbine blades
  - [NASA-CR-159748] p0037 N80-21330
- Similarity tests of turbine vanes, effects of ceramic thermal barrier coatings
  - [NASA-CR-159774] p0105 N80-21706
- Advanced ceramic material for high temperature turbine tip seals
- Nonlinear, three-dimensional finite-element analysis of air-cooled gas turbine blades
  - [NASA-TP-16653] p0152 N80-22373
- Significance of thermal contact resistance in two-layer thermal-barrier-coated turbine vanes
- Fully plasma-sprayed compliant backed ceramic turbine seal
  - [NASA-CASE-LW-13266-1] p0117 N80-24619
- Computerized video densitometry method for rapid analysis of infrared photographic images --- temperature distribution across a turbine blade
  - [NASA-TP-16666] p0110 N80-25635
- Nonlinear aerelastic equations of motion of twisted, nonsymetrical horizontal-axis wind turbine blades
  - [NASA-CR-159502] p0152 N80-26774
- Comparison of elastic and elastic-plastic structural analyses for cooled turbine blade aircraft
  - [NASA-TP-16779] p0132 N80-27719
- Tungsten wire/FeCrAlY matrix turbine blade fabrication processes
  - [NASA-CR-159768] p0044 N80-29331
- WINO: Computer program for calculation of three dimensional potential compressible flow about wind turbine rotors
  - [NASA-TF-1729] p003 N80-33357
- Experimental performance and analysis of 15.04-centimeter-tip-diameter, radial-inflow turbine with work factor of 1.126 and thick blading
  - [NASA-TP-1730] p0023 N80-33410

**TURBINE INSTRUMENTS**

- Evaluation of the cyclic behavior of aircraft turbine disk alloys, part 2
  - [NASA-CR-159522] p0087 N80-33482
- The use of wind data with an operational wind turbine in a research and development environment
  - [NASA-CP-2092] p003 N80-10038
- Materials and structures technology
  - [NASA-CR-159801] p0012 N80-10205
- Mechanical components
  - [NASA-TM-81466] p0012 N80-10210
- Development of improved high pressure turbine outer gas path seal components --- a high performance and thermal cycling test results
  - [NASA-CR-159801] p0036 N80-21332
- Application of superalloy powder metallurgy for aircraft engines
  - [NASA-TP-81846] p0076 N80-21488
- New opportunities for future, small, General Aviation Turbine Engines (GATE)
  - [NASA-CR-159832] p0017 N80-22335
- CF6 jet engine performance improvement program: High pressure turbine aerodynamic performance improvement
- Composite seal for turbomachinery
- Materials for advanced turbine engines, Volume 1: Power metallurgy. Need 95 rotating turbine engine parts
- NASA/General Electric broad-spectrum fuels combustion technology program, phase 1. Final report
  - [NASA-CR-159802] p0112 N80-29316
- Experimental study of turbine fuel thermal stability in an aircraft fuel system simulator, phase 1
  - [NASA-CE-159821] p0125 N80-29327
- Mechanisms of nitrogen heterocycle influence on turbine fuel stability
- Description of the aero core turbine facility recently installed at NASA Lewis Research Center
  - [NASA-TP-159352] p0110 N80-29333
- Laser-optical blade tip clearance measurement system development
- Impact of new instrumentation on advanced turbine research
  - [NASA-TM-81466] p0112 N80-36155
- Temperature and pressure measurement techniques for advanced turbine test facility
  - [NASA-CR-159802] p0112 N80-36157
- Phase-locked telemetry system for rotary instrumentation of turbomachinery, phase 1
  - [NASA-TP-1729] p0023 M60-33410
- Turbine Pumps

  - Supercharged topping rocket propellant feed system
    - [NASA-AER-002062-1] p0056 N80-14188
  - Small, high pressure liquid hydrogen turbopump
    - [NASA-CR-159021] p0125 N80-26662
- Turbine Wheels

  - Development of a high strength hot isostatically pressed /Ni/ disk alloy, NEIL 76
  - Evaluation of the cyclic behavior of aircraft turbine disk alloys, part 2
- Turbines

  - MT AXIAL FLOW TURBINES
    - MT AIR TURBINES
    - MT GAS TURBINES
    - MT SHROUDED TURBINES
    - MT STEAM TURBINES
    - MT SUPERSONIC TURBINES
    - MT TWO STAGE TURBINES
- TURBINE INSTRUMENTS

  - Executive summary: Hod-1 wind turbine generator
    - [DOE/NASA/0002-80/2] p0151 N80-36318
  - Some techniques for reducing the tower shadow of the DOE/NASA mod-0 wind turbine tower --- wind tunnel tests to measure effects of tower structure on wind velocity
    - [NASA-TP-79020] p0036 N80-10038
  - Executive summary: Mod-1 wind turbine generator analysis and design report
    - [NASA-CR-159807] p0137 N80-10594
  - Development of large wind turbine generators
    - [NASA-CR-159807] p0137 N80-11558
  - Preliminary analysis of performance and loads data from the 2-megawatt mod-1 wind turbine generator
    - [NASA-CR-159807] p0137 N80-14655
  - Executive summary: Mod-1 wind turbine generator analysis and design report, volume 1
  - Mod-2 wind turbine system concept and preliminary design report. Volume 1: Executive summary
    - [DOE/NASA/0002-80/2] p0151 N80-24758
  - Design and cold-air test of single-stage uncooled turbine with high work output

A-109
Cold-air investigation of a 4 1/2 stage turbine with stage-loading factor of 4.67 and high specific work output. 2: Stage group performance [ASME-TP-1688] p0019 N80-25337
A calculation procedure for viscous flow in turbomachines, volume 3 --- computer programs [NASA-TP-15958] p0019 N80-25338
Three-dimensional finite-element elastic analysis of a thermally cycled double-edge wedge geometry specimen --- nickel alloy turbine parts [NASA-EN-80906] p0005 N80-26274
Non-2 wind turbine system concept and preliminary design report. Volume 2: Detailed system design [DOE/NASA/0002-80/2] p0152 N80-26775
Feasibility study of silicon and spoiler control systems for large horizontal axis wind turbines [NASA-CR-15956] p0153 N80-27803
Evaluation of instability forces of labyrinth seals in turbines or compressors [NASA-EN-79-118] p0126 N80-29715

TURBOCHARGERS

U SUPERCHARGERS
U TURBOCOMPRESSORS

Comparisons between optical measurements and a numerical estimate of the flow field within a transonic axial-flow compressor rotor [AIAA PAPER 80-1078] p0003 A80-38097
Experimental study of low aspect ratio compressor blading [NASA-EN-79-2200] p0002 N80-11037
Diesel engine catalytic converter systems for turbocharging [NASA-CASE-12995-1] p0110 N80-26659
Three dimensional mean flow and turbulence characteristics of the near wake of a compressor rotor blade [NASA-CR-159518] p0005 N80-27288

TURBOCONVERTERS

U TURBOGENERATORS

TURBOELECTRIC CONVERSION

U TURBOGENERATORS

TURBOFAN ENGINES

Temperature and pressure measurement techniques for an advanced turbine test facility [NASA-EN-79-118] p0112 A80-36157
Advanced component technologies for energy-efficient turbofan engines [AIAA PAPER 80-1086] p0025 A80-38902
Experimental evaluation of exhaust mixer for an Energy Efficient Engine [AIAA PAPER 80-1088] p0025 A80-38903
Far-field radiation of aft turbofan noise [AIAA PAPER 80-1088] p0025 A80-39638
Fuel conservation through active control of rotor clearance [AIAA PAPER 80-1087] p0045 A80-81506
Influence of pressure driven secondary flows on the behavior of turbofan forced mixers [AIAA PAPER 80-1198] p0025 A80-81515
Results from tests on a high work transonic turbine for energy efficient engines [AIAA PAPER 80-07-146] p0026 A80-42258

CF6 fan performance improvement [ASME PAPER 80-GT-176] p0026 A80-42246
Uncertainty in predicting turbine blade metal temperatures [ASME PAPER 80-GT-25] p0027 A80-48016

Time dependent difference theory for sound propagation in a two-dimensional duct --- a turbofan engine [NASA-EN-79-118] p0167 N80-12022
A time dependent difference theory for sound propagation in ducts with flow --- characteristics and inlet and exhaust ducts of turbofan engines [NASA-EN-79-118] p0167 N80-12023

Static test-stand performance of the YF-102 turbofan engine with several exhaust configurations for the Quiet Short-Haul Research Aircraft (CSRA) [NASA-OP-1556] p0014 N80-14121


Quiet Clean Short-Haul Experimental Engine (CSRE) preliminary under the wing flight propulsion system analysis report [NASA-CR-159650] p0034 N80-15089

Core noise investigation of the CF6-50 turbofan engine [NASA-CR-159590] p0036 N80-16061
Core noise investigation of the CF6-50 turbofan engine [NASA-CR-159749] p0036 N80-16062

Method and apparatus for rapid thrust increases in a turbofan engine [NASA-CASE-1344-12971-1] p0016 N80-16039
Application of composite materials to turbofan engine fan exit guide vanes [NASA-EN-79-118] p0056 N80-18106
Experimental evaluation of a spinning-mode acoustic-treatment design concept for aircraft inlets --- suppression of YF-102 engine fan noise [NASA-TP-1613] p0046 N80-21323
Analysis of uncertainties in turbine metal temperature predictions [NASA-TP-1593] p0017 N80-21326

Aircraft QCCAT program --- quiet clean general aviation turbofan engines [NASA-CR-159756] p0037 N80-21331

Far-field radiation of aft turbofan noise [NASA-TP-81506] p0166 A80-24129
Advanced component technologies for energy-efficient turbofan engines [NASA-TP-81507] p0029 N80-24316

Static and transient performance of YF-102 engine with up to 14 percent core bleed for the Quiet Short-Haul Research Aircraft [NASA-TP-1692] p0014 N80-42233

Far-field radiation of aft turbofan noise [NASA-TP-81506] p0166 A80-24129
Advanced component technologies for energy-efficient turbofan engines [NASA-TP-81507] p0029 N80-24316

Static and transient performance of YF-102 engine with up to 14 percent core bleed for the Quiet Short-Haul Research Aircraft [NASA-TP-1692] p0020 N80-25339

A-110
Simulation of transducer-couplant effects on broadband ultrasonic signals  
[NASA-TR-81589] p0150 80-22713
Concepts and techniques for ultrasonic evaluation of material mechanical properties  
[NASA-TR-51523] p0130 80-24634
ULTRASONIC WAVE TRANSPORT  
Simulation of transducer-couplant effects on broadband ultrasonic signals --- in nondestructive flaw evaluation and materials testing  p0112 80-44233
ULTRASONICS  
Quantitative ultrasonic evaluation of engineering materials in metals, composites and ceramics  
[NASA-TR-61530] p0130 80-26660
UNIAXIAL STRAIN  
U AXIAL STRAIN
UNITED STATES OF AMERICA
VT KENTUCKY
VT NEW MEXICO
UNSTEADY FLOW  
Experimental determination of unsteady blade element aerodynamics in cascades. Volume 1: Torsion mode cascade  
[NASA-CP-159831] p0040 80-25335
UPPER STAGE ROCKET ENGINES  
Upper stages utilizing electric propulsion  
[NASA-CP-80-29969] p0059 80-29969
Upper stages utilizing electric propulsion  
[NASA-CP-80-30366] p0057 80-30366
UPPER VOLTA  
A photovoltaic power system in the remote African village of Tanganye, Upper Volta  
[NASA-TR-76518] p0137 80-12552
URBAN TRANSPORTATION  
A new traffic control design method for large networks with signalized intersections  
[NASA-CP-80-14841] p0113 80-14841
USER HANDBOOKS (COMPUTER PROGRAMS)  
[NASA-CP-159502] p0020 80-13044
A calculation procedure for viscous flow in turbomachines, volume 3 --- computer programs  
[NASA-CP-159084] p0005 80-26274
UTILITIES  
Description of photovoltaic village power systems in the United States and Africa  
[NASA-CP-80-46796] p0146 80-46796
Simulation studies of multiple large wind turbine generators on a utility network  
[NASA-CP-80-16480] p0139 80-16480
Summary and evaluation of the parametric study of potential early commercial MW power plants (FSPEC)  
[NASA-TR-81497] p0142 80-23780
Model wind turbine farm stability study  
[NASA-CP-165156] p0156 80-33662
VARIABLE CYCLE ENGINES  
Computational fluid mechanics of internal flow of supercritical propulsion technology --- variable cycle engines  
[NASA-CP-159789] p0040 80-10216
Experimental evaluation of a low emissions high performance duct burner for Variable Cycle Engines (VCE)  
[NASA-CP-159694] p0036 80-17074
Experimental aerodynamic and acoustic model testing of the Variable Cycle Engine (VCE) throat annular exhaust nozzle system  
[NASA-CP-1597101] p0040 80-26300
Experimental aerodynamic and acoustic model testing of the Variable Cycle Engine (VCE) throat annular exhaust nozzle system: Comprehensive data report  
[NASA-CP-159711] p0040 80-26301
VARIABLE GEOMETRY STRUCTURES  
A comparison of experiment and theory for sound propagation in variable area ducts  
[NASA-CP-80-45844] p0173 80-45844
Experimental investigation of a 0.15 scale model of a conformal variable ramp inlet for the F-16 airplane  
[NASA-CP-159640] p0005 80-24263
VARIANCE (STATISTICS)  
VARIABLE CYCLE ENGINES  
VECTOR SPACES  
VECTORS, MATRICES (MATHEMATICS)
VEGETATION  
Verification of satellite and aircraft multispectral scanner data for strip-mine monitoring  
[NASA-TR-79268] p0135 80-20787
VEHICLE WHEELS  
Improved tire/wheel concept --- pneumatic aircraft tire  
VELOCIY  
VT ACOUSTIC VELOCITY
High-speed-propeller wind-tunnel aeroacoustic results

A comparison between an existing propeller-alone theory and wind tunnel data

Selected data from a transonic flexible walled test section

Wind tunnel investigation of the Titan Forward Skirt compartment vent from a free-stream Mach number of 0.80 to 1.96 --- conducted in the Lewis Research Center 8 by 6 foot supersonic wind tunnel

WIND TUNNELS

WIND VELOCITY

Some techniques for reducing the tower shadow of the DOE/NASA mod-0 wind turbine tower --- wind tunnel tests to measure effects of tower structure on wind velocity

WIND VELOCITY MEASUREMENT

Some techniques for reducing the tower shadow of the DOE/NASA mod-0 wind turbine tower --- wind tunnel tests to measure effects of tower structure on wind velocity

WINDMILLS (WINDPOWERED MACHINES)

Numerical calculation of steady inviscid full potential compressible flow about wind turbine blades

WINDPOWER UTILIZATION

Modified power law equations for vertical wind profiles --- in investigation of windpower plant siting

WIND TUNNELS

Subject Index

Light-speed-propeller wind-tunnel aeroacoustic results

A comparison between an existing propeller-alone theory and wind tunnel data

Selected data from a transonic flexible walled test section

Wind tunnel investigation of the Titan Forward Skirt compartment vent from a free-stream Mach number of 0.80 to 1.96 --- conducted in the Lewis Research Center 8 by 6 foot supersonic wind tunnel

WIND TUNNELS

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Some techniques for reducing the tower shadow of the DOE/NASA mod-0 wind turbine tower --- wind tunnel tests to measure effects of tower structure on wind velocity

WIND VELOCITY MEASUREMENT

Some techniques for reducing the tower shadow of the DOE/NASA mod-0 wind turbine tower --- wind tunnel tests to measure effects of tower structure on wind velocity

WINDMILLS (WINDPOWERED MACHINES)

Numerical calculation of steady inviscid full potential compressible flow about wind turbine blades

WINDPOWER UTILIZATION

Modified power law equations for vertical wind profiles --- in investigation of windpower plant siting
ZINC SILVER OXIDE BATTERIES

ZINC SILVER
OXIDE BATTERIES

SILVER ZINC BATTERIES

ZINC COMPOUNDS

ZIRCONIUM

The effect of zirconium on the isothermal oxidation of nominal Ni-14Cr-24Al alloys  

Composite wall concept for high temperature turbine shrouds: Heat transfer analysis  

[NASA-TH-81539]

ZIRCONIUM COMPOUNDS

ZIRCONIUM OXIDES

ZIRCONIUM OXIDES

Effect of thermal cycling on ZrO2-Y2O3 thermal barrier coatings

Effects of yttrium, aluminum and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers

Analysis of the response of a thermal barrier coating to sodium and vanadium doped combustion gases

[NASA-TH-79205]

Effects of yttrium, aluminum and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers

[NASA-TH-81485]
# Personal Author Index

## Typical Personal Author Index Listing

<table>
<thead>
<tr>
<th>PERSONAL AUTHOR INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADLER, A.</td>
</tr>
<tr>
<td>Phase-locked telemetry system for rotary instrumentation of turbomachinery, phase 1</td>
</tr>
</tbody>
</table>

## Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report) The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence with the IAA accession numbers appearing first.

### A

<table>
<thead>
<tr>
<th>PERSONAL AUTHOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALBRECHT, J.</td>
</tr>
<tr>
<td>Active heat exchange system development for latent heat thermal energy storage</td>
</tr>
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<table>
<thead>
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<th>TITLE</th>
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<tr>
<td>Phase-locked telemetry system for rotary instrumentation of turbomachinery, phase 1</td>
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<th>REPORT NUMBER</th>
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<tbody>
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<td>159453</td>
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</table>
Numerical simulation of supersonic inlets using a three-dimensional viscous flow analysis
[NASA-TM-81611] p0104 N80-15365

ANDERSON, D. I.
The effect of catalyst length and downstream reactor distance on catalytic combustor performance

ANDERSON, D. N.
Gas phase oxidation downstream of a catalytic combustor
[NASA-TM-81551] p0144 N80-29663

ANDERSON, R. H.
Effect of geometry and operating conditions on spur gear system power loss
Evaluation of a high performance fixed-ratio traction drive
p0122 A80-46409
Spur-gear-system efficiency at part and full load
[NASA-TP-16622] p0115 N80-17466
Evaluation of a high performance fixed-ratio traction drive
Effect of geometry and operating conditions on spur gear system power loss
Parametric tests of a traction drive retrofitted to an automotive gas turbine

ANDERSON, W. J.
Rolling-element bearings
p0121 A80-31961
Mechanical components
p0013 N80-10213

AUSPACH, R. E.
Characterization of solar cells for space applications. Volume 10: Electrical characterization of Spectrolab BSF, textured, 10 ohm-cm, 300 micron cells as a function of intensity, temperature and irradiation
[NASA-CP-162422] p0147 N80-11566

ARM, R. J.
Improved components for engine fuel savings

ANTOINE, A. C.
Use of petroleum-based correlations and estimation methods for synthetic fuels

ANTONIOU, D.
Deposition of arterial heat pipes: An investigation of CTS thermal excursions

ARIAI, T.
Effects of oxide additions and temperature on sinterability of milled silicon nitride
[NASA-TP-16044] p0086 N80-21532

ARISTATOS, B. C.
Fatigue strength testing explored for evaluation and acceptance of jet-engine instrumentation probes
p0112 A80-42291
Fatigue strength testing explored for evaluation and acceptance of jet-engine instrumentation probes
[NASA-TM-81402] p0110 N80-17042

ARNDT, R. A.
Thin-film radiation-resistant solar cell feasibility study
[NASA-CR-159871] p0154 N80-29852

ARSBY, C. M.
A quantitative analysis of inter-island telephony in the Pacific Basin Region (PBR)

ASHLEY, T. L.
Concept definition study of small Brayton cycle engine for dispersed solar electric power systems
[NASA-CR-159592] p0150 N80-22778

ASTON, G.
Ion extraction from a plasma
[NASA-CR-159049] p0177 N80-26161

Auer, D. M.
Simulation and visualization of face seal motion stability by means of computer generated movies

AUGLER, R. N.
Prediction method for two-dimensional aerodynamic losses of cooled vanes using integral boundary-layer parameters
[NASA-TP-1623] p0002 N80-17030

ATATI, N. B.
A methodology for long-range prediction of air transportation
p0041 N80-29305

AYLETT, J. C.
LeRC reduced gravity fluid management technology program
p0048 A80-35504
LeRC reduced gravity fluid management technology program
LeRC reduced gravity fluid management technology program
p0057 N80-30683

BADGLEY, R. B.
Solar array subsystems study

BAKKE, E. P.
Tetra-ocular pressure normalization technique and equipment
[NASA-CASE-LEN-12955-1] p0161 N80-14684

BAKKE, A. R.
Durability tests of solenoid valves for digital actuators

Baker, D. W.
Quiet Clean Short-haul Experimental Engine (QCSEE). Double-annular clean combustor technology development report
Energy efficient engine
[NASA-CR-159605] p0045 N80-33408

BAKKE, W. L.
An interactive modular design for computerized photometry in spectrochemical analysis
p0074 A80-39640
An interactive modular design for computerized photometry in spectrochemical analysis

BAKER, N.
Concepts for 20/30 GHz satcom systems for direct-to-user applications
[IAIA 80-0582] p0050 A80-35329
Concepts for 16/30 GHz satellite communication system, volume 1
Concepts for 16/30 GHz satellite communication system, volume 1A: Appendix
[NASA-CR-159625-VOL-1A] p0096 N80-11278
Concepts for 16/30 GHz satellite communication system study, Volume 1: Executive summary
[NASA-CR-159580] p0098 N80-11279

BALDERSON, D. B.
Large wind turbines: A utility option for the generation of electricity
[NASA-TM-81502] p0144 N80-32858

BALCHBISH, R. B.
An exploratory survey of noise levels associated with a 100 kW wind turbine
p0171 A80-35499
Application of coherence in fan noise studies
[NASA-TC-1630] p0167 N80-18882
An exploratory survey of noise levels associated with a 100kW wind turbine
[NASA-TP-81496] p0169 N80-23102

BANKS, R. A.
Advanced concepts
p0058 N80-31471

BARBA, G. J.
Cogeneration Technology Alternatives Study (CTAS). Volume 1: Basis Survey

BARABAS, J. P.
Laser-optical blade tip clearance measurement system
p0011 A80-36137
Laser-optical blade tip clearance measurement system

BARRETT, C. A.
The effect of zirconium on the isothermal oxidation of nominal Ni-74Cr-29Al alloys
p0082 A80-26465
Mechanical properties and oxidation and corrosion
resistance of reduced-chromium 304 stainless steel alloys
[NASA-TP-1557] p0076 N80-11186

BAHER, L. A.
Stabilization of aerodynamically excited
turbomachinery with hydrodynamic journal
bearings and supports p0126 N80-29731

BEHER, C. F.
Cost analysis of composite fan blade manufacturing
processes [NASA-CH-159076] p0044 N80-31398

BAILEY, W. O.
Active control of spacecraft charging p0055 ABO-46890

BASKETT, C. H.
Conceptual design of an orbital propellant
transfer experiment. Volume 2: Study results
[NASA-TP-65150] p0046 N80-31423

BAUCHSPRECH, J. S.
Aerial applications dispensal system control
[NASA-159781] p0150 N80-18586

BAUER, H. J.
Optical sensors for aeronautics and space
Fiber optic sensors for measuring angular position
and rotational speed [NASA-TM-81454] p0110 N80-18368

BAUER, R. J.
Time-dependent difference theory for noise
propagation in a two-dimensional duct
[AIAA PAPER 80-0096] p0170 ABO-18269
A time dependent difference theory for sound
propagation in ducts with flow p0170 ABO-20951
Time-dependent difference theory for noise
propagation in a two-dimensional duct [NASA-TN-97208] p0167 N80-12822
A time dependent difference theory for sound
propagation in ducts with flow p0167 N80-12823
Time dependent difference theory for sound
propagation in axisymmetric ducts with plug flow
Numerical techniques in linear duct acoustics

BATLLE, J. R.
8-cm Engineering Model Thruster technology - A
review of recent developments [AIAA PAPER 79-2103] p0064 ABO-13311

BECCHAM, L. E.
Hyersonic propulsion p0013 N80-10217

BEATTIE, J. R.
A model for predicting the worstout load of the
LTV/Cage/Hughes 50-cm Mercury ion thruster
[AIAA PAPER 79-2079] p0064 ABO-20962
Primary electric propulsion technology study
[NASA-CH-159088] p0061 N80-13150

BECHEL, R.
An electric propulsion long term test facility
[NASA-TP-159688] p0061 N80-13150

BECHEL, R. T.
Preliminary results of the mission profile life
test of a 30 cm Hg bombardment thruster
[AIAA PAPER 79-2079] p0049 ABO-13308

BECK, R. L.
Testing of reciprocating seals for application in
a Stirling cycle engine [NASA-TP-159260] p0124 N80-22700

BECK, W. E.
Zero-length, slotted-rip inlet for subsonic
military aircraft [AIAA PAPER 80-1245] p0049 ABO-12103

BEERS, D. L.
Negative streamer development in FEP tubing
[NASA-TP-81387] p0138 N80-15554

BEATTY, J. N.
Control compressor exit stage study, 2
[NASA-CH-159812] p0039 N80-23312
Study of blade aspect ratio on a compressor front
stage [NASA-159556] p0040 N80-25333

BEATTY, J. P.
Design and cold-air test of single-stage uncooled
turbine with high work output [NASA-TP-1680] p0019 N80-25337

BEATTY, S.
Cold-air investigation of a 4 1/2 stage turbine
with stage-loading factor of 4.66 and high
specific work output. 2: Stage group performance
[NASA-TP-1680] p0019 N80-25338

BEMMERT, D. B.
Calculation of residual principal stresses in CVD
boron on carbon filaments p0072 ABO-4237
Calculation of residual principal stresses in CVD
boron on carbon filaments [NASA-TP-159456] p0068 N80-20314

BELL, E. S.
Fuel conservation through active control of rotor
clearances [AIAA PAPER 80-3207] p0045 ABO-41506

BELL, L. D.
Design study of toroidal traction CVT for electric
vehicles [NASA-CH-159603] p0124 N80-25661

BELL, R. E.
Potential release of fibers from burning carbon
composites p0069 N80-32431

BELLHAUS, C.
Material review for improved automotive gas
turbine engine [NASA-CH-159673] p0123 N80-17470

BENYAMIN, S. J.
Flow induced spring coefficients of labyrinth
seals for application in rotor dynamics
[NASA-TP-16577] p0126 N80-29717

BENZER, D. J.
Parametric study of prospective early commercial
HPO power plants (GPPC). General Electric
Company, task I: Parametric analysis
[NASA-CH-159634] p0152 N80-26779

BENSON, S. H.
The erosion/corrosion of small superalloy turbine
turbines operating in the effluent of a PFBC coal
combustor p0080 ABO-10043
Improved PFBC operation: 400-hour turbine test
results p0195 ABO-39639
Improved PFBC operation: 400-hour turbine test
results p0079 N80-26426

BEM, R. H.
3500-hour durability testing of ceramic materials
for automotive gas turbine engines
[AIAA RESEARCH-31-3542] p0092 ABO-35575
The 3500-hour durability testing of commercial
ceramic materials [NASA-CH-159785] p0091 N80-31552

BEJ, D. H.
The parameters and measurements of the
destabilizing actions of rotating machines, and
the assumptions of the 1950's p0125 N80-29712

BECKER, R. S.
Engineering test facility design definition
[NASA-TP-61499] p0143 N80-27799

BEERHBOAM, D. C.
Free-piston regenerative hot gas hydraulic engine
[NASA-CASE-LEN-12274-1] p0119 N80-31790

BEERS, L.
The method of lines in three dimensional fracture
mechanics [NASA-CH-159593] p0132 N80-32753

BEKEFOFC, P.
First results of material charging in the space
environment p0055 ABO-45609

BEKEFOFC, P. D.
Liquid metal slip ring [NASA-CH-159662] p0101 N80-18300

BEKERTY, A.
Multifuel rotary aircraft engine
[AIAA PAPER 80-1237] p0045 ABO-38962

BERATOMICOS, D. T.
Space solar cells: High efficiency and radiation
damage [NASA-TP-81387] p0138 N80-15554

BENT, R. T.
Preparation of cast aluminum alloy-mica particle
composites p0071 ABO-32632

BEATY, S.
Design study of a 15 kW free-piston Stirling
FLEXIBLE FORSULATED PLASTIC SEPARATORS FOR
ALKALINE BATTERIES
[SASA-CAST-82D5-41] P0040 W0-15555

AN ELECTRIC VEHICLE PROPULSION SYSTEM'S IMPACT ON
BATTERY PERFORMANCE: AN OVERVIEW
[SASA-TE-81515] P0013 W0-24756

CYCLES TILL FAILURE OF SILVER-ZINC CELLS WITH
COMPLETELY FAILED MODELS: PRELIMINARY DATA
[SASA-TE-81556] P0164 W0-29008

BRADLEY, R. N.
CONCEPTUAL DESIGN OF AN ORBITAL PROPELLANT
TRANSFER EXPERIMENT. VOLUME 2: STUDY RESULTS
[SASA-CH-165150] P0048 W0-31423

BRADFORD, R. D.
CAPILLARY ACQUISITION DEVICES FOR HIGH-PERFORMANCE
VEHICLES: EXECUTIVE SUMMARY
[SASA-MA-95658] P0062 W0-19185

BRAHAM, R. A.
IMPROVED ADHESION OF SPATTERED REFRACTORY CARBIDES
TO METAL SUBSTRATES
P0081 W0-25274

AN INVESTIGATION INTO THE ROLE OF ADHESION IN THE
ERODION OF DUCTILE METALS
[SASA-FP-89-58] P0122 W0-43155

IMPROVED REFRACTORY COATINGS AND METHOD OF
PRODUCING THE SAME
[SASA-CAST-15169-1] P0076 W0-16423

SCANNING-ELECTRON-MICROSCOPE STUDY OF
NORMAL-APPLIEMENT EROSION OF DUCTILE METALS
[SASA-TE-1605] P0077 W0-16181

AN INVESTIGATION INTO THE ROLE OF ADHESION IN THE
ERODION OF DUCTILE METALS
[SASA-TE-81556] P0076 W0-21489

BRAHMSTICK, R. W.
PHOTOVOLTAIC TECHNOLOGY DEVELOPMENT FOR
SYNCHRONOUS ORBIT
P0058 W0-33470

BRAHMS, H. W.
RADIATION DAMAGE IN HIGH VOLTAGE SILICON SOLAR CELLS
P0097 W0-33869

BRAHMS, H. W., JR.
RADIATION DAMAGE IN HIGH VOLTAGE SILICON SOLAR CELLS
P0079 W0-44234

BRAHMS, H.
RADIATION DAMAGE IN LITHIUM-COUNTERDOPED Z/P
SILICON SOLAR CELLS
[SASA-TE-13191] P0138 W0-15557

BRAHMS, J.
SPACE SOLAR CELLS: HIGH EFFICIENCY AND RADIATION
DAMAGE
[SASA-TE-81397] P0138 W0-15554

BRAHMS, J.
RADIATION DAMAGE IN HIGH VOLTAGE SILICON SOLAR CELLS
[SASA-TE-81478] P0178 W0-23180

BRAGG, R. T.
ON-BOARD PROCESSING CONCEPTS FOR FUTURE SATELLITE
COMMUNICATIONS SYSTEMS
[SASA-CH-159663] P0099 W0-24514

BRATTEN, R. J.
EVALUATION OF PRESENT-DAY THERMAL BARIER COATINGS
FOR INDUSTRIAL/UTILITY APPLICATIONS
P0092 W0-39637

BRENNAN, J. J.
DEVELOPMENT OF SILICON NITRIDE OF IMPROVED TOUGHNESS
[SASA-CH-159676] P0072 W0-10319

BRENNER, C. E.
A TEST PROGRAM TO MEASURE FLUID MECHANICAL
WHIRL-EXCITATION FORCES IN CONIFUGRAL PUMPS
P0126 W0-23719

BRENTI, D. K.
PRELIMINARY STUDY OF METHODS FOR PROVIDING THERMAL
SHOCK RESISTANCE TO PLASMA-SPRAYED CERAMIC
GAP-PATH SEAL
[SASA-TE-15161] P0067 W0-23453

BRIGGS, R. S.
A THREE-DIMENSIONAL TURBULENT COMPRESSIBLE
SUBSONIC DUCT FLOW ANALYSIS FOR USE WITH
CONSTRUCTED COORDINATE SYSTEMS
[AIAP PAPEK 60-1300] P0006 W0-41601

BROIT, J.
A DESIGN FOR A TELEC EXPERIMENT AT LEWIS RESEARCH CENTER
[SASA-CH-159712] P0113 W0-14286

BROOKS, B. M.
ACOUSTIC MEASUREMENTS OF THREE PROP-FAN MODELS
[AIAP PAPEK 60-09925] P0045 W0-35558

ADVANCED TURBO-PROP AIRPLANE INTERIOR NOISE
REDUCTION-SOURCE DEFINITION
[SASA-CH-159686] P0172 W0-13682

ACOUSTIC TESTS AND ANALYSES OF THREE ADVANCED
TURBOPROP MODELS
[SASA-CH-159667] P0039 W0-23311

BROOKS, J. D.
STUDY OF BLADE ASPECT RATIO ON A COMPRESSOR FRONT
STAGE
[SASA-CH-159556] P0040 W0-25333

BROOKS, J. P.
BALANCE APERTURE DESIGN STUDY OF HOWAT CARTEX
EQUATED A LOW-CARBON STEEL TUBE
[SASA-CH-165150] P0064 W0-33476

BRUCE, R. A.
AN 150 AND 300 KW LIGHTWEIGHT DIESEL AIRCRAFT
ENGINE DESIGN STUDY
[SASA-CH-3260] P0037 W0-20271

BRUCE, R. A.
DECEIT DESIGN STUDY OF A 186 KW LIGHTWEIGHT DIESEL
AIRCRAFT ENGINE
[SASA-CH-3261] P0038 W0-22326

BROWN, R. H.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS).
VOLUME 1: SUMMARY REPORT
[SASA-CH-159765] P0151 W0-24797

BROWN, R. H.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS).
VOLUME 2: ANALYTICAL APPROACH
[SASA-CH-159766] P0143 W0-28859

BROWN, R. H.
COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS).
VOLUME 4: ENERGY CONVERSION SYSTEMS
[SASA-CH-159768] P0155 W0-33859

BROWN, R. H.
LIMIT CYCLES OF A FLEXIBLE SHAFT WITH HYDRODYNAMIC
JOURNAL BEARINGS IN UNSTEADY REGIMES
P0127 W0-29725

BURNS, R. T.
FRAC TONGUE STRESS DETERMINATION OF AL2O3 USING
FOUR-POINT-BEND SPECIMENS WITH STRAIGHT-THROUGH
AND CHEVRON NOTCHES
P0090 W0-42085

BOUCKLE, R.
COMPLIANCE AND STRESS INTENSITY COEFFICIENTS FOR
SHORT BAR SPECIMENS WITH CHEVRON NOTCHES
P0133 W0-66032

BOUCKLE, R.
PERFORMANCE OF CHEVRON-NOTCH SHORT BAR SPECIMENS
IN DETERMINING THE FRACTURE TOUGHNESS OF SILICON
NITRIDE AND ALUMINUM OXIDE
P0090 W0-50696

BUCKE, R.
ASSESSMENT AND PRELIMINARY DESIGN OF AN ENERGY
BUFFER FOR REGenerative BRAKING IN ELECTRIC
VEHICLES
[SASA-CH-159756] P0184 W0-23216

BUCKET, R.
IMPROVED TRAVELING WAVE TUBES
[SASA-CH-159663] P0102 W0-44235

BUCKET, R.
IMPROVED TRAVELING WAVE TUBES
[SASA-CH-159676] P0102 W0-22598

BUCKET, R.
METAL-DIELECTRIC INTERACTIONS
P0061 W0-13067

THE FRICTION AND WEAR OF METALS AND BINARY ALLOYS
IN CONTACT WITH AN ABRASIVE GRIT OF SINGLE-CRYSTAL SILICON CARBIDE
[SASA-FP-79-5C-1] P0120 W0-14734

ADHESION AND FRICTION OF IRON-BASE BINARY ALLOYS
IN CONTACT WITH SILICON CARBIDE IN VACUUM
[SASA-TE-1604] P0076 W0-15234

TELEBRO, R.
PLATEN CUBERPROPERTIES OF SILICON CARBIDE IN
METAL REMOVAL PROCESSES
[SASA-TE-79238] P0114 W0-16340

WEAR PARTICLES OF SINGLE-CRYSTAL SILICON CARBIDE IN
VACUUM
[SASA-TE-1624] P0085 W0-18178

ADHESION, FRICTION, AND WEAR OF BINARY ALLOYS IN
CONTACT WITH SINGLE-CRYSTAL SILICON CARBIDE
[SASA-TE-79262] P0086 W0-21534

FRICTION AND WEAR OF IRON-BASE BINARY ALLOYS IN
SLIDING CONTACT WITH SILICON CARBIDE IN VACUUM
[SASA-TE-1612] P0067 W0-22494

BUCKET, R.
COMPUTATION OF THREE-DIMENSIONAL VISCOUS
SUPERSONIC FLOW IN INLETS
[AIAP PAPEK 60-01194] P0065 W0-23941

DEVELOPMENT OF A THREE-DIMENSIONAL SUPERSONIC
INLET FLOW ANALYSIS
[SASA-CH-3198] P0108 W0-14156

BUJOLD, R. F.
SMALL PASSENGER CAR TRANSMISSION TEST-CHEVROLET
200 TRANSMISSION
[SASA-CH-159635] P0105 W0-28255

SMALL PASSENGER CAR TRANSMISSION TEST; FORD C4
TRANSMISSION
[SASA-CH-159861] P0128 W0-31795

SMALL PASSENGER CAR TRANSMISSION TEST; CHEVROLET
LTV TRANSMISSION
CAGEAO, E. P.

Influence of coolant tube curvature on film cooling effectiveness as detected by infrared imagery

[WASA-79-1596] p0120 980-31796

BUCK, R. J.

Advanced screening of electrode couples

[WASA-79-1597] p0141 980-22777

BURROS, D. L.

Catalyst surfaces for the chromous/chromic redox couple

[WASA-CASE-LHE-11148-2] p0140 980-18557

BURTON, D. B.

Technique for determining the mechanical and physical properties of cerium oxide

[WASA-CR-159718] p0037 980-19111

BURRONE, J.

Cage, C. E.

Cogeneration Technology Alternatives Study (CTAS).

Volume 1: Summary

[WASA-91400] p0134 980-22733

BURRIS, J. W.

Oxygen-enriched air for HBE power plants

[p0096] 980-25096

BURRIS, J. M.

Economical space power systems

[WASA-159636] p0147 980-15559

BURRIS, J. W.

Some techniques for reducing the tower shadow of the ORNL/AA2 nod-0 wind turbine tower

[WASA-79-29202] p0137 980-10594

BURST, R. C.

Spectral effects on direct-absorption absorption of five collector coatings

[WASA PAPER 79-R2-10] p0146 980-45722

BURS, R. H.

Cogeneration Technology Alternatives Study (CTAS).

Volume 1: Summary

[WASA-91400] p0134 980-22733

BURST, R. N.

A study of the transmission characteristics of suppressor notches

[WASA-165133] p0172 980-32186

BURSOS, D.

Energy efficient engine

[WASA-159685] p0045 980-33408

BURSOS, D. L.

Quiet Clean Short-haul Experimental Engine (QCSEE). Double-annular clean combustor technology development report

[WASA-159685] p0045 980-33408

BURSEY, R. B.

Fracture toughness of brittle materials determined with chevron notch specimens

[WASA-91607] p0079 980-32486

BUSER, J. J.

Comparison tests and experimental compliance calibration of the proposed standard round compact plane strain fracture toughness specimen

[WASA-91379] p0132 980-13513

BUSER, D. C.

Characteristics of primary electric propulsion systems

[AIAA PAPER 79-2041] p0058 980-10376

Upper stages utilizing electric propulsion

[p0059] 980-29989

Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft

[WASA-91323] p0060 980-38975

Orbital transfer of large space structures with nuclear electric rockets

[AAS PAPER 80-08] p0054 980-41697

Upper stages utilizing electric propulsion

[WASA-91412] p0056 980-16097

Upper stages utilizing electric propulsion

[p0057] 980-30386

C

CAGEAO, E. P.

Influence of coolant tube curvature on film cooling effectiveness as detected by infrared imagery

[WASA-79-1596] p0133 980-11087

CAREL, R.

Advanced screening of electrode couples

[WASA-159736] p0141 980-22777

CAREL, R.

Catalyst faces for the chromous/chromic redox couple

[WASA-CASE-LHE-11148-1] p0140 980-18557

CARTER, J., JR.

Computerized video densitometry method for rapid analysis of infrared photographic images

[WASA-165150] p0143 980-24756

CATTIN, J. C.

A test program to measure fluid mechanical whirl-excitation forces in centrifugal pumps

[p0012] 980-29718

CAVAGH, J. R.

Planar sprayed dual density ceramic turbine seal system

[WASA-159739] p0123 980-15411

CAVA, R. J.

Second generation PEM polyamide/fiber composites

[p0072] 980-12118

CHAI, A. T.

The planar multijunction cell - A new solar cell

[p0176] 980-16194

CASSIDY, J.

A three-dimensional spacecraft-charging computer code

[p0055] 980-46891

CASTELL, V.

High speed cylindrical rolling element bearing analysis "STANLEY" - Analytic formulation

[AIAA PAPER 79-204] p0129 980-14761

CASTLEDEN, R. C.

An electric vehicle propulsion system's impact on battery performance: An overview

[WASA-TM-81515] p0143 980-24756

CHAI, A. T.

Back surface reflectors for solar cells

[WASA-TR-8130] p0133 980-15556

Planar multijunction high voltage solar cells

[WASA-TR-81309] p0176 980-16194

CAMPBELL, P. P.

Current jet fuel trends

[p0041] 980-29302

CARL, A. J.

Nuclear electric propulsion system utilization for lower stages utilizing electric propulsion

[WASA-159718] p0037 980-19111

CORE, J. A.

Study of blade aspect ratio on a compressor front stage

[WASA-159556] p0040 980-25333

CARD, H. K.

Diffusion bonded boron/aluminum spars-aiffel fan blade

[p0072] 980-25382

CARD, H. K.

Conceptual design of an orbital propellant transfer experiment. Volume 2: Study results

[WASA-165150] p0048 980-31423

CASTICHERS, E. D.

The 3500 hour durability testing of ceramic materials for automotive gas turbine engines

[AIAA PAPER 79-354] p0092 980-35757

CASTICHERS, E. D.

The 3500 hour durability testing of ceramic materials

[WASA-159785] p0091 980-31552

CASTICHERS, E. D.

A 15 kw (nominal) solar thermal-electric power conversion concept definition study: Steam Rankin recuperator system

[WASA-159591] p0149 980-19612

CASTICHERS, J. M.

Aerodynamic analysis of a supersonic cascade vibrating in a complex mode

[p0007] 980-45841

CATTIN, J.

A three-dimensional spacecraft-charging computer code

[p0055] 980-46891

CASSIDY, J.

A three-dimensional spacecraft-charging computer code

[p0055] 980-46891

CERON, R. E.

Computerized video densitometry method for rapid analysis of infrared photographic images

[WASA-165150] p0143 980-24756

CAYATES, J. C.

A test program to measure fluid mechanical whirl-excitation forces in centrifugal pumps

[p0012] 980-29718

CAYATES, J. C.

Planar sprayed dual density ceramic turbine seal system

[WASA-159739] p0123 980-15411

CAYATES, R. J.

Second generation PEM polyamide/fiber composites

[p0072] 980-12118

CASSIDY, J.

A three-dimensional spacecraft-charging computer code

[p0055] 980-46891

CETTLE, V.

High speed cylindrical rolling element bearing analysis "STANLEY" - Analytic formulation

[AIAA PAPER 79-204] p0129 980-14761

CASTLEDEN, R. C.

An electric vehicle propulsion system's impact on battery performance: An overview

[WASA-TM-81515] p0143 980-24756

CAYATES, J. C.

A test program to measure fluid mechanical whirl-excitation forces in centrifugal pumps

[p0012] 980-29718

CAYATES, J. C.

Planar sprayed dual density ceramic turbine seal system

[WASA-159739] p0123 980-15411

CAYATES, R. J.

Second generation PEM polyamide/fiber composites

[p0072] 980-12118

CASSIDY, J.

A three-dimensional spacecraft-charging computer code

[p0055] 980-46891

CETTLE, V.

High speed cylindrical rolling element bearing analysis "STANLEY" - Analytic formulation

[AIAA PAPER 79-204] p0129 980-14761

CASTLEDEN, R. C.

An electric vehicle propulsion system's impact on battery performance: An overview

[WASA-TM-81515] p0143 980-24756

CAYATES, J. C.

A test program to measure fluid mechanical whirl-excitation forces in centrifugal pumps

[p0012] 980-29718

CAYATES, J. C.

Planar sprayed dual density ceramic turbine seal system

[WASA-159739] p0123 980-15411

CAYATES, R. J.

Second generation PEM polyamide/fiber composites

[p0072] 980-12118

CASSIDY, J.

A three-dimensional spacecraft-charging computer code

[p0055] 980-46891
Combustion of solid carbon rods in zero and normal gravity [NASA-Th-79303] p0104 N80-13404

DICARLO, J. A.
Predicting the time-temperature dependent axial failure of B/Al composites [NASA-TP-80-14925] p0071 A80-35494

Dynamic modulus and damping of boron, silicon carbide, and alumina fibers [NASA-TP-80-14925] p0071 A80-44236

Dynamic modulus and damping of boron, silicon carbide, and alumina fibers [NASA-TP-80-14925] p0068 N80-20313

Predicting the time-temperature dependent axial failure of B/Al composites [NASA-TP-80-14925] p0069 N80-21452

DITTRICH, J. H.
Some techniques for reducing the tower shadow of the DOE/NASA mod-0 wind turbine tower [NASA-Th-79200] p0137 N80-10594


DIXON, L. A.
Emission reduction p0012 N80-10207

DITTRICH, M. E.
Energy conservation and environmental benefits of thermal energy storage systems in the pulp and paper industry p0146 A80-48194

Collection and dissemination of TS2 system information for the paper and pulp industry p0142 A80-22797

DITTMAR, J. N.
High-speed-propeller wind-tunnel aeroacoustic results p0016 N80-22344

A comparison between an existing propeller noise theory and wind tunnel data [NASA-Th-80-14519] p0169 N80-25101

DOBLE, P. X.
Concept definition study of small Brayton cycle engines for dispersed solar electric power systems [NASA-TP-80-14279] p0150 N80-22798

DOCNAV, G. H.

DOGBIS, W. J.
Advanced catalytic combustors for low pollutant emissions, phase 1 [NASA-TP-159535] p0028 N80-13048

NASA/General Electric broad-specification fuels combustion technology program, phase 1 p0042 N80-29316

DORIS, S.
Neutralization tests on the SERT II spacecraft [AIAA paper 79-2034] p0059 A80-10307

DONALD, G. H.
Analysis and identification of subsynchronous vibrations for a high pressure parallel flow centrifugal compressor p0125 N80-29710

DONOGHUE, P. L.
Communications technology satellite - United States experiments and disaster communications applications p0051 A80-10032

DOOLEY, J. P.
Assessment of satellite and aircraft multispectral scanner data for strip-mine monitoring [NASA-Th-79268] p0136 N80-20707

DOOLEY, R.
Torquing and electrostatic deformation of the solar sail p0065 A80-46901

DOMING, K. G.
Characterization of solar cells for space applications. Volume 10: Electrical characteristics of Spectrolab BHF, textured, 10 cm-cm, 300 micron cells as a function of intensity, temperature and irradiation [NASA-CR-162422] p0147 N80-11566

DOTY, W. N.
Field experiences with rotodynamic instability in high-performance turbomachinery p0125 N80-29707

DOYLE, V. L.
Core noise investigation of the CF6-50 turbofan engine [NASA-CR-159598] p0036 N80-16061
Core noise investigation of the CF6-50 turbofan engine [NASA-CR-159749] p0036 N80-16062

DRAKE, G. L.

DRAKE, G. N.
Three dimensional finite-element elastic analysis of a thermally cycled double-edge wedge geometry test specimen [NASA-TP-80908] p0079 N80-26433

DREISIG, D. H.

DUBSVIK, M. L.
Effects of thermally induced porosity on an am-HIP powder metallurgy superalloy p0082 A80-29990
Effects of fine porosity on the fatigue behavior of a powder metallurgy superalloy p0082 A80-35495
Application of superalloy powder metallurgy for aircraft engines p0122 A80-44240
Anisotropy of nickel-base superalloy single crystal p0063 A80-51573
Effect of thermally induced porosity on an a-HIP powder metallurgy superalloy [NASA-Th-79263] p0076 N80-11189
Application of superalloy powder metallurgy for aircraft engines [NASA-Th-791466] p0076 N80-21468
Effects of fine porosity on the fatigue behavior of a powder metallurgy superalloy [NASA-Th-79144] p0076 N80-21493

DURRANT, J. B.
Testing of turbulent models for rotodynamic coefficients p0126 N80-29714

DURRMA, R. E.
Effects of axisymmetric contractions on turbulence of various scales [NASA-CR-165136] p0006 A80-32236

DUDKIN, R. J.

DOGAN, J. F.
The NASA high-speed turboprop program [NASA-Th-81561] p0022 N80-31401

DOGAN, J. F., Jr.
Aircraft Energy Efficiency (ACEI) status report p0012 N80-10206

DUGGER, F.

DULBEVICH, D. S.
Numerical calculation of steady inviscid full potential compressible flow about wind turbine blades [AIAA 80-0607] p0145 A80-28804
Numerical calculation of transonic axial turbomachinery flows p0004 A80-44229
Numerical calculation of steady inviscid full potential compressible flow about wind turbine blades [NASA-Th-81438] p0136 N80-18497
CAS2D: FORTAN program for nonrotating blade-to-blade, steady, potential transonic cascade flows [NASA-Th-76105] p0003 N80-27284
Numerical calculation of transonic axial turbomachinery flows [NASA-Th-76104] p0020 N80-27363
The effect of finite turbulence spatial scale on the amplification of turbulence by a contracting stream

DDTA, S.

The state-of-the-art of characterization and properties of controlled industrial storage applications overview

DUSBA, D. J.

Nuclear reactor concept development and design

DUSBA, D. J.

Oxygen-enriched air for MHD power plants

DUSBA, D. J.

Analysis and design of a uniform-clearance, pumping-ring rod seal for the Stirling engine

DUSBA, D. J.

Dynamic response to rotating-coat rupture in non-contacting face seal

DUSBA, D. J.

Stability by means of computer generated movies

DUSBA, D. J.

Observation of pressure variation inside and outside the cavity region of submerged journal bearings

DUSBA, D. J.

A quantitative analysis of inter-island telephony traffic in the Pacific Basin Region (FBR)

DUSRA, E. A.

A methodology for long-range prediction of air transport

DUSRA, E. A.

A quantification of correlation and extrapolation methods for creep rupture data

DUSRA, E. A.

A planar silicon junction high voltage solar cell

DUSRA, E. A.

A planar silicon junction high voltage solar cell for earth and space

DUSRA, E. A.

An electric vehicle propulsion system for earth and space

DUSRA, E. A.

An electric vehicle propulsion system's impact on battery performance: An overview

DUSRA, E. A.

The effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

SiC oxidation behavior of a Si3N4-w ceramics

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.

Effect of starting powder characteristics on density, microstructure and low temperature oxidation behavior of a SiN-Mo 70-30 ceramic

DUSRA, E. A.

Characterization and properties of controlled nucleation thermochromic deposited (CMTD) silicon carbide

DUSRA, E. A.
FLIES, C. E.

Nasa broad-specification fuels combustion technology program: Status and description
(NASA-TM-79315)
WASA broad-specification fuels combustion technology program
p0014 N80-11426

FLIES, C. E.

Preparing aircraft propulsion for a new era in energy and the environment
p0021 N80-29313

Noise reduction
p0024 A80-17737

FERRETTI, J.

Consults on auger electron production by Ma/- bombardment of surfaces
p0174 A80-34046

Practical applications of surface analytic tools in tribology
(NASA-TM-81484)
p0079 N80-23430

FESTER, R. A.

A liquid hydrogen experiment as a Shuttle payload
(AIAA PAPER 80-1096)
p0054 A80-38909

FISCHER, J.

A digitally implemented communications experiment utilizing the communications technology satellite, Hermes
(NASA-TM-81452)
p0052 N80-21412

FISCHER, C. C.

Electric propulsion, circa 2000
(AIAA PAPER 80-0912)
p0059 A80-32866

Electric propulsion technology
p0057 N80-31452

Synchronous energy technology program
p0050 N80-33466

FISCHER, L. N.

Computerized systems analysis and optimization of aircraft engine performance, weight, and life cycle costs
p0165 A80-10035

Computer simulation of engine systems
(AIAPP PAPER 80-0051)
p0024 A80-16253

Computer simulation of engine systems
(NASA-TM-79290)
p0015 N80-5132

Computerized systems analysis and optimization of aircraft engine performance, weight, and life cycle costs
p0001 N80-21271

FISCHER, D. E.

Comparison tests and experimental compliance calibration of the proposed standard round compact plate strain fracture toughness specimen
(NASA-TM-81379)
p0132 N80-13513

FISCHER, W. J.

Diffusion bonded boron/aluminum spar-shell fan blade
p0072 N80-25302

FILKIN, R. D.

Instability thresholds for flexible rotors in hydrodynamic bearings
p0128 N80-29730

FILKIN, J. W.

Tungsten wire/foeCrAAI matrix turbine blade fabrication study
(NASA-CR-155768)
p0044 N80-29331

FILKIN, R. P.

Mechanical components
p0013 N80-10213

Damping in tapered annular seals for an incompressible fluid
(NASA-TP-1646)
p0116 N80-19495

Damping in ring seals for compressible fluid
p0119 N80-29716

FLEINING. R. C.

Directional solidification at ultra-high thermal gradient
(NASA-CR-159797)
p0096 N80-15300

FLIEHIN, D.

Balancing of a power-transmission shaft with the application of axial torque
(AIAA PAPER 80-02-143)
p0121 A80-42256

FLINES, J. J.

Fuels characterization studies
p0021 N80-29309

FLORES, R.

Preparation of multibeam, contiguous coverage satellite antenna for the USA
(AIAA 80-0557)
p0099 N80-29358

FOPPE, C. M.

Data analysis of F sub T/F sub S noseboom probe testing on F100 engine P680072 at NASA Lewis

PERSONAL AUTHOR INDEX

Research Center
(NASA-CR-159016)
p0038 N80-21334

POULIN, F. E.

Advanced electric propulsion system concept for electric vehicles
(NASA-CR-156531)
p0183 N80-17916

FORD, L. J.

Laser-optical blade tip clearance measurement system
(NASA-TM-81376)
p0111 N80-36137

Laser-optical blade tip clearance measurement system
p0115 N80-14128

FOURNIER, R.

Life test studies on tungsten impregnated cathodes
(NASA-TM-51441)
p0103 N80-65122

Thermionic cathode life test studies
(NASA-TM-51441)
p0101 N80-18302

FORZELL, A.

Heat exchanger and method of making
(NASA-CASE-LEW-12441-2)
p0105 N80-24573

FOX, T. A.

90-to-95 percent efficient collector for operation of a dual-mode traveling-wave tube in the linear region
p0102 A80-13909

Multistage depressed collector with efficiency of 90 to 96 percent for operation of a dual-mode traveling-wave tube in the linear region
(NASA-TM-1670)
p0101 N80-21669

FRALEY, T. O.

Method and apparatus for rapid thrust increases in a turbofan engine
(NASA-CASE-LEW-12971-1)
p0116 N80-18039

FRALEY, G. C.

Some dynamic and time-averaged flow measurements in a turbine rig
p0178 A80-21120

Dynamic behavior of a beam-drag force accelerometer
p0110 N80-24595

FRENNER, D. S.

Quiet Clean Short-haul Experimental Engine (QCPHEE) Under-The-Wing (UTW) composite nacelle subsystem test report
(NASA-CR-155075)
p0034 N80-15100

Quiet Clean Short-haul Experimental Engine (QCPHEE) Under-The-Wing (UTW) composite nacelle subsystem test report
(NASA-CR-155075)
p0034 N80-15100

FRENNER, S. E.

Instructions for the use of the CIVET-Jet 4C finite-strain computer code to calculate the transient structural responses of partial and/or complete arbitrarily-curved rings subjected to fragment impact
(NASA-CR-155873)
p0134 N80-27720

FRENNER, M.

Temperature and flow measurements on near-freezing aviation fuels in a wing-tank model
(NASA PAPER 80-0912)
p0094 A80-62193

Temperature and flow measurements on near-freezing aviation fuels in a wing-tank model
p0093 N80-13268

Fuel system technology overview
p0022 N80-29328

FROST, L. W.

Silicone modified resins for graphite fiber laminates
(NASA-CR-159750)
p0072 N80-22407

FRIEBURG, G. C.

Tao chemistry of sodium chloride involvement in processes related to hot corrosion
p0074 A80-10041

Chemical processes involved in the initiation of hot corrosion of P-1900 and NASA-SI-137758
(NASA-82-18399)
p0077 N80-17199

FAYE, R. J.

Power processing technology for spacecraft primary ion propulsion
p0065 A80-62685

FUCIOHKA, C. A.

Feasibility study of silicon nitride regenerators
(NASA-CR-159713)
p0184 N80-25309

Regenerator matrix physical property data
(NASA-CR-159854)
p0185 N80-30228

FUKUHARA, Y.

Asynchronous vibration problem of centrifugal compressor
p0125 N80-29713

FULLER, W.

A 15kWe (nominal) solar thermal electric power system
GATTI, A.
GAHBAUER, R.
GABEL, L. R.
FUSARGI, G.
GAMBLE, V. B.
GALLAGHER, J. L.
GABBIN, T.
FURNIN, E. T.
GABRISZESKI, T.

Comparison of thermal energy storage technologies for solar industrial process heat applications

Candid thermal energy storage technologies for solar industrial process heat applications

Effect of thermal aging on the tribological properties of polyimide films and polyimide-bonded graphite fluoride films

Mechanisms of lubrication and wear of a bonded solid-lubricant film

Mechanisms of lubrication and wear of a bonded solid lubricant film

Evaluation of feasibility of the 30/20 GHz fixed communications systems service

The 30/20 GHz fixed communications systems service

Low sidelobe level low-cost earth station antennas

The 18/30 GHz fixed communications system service

Low sidelobe level low-cost earth station antennas

Effect of thermal aging on the tribological properties of polyimide films and polyimide-bonded graphite fluoride films

Mechanisms of lubrication and wear of a bonded solid-lubricant film

Mechanisms of lubrication and wear of a bonded solid lubricant film

Comparison of the weight loss and adherence of nine different polyimide films thermally aged at 315 C and 350 C in air

Comparison of the tribological properties at 25 C of seven different polyimide films bonded to 301 stainless steel

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

The 18/30 GHz fixed communications system service
demand assessment. Volume 1: Executive summary

The 18/30 GHz fixed communications system service
demand assessment. Volume 2: Analytical approach

The 18/30 GHz fixed communications system service
demand assessment. Volume 3: Industrial processes

Improving bond coatings for use with thermal barrier coatings

Aerodynamic performances of three fan stator designs operating with rotor having tip speed of 337 meters per second and pressure ratio of 1:56. 1: Experimental performance

Improved bond coatings for use with thermal barrier coatings

Aerodynamic performances of three fan stator designs operating with rotor having tip speed of 337 meters per second and pressure ratio of 1:56. 1: Experimental performance

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

The 18/30 GHz fixed communications system service
demand assessment. Volume 1: Executive summary

The 18/30 GHz fixed communications system service
demand assessment. Volume 2: Analytical approach

The 18/30 GHz fixed communications system service
demand assessment. Volume 3: Industrial processes

Improving bond coatings for use with thermal barrier coatings

Aerodynamic performances of three fan stator designs operating with rotor having tip speed of 337 meters per second and pressure ratio of 1:56. 1: Experimental performance

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The 18/30 GHz fixed communications system service
demand assessment. Volume 1: Executive summary

The 18/30 GHz fixed communications system service
demand assessment. Volume 2: Analytical approach

The 18/30 GHz fixed communications system service
demand assessment. Volume 3: Industrial processes

Improving bond coatings for use with thermal barrier coatings

Aerodynamic performances of three fan stator designs operating with rotor having tip speed of 337 meters per second and pressure ratio of 1:56. 1: Experimental performance

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

The 18/30 GHz fixed communications system service
demand assessment. Volume 1: Executive summary

The 18/30 GHz fixed communications system service
demand assessment. Volume 2: Analytical approach

The 18/30 GHz fixed communications system service
demand assessment. Volume 3: Industrial processes

Improving bond coatings for use with thermal barrier coatings

Aerodynamic performances of three fan stator designs operating with rotor having tip speed of 337 meters per second and pressure ratio of 1:56. 1: Experimental performance

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

The 18/30 GHz fixed communications system service
demand assessment. Volume 1: Executive summary

The 18/30 GHz fixed communications system service
demand assessment. Volume 2: Analytical approach

The 18/30 GHz fixed communications system service
demand assessment. Volume 3: Industrial processes

Improving bond coatings for use with thermal barrier coatings

Aerodynamic performances of three fan stator designs operating with rotor having tip speed of 337 meters per second and pressure ratio of 1:56. 1: Experimental performance

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service

Low side lobel level low-cost earth station antennas for the 12 GHz broadcasting satellite service
ceramic thermal barrier coatings
[ASME PAPER 80-WA-28]  p0027 A80-48013
Effect of a ceramic coating on metal temperatures of an air-cooled turbine vane
[NASA-TP-1598]  p0105 N80-17397
GOLDRAE, J.

Similarity tests of turbine vanes, effects of ceramic thermal barrier coatings
[NASA-TP-1472]  p0105 N80-21706

Extension of similarity test procedures to cooled engine components with insulating ceramic coatings
GOLDRAE, P. W.

Effect of inflow control on inlet noise of a cut-on fan
[AIAA PAPER 80-1049]  p0171 A80-35953
Effect of inflow control on inlet noise of a cut-on fan
[AIAA PAPER-81447]  p0169 N80-23098

GOLGOW, E. R.

Zero-length, slotted-lip inlet for subsonic military aircraft
[AIAA PAPER 80-1245]  p0004 A80-141203

GOLGOW, J. C.

Tested, tip-controlled rotor - Preliminary test results from 50-0-100-kW experimental wind turbine
[AIAA-80-8462]  p0165 A80-28836
Tested, tip-controlled rotor: Preliminary test results from 50-0-100-kW experimental wind turbine
[AIAA-80-81495]  p0140 N80-19613

GOLGOW, L. E.

Reaction bonded silicon nitride prepared from wet attrition-silled silicon
[ASME PAPER 79-MA]  p0089 A80-32828
Formation of porous surface layers in reaction bonded silicon nitride during processing
[ASME-18563]  p0090 A80-51574

Materials and structures technology
[ASME-20013]  p012 N80-10210
Reaction bonded silicon nitride prepared from wet attrition-silled silicon
[NASA-TP-81428]  p0086 N80-18181
Formation of porous surface layers in reaction bonded silicon nitride during processing
[NASA-TP-81493]  p0087 N80-23456

GLASSMAN, A. J.

Loss model for off-design performance analysis of radial turbines with pivoting- vane, variable-area rotors
[NASA-81532]  p0020 A80-27356
Some advantages of methane in an aircraft gas turbine
[NASA-81559]  p0094 N80-29502

GLAVL, C. R.

Instrumentation technology
[ASME PAPER 79-WE]  p013 N80-10214

GLEEF, S. B.

Design, fabrication and testing of an optical temperature and sensing network
[NASA-CK-165125]  p0112 N80-31777

GLOBAL, R. E.

Improved fiber retention by the use of fillers in graphite fiber/resin matrix composites
[NASA-TP-81206]  p0071 A80-32066
Improved fiber retention by the use of fillers in graphite fiber/resin matrix composites
[NASA-81557]  p0067 N80-13171

GOODKRISEK, R. P.

Open-circuit voltage improvements in low resistivity solar cells
[NASA-8138]  p0138 N80-15555

GOODLAP, L. J.

Extension method for two-dimensional aerodynamic losses of cooled vanes using integral boundary-layer parameters
[NASA-TP-1623]  p0002 N80-17030

GOLDSTEIN, R. E.

Workshop report for the AIAA 5th Aeroacoustics Conference
[ASME PAPER 80-11556]  p0172 A80-41156
The effect of finite turbulence spatial scale on the amplification of turbulence by a contracting stream
[ASME PAPER-81566]  p0004 A80-48862

GOLITEIN, R. B.

Spray nozzle designs for agricultural aviation applications
[NASA-815702]  p0108 N80-10460

GOODKRECEK, J.

Noise suppression due to annulus shaping of a conventional coaxial nozzle
[ASME-18563]  p0171 A80-359497
Noise suppression due to annulus shaping of an inverted-velocity-profile coaxial nozzle
[ASME-18563]  p0171 A80-359489
Noise suppression due to annulus shaping of an inverted-velocity-profile coaxial nozzle
[NASA-81460]  p0168 N80-22046
Noise suppression due to annulus shaping of conventional coaxial nozzle
[NASA-81461]  p0168 N80-22047

GORDON, C.

The planar multijunction cell - A new solar cell for earth and space
[ASME PAPER-81546]  p0143 A80-46205
Planar multijunction high voltage solar cells
[NASA-81589]  p0176 N80-16914

GORDAN, A. L.

Impact of propulsion system B and D on electric vehicle performance and cont
[NASA-81548]  p0143 N80-27805

GORDAN, R. H.

An automatically-shifted two-speed transaxle system for an electric vehicle
[NASA-81570]  p0184 A80-18992

GORDON, L. H.

Engineering evaluation of a sodium hydroxide thermal energy storage module
[NASA-81417]  p0140 N80-18563
Program definition and assessment overview
[NASA-81428]  p0141 N80-22790

GOLLSIE, L. K.

Materials for advanced turbine engines. Volume 1: Power metallurgy/some HT rotor turbine engine parts
[NASA-81589]  p0176 N80-26499

GRABER, H. J.

The NASA high-speed turboprop program
[ASME-81561]  p0022 A80-31401

GRAHAM, A. E.

Characterization and properties of controlled nucleation thermochemical deposited CNTD/silicon carbide
[ASME-81563]  p0089 A80-13063
Characterization and properties of controlled nucleation thermochemical deposited (CNTD) silicon carbide
[ASME-81565]  p0085 N80-12524

GRAHAM, G. W.

Coolant tube curvature effects on film cooling as detected by infrared imagery
[ASME PAPER 79-MA]  p0107 A80-18638
Impact of new instrumentation on advanced turbine research
[ASME-81548]  p0112 A80-36155
Influence of coolant tube curvature on film cooling effectiveness as detected by infrared imagery
[NASA-TP-1546]  p0013 N80-11087
Impact of new instrumentation on advanced turbine research
[NASA-81501]  p0015 N80-15133
Some advantages of methane in an aircraft gas turbine
[NASA-81559]  p0094 N80-29502

GRAUMAN, W. F.

Measuring unsteady pressure on rotating compressor blades
[NASA-CK-159782]  p0110 A80-12630
Thin film temperature sensor
[NASA-81589]  p0176 N80-17425

GREENBERG, N.

The optimization air separation plants for combined cycle H&H-powers plant applications
[NASA-81510]  p0042 N80-23778

GREENBERG, G. H.

A theoretical and experimental investigation of propeller performance methodologies
[AIAA PAPER-80-1240]  p0026 A80-32003
An acoustic sensitivity study of general aviation propellers
[AIAA PAPER 80-1245]  p0045 A80-50191

GREENBERG, R. S.

Effect of velocity overshoot on the performance of magnetohydrodynamic subsonic diffusers
[NASA-81500]  p0175 N80-14922
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOBTA, R.</td>
<td>Comparison of several inflow control devices for quiet short-haul research aircraft (QSRA)</td>
</tr>
<tr>
<td>ROY, G. M.</td>
<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under the wing flight propulsion system analysis report</td>
</tr>
<tr>
<td>HORTON, J.</td>
<td>Hybrid composites that retain graphite fibers on burned surface</td>
</tr>
<tr>
<td>HOLLAND, L. D.</td>
<td>Laboratory measurements in a turbulent, swirling flow</td>
</tr>
<tr>
<td>HOLMES, A. G.</td>
<td>Plasma effects on direct-injection diesel engines</td>
</tr>
<tr>
<td>HONG, J. T.</td>
<td>System analysis for millimeter-wave communication satellites</td>
</tr>
<tr>
<td>HOOVER, D. Q.</td>
<td>System analysis report (NASA-CH-159600)</td>
</tr>
<tr>
<td>HONG, T. T.</td>
<td>Method of cross-linking polyvinyl alcohol and other water soluble resins</td>
</tr>
<tr>
<td>Hsu, L. C.</td>
<td>Preliminary studies of combusting sensitivity to alternative fuels</td>
</tr>
<tr>
<td>HULLER, J. T.</td>
<td>Electric propulsion, circa 2000</td>
</tr>
<tr>
<td>HUDSOM, J. A.</td>
<td>Development of a beaded/FRP-15 reduced drag DC-9 nacelle fairing</td>
</tr>
<tr>
<td>HUDSON, J.</td>
<td>An investigation of the initiation stage of hot corrosion in Ni-base alloys</td>
</tr>
<tr>
<td>HUDSON, J. H.</td>
<td>Preliminary study of combustor sensitivity to alternative fuels</td>
</tr>
<tr>
<td>HULL, L. G.</td>
<td>Development of a fiber optic-based aircraft structural health monitoring system</td>
</tr>
<tr>
<td>HUANG, T. Y.</td>
<td>Experimental evaluation of a spinning-mode acoustic-treatment design concept for aircraft inlet ducts</td>
</tr>
<tr>
<td>HUMPHRIES, T. S.</td>
<td>Development of exothermically cast single-crystal Mar-M 247 and derivative alloys</td>
</tr>
<tr>
<td>HUMPHREY, V. E.</td>
<td>Thermal fatigue and oxidation data for directionally solidified MAR-M247 turbine blades</td>
</tr>
<tr>
<td>HUNDRUP, P. V.</td>
<td>Stress corrosion cracking evaluation of martensitic precipitation hardened stainless steel nacelle fairings</td>
</tr>
<tr>
<td>HUNZIKI, A.</td>
<td>Communications technology satellite - United States experiments and disaster communications applications</td>
</tr>
<tr>
<td>HUST, R.</td>
<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under the wing flight propulsion system analysis report</td>
</tr>
<tr>
<td>HUST, R. N.</td>
<td>An investigation of the initiation stage of hot corrosion in Ni-base alloys</td>
</tr>
<tr>
<td>HUST, C. J.</td>
<td>Possible methods for distinguishing icebergs from ships by aerial remote sensing</td>
</tr>
<tr>
<td>HUSTEY, G.</td>
<td>Preliminary system analysis report (NASA-CH-159600)</td>
</tr>
<tr>
<td>HUST, B.</td>
<td>System analysis report (NASA-CH-159600)</td>
</tr>
<tr>
<td>HUST, H. C.</td>
<td>Negative streamer development in PTFE teflon</td>
</tr>
<tr>
<td>HUST, H. C.</td>
<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under the wing flight propulsion system analysis report</td>
</tr>
<tr>
<td>HUST, H. C.</td>
<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary over-the-wing flight propulsion system analysis report</td>
</tr>
<tr>
<td>HUST, H. C.</td>
<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
</tr>
<tr>
<td>HUST, H. C.</td>
<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
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<tr>
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<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
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<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
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<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
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<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
</tr>
<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
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<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
</tr>
<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
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<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
</tr>
<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
</tr>
<tr>
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<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary on-the-wing flight propulsion system analysis report</td>
</tr>
<tr>
<td>HUST, H. C.</td>
<td>Quiet Clean Short-Haul Experimental Engine (QCSEE) preliminary under-the-wing flight propulsion system analysis report</td>
</tr>
</tbody>
</table>
Effect of fuel molecular structure on soot formation in gas turbine combustion
Wind-tunnel investigation of the flow correction for a model-mounted angle of attack sensor at angles of attack from -10 deg to 110 deg
Durability testing of advanced catalysts and catalyst supports for gas turbine engine combustors

An improved prediction method for the noise generated in flight by circular jets
Static and transient performance of YP-102 engine
An improved prediction method for the noise of a 4 1/2 stage turbine with stage-loading factor of 4.66 and high specific work output. 2: Stage group performance
Description of the valve core turbine facility recently installed at NASA Lewis Research Center

Personal Author Index

Effect of fuel molecular structure on soot formation in gas turbine combustion
Wind-tunnel investigation of the flow correction for a model-mounted angle of attack sensor at angles of attack from -10 deg to 110 deg
Durability testing of advanced catalysts and catalyst supports for gas turbine engine combustors

Experimental aerodynamic and acoustic model
Consents on TEC trends
Core noise investigation of the CF6-50 turbofan
Feasibility of active feedback control of static and transient performance of YP-102 engine
An improved prediction method for the noise cold-air investigation of a 4 1/2 stage turbine

Potentialities of TEC topping: A simplified view
Flight test of navigation and guidance sensor
testing of the Variable Cycle Engine (VCE)

Design, fabrication and testing of an optical resistance and diffusion welding characteristics of Ti-6Al-20-1Ta-0.68o

Effect of fuel molecular structure on soot formation in gas turbine engines
Fuel quality combustion analysis

Fracture toughness determination of Al203 using four-point-bend specimens with straight-through and chevron notches
Compliance and stress intensity coefficients for short bar specimens with chevron notches
Performance of Chevron-notch short bar specimen in determining the fracture toughness of silicone nitride and aluminum oxide
Fracture toughness of brittle materials determined with chevron notch specimens
Analyis and identification of subsynchronous vibration for a high pressure parallel flow centrifugal compressor

Effects of axisymmetric contractions on turbulence of various scales
Effects of fuel molecular structure on soot formation in gas turbine engines

Measurements of cabin and ambient ozone on Boeing 747 airplanes
Simultaneous cabin and ambient ozone measurements on two Boeing 747 airplanes, volume 1

A comparison of experiment and theory for sound propagation in variable area ducts
NEPH, R. A.
Directional solidification at ultra-high thermal gradient
[NASA-CA-159/97] p0096 #80-15300

NELSON, D. P.
Griffith diffusers
[NASA-AR-20748] p0006 #80-20748

NELSON, B. E.
Experimental aerodynamic and acoustic model
testing of the Variable Cycle Engine (VCE)
testbed coannular exhaust nozzle system
[NASA-CA-159710] p0040 #80-26300
Experimental aerodynamic and acoustic model
testing of the Variable Cycle Engine (VCE)
testbed coannular exhaust nozzle system:
Comprehensive data report
[NASA-CA-159711] p0040 #80-26301

NELSON, J. E.
Strength corrosion cracking evaluation of
martensitic precipitation hardening stainless steels
[NASA-TM-88257] p0083 #80-16142

NEON, K.
Soot formation and burnout in flames
[NASA-AR-20748] p0043 #80-29320

NEWBERN, R. H.
An analytical and experimental study of a short
s-shaped nubonic diffuser of a supersonic inlet
[NASA-TM-89679] p0015 #80-15134

NEUSTADTER, H. E.
The use of wind data with an operational wind
turbine in a research and development environment
p0145 A80-25730
Preliminary analysis of performance and loads data
from the 2-megawatt mod-1 wind turbine generator
[NASA-TM-81408] p0139 #80-16494

NIKOLAS, J. N.
Analysis and identification of subsynchronous
vibration for a high pressure parallel flow
centrifugal compressor
p0125 #80-29710

NICHOLS, J.
Low NO(x) heavy fuel combustor program
[ASME PAPER 80-GT-69-69] p0026 A80-42199
Low NO(x) heavy fuel combustor program
[NASA-TM-79313] p0137 #80-13624

NIEDERREICH, W. C.
Instrumentation technology
p0013 #80-10214

NIEDERREICH, E. W.
Low NO(x) heavy fuel combustor program
[ASME PAPER 80-GT-69-69] p0026 A80-42199
Low NO(x) heavy fuel combustor program
[NASA-TM-79313] p0137 #80-13624

NIELSON, R. A.
Literature survey of properties of synfuels
[NASA-TP-1600] p0048 #80-22776

NICKRIS, C. J.
Preparation aircraft propulsion for a new era in
energy and the environment
p0024 A80-17737

Aircraft Energy Efficiency (ACER) status report
p0012 #80-10206

NORRIS, R. W.
Aircraft direct lift array testbed program
[NASA-CA-159758] p0037 #80-21331

NORRIS, H. G.
Calculation of water droplet trajectories to and
about arbitrary three-dimensional bodies in
potential airflow
[NASA-CA-3291] p0005 #80-28302

NORRIS, L. V.
Advances in propulsion system for hybrid vehicles
[NASA-CA-159771] p0184 #80-26212

NORTH, C. P.
Conceptual design of two-phase fluid mechanics and
heat transfer facility for spacecraft
[NASA-CA-159810] p0049 #80-27403

Determination of jet fuel thermal deposit rate
using a modified JFOT

NEUESCH, K.
Fluid forces on rotating centrifugal impeller with
whirling motion
p0127 #80-29724

OLSHON, B.
Effect of temperature on surface noise
p107 #80-28619

OLSON, R. A.
CATCNG catalyst 5 atm 1000 hour aging study using
No. 2 fuel oil
p0075 A80-35508

Durability testing at 5 atmospheres of advanced
catalysts and catalyst supports for gas turbine
engine combustors
[NASA-CA-159839] p0151 #80-24748

OLSSON, B. J.
J27A-9A /SP/ jet engine performance deterioration
trends
p0026 #80-44230

J27A-9A (SP) jet engine performance deterioration
trends
[NASA-TM-81459] p0016 #80-20274

OREILLER, R. F.
Cooperative thermal analysis of alternate
Cryogenic Fluid Management Experiment (CPM)
configurations
[NASA-CA-163151] p0048 #80-32412

O'REILLY, T. W.
Simple spline-function equations for fracture
mechanics calculations
p0133 A80-10832

A relation between semiempirical fracture analyses
and H-curves
p0132 #80-15628

ORDIN, R. A.
Mechanical impact tests of materials in oxygen
effects of contamination
[NASA-TP-15771] p0093 #80-21551

OSGOOD, J. T.
CATCNG catalyst 5 atm 1000 hour aging study using
No. 2 fuel oil
p0075 A80-35508

Durability testing at 5 atmospheres of advanced
catalysts and catalyst supports for gas turbine
engine combustors
[NASA-CA-159839] p0151 #80-24748

OTTOBERN, D. A.
Sulfate and nitrate collected by filter sampling
near the tropopause
[NASA-TP-1567] p0157 #80-14581

OAKES, J. E.
CF6-6D engine short-term performance deterioration
[NASA-CA-159830] p0039 #80-22316

PALMER, J. M.
Cogenereation Technology Alternatives Study (CTAS).
Volume 3: Industrial processes
[NASA-CA-159767] p0155 #80-31870

PARBEE, R. C.
Baseline automotive gas turbine engine development
program
[NASA-CA-159670] p0124 #80-24620

Conceptual design of an improved automotive
gas turbine powertrain
[NASA-CA-159672] p0124 #80-24621

Upgraded automotive gas turbine engine design and
development program, volume 2
[NASA-CA-159671] p0128 #80-32714

PAPKIS, M. H.
Coolant tube curvature effects on film cooling as
detected by infrared imagery
[ASME PAPER 79-NA/GT-71] p1007 A80-16639

Influence of coolant tube curvature on film
cooling effectiveness as detected by infrared
imagery
[NASA-TP-1546] p0013 A80-11087

PARKER, J. A.
Conceptual design of an orbital propellant
transfer experiment. Volume 2: Study results
[NASA-CA-165150] p0046 #80-31423

PARKER, R. J.
Performance of computer-optimized tapered-roller
bearings to 2.4 million DH
INVESTIGATION INTO THE EFFECT OF PLASMA TREATMENT ON THE ADHESION OF PARAFFIN TO VARIOUS SUBSTRATES
(M. A. RISBROOK, p0066 ABO-25900)

CARBON MONOXIDE ACQUISITION DEVICES FOR HIGH-PERFORMANCE VEHICLES: EXECUTIVE SUMMARY
(M. A. ROBERTS, p0114 NBO-13473)

LARGE WIND TURBINES: A UTILITY OPTION FOR THE GENERATION OF ELECTRICITY
(M. A. ROBERTS, p0062 NBO-19185)

COMPUTERIZED VIDEO DENSITOMETRY METHOD FOR RAPID ANALYSIS OF INFRARED PHOTOGRAPHIC IMAGES
(M. A. ROBERTS, p0114 NBO-32385)

PRELIMINARY RESULTS OF FAST NEUTRON TREATMENTS IN CARCINOMA OF THE PANCREAS
(M. A. ROBERTS, p0160 NBO-24983)

OFF-DESIGN CORRELATION FOR LOSES DUE TO PART-SPAN DAMPERS ON AERONAUTIC RODORS
(M. A. ROBERTS, p0020 NBO-28352)

INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA
(M. A. ROBERTS, p0176 NBO-14423)

INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA
(M. A. ROBERTS, p0062 NBO-24362)

INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA
(M. A. ROBERTS, p0177 NBO-32223)

ROCHE, J. C.
A THREE-DIMENSIONAL SPACECRAFT-CHARGING COMPUTER CODE
(p0055 ABO-46691)

ROCHE, J. A.
PHOTOLECTRON CHARGE DENSITY AND TRANSPORT NEAR DIFFERENTIAL CHARGED SPACECRAFT
(p0053 ABO-19773)

NASA MODELLING OF ENVIRONMENTAL-CHARGING-INDUCED DISCHARGES IN SATELLITES
(p0056 ABO-19774)

INITIAL COMPARISON OF SSPP GROUND TEST RESULTS AND FLIGHT DATA TO NASCAP SIMULATIONS
(p0056 ABO-29975)

RODAL, J. J. A.
TWO-DIMENSIONAL FINITE-ELEMENT ANALYSES OF SIMULATED Rotor-Fragment IMPACTS AGAINST RINGS AND BEAMS COMPARED WITH EXPERIMENTS
(M. A. ROBERTS, p0036 NBO-22323)

INSTRUCTIONS FOR THE USE OF THE CIVM-ACT 4C FINITE-STRAIN COMPUTER CODE TO CALCULATE THE TRANSIENT RESPONSE OF PARTIAL AND/OR COMPLETE ARBITRARILY-CURVED RINGS SUBJECTED TO FRAGMENT IMPACT
(M. A. ROBERTS, p0134 NBO-27720)

FINITE-STRAIN LARGE-DEFLECTION ELASTIC-VISCOPLASTIC FINITE-ELEMENT TRANSIENT RESPONSE ANALYSIS OF STRUCTURES
(M. A. ROBERTS, p0134 NBO-29762)

RODRIGUEZ-ANTONES, A.
PRELIMINARY RESULTS OF FAST NEUTRON TREATMENTS IN CARCINOMA OF THE PANCREAS
(M. A. ROBERTS, p0160 NBO-24983)

ROEHL, H. J.
AN EXPERIMENTAL EVALUATION OF THE PERFORMANCE DEFICIT OF AN AIRCRAFT ENGINE STARTER TURBINE
(p0022 ABO-31400)

ROGERS, D. A.
PARAMETRIC STUDY OF PROSPECTIVE EARLY COMMERCIAL MHD POWER PLANTS (PSPEC). GENERAL ELECTRIC COMPANY, TASK 1: PARAMETRIC ANALYSIS
(M. A. ROBERTS, p0099 NBO-46410)

ROGERS, J. B.
THE 18/30 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT: VOLUME 1: EXECUTIVE SUMMARY
(M. A. ROBERTS, p0099 NBO-21674)

THE 18/30 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT: VOLUME 2: MAIN TEXT
(M. A. ROBERTS, p0099 NBO-22347)

THE 30/20 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT: VOLUME 3: APPENDIX
(M. A. ROBERTS, p0099 NBO-22549)

ROGERS, R. F.
AERIAL APPLICATIONS DISPARATE SYSTEMS CONTROL REQUIREMENTS STUDY
(M. A. ROBERTS, p0099 NBO-22549)

BROOKS, J. E.
PREPARATION OF CERAMIC ALUMINUM ALLOY-SILica PARTICLE COMPOSITES
(p0071 ABO-32632)

BROOKS, D. A.
CONSTRAINED FATIGUE LIFE OPTIMIZATION OF A NASVITIS MULTICULLER Traction DRIVE
(p0122 ABO-46407)

EVALUATION OF A HIGH PERFORMANCE FIXED-RATIO TRACTION DRIVE
(p0122 ABO-46410)

SIMPLIFIED FATIGUE LIFE ANALYSIS FOR TRACTION DRIVE CONTACTS
(p0132 ABO-46413)

SIMPLIFIED FATIGUE LIFE ANALYSIS FOR INERT GAS THRUSTERS
(p0115 NBO-17469)

EVALUATION OF A HIGH PERFORMANCE FIXED-RATIO TRACTION DRIVE
(p0115 NBO-18404)

CONSTRAINED FATIGUE LIFE OPTIMIZATION OF A NASVITIS MULTICULLER Traction DRIVE
(p0116 NBO-18407)

PARAMETRIC TESTS OF A TRACTION DRIVE RETROFITTED TO AN AUTOMOTIVE GAS TURBINE
(p0117 NBO-21754)

BROUSSE, R. J.
IMPROVED FPP OPERATIONS - 400-HOUR TURBINE TEST RESULTS
(p0145 ABO-39369)

FACTORS AFFECTING CLEANUP OF EXHAUST GASES FROM A PRESSURIZED, FLUIDIZED-BED COAL COMBUSTOR
(M. A. ROBERTS, p0105 NBO-20532)

IMPROVED FPP OPERATIONS: 400-HOUR TURBINE TEST RESULTS
(M. A. ROBERTS, p0079 NBO-26426)

BROAN, A. J.
PARAMETRIC STUDY OF PROSPECTIVE EARLY COMMERCIAL MHD POWER PLANTS (PSPEC). GENERAL ELECTRIC COMPANY, TASK 1: PARAMETRIC ANALYSIS
(M. A. ROBERTS, p0152 NBO-26779)

BRODERICK, R. F.
HYDROGEN HYDROGEN CATHODE ION SOURCE
(p0174 NBO-33166)

BROE, C.
AIRCRAFT PROPULSION COMPONENT TECHNOLOGIES
(p0024 ABO-37842)

BROSHAM, D.
COMPUTER PROGRAM FOR GENERATING INPUT FOR ANALYSIS OF IMPREGNATION-COOLED, AXIAL-FLOW TURBINE BLADES
(M. A. ROBERTS, p0104 NBO-15361)

BROOKS, D. E.
EFFECT OF DEPOSITION OF CONDENSABLE IMPURITIES ON SURFACES INSERRED IN COMBUSTION GASES
(M. A. ROBERTS, p0023 ABO-15130)

EXPERIMENTAL STUDIES OF THE FORMATION/Deposition OF NITROGEN SULFATE IN/COMBUSTION GASES
(M. A. ROBERTS, p0033 NBO-15131)

BROPE, J. E.
THE EFFECT OF A WEAK VERTICAl MAGNETIC FIELD ON FLUCTUATION-INDUCED TRANSPORT IN A BUDDY-FORS PLASMA
(M. A. ROBERTS, p0176 ABO-25476)

BROOKS, H. A.
EXPERIMENTAL DETERMINATION OF UNSTEADY STEEL ELEMENT AERODYNAMICS IN CASCADES: VOLUME 1: TRANSITION NOSE CASCADE
(M. A. ROBERTS, p0040 ABO-25335)

BROOKS, A. F.
THE EROSION/Corrosion OF SMALL SUPERALLOY TURBINE ROTORS OPERATING IN THE EFFLUENT OF A FBB COAL COMBUSTOR
(p0080 ABO-10043)

BROOKS, A. G.
A THREE-DIMENSIONAL SPACECRAFT-CHARGING COMPUTER CODE
(p0055 ABO-46891)

BULLOCK, D. L.
DEVELOPMENT OF IMPROVED-DURABILITY PLASMA SPRAYED CERAMIC COATINGS FOR GAS TURBINE ENGINES
(M. A. ROBERTS, p0099 ABO-38963)

BULLOCK, D. L.
DEVELOPMENT OF IMPROVED-DURABILITY PLASMA SPRAYED CERAMIC COATINGS FOR GAS TURBINE ENGINES
(M. A. ROBERTS, p0115 ABO-23313)

BUDDE, J. A.
APPLICATION OF ADVANCED ON-BOARD PROCESSING CONCEPTS TO FUTURE SATELLITE COMMUNICATIONS SYSTEMS
(p0158 ABO-16866)
SHANNON, L.

Performance of Chevron-notch short bar specimen in determining the fracture toughness of silicium nitride and alumina oxide on [NASA-TM-81456]

Fracture toughness of brittle materials determined with chevron-notch specimen [NASA-TM-81607]

SHEIBLET, S. H.

Thermal energy storage systems using fluidized bed heat exchangers [NASA-CH-159866]

SHEIKH, A. R.

Nonparametric function generation routines for 16-bit microprocessors [NASA-CH-159866]

SHEIN, S. P.

Experimental and theoretical investigation for the suppression of the planar arc drop in the thermonuclear converter [NASA-CH-159611]

SHEVEN, E.

Reaction bonded silicon nitride prepared from wet attrition-sieved silica [NASA-TM-81428]

SHEBLY, M.

Formation of porous surface layers in reaction bonded silicon nitride during processing [NASA-TM-81493]

SHEPPLE, J. D.

Long-time creep behavior of the tantalum alloy Hastelloy X11C [NASA-TM-81619]

SHEPPLE, J. R.

Method of cross-linking polyvinyl alcohol and other water soluble resins [NASA-CR-239-13103-1]

SHER, S. F.

Non-synchronous whirling due to fluid-dynamic forces in axial turbo-machinery rotors [NASA-CH-159776]

SHERMAN, Y.

A calculation procedure for viscous flow in turbomachines, volume 3 [NASA-CH-159864]

Shing, G. C.

Sudden stretching of a four layered composite plate [NASA-CH-159970]

SILVA, J. E.

Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures [AIAA PAPER 80-1223]

Simpson, R. E.

Aerial applications dispersal systems control requirements study [NASA-TM-159781]

SINCLAIR, J. H.

Mechanical property characterization of intraply hybrid composites [NASA-TM-815980]

SING, J.

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of IN-100, IN-700, IN-792, and MAR-M-509 [NASA-CH-159776]

SIDDIQI, H.

Conceptual design of an orbital propellant transfer experiment. Volume 2: Study results [NASA-CH-165150]

SIDDIQI, S. M.

Effect of sodium, potassium, magnesium, calcium, and chlorine on the high temperature corrosion of IN-100, U-700, IN-792, and MAR-M-509 [NASA-CH-159776]

SINHH, G. K.

Summary of NASA QCGAT program [NASA-CH-159860]

SINGHAL, R. N.

Performance of computer-optimized tapered-roller bearings to 2.4 million lbf [NASA-CH-159860]

SPELMAN, M.

Elastic and thermal properties of outer gas path seal components subjected to off-axis tensile loads [NASA-CH-159776]

SPELMAN, M.

Elastic and thermal properties of outer gas path seal components subjected to off-axis tensile loads [NASA-CH-159776]

SPELMAN, M.

Elastic and thermal properties of outer gas path seal components subjected to off-axis tensile loads [NASA-CH-159776]

SPELMAN, M.

Elastic and thermal properties of outer gas path seal components subjected to off-axis tensile loads [NASA-CH-159776]

SPELMAN, M.

Elastic and thermal properties of outer gas path seal components subjected to off-axis tensile loads [NASA-CH-159776]
Analytical prediction and experimental verification of TNT and depressor collector performance using multidimensional computer programs

A matrix solution for the simulation of magnetic fields with ideal current loops

Two-dimensional representations of axisymmetric fields for computer calculations

NASA communications technology research and development

First results of material charging in the space environment

Initial comparison of SSPM ground test results and flight data to NASCAP simulations

The chemistry of sodium chloride involvement in processes related to hot corrosion

Combustion of solid carbon rods in zero and normal gravity

Combustion of solid carbon rods in zero and normal gravity

Chemical processes involved in the initiation of hot corrosion of B-1900 and NASA-TN-V

Performance of two-layer thermal barrier systems on directionally solidified W-Al-Ni and comparative effects of alloy thermal expansion on system life

Thermal barrier coatings for aircraft gas turbines

Effects of yttrium, aluminium and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers

Effects of yttrium, aluminium and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers

Performance of two-layer thermal barrier systems on directionally solidified W-Al-Ni and comparative effects of alloy thermal expansion on system life

Moondisperse atomizers for agricultural aviation applications

A three-dimensional spacecraft-charging computer code

Plasma collection by high voltage spacecraft at low earth orbit

An implicit finite-difference code for inviscid and viscous cascade flow

Cost analysis of composite fan blade manufacturing processes

Anodic polarization behavior of austenitic stainless steel alloys with low chromium content

Strengthening of tough iron-12% nickel-alloyed gamma/gamma prime-aluminum-beta eutectic alloy in a thermal gradient

High toughness-high strength iron alloy

Creep-rupture behavior of seven iron-base alloys after long term aging at 760 deg in low pressure hydrocarbons

The 30/20 GHz fixed communications systems service demand assessment. Volume 3: Annex

Modified power law equations for vertical wind profiles

Stability of several oxide dispersion strengthened alloys and a directionally solidified gamma/gamma prime-alpha eutectic alloy in a thermal gradient

Modification of large wind turbine generators

NOMENCLATURE, N.

Analytical prediction and experimental verification of TNT and depressed collector performance using multidimensional computer programs

A matrix solution for the simulation of magnetic fields with ideal current loops

Two-dimensional representations of axisymmetric fields for computer calculations

NASA communications technology research and development

First results of material charging in the space environment

Initial comparison of SSPM ground test results and flight data to NASCAP simulations

The chemistry of sodium chloride involvement in processes related to hot corrosion

Combustion of solid carbon rods in zero and normal gravity

Combustion of solid carbon rods in zero and normal gravity

Chemical processes involved in the initiation of hot corrosion of B-1900 and NASA-TN-VII

Performance of two-layer thermal barrier systems on directionally solidified W-Al-Ni and comparative effects of alloy thermal expansion on system life

Thermal barrier coatings for aircraft gas turbines

Effects of yttrium, aluminium and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers

Effects of yttrium, aluminium and chromium concentrations in bond coatings on the performance of zirconia-yttria thermal barriers

Performance of two-layer thermal barrier systems on directionally solidified W-Al-Ni and comparative effects of alloy thermal expansion on system life

Moondisperse atomizers for agricultural aviation applications

A three-dimensional spacecraft-charging computer code

Plasma collection by high voltage spacecraft at low earth orbit

An implicit finite-difference code for inviscid and viscous cascade flow

Cost analysis of composite fan blade manufacturing processes

Anodic polarization behavior of austenitic stainless steel alloys with low chromium content

Strengthening of tough iron-12% nickel-alloyed gamma/gamma prime-alpha eutectic alloy in a thermal gradient

High toughness-high strength iron alloy

Creep-rupture behavior of seven iron-base alloys after long term aging at 760 deg in low pressure hydrocarbons

The 30/20 GHz fixed communications systems service demand assessment. Volume 3: Annex
<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stirring engine development</td>
<td>[NASA-TN-81460]</td>
<td></td>
</tr>
<tr>
<td>TOYIN000, O. A.</td>
<td>Concepts and techniques for ultrasonic evaluation of material mechanical properties [NASA-TN-81573]</td>
<td>p0112 A0-48233</td>
</tr>
<tr>
<td>TOWSHER, D. F.</td>
<td>NASA year research and its probable effect on rotorcraft transmission design [NASA-TR-81480]</td>
<td>p0120 A0-13006</td>
</tr>
<tr>
<td>TURCOT, A.</td>
<td>Preliminary results of fast neutron treatments in carcinoma of the pancreas [NASA-TR-81516]</td>
<td>p0160 N0-24983</td>
</tr>
<tr>
<td>TURNER, R.</td>
<td>High temperature thermal energy storage in steel and sand [NASA-TR-81570]</td>
<td>p0154 N0-29060</td>
</tr>
<tr>
<td>TURNER, G.</td>
<td>Preliminary study of VTO thrust requirements for a V/STOL aircraft with lift plus lift/cruise propulsion [NASA-TR-81429]</td>
<td>p0016 N0-19110</td>
</tr>
<tr>
<td>VASILKOV, V.</td>
<td>Simulation of transducer-coupled effects on broadband ultrasonic signals [NASA-TN-81480]</td>
<td>p0130 A0-51575</td>
</tr>
<tr>
<td>VASILKOV, Y. R.</td>
<td>An experimental investigation of superag gear tooth tooth temperature as affected by operating variables [NASA-TR-81480]</td>
<td>p0120 A0-46412</td>
</tr>
<tr>
<td>VASILKOV, Y. R.</td>
<td>Analytical and experimental spur gear tooth tooth temperature as affected by operating variables [NASA-TR-81480]</td>
<td>p0120 A0-46412</td>
</tr>
<tr>
<td>VICTORIA, D.</td>
<td>Amplification of Reynolds number dependent on flow processes by wave distortion [NASA-TR-81572]</td>
<td>p0075 N0-13193</td>
</tr>
<tr>
<td>VINOGRADO, A.</td>
<td>An electric propulsion long term test facility [AIAA PAPER 79-2080]</td>
<td>p0045 A0-13308</td>
</tr>
<tr>
<td>VIELLE, J.</td>
<td>Reduced bleed air extraction for DC-10 cabin air conditioning [AIAA PAPER 80-1199]</td>
<td>p0010 A0-41194</td>
</tr>
<tr>
<td>VINCENTI, R.</td>
<td>Engine bleed air reduction in DC-10 [NASA-TR-81584]</td>
<td>p0010 A0-32378</td>
</tr>
<tr>
<td>VITETTI, R.</td>
<td>Mechanical properties in metals, composites and ceramics [NASA-TR-81475]</td>
<td>p0091 MO-15264</td>
</tr>
<tr>
<td>VISSCHER, M.</td>
<td>A phenomenological model of the dynamic stall of a helicopter blade profile [NASA-TR-81480]</td>
<td>p0006 A0-20066</td>
</tr>
<tr>
<td>VOSGLANN, O.</td>
<td>Noise suppression due to annulus shaping of a conventional coaxial nozzle [NASA-TR-81480]</td>
<td>p0139 A0-16494</td>
</tr>
<tr>
<td>VRANOS, A.</td>
<td>An experimental investigation of endwall profiling in a turbine vane cascade [AIAA PAPER 80-1069]</td>
<td>p0004 A0-38904</td>
</tr>
<tr>
<td>VASSAHI, N.</td>
<td>High char size-modified epoxy matrix composites [NASA-TR-81457]</td>
<td>p0026 A0-42258</td>
</tr>
<tr>
<td>VASILKOV, Y. R.</td>
<td>High char size-modified epoxy matrix composites [NASA-TR-81457]</td>
<td>p0026 A0-42258</td>
</tr>
<tr>
<td>VASY, A.</td>
<td>Prediction of fragment velocities and trajectories [NASA-TR-81457]</td>
<td>p0026 A0-16210</td>
</tr>
</tbody>
</table>
### CORPORATE SOURCE INDEX

#### Typical Corporate Source Index Listing

<table>
<thead>
<tr>
<th>CORPORATE SOURCE</th>
<th>TITLE</th>
<th>REPORT NUMBER</th>
<th>PAGE NUMBER</th>
<th>ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRW, INC., CLEVELAND, OHIO.</td>
<td>Tungsten wire/FeCrAl matrix turbine blade fabrication study</td>
<td>[NASA-CR-159665]</td>
<td>p0044 W00-29331</td>
<td></td>
</tr>
<tr>
<td>AEROFORCE LIQUID ROCKET CO., SACRAMENTO, CALIF.</td>
<td>Performance of a transpiration-regenerative cooled rocket thrust chamber</td>
<td>[NASA-CR-159742]</td>
<td>p0061 W00-14182</td>
<td></td>
</tr>
<tr>
<td>AEROSPACE CORP., EL SEGUNDO, CALIF.</td>
<td>Low-thrust chemical rocket engine study</td>
<td>[AAS PAPER 80-083]</td>
<td>p0055 NH0-30-4967</td>
<td></td>
</tr>
<tr>
<td>AEROSPACE CORP., LOS ANGELES, CALIF.</td>
<td>Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures</td>
<td>[AIAA PAPER 80-0236]</td>
<td>p0054 W00-29751</td>
<td></td>
</tr>
<tr>
<td>AEROSPACE CORP., MOUNTAIN VIEW, CALIF.</td>
<td>Synthesis of improved phenolic resins</td>
<td>[NASA-CR-159724]</td>
<td>p0091 W00-17221</td>
<td></td>
</tr>
<tr>
<td>AIR FORCE AERO PROPULSION LAB., WEIGHT-PATTERSON APB, OHIO.</td>
<td>Military jet fuel from shale oil</td>
<td>[NASA-CR-159665]</td>
<td>p0042 W00-25308</td>
<td></td>
</tr>
<tr>
<td>AIR FORCE AEROSPACE LAB., HAMSCO APB, MASS.</td>
<td>A three-dimensional spacecraft-charging computer code</td>
<td>[NASA-CR-159665]</td>
<td>p0055 W00-46691</td>
<td></td>
</tr>
<tr>
<td>AIR FORCE MATERIALS LAB., WEIGHT-PATTERSON APB, OHIO.</td>
<td>Boundary lubrication, thermal and oxidative stability of a fluorinated polyether and a perfluoropolyether triazine</td>
<td>[AISL PREPRINT 79-AM-18-1]</td>
<td>p0088 W00-12089</td>
<td></td>
</tr>
<tr>
<td>AIR FORCE MATERIALS LAB., WEIGHT-PATTERSON APB, OHIO.</td>
<td>Characterization and properties of controlled nucleation thermochemical deposited /CVD/ silicon carbide</td>
<td></td>
<td>p0089 W00-13063</td>
<td></td>
</tr>
<tr>
<td>AEROSPACE CORP., LOS ANGELES, CALIF.</td>
<td>Synthesis of improved polyester resins</td>
<td>[AIRESERCH-21-3542]</td>
<td>p0092 W00-35575</td>
<td></td>
</tr>
<tr>
<td>AIRSEARCH MFG. CO., PHOENIX, ARIZ.</td>
<td>Airesearch CQAT program</td>
<td>[NASA-CR-159758]</td>
<td>p0087 W00-21331</td>
<td></td>
</tr>
<tr>
<td>AIRSEARCH MFG. CO., TORRANCE, CALIF.</td>
<td>Synthesis of improved phenolic resins</td>
<td>[NASA-CR-159742]</td>
<td>p0100 W00-22778</td>
<td></td>
</tr>
<tr>
<td>ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.</td>
<td>Nuclear electric rockets</td>
<td>[NASA-CR-159817]</td>
<td>p0055 W00-30-4969</td>
<td></td>
</tr>
<tr>
<td>APPLIED MEDICAL TECHNOLOGY, CLEVELAND HEIGHTS, OHIO.</td>
<td>Constrained fatigue life optimization of a NASVYTIS multiroller traction drive</td>
<td>[NASA-CR-159817]</td>
<td>p0115 W00-33478</td>
<td></td>
</tr>
<tr>
<td>ARMED AVIATION RESEARCH AND DEVELOPMENT CORPS., CLEVELAND, OHIO.</td>
<td>Computer program for generating input for analysis of impingement-cooled, axial-flow turbine blade</td>
<td>[NASA-TP-1603]</td>
<td>p0100 W00-15361</td>
<td></td>
</tr>
<tr>
<td>ARMED AVIATION RESEARCH AND DEVELOPMENT CORPS., CLEVELAND, OHIO.</td>
<td>First results of material charging in the space environment</td>
<td></td>
<td>p0089 W00-13063</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The title of the document is used to provide a brief description of the subject matter. The page number and NASA or AIAA accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.
and composition of JP-5
Fuel property effects in stirred combustors
[ASA 80-10590] p0065 $00-29306
[ASA 80-20048] p0043 $00-29321

**F**

FISHER MATERIALS, INC., BIDDEFORD, MAINE.
Fabrication and evaluation of low fiber content alumina fiber/aluminum composite
[ASA CR-159951] p0073 $00-29430
FLOW SIMULATIONS, INC., SUNNYVILLE, CALIF.
An implicit finite-difference code for inviscid and viscous cascade flow
[ASA CR-159666] p0071 $00-44128
FORD AEROSPACE AND COMMUNICATIONS CORP., PALO ALTO, CALIF.
Packet communications in satellites with multiple-beam antennas and signal processing
[ASA 80-0527] p0099 $00-29574
Concepts for 20/30 GHz satellite systems for direct-to-user applications
[ASA CR-159659] p0050 $00-35229
Concepts for 16/30 GHz satellite communication system, volume 1
[ASA CR-159625-VOL-1] p0098 $00-11277
Concepts for 16/30 GHz satellite communication system, volume 1A: Appendix
[ASA CR-159625-VOL-1A] p0098 $00-11278
Concepts for 16/30 GHz satellite communication system study. Executive summary
[ASA CR-159625-VOL-2] p0098 $00-11279
FORD MOTOR CO., DEARBORN, MICH.
Feasibility study of silicon nitride regenerators
[ASA CR-159713] p0106 $00-25509
Regenerator matrix physical property data
[ASA CR-159954] p0105 $00-30228
FOSTER-KILLER ASSOCIATES, INC., VALHALLA, N.Y.
A 15kWe (nominal) solar thermal electric power conversion concept definition study: Steam Rankine cycle reciprocator system
[ASA CR-159590] p0148 $00-16491
FOSTER WHEELER CORP., LIVINGSTON, N.J.
Parametric study of multi-100KWe prospective early commercial NHD power plants (FSPEC). General Electric Company, task 1: Parametric analysis
[ASA CR-159624] p0152 $00-26779
FWG ASSOCIATES, INC., TOLLHORN, TN.
Monsodium atomizers for agricultural aviation application development
[ASA CR-159777] p0108 $00-19540

**G**

GAERST CORP., TORRANCE, CALIF.
Advanced electric propulsion system concept for electric vehicles
[ASA CR-159651] p0103 $00-17916
GENERAL DYNAMICS/CONVAIR, SAN DIEGO, CALIF.
Capillary device refilling
[ASA 80-10590] p0065 $00-38908
Power management for multi-100 KWe space systems
[ASA 80-48357] p0065 $00-48357
Capillary acquisition devices for high-performance vehicles: Executive summary
[ASA CR-159658] p0062 $00-19105
Conceptual design of two-phase fluid mechanics and heat transfer facility for spacecraft
[ASA CR-159610] p0049 $00-27403
Study of power management technology for orbital multi-100kWe applications. Volume 2: Study results
[ASA CR-159634-VOL-2] p0153 $00-28862
Study of power management technology for orbital multi-100kWe applications. Volume 3: Requirements
[ASA CR-159634] p0154 $00-29845
Conceptual design of an on-board propellant transfer experiment. Volume 2: Study results
[ASA CR-165150] p0048 $00-37423
Comparative thermal analysis of alternate Cryogenic Fluid Management Experiment (CFME) configurations
[ASA CR-165151] p0048 $00-32412
GENERAL DYNAMICS CORP., SAN DIEGO, CALIF.
Low-thrust vehicles concept studies
[ASA 80-31456] p0063 $00-31456
GENERAL DYNAMICS/FORT WORTH, TEX.
Experimental investigation of a 0.15 scale model of a conformal variable-ramp inlet for the F-16 airplane
[ASA CR-159640] p0055 $00-24263
GENERAL ELECTRIC CO., CINCINNATI, OHIO.
Scale model performance test investigation of exhaust system mixers for an Energy Efficient Engine/ES propulsion system
[ASA PAPER 80-0229] p0024 $00-20960
Alcohol-burning propulsion component technologies
[ASA PAPER 80-0241] p0024 $00-37482
C6F-50 Short Core Exhaust Nozzle
[ASA PAPER 80-11946] p0025 $00-41514
Advanced catalytic combustors for low pollutant emissions, phase 1
[ASA CR-159530] p0028 $00-13040
Feasibility of SIC composite structures for 1640 deg C turbine seal applications
[ASA CR-159597] p0123 $00-13743
Quiet Clean Short-Haul Experimental Engine (GCSEE) acoustic and aerodynamic tests on a scale model over-the-wing thrust reverser and forward thrust nozzle
[ASA CR-135254] p0028 $00-14115
[ASA CR-135250] p0028 $00-14116
Quiet, Clean, Short-Haul, Experimental Engine (GCSEE) Under-The-Wing (UTW) engine acoustic design
[ASA CR-135267] p0028 $00-14117
Quiet, Clean, Short-Haul Experimental Engine (GCSEE) Over-The-Wing (OTW) engine acoustic design
[ASA CR-135260] p0028 $00-14116
Quiet Clean Short-Haul Experimental Engine (GCSEE) Under-The-Wing (UTW) graphite/DES cowl development
[ASA CR-135279] p0029 $00-14119
Quiet Clean Short-Haul Experimental Engine (GCSEE) Over-The-Wing (OTW) propulsion system test report. Volume 2: Aerodynamics and performance
[ASA CR-135324] p0029 $00-14120
The C6F jet engine performance improvement: New front mount
[ASA CR-159639] p0029 $00-14127
Demonstration of short haul aircraft aft noise reduction techniques on a twenty inch (50.8 cm) diameter fan, volume 3
[ASA CR-134951] p0334 $00-15085
Quiet Clean Short-haul Experimental Engine (GCSEE) Under The Wing (OTW) design report
[ASA CR-134948] p0334 $00-15086
Quiet Clean Short-haul Experimental Engine (GCSEE) Preliminary under the wing flight propulsion system analysis report
[ASA CR-134860] p0034 $00-15080
Quiet Clean Short-haul Experimental Engine (GCSEE) under the wing engine digital control system design report
[ASA CR-134920] p0034 $00-15090
Quiet Clean Short-haul Experimental Engine (GCSEE) under-the-wing engine simulation report
[ASA CR-134514] p0036 $00-15091
Quiet Clean Short-haul Experimental Engine (GCSEE) over-the-wing control system design report
[ASA CR-134537] p0035 $00-15092
Quiet Clean Short-haul Experimental Engine (GCSEE). Core engine noise measurements
[ASA CR-135160] p0035 $00-15093
Quiet Clean Short-haul Experimental Engine (GCSEE) Under-The-Wing (UTW) engine composite nacelle test report. Volume 1: Summary, aerodynamic and mechanical performance
[ASA CR-159671] p0035 $00-15094
Quiet Clean Short-haul Experimental Engine (GCSEE) Preliminary over-the-wing flight propulsion system analysis report
[ASA CR-135296] p0035 $00-15095
Quiet Clean Short-haul Experimental Engine (GCSEE). Under-The-Wing (UTW) engine boilerplate nacelle test report, volume 1
[ASA CR-135296] p0035 $00-15096
CORPORATE SOURCE INDEX
<table>
<thead>
<tr>
<th>Topic</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculations for potential early commercial NHG power plants</td>
<td>p0156 ABO-25099</td>
</tr>
<tr>
<td>Ka-band, multibeam, contiguous coverage</td>
<td></td>
</tr>
<tr>
<td>satellite antenna for the USA</td>
<td></td>
</tr>
<tr>
<td>[AIAA 80-0557]</td>
<td>p0099 ABO-25958</td>
</tr>
<tr>
<td>Executive summary: Rod-1 wind turbine generator analysis and design report</td>
<td>[NASA-CH-159497]              p0147 M80-11558</td>
</tr>
<tr>
<td>Sintered silicon nitride recuperator fabrication</td>
<td>[NASA-CH-159706]              p0090 M80-16263</td>
</tr>
<tr>
<td>Appendix: Rod-1 wind turbine generator analysis and design report, volume 2</td>
<td>[NASA-CH-159496]              p0149 M80-18565</td>
</tr>
<tr>
<td>Rod-1 wind turbine generator failure modes and effects</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159494]</td>
<td>p0150 M80-20864</td>
</tr>
<tr>
<td>Rod-1 wind turbine generator analysis and design report</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159495]</td>
<td>p0150 M80-23775</td>
</tr>
<tr>
<td>Study of advanced communication satellite systems based on SO-PDRA</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159778]</td>
<td>p0050 M80-25357</td>
</tr>
<tr>
<td>Cogeneration Technology Alternatives Study</td>
<td></td>
</tr>
<tr>
<td>(CTAS). Volume 3: Industrial processes</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159765]</td>
<td>p0151 M80-24797</td>
</tr>
<tr>
<td>Cogeneration Technology Alternatives Study</td>
<td></td>
</tr>
<tr>
<td>(CTAS). Volume 4: Energy conversion system</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159768]</td>
<td>p0155 M80-33859</td>
</tr>
<tr>
<td>Cogeneration Technology Alternatives Study</td>
<td></td>
</tr>
<tr>
<td>Cogeneration Technology Alternatives Study</td>
<td></td>
</tr>
<tr>
<td>GENERAL ELECTRIC CO., SCHENECTADY, N. Y.</td>
<td></td>
</tr>
<tr>
<td>Cogeneration Technology Alternatives Study</td>
<td></td>
</tr>
<tr>
<td>(CTAS). Volume 1: Summary report</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159547]</td>
<td>p0094 M60-21977</td>
</tr>
<tr>
<td>General Electric Company, Washington, D.C.</td>
<td></td>
</tr>
<tr>
<td>Demonstration of short-haul aircraft aft noise reduction techniques on a twenty inch (50.8 cm) diameter fan, volume 1</td>
<td>[NASA-CH-159409]              p0033 M80-15003</td>
</tr>
<tr>
<td>Demonstration of short-haul aircraft aft noise reduction techniques on a twenty inch (50.8 cm) diameter fan, volume 2</td>
<td>[NASA-CH-159450]              p0034 M80-15004</td>
</tr>
<tr>
<td>GENERAL MOTORS CORP., DETROIT, MICH.</td>
<td></td>
</tr>
<tr>
<td>Advanced Gas Turbine Powertrain System Development Project</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159756]</td>
<td>p0129 A60-35574</td>
</tr>
<tr>
<td>Aerodynamic analysis of a supersonic cascade vibrating in a complex mode</td>
<td></td>
</tr>
<tr>
<td>GEORGE WASHINGTON UNIV., WASHINGTON, D.C.</td>
<td>p0027 A60-35841</td>
</tr>
<tr>
<td>Statistical aspects of carbon fiber risk assessment modeling</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159218]</td>
<td>p0073 M60-29492</td>
</tr>
<tr>
<td>GEORGIA INST. OF TECH., ATLANTA.</td>
<td></td>
</tr>
<tr>
<td>System analysis for millimeter-wave communication satellites</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159756]</td>
<td>p0100 A60-52479</td>
</tr>
<tr>
<td>GILBERT/COMINORWEALTH, READING, PA.</td>
<td></td>
</tr>
<tr>
<td>Survey of NHG plant applications</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159556]</td>
<td>p0112 A60-10972</td>
</tr>
<tr>
<td>GILBERT ASSOCIATES, INC., READING, PA.</td>
<td></td>
</tr>
<tr>
<td>Oxygen-enriched air for NHG power plants</td>
<td></td>
</tr>
<tr>
<td>[NASA-CH-159496]</td>
<td>p0094 A80-25096</td>
</tr>
<tr>
<td>GINER, INC., WALNUT, MASS.</td>
<td></td>
</tr>
<tr>
<td>Catalyst surfaces for the chromous/chronic redox couple</td>
<td></td>
</tr>
<tr>
<td>Catalyst surfaces for the chromous/chronic redox couple</td>
<td></td>
</tr>
<tr>
<td>GORDON AIRCRAFT CORP., BOTSFORD, N. Y.</td>
<td></td>
</tr>
<tr>
<td>Active heat exchange system development for latent heat thermal energy storage</td>
<td>[NASA-CH-159726]              p0149 M80-18562</td>
</tr>
</tbody>
</table>

H

HAMILTON STANDARD, WINDSOR LOCKS, CORN.                                |                                                                          |
| Quiet Clean Short-haul Experimental Engine                            |                                                                          |
| Quiet Clean Short-haul Experimental Engine                            |                                                                          |
| (QCSE2) whirl test of cam/harmonic pitch change actuation system      |                                                                          |
| [NASA-CH-159456]                                                      | p0032 M80-15117                                                           |
| Acoustic test and analysis of three advanced turboprop models         |                                                                          |
| [NASA-CH-159567]                                                      | p0039 M80-23311                                                           |
| Diffusion bonded boron/aluminum spar-shell fan blade                  |                                                                          |
| [NASA-CR-15971]                                                      | p0072 M80-25380                                                           |

HAMILTON STANDARD DIV., UNITED AIRCRAFT CORP., WINDSOR LOCKS, CORN.    |                                                                          |
| Acoustic measurements of three Prop-Fan models                       |                                                                          |
| [AIAA PAPER 80-0995]                                                 | p0045 A80-35958                                                           |
| Acoustic pressures on a prop-fan aircraft                            |                                                                          |
| Fuselage surface                                                     |                                                                          |
| [AIAA PAPER 80-1002]                                                 | p0172 M80-35965                                                           |
| HESS ACOUSTICAL ENGINEERING, CHATSWORTH, CALIF.                      |                                                                          |
| Acoustic behavior of Fibrous bulk materials                          |                                                                          |
| [NASA PAPER 80-0986]                                                 | p0172 M80-35951                                                           |
| Effect of grazing flow on the nonlinear acoustic behavior of helical resonators | [NASA-CH-159667]              p0039 H60-21361 |
| HITACHI LTD., TOSCHEIRA (JAPAN).                                     |                                                                          |
| Hydraulic forces caused by annular pressure seals in centrifugal pumps | [NASA-CH-159756]              p0126 M80-29718 |
| MORTWELL INC., MINNEAPOLIS, MN.                                      |                                                                          |
| Active heat exchange system development for latent heat thermal energy storage | [NASA-CR-159556]              p0154 M80-29875 |
| MORTWELL INC., ST. PAUL, MN.                                         |                                                                          |
| Assessment and preliminary design of an energy buffer for regenerative braking in electric vehicles | [NASA-CR-159756]              p0103 M80-29975 |
| BOEING CHROMICAL CORP., NIAGARA FALLS, N.Y.                          |                                                                          |
| BOEING RESEARCH LABS., RAILING, CALIF.                               |                                                                          |
| A model for predicting the wearout lifetime of artificially-produced nonsmooth surfaces | [NASA-CR-159756]              p0103 M80-11320 |
| Primary electric propulsion technology study                          |                                                                          |

ILT RESEARCH INST., CHICAGO, ILL.                                      |                                                                          |
| ILLINOIS INST. OF TECH., CHICAGO.                                    |                                                                          |
| Effects of axisymmetric contractions on turbulence of various scales | [NASA-CR-159456]              p0006 M80-32328 |
| ILLINOIS UNIV., CHICAGO.                                             |                                                                          |
| Elastohydrodynamic film thickness measurements of artificially-produced nonsmooth surfaces | [ASA PAPER 79-JC-IA-3]       p0102 A80-14720 |
INCO RESEARCH AND DEVELOPMENT CENTER, SUFFERN, N. Y.
Characterization of an oxide dispersion strengthened superalloy, MA-60008, for turbine blade applications [NASA-CR-159693] p0083 W0-12316

INDIAN INST. OF SCIENCES, BANGALORE.

INKERSON-HAND CO., BOSTON, PA.

INSTITUTE OF GAS TECHNOLOGY, CHICAGO, ILL.
High-temperature solen salt thermal energy storage systems [NASA-CR-159620] p0099 W0-18263

INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., NEW YORK.

IONICS, INC., WATERTOWN, MASS.
Anton permselective membrane [NASA-CR-159599] p0147 W0-12551

J

JAY - CARTER ENTERPRISES, INC., BURBANK, CALIF.
A 15 kWe (nominal) solar thermal-electric power conversion concept definition study: Steam Rankin recuperator system [NASA-CR-159591] p0149 W0-19612

JET PROPULSION LAB., "CALIFORNIA INST. OF TECH.," PASADENA.
Characterization of solar cells for space applications. Volume 10: Electrical characteristics of Spectrolab BCP, textured, 10 ohm-cm, 300 micron cells as a function of intensity, temperature and irradiation [NASA-CR-162422] p0147 W0-11566
High temperature thermal energy storage in steel and sand [NASA-CR-159708] p0154 W0-29660

JEFFERIES, INC., NOCRIUS, N. J.
Development of exothermically cast single-crystal Y-123 247 and derivative alloys [ARIEESEARCH-23-3469] p0044 A80-45825

K

KAMAN AEROSPACE CORP., BLOOMFIELD, CONN.

KANSAS UNIV., LAWRENCE.
Spectral effects on direct-injection abscornption of five collector coatings [NASA-CR-159818] p0146 A80-65722

KENT STATE UNIV., OHIO.
Homogeneous alignment of nematic liquid crystals by ion beam treated surfaces p0178 A80-26007

KOBEL STEEL LTD., JAPAN.
Asynchronous vibration problems of centrifugal compressor p0125 W0-25713

KOBÉ UNIV., JAPAN.
Evaluation of instability forces of labyrinth seals in turbines or compressors p0126 W0-29715

KUMA (ENRSON L.), THORP, ARIZ.
Design study of flat bolt CTV for electric vehicles [NASA-CR-159822] p0124 W0-22702

LEHIGH UNIV., BETHLEHEM, PA.
Bend bending of cracked laminates [NASA-CR-159860] p0073 W0-25383

LINCOLN UNIV., PA.

LONGHORN-CALIFORNIA CO., BURBANK.

LONGHORN-GEORGIA CO., MARIETTA.
Characteristics of internal- and jet-noise radiation from a multi-lobe, multi-tube supersonic nozzle tested statically and under flight simulation [AIAA PAPER 80-1027] p0172 A80-38642

MARTIN MARITTA CORP., BETHESDA, MD.
DOO low-thrust mission studies p0063 W0-31455

MARYLAND UNIV., COLLEGE PARK.
Application of the principle of similarity fluid mechanics [NASA-CR-159796] p0073 W0-25384

MARTH MARIETTA AEROSPACE, DENVER, COLO.
A liquid hydrogen experiment as a Shuttle payload p0099 W0-10264

MARSCHMANN, K., TEMPE, ARIZ.
A study of the transmission characteristics of coaxial nozzles with inverted velocity profiles, volume 1 [NASA-CR-159590] p0172 W0-11070

MASSACHUSETTS INST. OF TECH., CAMBRIDGE.

- Directional solidification at ultra-high thermal gradient [NASA-CR-159797] p0096 W0-15300
- Air pollution from aircraft [NASA-CR-159712] p0010 W0-16060
- Two-dimensional finite-element analysis of simulated rotor-fragment impacts against rings and beams compared with experiments [NASA-CR-159645] p0038 W0-22323

- Low thrust chemical orbit to orbit propulsion system propellant management study [NASA-CR-159577] p0104 W0-31455
- Primary propulsion/large space system interactions p0063 W0-31458
- Low-thrust chemical orbit to orbit propulsion system propellant management study p0064 W0-31469

MASSACHUSETTS INST. OF TECH., CAMBRIDGE.

- Directional solidification at ultra-high thermal gradient [NASA-CR-159797] p0096 W0-15300
- Air pollution from aircraft [NASA-CR-159712] p0010 W0-16060
- Two-dimensional finite-element analysis of simulated rotor-fragment impacts against rings and beams compared with experiments [NASA-CR-159645] p0038 W0-22323

C-7
Higher order mode propagation in nonuniform circular ducts  
[NASA-TM-19618]  
p0169 A80-23101

Instructions for the use of the CRYSTAL 4C finite-strain computer code to calculate the transient structural responses of partial and/or complete arbitrarily-curved rings subjected to fragment impact  
[NASA-CR-159073]  
p013N N80-27720

Soot formation and burnout in flames  
[p0043 N80-29320

Physical explanations of the destabilizing effect of damping in rotating parts  
[p0127 N80-29728

Finite-strain large-deformation elastomer damper transient response analysis of structures  
[NASA-CR-159074]  
p013N N80-29762

MAYA DEVELOPMENT CORP., SAN DIEGO, CALIF.  

Torquing and electrostatic deformation of the solar sail  
[p0065 A80-46901

MECHANICAL TECHNOLOGY, INC., LATHAM, N. Y.  

The effects of strain and temperature on the dynamic properties of elastomers  
[ASME PAPER 79-DT-57]  
p0092 A80-15720

Design of elastomer dampers for a high-speed flexible rotor  
[ASME PAPER 79-DT-60]  
p0121 A80-15736

Dynamic proportion of elastomer cartridge specimens under a rotating load  
[p0121 A80-24002

Balancing of a power-transmission shaft with the application of axial torque  
[ASME PAPER 80-GT-143]  
p0121 A80-42256

Elastomer damper performance - A comparison with a squeeze film for a supersonic power transmission shaft  
[ASME PAPER 80-GT-142]  
p0121 A80-42272

Assessment of the state of technology of automotive Stirling engines  
[NASA-CR-159631]  
p0163 N80-13989

Development of procedures for calculating stiffness and damping of elastomers in engineering applications, part 6  
[NASA-CR-159636]  
p013N N80-22733

Design study of a 15 kW free-piston Stirling engine-linear alternator for dispersed solar power systems  
[NASA-CR-159507]  
p0150 N80-22787

High temperature self-lubricating coatings for air lubricated foil bearings for the automotive gas turbine engine  
[NASA-CR-159509]  
p0091 N80-26440

Practical experience with unstable compressors  
[p0125 N80-29709

Use of elastomeric elements in control of rotor instability  
[p0128 N80-29732

Development of procedures for calculating stiffness and damping of elastomers in engineering applications, part 7  
[NASA-CR-159518]  
p0128 A80-32718

MIAMI UNIV., OXFORD, OHIO.  

Hyperfine magnetic field at Cd impurity site in LiF/W, further analysis by TOFAC technique  
[p0178 A80-16843

MIDWEST RESEARCH INST., KANSAS CITY, MO.  

Thermal energy storage systems using fluidized bed heat exchangers  
[NASA-CR-159560]  
p0153 N80-28666

MITEE CORP., BEDFORD, MASS.  

Application of advanced on-board processing concepts to future satellite communications systems  
[NASA-CR-159562]  
p0098 N80-12260

Application of advanced on-board processing concepts to future satellite communications systems: Bibliography  
[NASA-CR-159568A]  
p0098 N80-12261

On-board processing concepts for future satellite communications systems  
[NASA-CR-1595683]  
p0098 N80-24514

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D. C.  

Electric propulsion, circa 2000  
[AILA PAPER 80-0912]  
p0059 A80-32866

Airbreathing propulsion component technologies  
[p0024 A80-7762

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, AERORESEARCH CENTER, ROBBINS FIEL, CALIF.  

An implicit finite-difference code for inviscid and viscous cascades flows  
[ASME PAPER 80-1427]  
p0007 A80-44126

Flight test of navigation and guidance sensor errors measured on STOL approaches  
[NASA-TM-81154]  
p028 N80-13041

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.  

SLS DEVELOPMENT CENTER, BEDFORD, MA.  

NASAs communications technology research and development  
[p0097 A80-25920

Active control of spacecraft charging  
[p0055 A80-46890

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.  

LANCASTER RESEARCH CENTER, HARRISON, PAT.  

Examination of the flap-lag stability of rigid articulated rotor blades  
[p010 A80-15123

Buckling of rotating beams  
[p013 A80-20149

Wind-tunnel investigation of the flow correction for a model-mounted angle of attack sensor at angles of attack from -10 deg to 110 deg  
[NASA-TM-69189]  
p0111 N80-14110

Improved tire/wheel concept  
[NASA-CAP-11695-2]  
p0124 N80-16402

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.  

MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.  

Stream corrosion cracking evaluation of martensitic precipitation hardening stainless steels  
[NASA-TM-76237]  
p0083 N80-16142

NAVAL AIR PROPULSION TEST CENTER, TRENTHAM, N.J.  

Determination of jet fuel thermal deposit rate using a modified JFOT  
[p0043 A80-29326

NAVAL RESEARCH LAB., WASHINGTON, D. C.  

Characterization and properties of controlled nucleation thermochemo-deposited /CVD/ silicon carbide  
[p009 A80-13063

WILKINSON ENGINEERING AND RESEARCH, INC., MOUNTAIN VIEW, CALIF.  

Evaluation of a strained-coordinate perturbation procedure - Nonlinear subsonic and transonic flows  
[ASME PAPER 80-0339]  
p006 A80-18324

OHIO STATE UNIV., COLUMBUS.  

A theoretical and experimental investigation of propellant performance methodologies  
[AILA PAPER 80-1240]  
p0026 A80-43283

Vibration and buckling of rectangular plates under in-plane hydrostatic loading  
[p0133 A80-45364

An acoustic sensitivity study of general aviation propellers  
[AILA PAPER 80-1671]  
p0045 A80-50919

OPERAشن RESEARCH, INC., SILVER SPRING, MD.  

Aerial applications dispersal system control requirements study  
[NASA-CR-159781]  
p0158 N80-16586

PAN AMERICAN WORLD AIRWAYS, INC., JAMAICA, N. Y.  

JT9D-7A /SE/ jet engine performance deterioration trends  
[p0026 A80-44230

JT9D-7A (SP) jet engine performance deterioration trends  
[NASA-TM-81459]  
p0016 N80-20274

PARAGON PACIFIC, INC., EL SEGUNDO, CALIF.  

Evaluation of feasibility of prestressed concrete for use in wind turbine blades  
[NASA-CR-159725]  
p0147 N80-15553
Three dimensional mean flow and turbulence characteristics of the near wake of a compressor rotor blade

[PHILIPS PETROLEUM CO. EUROPE-AFRICA, LONDON (ENGLAND).]

Field experiences with rotordynamic instability in high-performance turbomachinery

[PRATT AND WHITNEY AIRCRAFT, EAST HARTFORD, CONN.]

Di-directional four quadrant (BDQ4) power converter development

[UNIVERSITY GROUP, hartford, Conn.]

Performance deterioration based on existing (historical) data: J79 jet engine diagnostics program

[ROCKWELL INTERNATIONAL CORP., PITTSBURGH, PA.]

Manufacture of low carbon astroloy turbine disk shapes by hot isostatic pressing. Volume 2, part 1

[ROCKWELL INTERNATIONAL CORP., PITTSBURGH, PA.]

Performance deterioration based on existing (historical) data: J79 jet engine diagnostics program

[ROCKWELL INTERNATIONAL CORP., PITTSBURGH, PA.]

Coro compressor exit stage study, 2

[PRATT AND WHITNEY AIRCRAFT, EAST HARTFORD, CONN.]

Study of blade aspect ratio on compressor front stage

[PRATT AND WHITNEY AIRCRAFT GROUP, WEST PALM BEACH, FLA.]

Laser-optical blade tip clearance measurement system

[ROCKWELL INTERNATIONAL CORP., PITTSBURGH, PA.]

Performance deterioration based on existing (historical) data: J79 jet engine diagnostics program

[ROCKWELL INTERNATIONAL CORP., PITTSBURGH, PA.]

Deterioration trends of low carbon astroloy turbine disks shapes by hot isostatic pressing. Volume 2, part 1
SCIENCE APPLICATIONS, INC., VIENNA, VA.

STATE UNIVERSITY OF NEW YORK, ALBANY.
Comments on 'experimental evidence for interhemispheric transport from airborne carbon monoxide measurements'

SCIENTIFIC RESEARCH ASSOCIATES, INC., GLASTONBURY, CONN.

STATE UNIVERSITY OF NEW YORK AT BUFFALO.
Experimental and theoretical investigation for the suppression of the planar arc drop in the thermionic converter

SOLANEI COMP., ROCKVILLE, MD.

STUTTGART UNIV., (WEST GERMANY).
Flow induced spring coefficients of labyrinth seals for application in rotor dynamics

SOLAR TURBINES INTERNATIONAL, SAN DIEGO, CALIF.

SUNDANCE CORP., ROCKFORD, ILL.
The 15 kW sub a (nominal) solar thermal electric power conversion concept definition study;

SKY INDUSTRIES, INC., KING OF PRUSSIA, PA.

STEAM RANKINE TURBINE SYSTEM, STUTTGART, (WEST GERMANY).

STANITZ (JOHN D.), UNIVERSITY OF MINNESOTA, MINNEAPOLIS.

TELEDYNE CONTINENTAL MOTORS, MUSKEGON, MICH.

TECHNICAL UNIVERSITY OF DENMARK, COPENHAGEN.

STATE UNIVERSITY OF NEW YORK, ALBANY.

TECHMISCHEN UNIVERSITAT, MUNICH (WEST GERMANY).

TENNESSEE TECHNICAL UNIVERSITY, COOKEVILLE.

TECHNICHE UNIVERSITY LUBECK, (WEST GERMANY).

TECHNICAL UNIVERSITY OF DENMARK, COPENHAGEN.

TECHNICAL UNIVERSITY OF DENMARK, COPENHAGEN.

TECHNICAL UNIVERSITY OF DENMARK, COPENHAGEN.

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TECHNICAL UNIVERSITY OF DENMARK, COPENHAGEN.

TENNESSEE SPACE INST., TULLAHOMA.

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TENNESSEE SPACE INST., TULLAHOMA.

TENNESSEE SPACE INST., TULLAHOMA.

TENNESSEE SPACE INST., TULLAHOMA.

TENNESSEE SPACE INST., TULLAHOMA.

TENNESSEE SPACE INST., TULLAHOMA.

TENNESSEE SPACE INST., TULLAHOMA.

TENNESSEE SPACE INST., TULLAHOMA.

TENNESSEE SPACE INST., TULLAHOMA.
Spectral structure of pressure measurements made in a combustion duct
Cost analysis of composite fan blade manufacturing processes
Depriming of arterial heat pipes: An investigation of C5T thermal excitations
Modeling and analysis of Power Processing Systems for the P80-1 spacecraft
An advanced mixed-user domestic satellite system architecture
Power processing technology for spacecraft primary ion propulsion
Specific spacecraft evaluation: Special report
Heat pipe cooled power magnets
Analysis of moisture in polymers and composites
Deposition of arterial heat pipes: An investigation of C5T thermal excitations
Second generation PNR polyimide/fiber composites
Tungsten wire/metal matrix turbine blade fabrication study
Cost analysis of composite fan blade manufacturing processes
Feasibility of active feedback control of rotodynamic instability

Low speed test of the aft inlet designed for a tandem fan V/STOL nacelle

Life test studies on tungsten impregnated cathodes

The 18/30 GHz fixed communications system service demand assessment. Volume 1: Executive summary

The 18/30 GHz fixed communications system service demand assessment. Volume 2: Main text

The 30/20 GHz fixed communications system service demand assessment. Volume 3: Appendices

Silicone modified resins for graphite fiber laminates

Cell module and fuel conditioner development

Conceptual design study of an improved gas turbine powertrain

High speed cylindrical rolling element bearing analysis ‘CYDEAN’ — Analytic formulation

Preliminary results of the mission profile life test of a 30 cm Hg bombardment thruster

Inert gas ion thruster development

Theory of deposition of condensible impurities on surfaces immersed in combustion gases

Experimental studies of the formation/deposition of sodium sulfate in/from combustion gases
# CONTRACT NUMBER INDEX

## Typical Contract Number Index Listing

<table>
<thead>
<tr>
<th>CONTRACT NUMBER</th>
<th>PAGE NUMBER</th>
<th>ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASE-1249-122</td>
<td>0002</td>
<td>AO-05-3670</td>
</tr>
<tr>
<td>NASE-1250-123</td>
<td>0001</td>
<td>AO-05-3671</td>
</tr>
<tr>
<td>NASE-1251-124</td>
<td>0003</td>
<td>AO-05-3672</td>
</tr>
<tr>
<td>NASE-1252-125</td>
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<td>AO-05-3673</td>
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<tr>
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<td>0005</td>
<td>AO-05-3674</td>
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<tr>
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<tr>
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<td>0009</td>
<td>AO-05-3678</td>
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<tr>
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<td>0012</td>
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<td>0013</td>
<td>AO-05-3682</td>
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<tr>
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<td>0014</td>
<td>AO-05-3683</td>
</tr>
<tr>
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<td>0016</td>
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<td>0017</td>
<td>AO-05-3686</td>
</tr>
<tr>
<td>NASE-1266-139</td>
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<td>AO-05-3688</td>
</tr>
<tr>
<td>NASE-1268-141</td>
<td>0020</td>
<td>AO-05-3689</td>
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<tr>
<td>NASE-1269-142</td>
<td>0021</td>
<td>AO-05-3690</td>
</tr>
</tbody>
</table>

*Listing in this index are arranged alphabetically by contract number. Under each contract number, the accession numbers, denoting documents that have been produced as a result of research done under that contract are arranged as ascending order with the A4 accession numbers appearing first. Proceeding the accession number is the page number in the abstract section in which the cita*
## REPORT/ACCESSION NUMBER INDEX

### Typical Report/Accession Number Index Listing

<table>
<thead>
<tr>
<th>Report Number</th>
<th>Microfiche Symbol</th>
<th>NASA Accession Number</th>
<th>Document Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIAA PAPER 79-2041</td>
<td>p0058 A80-10376*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2043</td>
<td>p0048 A80-20961*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2047</td>
<td>p0055 A80-13301*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2061</td>
<td>p0056 A80-10386*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2063</td>
<td>p0059 A80-10386*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
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<td>p0059 A80-10386*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2078</td>
<td>p0050 A80-10389*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2079</td>
<td>p0066 A80-20962*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2083</td>
<td>p0049 A80-13301*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2081</td>
<td>p0059 A80-10392*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2082</td>
<td>p0107 A80-20960*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2103</td>
<td>p0066 A80-13311*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2104</td>
<td>p0054 A80-29750*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2110</td>
<td>p0054 A80-20950*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 79-2116</td>
<td>p0076 A80-18208*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0042</td>
<td>p0055 A80-16249*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0051</td>
<td>p0024 A80-16253*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0068</td>
<td>p0170 A80-16260*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0100</td>
<td>p0170 A80-20964*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0164</td>
<td>p0171 A80-20964*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
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<tr>
<td>AIAA PAPER 80-0194</td>
<td>p0065 A80-23954*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0213</td>
<td>p0024 A80-19300*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0225</td>
<td>p0003 A80-20966*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0227</td>
<td>p0024 A80-20960*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
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<td>AIAA PAPER 80-0229</td>
<td>p0076 A80-18208*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
<td>AIAA PAPER 80-0302</td>
<td>p0017 A80-18204*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
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<td>p0054 A80-29751*</td>
<td>N80-13041*#</td>
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<td>N80-13041*#</td>
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<tr>
<td>AIAA PAPER 80-0912</td>
<td>p0059 A80-32866*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
</tr>
<tr>
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<td>p0024 A80-32867*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
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<td>p0017 A80-35551*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
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<td>p0045 A80-35950*</td>
<td>N80-13041*#</td>
<td>A80-13041</td>
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<tr>
<td>AIAA PAPER 80-1002</td>
<td>p0172 A80-35966*</td>
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<td>p0027 A80-46691*</td>
<td>N80-13041*#</td>
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<td>p0171 A80-35974*</td>
<td>N80-13041*#</td>
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</table>

### Listings in the index are arranged alphabetically by report number. The page number indicates the page in the abstract section in which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.
<table>
<thead>
<tr>
<th>Accession Number</th>
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<tbody>
<tr>
<td>NASA-CR-165125</td>
<td>Document 1</td>
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<td>NASA-CR-165133</td>
<td>Document 2</td>
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<td>NASA-CR-165136</td>
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</tr>
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<td>NASA-TM-78288</td>
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<td>Document 18</td>
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<td>Document 56</td>
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<td>NASA-TM-78373</td>
<td>Document 60</td>
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<td>NASA-TM-78374</td>
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<td>Document 63</td>
</tr>
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</tr>
<tr>
<td>NASA-TM-78383</td>
<td>Document 70</td>
</tr>
<tr>
<td>NASA-TM-78384</td>
<td>Document 71</td>
</tr>
<tr>
<td>NASA-TM-78385</td>
<td>Document 72</td>
</tr>
</tbody>
</table>

**Report/Accession Number Index**

- **NASA-TM-78257**: Document 1
- **NASA-TM-78266**: Document 2
- **NASA-TM-78288**: Document 3
- **NASA-TM-78291**: Document 4
- **NASA-TM-78293**: Document 5
- **NASA-TM-78296**: Document 6
- **NASA-TM-78297**: Document 7
- **NASA-TM-78299**: Document 8
- **NASA-TM-78300**: Document 9
- **NASA-TM-78302**: Document 10
- **NASA-TM-78305**: Document 11
- **NASA-TM-78306**: Document 12
- **NASA-TM-78314**: Document 13
- **NASA-TM-78315**: Document 14
- **NASA-TM-78317**: Document 15
- **NASA-TM-78318**: Document 16
- **NASA-TM-78320**: Document 17
- **NASA-TM-78321**: Document 18
- **NASA-TM-78323**: Document 19
- **NASA-TM-78324**: Document 20
- **NASA-TM-78331**: Document 21
- **NASA-TM-78333**: Document 22
- **NASA-TM-78334**: Document 23
- **NASA-TM-78344**: Document 24
- **NASA-TM-78345**: Document 25
- **NASA-TM-78346**: Document 26
- **NASA-TM-78347**: Document 27
- **NASA-TM-78348**: Document 28
- **NASA-TM-78349**: Document 29
- **NASA-TM-78351**: Document 30
- **NASA-TM-78352**: Document 31
- **NASA-TM-78353**: Document 32
- **NASA-TM-78354**: Document 33
- **NASA-TM-78355**: Document 34
- **NASA-TM-78356**: Document 35
- **NASA-TM-78357**: Document 36
- **NASA-TM-78358**: Document 37
- **NASA-TM-78359**: Document 38
- **NASA-TM-78360**: Document 39
- **NASA-TM-78361**: Document 40
- **NASA-TM-78362**: Document 41
- **NASA-TM-78363**: Document 42
- **NASA-TM-78364**: Document 43
- **NASA-TM-78365**: Document 44
- **NASA-TM-78366**: Document 45
- **NASA-TM-78367**: Document 46
- **NASA-TM-78368**: Document 47
- **NASA-TM-78369**: Document 48
- **NASA-TM-78370**: Document 49
- **NASA-TM-78371**: Document 50
- **NASA-TM-78372**: Document 51
- **NASA-TM-78373**: Document 52
- **NASA-TM-78374**: Document 53
- **NASA-TM-78375**: Document 54
- **NASA-TM-78376**: Document 55
- **NASA-TM-78377**: Document 56
- **NASA-TM-78378**: Document 57
- **NASA-TM-78379**: Document 58
- **NASA-TM-78380**: Document 59
- **NASA-TM-78381**: Document 60
- **NASA-TM-78382**: Document 61
- **NASA-TM-78383**: Document 62
- **NASA-TM-78384**: Document 63
- **NASA-TM-78385**: Document 64

Each document number is followed by a five-digit code, indicating the specific document within the series.
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