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 Turbo-machinery," 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
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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.
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.

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.

Author

HIGH SPEED PROPELLER PERFORMANCE

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

LASER ANEMOMETER MEASUREMENTS IN A TRANSONIC AXIAL FLOW COMPRESSOR ROTOR

A laser anemometer system employing an 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
N80-27284* // National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
CAS2D: FORTAN PROGRAM FOR NONROTATING BLADE-TO-BLADE STEADY, POTENTIAL TRANSSONIC CASCADE FLOWS
Djordje S. Dulikravich Jul. 1980 36 p refs (NASA-TP-1708; E-253) Avail: NTIS HC A03/MF A01 CSCL 01A

An exact, full-potential-equation (FPE) model for the steady, irrotational, homentropic and homothermal 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, CAS2D, 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 isentropic shocks were correctly captured by adding explicitly an artificial compressible form. In addition, a three-level consecutive, mesh refinement feature makes CAS2D a reliable and fast algorithm for the analysis of transonic, two dimensional cascade flows.

Author

N80-27285* // National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
AN ALTERNATIVE APPROACH TO THE NUMERICAL SIMULATION OF STEADY INVISID FLOW

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 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.

N80-33357* // National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
WIND: COMPUTER PROGRAM FOR CALCULATION OF THREE DIMENSIONAL POTENTIAL COMPRESSIBLE FLOW ABOUT WIND TURBINE ROTOR BLADES
Djordje S. Dulikravich Oct. 1980 20 p refs (NASA-TP-1729; E-474) Avail: NTIS HC A02/MF A01 CSCL 01A

A computer program is presented which numerically solves an exact, full potential equation (FPE) for three dimensional, steady, inviscid flow through an isolated wind turbine rotor. The program automatically generates a three dimensional, boundary conforming grid and iteratively solves the FPE while fully accounting for both the rotating cascade and Coriolis effects. The numerical techniques incorporated involve rotated, type dependent finite differencing, a finite volume method, artificial viscosity in conservative form, and a successive line relaxation method combined with the sequential grid refinement procedure to accumulate the iterative convergence rate. Consequently, the WIND program is capable of accurately analyzing incompressible and compressible flows, including those that are locally transonic and terminated by shock waves. The program can also be used to analyze the flow about isolated aircraft propellers and helicopter rotors in hover as long as the total relative Mach number of the oncoming flow is subsonic.

A.R.H.


Three advanced analyses for predicting aircraft propeller performance at high subsonic speeds are described. Two of these analyser 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 6 swept blades integrally designed with the spinner and nacelle. These analyses provide tools for the propeller designer ranging from a short running program for initial design studies to a very long running program for checking final configurations.

Author


A three-dimensional, viscous computer code was used to calculate the mixing downstream of a typical turbofan mixer geometry. Experimental data was 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.

Author


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 full Navier-Stokes solutions. Computed results are presented for a Mach 3.0 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.

Author


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 shock structure on the rotor tip. 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.

Author

Measurements of surface static pressures, flow total pressure loss, and exit 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)


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-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)


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)


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 (1979) 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.


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 (1979) 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.


A panel method is used to calculate incompressible flow around 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 curves of constant pressure, Mach number, and flow inclination.


This paper presents a numerical method and the results of a computer program 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, rotated time-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. (Author)
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.

NBO-242627* 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

CALCULATION OF WATER DROP TRAJECTORIES TO AND ABOUT ARBITRARY THREE-DIMENSIONAL BODIES IN POTENTIAL AIRFLOW Final Report
Hillyer G. Norment Washington NASA Aug 1980 83 p refs
(Contract NAS3-22199)

NBO-28274* Cincinnati Univ., Ohio.
A CALCULATION PROCEDURE FOR VISCOS FLOW IN TURBOMACHINES, VOLUME 3
(Contract NASA-215009)
(NASA-CR-159864) Avail. NTIS HC A03/MF A01 CSCL 01A

A method for analyzing the nonadiabatic viscous flow through turbomachne blade passages was developed. The field analysis is based upon the numerical integration of the full incompressible Navier-Stokes equations, together with the energy equation on the body surface. A FORTRAN IV computer program was written based on this method. The numerical code used to solve the governing equations employs a nonorthogonal boundary fitted coordinate system. The flow may be axial, radial or mixed and there may be a change in stream channel thickness in the through-flow direction. The inputs required for two FORTRAN IV programs are presented. The first program considers laminar flows and the second can handle turbulent flows. Numerical examples are included to illustrate the use of the program, and to show the results that are obtained. A.R.H.

NBO-22951* Stanitz (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)

NBO-31361* 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; R80-814545-16) Avail. NTIS HC A04/MF A01 CSCL 01A
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. Masking is accounted for in the analysis so that individual blade inertias, frequencies, or damping can be considered and flutter 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; however, aerodynamic coupling together with mechanical coupling could change not only frequencies, but also damping in the system, with a trend toward instability.


Digitally acquired and processed results from an experimental investigation of grid generated turbulence of various scales through and downstream of nine matched cubic contour contractions ranging in area ratio from 2 to 36, and in length to inlet diameter ratio from 0.25 to 1.50 are reported. An additional contraction was chosen to determine the effects of a fifth order contour 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 suction flow for various aspect ratios 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.


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.


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 suction flow for various aspect ratios 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.

A80-38895 # Inlet flow distortion in turbomachinery, I - Comparison of theory and experiment in a transonic fan stage, II - A parameter study; B. S. Siedel, M. D. Mankay (Delaware, University, Newark, Del.), and J. J. Adamczyk (NASA, Lewis Research Center, Cleveland, Ohio); AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1076, 6 p. 7 refs. Grant No. NSG-3198.

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.


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 straight and curved ducts. 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 amplitude. 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.
SIMULTANEOUS CABIN AND AMBIENT OZONE MEASUREMENTS ON TWO BOEING 747 AIRPLANES, VOLUME 1
Measurements of ozone concentrations both outside and in the cabin of an airline operated Boeing 747SP and Boeing 747-100 airliner 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.

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.

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 aerodynamic 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)

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 engine bleed air as much as 50 percent. Flight test verified the predicted fuel saving of 0.8 percent. R.C.T.


The resultant composite fairing reduces the overall aircraft drag 1% with a weight reduction of 40% when compared with a metal component.
AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.
For related information see also 19 Spacecraft Instrumentation and 35 Instrumentation and Photography.

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 fed 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

Avail: NTIS HC A20/MF A01 CSCL 21E

Joseph A. Ziemianskl

vidual titles, see N80-10206 through N80.10219.

along with engine design for improved fuel consumption. For indi-

als and structures for reliable engine components are covered

supersonic propulsion for transport aircraft, and composite materi-

als. Noise and air pollution control techniques, advances in

and James R. Stone

directed at advancing the technology of turboprop powered aircraft

efficient engine, directed at proving the technology base for the

next generation of turbofan engines; and (3) advanced turboprop,

as well as for its effect on commercial aircraft operating economics

Is considered. Projects of the Aircraft Energy Efficiency Program

progress in improving the intermediate and cold section compo-

nents of turbine engines are covered. J.M.S.

specific topics covered include fan noise, acoustic

phenomena in cooled turbines are also discussed. R.E.S.

characteristics in compressors and turbines and the heat transfer

and Power, 28 Propellants and Fuels, and 44 Energy

Production and Conversion.

N80-10205* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PORT

N80-10216* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MATERIALS AND STRUCTURES TECHNOLOGY

Robert A. Signorelli, Thomas K. Glasgow, 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) increase 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 compo-

nents of turbine engines are covered. J.M.S.

N80-10211* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

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

N80-10205 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. R.E.S.

N80-10212* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

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 N80-10205 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. R.E.S.
MECHANICAL COMPONENTS
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. Nieberding, David R. Englund, Jr., and George E. Grawe. In Its Aeropropulsion 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

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 Aeropropulsion 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 subscale 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.
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. 

ATOMICIZING 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 7.8 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 at 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. All conditions were inlet air static pressures of 100,000 to 200,000 N/sq m at an inlet air temperature of 293 K. 

TURBOJET-EXHAUST-NOZZLE SECONDARY-AIRFLOW PUMPING AS AN EXIT CONTROL OF AN INLET-STABILITY BYPASS SYSTEM FOR A MACH 2.5 AXISYMMETRIC MIXED-COMPRESSION INLET
Bobby W. Sanders Jan. 1980 82 p refs (NASA-TP-1532; E-9468) Avail: NTIS HC A05/MF A01 CSCL 21E

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. For reference, data are also included for a conventional, fixed-exit bleed system. The poppet valves greatly increased inlet stability and had no adverse effects on propulsion system performance. Limited unstarted-inlet bleed performance data are presented. 

TURBOFAN ENGINE WITH SEVERAL EXHAUST CONFIGURATIONS FOR THE CHARTER SHORT-HAUL RESEARCH AIRCRAFT (GSMR)

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 at a traversing plane in the exhaust-nozzle flow for some confluent-flow configurations. The survey data at the mixing plane, plus the 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. 

EFFECT OF DEGREE OF FUEL VAPORIZATION UPON EMISSIONS FOR A PREMIXED PARTIALLY VAPORIZED COMBUSTION SYSTEM
Larry P. Cooper Jan. 1980 25 p refs (NASA-TP-1582; E-010) Avail: NTIS HC A02/MF A01 CSCL 21E

An experimental and analytical study of the combustion of partially vaporized fuel-air mixtures was performed to assess the impact of the degree of fuel vaporization upon emissions for a premixing-prevaporizing flamed tube combustor. Data collected in this study showed near linear increases in nitric oxide emissions and had no effect on nitric oxide emissions. A simple mechanism which accounts for the combustion of liquid droplets in partially vaporized mixtures was found to agree with the measured results with fair accuracy with respect to both trends and magnitudes. 

DYNAMIC RESPONSE OF A MACH 2.5 AXISYMMETRIC INLET AND TURBOJET ENGINE WITH A POPPET-VALUE CONTROLLED INLET STABILITY BYPASS SYSTEM WHEN
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 CF6-60 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 gas 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.

N80-15127
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
QUIET POWERED-LIFT PROPULSION
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 ‘toll-rotor research aircraft’ programs. In addition to these NASA programs, the Air Force AMST YC 14 and YC 15 programs were reviewed.

N80-15128
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
DIRECT INTEGRATION OF TRANSIENT ROTOR DYNAMICS
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.
COMPUTER SIMULATION OF ENGINE SYSTEMS
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 is 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.
IMPACT OF NEW INSTRUMENTATION ON ADVANCED TURBINE RESEARCH
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.
AN ANALYTICAL AND EXPERIMENTAL STUDY OF A SHORT S-SHAPED SUBSONIC DIFFUSER OF A SUPERSONIC INLET
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 indicatedreattachment 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.
AERODYNAMIC PERFORMANCE OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 METERS PER SECOND AND PRESSURE RATIO OF 1.54. 1: EXPERIMENTAL PERFORMANCE
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
and emissions reductions achieved by the effect of variable compressor and power turbine geometry, water injection downstream of the compressor, and increases in gas generator speed. Results were dependent on the modes of variable geometry utilization. Over 20 percent increase in power was accompanied by over 5 percent reduction in SFC. A fuel economy improvement of at least 6 percent was estimated for a vehicle with a 75 kW (100 hp) engine which could be augmented to 89 kW (120 hp) relative to an 89 kW (120 hp) unaugmented engine.

Author
AERODYNAMIC PERFORMANCES OF THREE FAN STATOR DESIGNS OPERATING WITH ROTOR HAVING TIP SPEED OF 337 METERS PER SECOND AND PRESSURE RATIO OF 1.64. 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 parallel to blade rows. The predicted ratios of maximum suction-surface velocity to trailing-edge velocity correlated well in the midspan region, with the measured total-parameters over the minimum-loss to near stall operating range for all stators and speeds studied. The 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.

PERFORMANCE OF SINGLE-STAGE AXIAL-FLOW TRANSONIC COMPRESSOR WITH ROTOR AND STATOR ASPECT RATIOS OF 1.19 AND 1.28 RESPECTIVELY, AND WITH DESIGN PRESSURE RATIO OF 2.06

Royce D. Moore and Lonnie Reid

The overall and blade-element performances of a low-aspect-ratio transonic compressor stage are presented over the stable operating range for speeds from 50 to 100 percent of design. At design speed the rotor and stage achieved peak efficiencies of 0.876 and 0.840 at pressure ratios of 2.056 and 2.000, respectively. The stage stall margin at design speed was 10 percent.

AN OVERVIEW OF NASA RESEARCH ON POSITIVE DISPLACEMENT GENERAL-AVIA TION ENGINES

William C. Strack


The results of four independent contracted studies to explore the opportunities for future small turbine engines are summarized in a composite overview. Candidate advanced technologies are screened, various cycles and staging arrangements are parametrically evaluated, and optimum conceptual engines are identified for a range of 300 to 600 horsepower applications. Engine improvements of 20 percent in specific fuel consumption and 40 percent in engine cost were forecast using high risk technologies that could be technically demonstrated by 1988. The ensuing economic benefits are in the neighborhood of 20 to 30 percent for twin-engine aircraft currently powered by piston engines.
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 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.

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

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

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.

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

NASA PROPELLER TECHNOLOGY PROGRAM

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.

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

HIGH-SPEED-PROPPELLER WIND-TUNNEL AEROACOUSTIC RESULTS

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.

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

ADVANCED PROPPELLER AERODYNAMIC ANALYSIS

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

R.C.T.

N80-23144* 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 1040°C in a 0.3 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-epoxy bond 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 rate of high heating rate by avoiding compressive stress.

Author

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

PRELIMINARY STUDY OF ADVANCED TURBOPROP AND TURBOSHAFT 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, engine technology 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 74 percent with a hypothetical advanced SIR engine. Compared with a hypothetical turboshaft using currently available technology (1976), 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.

N80-23310* 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.

N80-23313* 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. Ruckle (Pratt and Whitney Aircraft, Lewis :...
EVALUATION

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 broadband suppression.

R.C.T.

N80-26337" National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND COLD-AIR TEST OF SINGLE-STAGE UN-COOLED TURBINE WITH HIGH WORK OUTPUT


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 76.84 J/g at an engine turbine tip speed of 578.1 m/sec. At design speed and pressure ratio, the total efficiency of the turbine was 88.5 percent, which is 0.8 point lower than the design value of 89.3 percent. The corresponding mass flow was 4.0 percent greater than design.

Author

N80-26338" National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

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


The stage group performance of a 4 1/2 stage turbine was calculated at a stage loading factor of 1.466 and high specific work output was determined in cold air at design equivalent speed. The four stage turbine configuration produced design equivalent work output with an efficiency of 0.856; a barely discernible 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...
TURBINE SHROUDS: HEAT TRANSFER ANALYSIS

compared to an all impingement air cooled, all metal shroud, shroud consisting of a ceramic thermal barrier layer bonded to a graphite composite poppet. The graphite composite poppet in combination with a valve poppets and seats was investigated. Six different poppet materials were tested for over 100 million cycles. Serious damage was encountered in any of the tests. Steady-state and transient engine performance data are presented in graphs, and fuel-control trajectories for typical transient tests are shown.

An outdoor static test stand was used to measure the steady-state and transient performance of the YF-102 turbofan engine with core airblown core airbled. The test configuration included a bellmouth inlet and a confluent-flow exhaust system similar in size to the quiet short-haul research aircraft (QSRA) exhaust system. For the steady-state tests, the engine operated satisfactorily 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-bleed flow rate was scheduled to vary with fan discharge pressure, to simulate the QSRA bleed requirements. No stability, surge, stall, overtemprature, combustor flameout, or other operating problems were encountered in any of the tests. Steady-state and transient engine performance results were used to determine the individual stage efficiencies for the condition at which design 4 1/2 stage work variation of total-pressure loss coefficient in the damper region. No stator end-clearance gap was determined through analytical matching of experimental data. A stator vane end-clearance leakage model is also based on matching of the experimental data. A stator vane end-clearance leakage model is developed and sample calculations are made to show the predicted effects of stator vane end-clearance leakage on performance.

N80-25328*/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DURABILITY TESTS OF SOLENOID VALVES FOR DIGITAL ACTUATION

The durability of various materials used to make solenoid valve poppets and seats was investigated. Six different poppet materials and two seat materials were considered. Each material was tested for over 100 million cycles. Serious damage was found in four kinds of poppet materials tested. Less damage was evident in an aluminum poppet and in graphite composite poppet. The graphite composite poppet in combination with a Vespel seat was considered the most promising combination for use in digital electronic controls for gas turbine engines.

N80-27363*/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NUMERICAL CALCULATION OF TRANSSONIC AXIAL TURBOMACHINERY FLOWS

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, a second order accurate, 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, being determined by a two dimensional cascade analysis.

The quiet short-haul research aircraft (QSRA) exhaust bellmouth inlet and a confluent-flow exhaust system similar in size to the quiet short-haul research aircraft (QSRA) exhaust system. For the steady-state tests, the engine operated satisfactorily 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-bleed flow rate was scheduled to vary with fan discharge pressure, to simulate the QSRA bleed requirements. No stability, surge, stall, overtemprature, combustor flameout, or other operating problems were encountered in any of the tests. Steady-state and transient engine performance data are presented in graphs, and fuel-control trajectories for typical transient tests are shown.

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Off-design performance loss model is developed for variable-area (pivoted vane) radial turbines. The variation in stator loss with stator area is determined by a viscous loss model while the variation in rotor loss due to stator area variation (for no stator end-clearance gap) is determined through analytical matching of experimental data. An incidence loss model is also based on matching of the experimental data. A stator vane end-clearance leakage model is developed and sample calculations are made to show the predicted effects of stator vane end-clearance leakage on performance.

Experimental data from 10 transonic fan rotors were used to correlate losses created by part-span dampers located near the midchord position on the rotor blades. The design tip speed of these rotors varied from 419 to 425 m/sec, and the design pressure ratio varied from 1.8 to 2.0. Additional loss caused by the dampers for operating conditions between 50 and 110 percent of design speed were correlated with relevant aerodynamic and geometric parameters. The resulting correlation predicts the variation of total-pressure-loss coefficient in the damper region to a good approximation.
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 states, see N80-29301 through N80-29330.

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

FUTURE AVIATION FUELS OVERVIEW Gregory M. Ruck, In In Its Aircraft Res and Technol. for Future Fuels Jul. 1980 p 1-4 refs (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSL1 21D

The outlook for aviation fuels through the turn of the century is briefly discussed and the general objectives of the NASA Lewis Alternative Aviation Fuels Research Project are outlined. The NASA program involves the evaluation of potential characteristics of future jet fuels, the determination of the effects of those fuels on engine and fuel system components, and the development of a component technology to use those fuels. M.G.


Avail: NTIS HC A11/MF A01 CSL1 21D

Current analytical techniques used in the characterization of broadened properties fuels are briefly described. Included are liquid chromatography, gas chromatography, and nuclear magnetic resonance spectroscopy. High performance liquid chromatographic techniques for determining a broad variation in fuel property characteristics were also being pursued. Some of the more successful gas chromatographic methods were determined. Advanced combustion concepts and subcomponents that could lessen the effects of using broadened property fuels were also identified. R.C.T.

COMBUSTION TECHNOLOGY OVERVIEW Richard W. Niedzwiecki In Its Aircraft Res and Technol. for Future Fuels Jul. 1980 p 87-93 refs (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSL1 21B

An overview of combustor technology developments required for use of broadened property fuels in jet aircraft is presented. The intent of current investigations is to determine the extent to which fuel properties can be varied, to obtain a data base of combustion - engine quality factors, and to determine the trade-offs associated with broadened property fuels. Subcomponents of in-service combustors such as fuel injectors and liners, as well as atomization and stoichiometry, are being altered to determine the extent to which fuel flexibility can be extended. Finally, very advanced technology consisting of new combustor concepts is being evolved to optimize the fuel flexibility of gas turbine combustors. M.G.

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

PRELIMINARY STUDIES OF COMBUSTOR SENSITIVITY TO ALTERNATIVE FUELS Francis M. Hummel In Its Aircraft Res and Technol, for Future Fuels Jul. 1980 p 153-160 refs (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSL1 21B

Combustion problems associated with using alternative fuel ground power and aero-propulsion applications were studied. Rectangular sections designed to simulate large annular combustor test conditions were examined. The effects of using alternative fuels with increased hydrogen content, increased aromatic content, and a broad variation in fuel property characteristics were also studied. Data of special interest were collected which include: flame radiation characteristics in the various combustor zones; the corresponding increase in liner temperature from increased radiant heat flux; the effect of fuel bound nitrogen on oxides of nitrogen (NO sub x) emissions; and the overall total effect of fuel variations on exhaust emissions. R.C.T.

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


Avail: NTIS HC A11/MF A01 CSL1 21B

The effects of broadened property fuels on gas turbine combustors were assessed. Those physical and chemical properties of fuels that affect aviation gas turbine combustion were isolated and identified. Combustion sensitivity to variations in particular fuel properties were determined. Advanced combustion concept screening, combustor optimization testing, and engine verification testing Constraints for designing combustion systems are outlined and problems to be expected in the use of broadened properties fuels are listed. E.D.K.

TIE TECHNOLOGY PROGRAM James S. Fear In Its Aircraft Res and Technol. for Future Fuels Jul. 1980 p 95-98 (For primary document see N80-29300 20-07)

Avail: NTIS HC A11/MF A01 CSL1 21B

The broadened-Specification Fuels Combustion Technology program's purpose is to evolve and demonstrate the technology required to enable current and next generation high-thrust, high-bypass-ratio turbofan engines to use fuels with broadened properties and to verify the evolved technology in full scale engine test. The three phases of the program are combustor concept screening, combustor optimization testing, and engine verification testing. Constraints for designing combustion systems are outlined and problems to be expected in the use of broadened properties fuels are listed. E.D.K.
Alternative fuels or crude supplies 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 research and technology studies are being conducted to investigate the correlations and interactions of aircraft fuel system design and environment with applicable characteristics of the 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.

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 & Whitney Aircraft JT9D and General Electric CF6 high-bypass ratio turbofan engines.

The CFS/JTSD, NiON-BYPASS RATIO TURBOFAN ENGINE

The NASA high-speed turboprop program

The NASA high-speed turboprop program

An experimental investigation was made to determine the reasons for the low aerodynamic performance of a 13.5 centimeter tip diameter aircraft engine starter turbine. The investigation consisted of an evaluation of both the stator and the stage. An approximate ten percent improvement in turbine efficiency was obtained when the honeycomb shroud over the rotor blade tips was filled to obtain a solid shroud surface.

Author
Improvement of Component Technologies


The Engine Component Improvement (ECI) Project formulated to address near term improvements for current engines is described. The technical and economical capability and the fuel saving potential of various design changes 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.


The results of engine performance deterioration investigations based on recursive, special engine tests, and specific tests to define the influence of flight loads and component clearances on performance are presented. The results of analyses of several damage mechanisms that contribute to performance deterioration such as blade tip, airfoil surface roughness 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 Energy Efficient Engine Project is directed at providing, by 1984, the advanced technologies which could be used for a generation of fuel conserving turbofan engines. The project is conducted under contract with the General Electric Company and Pratt and Whitney Aircraft. The scope of the entire project and the current status of these efforts are summarized. A description of the preliminary design of the fully developed engines is included and the potential benefits of these advanced engines, as well as highlights of some of the component technology efforts conducted to date, are discussed.

E.D.K.

N80-33294# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LOW-PRESSURE PERFORMANCE OF ANNUAL HIGH-PRESSURE (40 ATM) HIGH-TEMPERATURE (2480 K) COMBUSTION SYSTEM Jerril D. Wear Washington Sep, 1980 20 p refs (NASA-TP-1713; E-372) Avail: NTIS HC A02/MF A01 CSCL 21E

Experimental tests were conducted to develop a combustion system for a 40 atmosphere pressure, 2480 K exhaust gas temperature, turbine cooling facility. The tests were conducted in an existing facility with a assumed pressure capability of 10 atmospheres and where inlet air temperatures as high as 894 K could be attained. Exhaust gas temperatures were as high as 2365 K. Combustion efficiencies were about 100 percent over a fuel air ratio range of 0.016 to 0.056. Combustion efficiency decreased at leaner and richer ratios when the inlet air temperature was 889 K. Data are presented that show the effect of fuel air ratio and inlet air temperature on liner metal temperature isothermal system pressure loss as a function of diffuser inlet Mach number as well as presented. Data included exhaust gas pattern factors, unburned hydrocarbon, carbon monoxide, and oxides of nitrogen emission index values, and smoke numbers.

N80-33410# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EXPERIMENTAL PERFORMANCE AND ANALYSIS OF 16.04-CENTIMETER-TIP-DIAMETER, RADIAL-INFLOW TURBINE WITH WORK FACTOR OF 1.128 AND THICK BLADING Kerry L. McIlvain and Jeffrey E. Haas Oct, 1980 21 p refs Prepared in cooperation with Army Aviation Research and Development Command, St. Louis, Mo. (NASA-TP-1730; E-391, AVRADCOM-TR-80-09) Avail: NTIS HC A02/MF A01 CSCL 21E

The aerodynamic design, the performance, and an internal loss breakdown were examined for a 150 cm tip diameter, radial-inflow turbine. The design application was to drive a two stage, 10 to 1 pressure ratio compressor with a mass flow of 0.0952 kg/sec and a rotational speed of 70,000 rpm. The turbine inlet temperature was 1478 K, and the turbine was designed with blades thin enough for internal cooling passages. The rotor tip diameter was limited to 86 percent of optimum in order to obtain a reduced tip speed design. The turbine was fabricated with solid, uncooled blades and tested in air at nominal inlet pressure and temperature of 1.379 x 10000 N/sq m and 322.2 K respectively. Results indicated the turbine total efficiency to be 5.3 percent less than design. Analysis of these results has indicated the deficit in performance to be due to secondary flow losses, vanes' surface friction losses, and trailing edge wake mixing losses.

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.


In the late fifties the Lewis Research Center evaluated experimentally the use of hydrogen using three different turbojet engines in altitude test chambers. One of these engines was later flown experimentally using liquid hydrogen fuel. This paper is a brief overview of the significant aspects of this exploratory research and

Improving fuel efficiency, new sources of jet fuel, and noise and emission control subjects of NASA's aeronautics program. Projects aimed at attaining a 5% fuel savings for existing engines and a 15% savings for the next generation of turbofan engines using advanced propulsion and exhaust systems. A performance improvement (PI) effort aimed at reducing the fuel consumption of jet engines is underway. This paper reviews the manner in which the PI concepts were selected for the program, a Performance Improvement (PI) effort aimed at developing new systems to be used on a variety of advanced propulsion systems. The PI effort is specifically directed at reducing the fuel consumption of existing engines by 5% and new engines by 15%. 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 paper discusses the availability throughout the government and industry of analytical methods for calculating both the steady and unsteady performance. 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 new sources of jet fuel and noise and emission control subjects of NASA's aeronautics program. Projects aimed at attaining a 5% fuel savings for existing engines and a 15% savings for the next generation of turbofan engines using advanced propulsion and exhaust systems. A performance improvement (PI) effort aimed at reducing the fuel consumption of existing engines by 5% and new engines by 15%. 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.


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 aerodynamic design 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. Mixing effectiveness and mixer pressure loss were determined using measured thrust and nozzle exit total pressure and temperature surveys. Results provide a database to aid the analysis and design development of the E3 mixed-flow exhaust system. B.J.


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 turbojet 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 wt %), while polyimide resin composites absorbed 0.8%. High moisture contents degraded the flexural and interlaminar shear properties, and the environmental and impact conditions severely damaged epoxy composites. The impact damage of fiber composites in moisture temperature environments can be assessed with finite element and composite mechanics analyses. Engine operation environmental conditions of 0.8% moisture and 140 F had no discernible effect on the fatigue resistance of composite fan exit guide vanes, which can be designed to exceed engine operational requirements using composite materials. A.T.
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 turblences 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 directivity patterns, but the smallest ICD's introduced propagating modes which could be recognized by additional lobes in the patterns. The JT15D-1 engine had a tone source which generated a strong propagating mode at fan speeds corresponding to 'approach' power and higher. Data from a typical transducer showed that the unsteady inflow distortion modes were eliminated or reduced when either of the ICD's was installed. A.T.


Powered-lift acoustic tests of a quiet clean short-haul experimental engine (GCESEE) 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 GCESEE 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)
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 provided the best performance at the tip of the blades.

A. T.


The trend in atomizing performance, as based on the mean drop size, increased airflow rates (per unit area) of 7.3 to 253 g/sq cm sec and water flow rates of 6.3 to 18.9 g/s, the effect of air and water flow rates on the mean drop size of water sprays produced with the swirl blast airflow. Experimental investigations of the aerodynamic performance of several annular prediffuser-combustor systems were presented. Three wall, dump prediffusers of different length, area ratio, and turning angle were tested and 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, 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. (Author)


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 253 g/sq cm sec and water flow rates of 6.3 to 18.9 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 were determined. Also, from these data it was possible to determine the effects of design modifications on the atomizing performance of various fuel injectors and swirl nozzle configurations. The trend in atomizing performance was 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. (Author)


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 minimized processed petroleum residual fuels. The program will focus on 'dry' reductions of nitrogen oxides of NOx/xt, 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 synfuels (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. (Author)


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 the next 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 high engine pressure ratios resulting in high expansion ratio, 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. (Author)

A80-42283 * # A theoretical and experimental investigation of propeller performance methodologies. K. D. Korkan, G. M. Greigrek (Ohio State University, Columbus, Ohio), and D. C. Mikkelson (NASA, Lewis Research Center, Subsonic Propulsion Section, Cleveland, Ohio). AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper No. 80-1240. 22 p. 37 refs. Grant No. NAG-3247.

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. (Author)


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 a fan 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-SOC/1A engine. A significant improvement in cruise power SFC of 1.8 percent was demonstrated in Sea Level sips conditions. (Author)


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

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 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 data noise and the jet and shock noises 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 using published NASA methods.


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 relatively 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.


An analytical model is presented of the effects of the hot-gas and coolant temperatures, the gas-to-blade and blade-to-coolant heat transfer coefficients, and the thermal conductance 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, 40 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 52 kelvins or 5.7% for ceramic-thermal-barrier-coated blades.


A three-stage Vortex 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 fuel burnout was 98.9 percent at takeoff, 91.7 percent at transonic climb, and 94.5 percent reaching a value of 97 percent at supersonic cruise. The exhaust temperature was 365 kelvins at takeoff, 305 kelvins at transonic climb, and 152 kelvins at supersonic cruise. The excess fuel burnout compared to the goal of 99.0 percent. Nitric oxide emissions were moderate but in excess of the program goal of 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. The thrust efficiency was 97.8 percent at takeoff, 96.7 percent at transonic climb, and 93.0 percent at supersonic cruise. The total pressure loss across the duct burner, at 6.76 the loss mechanisms have been identified and, in one configuration 40 percent of this excess loss was eliminated without compromising the emissions or thrust efficiency.


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

AB 102913 Design, durability and low cost processing technology for composite fan exit guide vanes. S. S. Blecherman Aug. 1979 129 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 in which an integral graphite kerf core fiber was the same for all candidates. The shell material, fiber orientation, and ply configuration were varied. Material tests were conducted on raw materials and composite specimens to establish specification requirements. Pre-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 respect to design analysis, materials properties, inspection standards, improved durability, weight benefits, and part price of the composite fan exit guide vane.
presented 

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/afterbody performance characteristics for inlets and nozzle/afterbodies and an example of the 1000 series of engine data tables is presented.

A.W.H.


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.W.H.


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 user oriented description of the program input requirements, program output, deck setup, and operating instructions is presented.

A.W.H.


The feasibility of employing the known attractive and distinguishing features of catalytic combustion technology to reduce nitric oxide emissions from gas turbine engines during ejection performance. These characteristic points determined which of nine possible ejection configurations provided optimal performance. Detailed examination of the thermodynamic cycle was made for representative cases and data was presented to illustrate the influence of ejection 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 ejection experiments showed excellent agreement between theory and experiment. It has been shown that ejections designed according to the methods described, can provide large improvement in propulsion system performance throughout the entire practical flight regime.


An acoustic and aerodynamic test program was conducted on a 1/6.25 scale model of the Quiet, Clean, Short-Haul Experimental Engine (GCSEE). 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, lip 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.

Author


The initial phase of testing of the under the wing engine and boilerplate nacelle components is discussed. The aerodynamics and performance are outlined.
The acoustic considerations involved in the low source noise engine design and the design procedures followed in the development of the over-the-wing (OTW) nacelles. Acoustic treatment design are presented. Laboratory experiments, component tests, and scale model and engine tests supporting the OTW engine acoustic design are referenced. 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 vanes treatment. M.M.M.

** DEVELOPMENT **

Laboratory experiments, component tests, and scale model and engine tests supporting structural integrity. M.M.M.

** CONDUCTED TO GENERATE MATERIALS PROPERTIES DATA, AND THE **

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.

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

The silicon carbide composites evaluated consisted of 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 lay chemistry, density, microstructure, and thickness were evaluated for compatibility, 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.

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

C. L. Ruggles Jul. 1978 75 p refs
(Contract NAS3-18021)
NASA-CR-135279; R78AE986
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.

** QUIET 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 NAS3-18021)
NASA-CR-135279; R78AE986
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.

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

C. L. Ruggles Jul. 1978 75 p refs
(Contract NAS3-18021)
NASA-CR-135279; R78AE986
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.
transmitter module was tested at 175 C combined with 40,000 g's acceleration. A.R.H.

N80-15100‡ General Electric Co, Cincinnati, Ohio. Aircraft
Engine Group.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE
(GCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE
SUBSYSTEM TEST REPORT
C. L. Stottlem, 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 C1SL 21E

The element and subcomponent testing conducted to verify
the under the wing composite nacelle design is reported. This
composite nacelle consists of an inner, outer cowl doors, inner
sectors, 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.

J.M.S.

N80-15101‡ General Electric Co., Cincinnati, Ohio. Advanced
Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE
(GCSEE). BALL SPLINE PITCH CHANGE MECHANISM
DESIGN REPORT
Apr. 1976 73 p refs
(Contract NAS3-18021)
(NASA-CR-134873; R77AEG327) Avail. NTIS
HC A04/MF A01 C1SL 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 countering master
gear pairs meshing pinion gears attached to each of 18 fan
blades.

R.E.S.

N80-15102‡ General Electric Co., Cincinnati, Ohio.

ACOUSTIC ANALYSIS OF AFT NOISE REDUCTION
TECHNIQUES MEASURED ON A SUBSONIC TIP SPEED
50.8 cm (TWENTY INCH) DIAMETER FAN
D. L. Stimpert and A. Clemons Jan. 1977 149 p refs
(Contract NAS3-18021)
(NASA-CR-134891; R75AEG368) Avail. NTIS
HC A07/MF A01 C1SL 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 techniques. 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
fan 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 and
variable thickness were examined. Significant results are reported.

R.C.T.

N80-15103‡ Curtiss-Wright Corp., Wood-Ridge, N.J. Power
Systems.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE
(GCSEE) MAIN REDUCTION GEARS TEST PROGRAM Final
Report
D. W. Misel Mar. 1977 220 p refs
(Contract NAS3-18021)
(NASA-CR-134668; CW-WR-77-008) Avail. NTIS
HC A10/MF A01 C1SL 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 the engine. The UTW
engine reduction gears which have a ratio of 2.4651 and
a design rating of 9712 kW at 3157 rpm fan speed were operated
at up to 105% of speed at 60% torque and 100% speed at 125%
torque. The OTW engine reduction gears which have a ratio of
2.0621 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 109% 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 (22,300 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.

R.C.T.

N80-15104‡ General Electric Co., Cincinnati, Ohio. Advanced
Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE
(GCSEE) CLEAN COMBUSTOR TEST REPORT
Oct. 1975 66 p refs
(Contract NAS3-18021)
(NASA-CR-134916; R75AEG449) Avail. NTIS
HC A04/MF A01 C1SL 21E

A component pressure test was conducted on a F101 PPIT
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
(GCSEE). 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 GCSEE emissions levels with the emission goals of
the GCSEE engine program.

A.C.T.

N80-15105‡ Curtiss-Wright Corp., Wood-Ridge, N.J.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE
(GCSEE) MAIN REDUCTION GEARS BEARING DEVELOPMENT
PROGRAM Final Report
Dec. 1975 40 p
(Contract NAS3-18021)
(NASA-CR-134890) Avail. NTIS HC A03/MF A01 C1SL 21E

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

R.C.T.

N80-15106‡ Curtiss-Wright Corp., Wood-Ridge, N.J.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE
(GCSEE) MAIN REDUCTION GEARS DETAILED DESIGN
REPORT Final Report
A. Defeo and M. Kulina Jul. 1977 221 p
(Contract NAS3-18021)
(NASA-CR-134872; CW-WR-77-024) Avail. NTIS
HC A10/MF A01 C1SL 21E

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 2.4651 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 2.0621 and a 100% power design rating of
12,813 kW (17,183 hp) at 3861 rpm fan speed. Details of
configuration, stresses, deflections, and lubrication are
presented.

J.M.S.

N80-15107‡ Hamilton Standard, Windsor Locks, Conn. Aircraft
Systems Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE
(GCSEE): 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 ratio harmonic drive attached to a multitrack 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

N80-15108 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

Mar. 1977 144 p

NASA-CR-135046; R77AEG177

Avail: NTIS

HC A07/MF A01 CSCL 21E

A total of 3B 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 DESIGN OF THE QCSEE UNDER-THE-WING FAN
Mar. 1977 104 p

Contract NAS3-18021

NASA-CR-135008; 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.

N80-15110 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-135278; R78AEG439

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 96 hours respectively of successful running on the UTW and OTW engines.

J.M.S.
A hybrid computer simulation of the over the wing turbofan engine was constructed to develop the dynamic design of the control system. This engine and control system includes a full authority digital electronic control using compressor stator reset to achieve fast thrust response and a modified Kalman filter to control steady state control of the engine. This engine and control system includes a full authority digital electronic control using compressor stator reset to achieve fast thrust response and a modified Kalman filter to control steady state control of the engine. Simulation results for throttle bursts from 62 to 100 percent takeoff thrust predict that the engine will accelerate from 62 to 95 percent takeoff thrust in one second.

NBO-15115 General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (GCSEE) SPINE PITCH-CHANGE MECHANISM WHIRLIGIG TEST REPORT
Sep 1978 64 p refs
(Contract NAS3-18021)
(HC A04/MAF A01 CSCL 21E)
The component testing of a ball spline variable pitch mechanism is described 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 125 deg per second at up to 102 percent fan speed (3400 rpm).

NBO-15116 General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (GCSEE) UNDER-THE-WING (UTW) BOILER PLATE NACELLE AND CORE EXHAUST NOZZLE DESIGN REPORT
Oct. 1976 104 p
(Contract NAS3-18021)
(HC A06/MAF A01 CSCL 21E)
The design of the boiler plate nacelle and core exhaust nozzle for the GCSEE under the wing engine is presented. The nozzle, 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 GCSEE over the wing engine configuration.

NBO-15117 Hamilton Standard, Windsor Locks, Conn.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (GCSEE) WHIRL TEST OF CAM/HARMONIC PITCH CHANGE ACTUATION SYSTEM Contractor Report, 10 Nov. 1976 - 16 Feb. 1978
Apr. 1976 208 p refs
(Contract NAS3-18021)
(HC A10/MAF A01 CSCL 21E)
The mechanical design of the boiler plate nacelle and core exhaust nozzle for the GCSEE under the wing engine is presented. The nozzle, 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 GCSEE over the wing engine configuration.

NBO-15118 General Electric Co., Cincinnati, Ohio.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (GCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEMS TEST REPORT. VOLUME 4: ACOUSTIC PERFORMANCE
D. L. Simpert, Feb. 1979 144 p refs
(Contract NAS3-18021)
(NASA-CR-135326: R77AEG376-Vol-4)
(HC A07/MAF 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 the 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.
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.

The components resulting from the deposition of morganic salts (e.g., Na2SO4) and oxides present in the combustion products from gas turbine engines were investigated. Emphasis was placed on the effects of multicomponent vapor transport, thermophoretic transport of vapor and small particles to actively cooled surfaces, variable fluid properties within mass transfer boundary layers, and free stream turbulence.

The optical polarization (ellipsometric) technique was developed for measuring rapidly growing and evaporating transparent liquid condensate films (e.g., boric oxide) on solid surfaces exposed to combustion product gases. Results for the B203 deposition rate from E13-seeded propane/air flames are shown to agree well with the results of earlier interference measurements, and also with theoretical CVD predictions. Evaporation rates (from platinum ribs into seeded propane air flames) are estimated using the polarization technique. It appears that, compared with the interference method, the polarization technique places less stringent requirements on surface quality, which may justify the added optical components needed for such measurements. It is concluded that the complementary optical methods of polarization (ellipsometry) and interference hold considerable promise for application to the rapid measurement of condensation and evaporation rates in high temperature (e.g., combustion product) environments.

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swept wing configurations were tested across a range of nozzle position are among the parameters investigated. Straight and located both under the wing and over the wing is demonstrated.


(NASA CR 134860, R75AE252 Vol 2) Avail NTIS HC A14/MF A01 CSCL 21E.

All fan noise reduction techniques were investigated. The 1/3 octave band sound data were plotted with the following plots included: perceived noise level vs acoustic angle at 2 fan speeds; PWL vs frequency at 2 fan speeds, and sound pressure level vs frequency at 2 fan speeds. The source noise plots included: band pass filter sound pressure level vs acoustic angle at 2 fan speeds, and 2nd harmonic SPL acoustic angle at 2 fan speeds.

N80-15085# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group. DEMONSTRATION OF SHORT HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES ON A TWENTY INCH (50.8 cm) DIAMETER FAN, VOLUME 3.


(NASA CR 134951, R75AE252 Vol 3) Avail NTIS HC A09/MF A01 CSCL 21E.

Tests of a twenty inch diameter, low tip speed, low pressure ratio fan which investigated all fan noise reduction techniques are reported. The 1/3 octave band sound data are presented for all the configurations tested. The model data are presented on 17 foot arc and extrapolated to 200 foot sideline.

N80-15086# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept. QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER THE WING (OTW) DESIGN REPORT Final Report.

Jun 1977 530 p (Contract NAS3 18021).

(NASA CR 134848, R75AE443) Avail NTIS HC A23/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 propulsion technology required for externally blown flap aircraft with engines located both under the wing and over the wing is demonstrated.

N80-15087# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group. QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING FLIGHT PRODUCTION SYSTEM ANALYSIS REPORT.

May 1976 98 p (Contract NAS3-18021).

(NASA CR-134915) Avail NTIS HC A05/MF A01 CSCL 21E.

The aerodynamic and mechanical design of a fixed-pitch 1.36 pressure ratio fan for the over-the-wing (OTW) engine is presented. The fan has 28 blades. Aerodynamically, the fan blades were designed for a composite blade, but titanium blades were used in the experimental fan as a cost savings measure.


Apr 1976 58 p (Contract NAS3-18021).

(NASA CR-134915) Avail NTIS HC A05/MF A01 CSCL 21E.

The aerodynamic and mechanical design of a fixed-pitch 1.36 pressure ratio fan for the over-the-wing (OTW) engine is presented. The fan has 28 blades. Aerodynamically, the fan blades were designed for a composite blade, but titanium blades were used in the experimental fan as a cost savings measure.

N80-15089# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept. QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE DIGITAL CONTROL SYSTEM DESIGN REPORT.

Jan 1978 321 p refs (Contract NAS3-18021).

(NASA CR-134920, R75AE483) Avail NTIS HC A14/MF A01 CSCL 21E.

The digital electronic 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.

N80-15090# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept. QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE SIMULATION REPORT.

Jul 1977 103 p refs (Contract NAS3-18021).

(NASA CR-134914, R75AE444) 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.

N80-15091# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept. QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) PRELIMINARY UNDER THE WING FLIGHT SYSTEM DESIGN REPORT.

Dec 1976 261 p refs (Contract NAS3-18021).

(NASA CR-134920, R75AE483) Avail NTIS HC A14/MF A01 CSCL 21E.

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 is described. The technology required for externally blown flap aircraft with engines located both under the wing and over the wing is demonstrated.

N80-15092# General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept. QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING ENGINE DESIGN REPORT.

Jan 1978 321 p refs (Contract NAS3-18021).

(NASA CR-134920, R75AE483) Avail NTIS HC A14/MF A01 CSCL 21E.

A digital electronic 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.
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.

N80-16082* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING CONTROL SYSTEM DESIGN REPORT
Dec 1977 249 p ref
(Contract NAS3-18021) (NASA-CR-135279; R77AEG664) Avail. NTIS HC A11/MA 01 CSCL 21E
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.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). CORE ENGINE NOISE MEASUREMENTS
(Contract NAS3-18021) (NASA-CR-135280; R75AEG511) Avail. NTIS HC A04/MA 01 CSCL 21E
Noise measurements were taken on a turbofan engine which uses the same core, with minor modifications, employed on the quiet clean short-haul experimental engine (QCSEE) propulsion systems. 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.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). UNDER-THE-WING (UTW) ENGINE COMPOSITE NACELLE TEST REPORT. VOLUME 1: SUMMARY, AERODYNAMIC AND MECHANICAL PERFORMANCE
Apr. 1979 214 p ref
(Contract NAS3-18021) (NASA-CR-159471; R78AEG573-Vol-1) Avail. NTIS HC A10/MA 01 CSCL 21E
The performance test results of the final under-the-wing engine configuration are presented. One hundred and six hours of engine operation were completed, 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. Author.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) PRELIMINARY OVER-THE-WING FLIGHT PROPULSION SYSTEM ANALYSIS REPORT
(Contract NAS3-18021) (NASA-CR-135286; R77AEG305) Avail. NTIS HC A08/MA 01 CSCL 21E
The preliminary design of the over-the-wing flight propulsion system is presented. Features of a short-haul, powered lift aircraft are presented.

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 EPNdBA on a 152.4 m sideline.

N80-15096* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). UNDER-THE-WING (UTW) ENGINE BOILERPLATE NACELLE TEST REPORT. VOLUME 1: SUMMARY
Dec. 1977 85 p ref
(Contract NAS3-18021) (NASA-CR-135249; R77AEG2121-Vol-1) Avail. NTIS HC A04/MA 01 CSCL 21E
The design and testing of high bypass geared turbofan engines with nacelles forming the propulsion system for short haul passenger aircraft are considered. The 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.

N80-15097* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). UNDER-THE-WING (UTW) ENGINE BOILERPLATE NACELLE TEST REPORT. VOLUME 3: MECHANICAL PERFORMANCE
31 Dec. 1977 128 p ref
(Contract NAS3-18021) (NASA-CR-135251; R77AEG2122-Vol-3) Avail. NTIS HC A07/MA 01 CSCL 21E
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: system dynamics, composite fan blades, reduction gear, lube and accessory drive system, fan frame, inlet, core cooling, fan exhaust nozzle, and digital control system.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). COMPOSITE FAN FRAME SUBSYSTEM TEST REPORT
C. L. Stotler, Jr. and J. H. Bowden Sep. 1977 71 p ref
(Contract NAS3-18021) (NASA-CR-135010; R76AEG233) Avail. NTIS HC A04/MA 01 CSCL 21E
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 process 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 CF6-50 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 acoustical requirements for nozzles and reversers of this type. J.M.S.

**N80-16061**
General Electric Co., Cincinnati, Ohio Aircraft Engine Group

**CORE NOISE INVESTIGATION OF THE CF6-50 TURBOFAN ENGINE Data Report, 1978-1979**
V. L. Doyle Jan 1980 357 p

(NASA•CR-159598; R79AE247) Avail NTIS HC A16/MF A01 CSCL 21E

Acoustic data obtained during the running of the CF6-50 turbofan engine on an outdoor test stand are presented. The test was conducted to acquire simultaneous internal and far-field narrowband and one-third octave band pressure spectra. R.E.S.

**N80-16042**
General Electric Co., Cincinnati, Ohio Aircraft Engine Group

**CORE NOISE INVESTIGATION OF THE CF6-50 TURBOFAN ENGINE** Final Report
V. L. Doyle and M. T. Moore Jan 1980 520 p refs

(Contract NAS3•21260) (NASA•CR-159749; R79AGE395) Avail NTIS HC A22/MF A01 CSCL 21E

The contribution of the standard production annular combustor to the far-field noise signature of the CF6-50 engine was investigated. The acoustic data were determined for selected pairs of combustor sensors and from two internal sensors to the airflow. The coherent output power was determined in the far-field measurements, and comparisons of measured overall power levels were made with component and engine correlating parameters. R.E.S.

**N80-16063**
Pratt and Whitney Aircraft Group, East Hartford, Conn.

**EXPANDED STUDY OF FEASIBILITY OF MEASURING IN-FLIGHT 747/JT9D LOADS, PERFORMANCE, CLEARANCE, AND THERMAL DATA**

(Contract NAS3-20632) (NASA•CR-159771; PWA-5512-46) Avail: NTIS HC A06/MF A01 CSCL 21E

The JT9D jet engine exhibits a TFSC loss of about 1 percent 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, causing the rotating blades to rub against the seal surfaces, producing permanent clearance changes. The real level of flight loads encountered during airplane acceptance testing and revenue service and the engine’s response in the dynamic environment were investigated. The feasibility of direct measurement of these flight loads and their effects by concurrent measurement of 747/JT9D propulsion system aerodynamic and inertial 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 inertial loads to which the engine is exposed during the initial flight acceptance test and normal flight maneuvers is feasible and desirable. A specific recommended flight test program, based on the evaluation of cost effectiveness, is defined. A.R.H.

**N80-17073**
Pratt and Whitney Aircraft Group, West Palm Beach, Fla.

**DISTRIBUTION ANALYSIS FOR F100(3) ENGINE** Final Report
W. A. Walter and M. Shaw Jan 1980 66 p refs

(Contract NAS3•20835) (NASA•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.

**N80-17074**
Pratt and Whitney Aircraft, East Hartford, Conn.

**EXPERIMENTAL EVALUATION OF A LOW EMISSIONS HIGH PERFORMANCE DUCT BURNER FOR VARIABLE CYCLE ENGINES (VCE)** Final Report
R. P. Lehmann and R. J. Mador Oct 1979 118 p refs

(Contract NAS3•20602) (NASA•CR-159694; PWA-5512-32A) Avail: NTIS HC A06/MF A01 CSCL 21A

An evaluation was conducted with a three stage Vortex duct burner to determine the performance and emissions characteristics of the concept used to refine and configure the duct 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, exit temperature, thrust efficiency, and gaseous emissions calculations are defined. The test procedures are reviewed and the results are discussed. A.W.H.

**N80-18040**

**STUDY OF RESEARCH AND DEVELOPMENT REQUIREMENTS OF SMALL GAS-TURBINE COMBUSTORS**

(Contract NAS3-21980) (NASA•CR-159796; ADL-83381-2) Avail: NTIS HC A04/MF A01 CSCL 21E

A survey is presented of the major small-engine manufacturers and governmental users. A consensus was undertaken regarding small-combustor requirements. The results presented are based on an evaluation of the information obtained in the course of the study. The current status of small-combustor technology is reviewed. The principal problems lie in liner cooling, fuel injection, part-power performance, and ignition. Projections of future engine requirements and their effect on the combustor are discussed. The major changes anticipated are significant increases in operating pressure and temperature levels and greater capability of using heavier alternative fuels. All aspects of combustor design are affected, but the principal impact is on liner durability. An R&D plan which addresses the critical combustor needs is described. The plan consists of 15 recommended programs for achieving necessary advances in the areas of liner thermal design, primary-zone performance, fuel injection, dilution, analytical modeling, and alternative-fuel utilization. M.M.M.

**N80-18041**

**INTERNAL COATING OF AIR COOLED GAS TURBINE BLADES** Final Report
P. L. Ahuja Nov. 1979 73 p refs
Six coating systems were evaluated for internal coating of decoting stage (DS) eutectic high pressure turbine blades. Sequential deposition of electroless Ni by the hydrazine process, slurry Cr, and slurry Al, followed by heat treatment provided the coating composition and thickness for internal coating of DS eutectic turbine blades. Both NiCr and NiCrAl coating compositions were evaluated for strain capability and ductile to brittle transition temperature.

NBO-218042$^{a}$ 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 NAS3-21468)

(NASA-CR-159762, TR-2-00320/D-52360) Avail NTIS HC A05/MF A01 CSCL 21E

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, 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 thrust 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 pressure recovery except at the highest combination of angle of attack and forward speed. The flow quality at the fan face was somewhat degraded by the addition of blow-in door passages to the long aft inlet configuration due to the pressure disturbances generated by the flow entering the diffuser through the auxiliary air passages.

NBO-191113$^{a}$ 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 NAS3-20578)

(NASA-CR-159714; PVW•5561-55) Avail: NTIS HC A07/MF A01 CSCL 21E

The effect of aspect ratio on the performance of core compressor exit stages was demonstrated using two three 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 lbm/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 0.528. 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. R.C.T.

NBO-202311$^{a}$ Texcynic Continental Motors, Muskegon, Mich.

A 150 AND 300 kW LIGHTWEIGHT DIETIL AIRCRAFT ENGINE DESIGN STUDY Final Report

Alex P. Brouwers Apr. 1980 149 p refs

(Contract NAS3-20853)

(NASA-CR-3280; Rept-750) Avail: NTIS HC A07/MF A01 CSCL 21A

The diesel engine was reexamined 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, a 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.

NBO-21328$^{a}$ General Electric Co., Cincinnati, Ohio Aircraft Engine Group.

PROGRAM FOR IMPACT TESTING OF SPAR-SHELL FAN BLADES, TEST REPORT

R. Ravanholl and C. T. Salamme Apr. 1978 95 p

(Contract NAS3-20801)

(NASA-CR-135393, NC8AE•444) Avail: NTIS HC A05/MF A01 CSCL 21E

Six filament-wound, composite spar-shell fan blades were impact tested in a whirligig relative to foreign object damage resulting from ingestion of birds into the fan blades of a GSEE•type engine. Four of the blades were tested by injecting a simulated two pound bird into the path of the rotating blade and two were tested by injecting a striking into the path of the blade.

NBO-21329$^{a}$ Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

MANUFACTURE OF LOW CARBON ALLOY STROLOGY TURBINE DISK SHAPES BY HOT ISOSTATIC PRESSING, VOLUME 2, PROJECT 1 Final Report

R. D. Eng and D. J. Evans Jan. 1979 10 p

(Contract NAS3-20072)

(NASA-CR-135410; PVW•5574-37) Avail: NTIS HC A02/MF A01 CSCL 21E

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.

NBO-21330$^{a}$ IIT Research Inst., Chicago, Ill.

THERMAL FATIGUE AND OXIDATION DATA FOR DIRECTIONALLY SOLIDIFIED MAR-M 246 TURBINE BLADES

V. L. Hill and V. E. Humphreys Jan. 1980 45 p refs

(Contract NAS-19696)


Thermal fatigue and oxidation data were obtained for 11 plasma spray coated and 13 uncoated directionally solidified and single crystal MAR-M 246 blades. Blade coatings on the airfoil included several metal-oxide thermal barrier layers based on Al2O3, Cr2O3, 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 in 3000 cycles. All coatings indicated microscopically visible spalling at the trailing edge radius after 3000 cycles. Severe general spalling on the airfoil was observed for two multilayered coatings.
A model TFE731-1 engine was used as a baseline for the NASA quiet general aviation turbofan engine and engine/nacelle program designed to demonstrate the applicability of large turbofan engine technology to small general aviation turbofan engines, and to obtain 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 38 conditions, are 10 to 15 ENPdB below FAA engines, and to obtain significant reductions in noise and pollutant emissions the engine performance by use of sprayed ceramic seals.

The three seals did have slight laminar cracks at the 85/15-40/60 test conditions but completed the test successfully without severe cracking or spalling. Three ceramic seals were installed in the engine with fourteen abrasive tip blades. Three of the eight blades wore a maximum of five mils. Engine rub test results demonstrated the potential of reducing turbine clearances and thereby improving engine performance by use of sprayed ceramic seals.

The needs for additional component sensitivity testing as well as outstanding issues are discussed.
166 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 cruise mode operation. Based on the results of this analysis, a three-phase technology development program is projected resulting in production dates of 1985, 1992, and 2000. R.E.S.

N80-22333$ Avco Lycoming Div., Stratford, Conn. AVCO LYCOMING QUIET CLEAN GENERAL AVIATION TURBOPROP ENGINE Craig A. Wilson. As part of the NASA sponsored engine component improvement program, and fan package was de

N80-22330$ General Electric Co., Cincinnati, Ohio. CF6 JET ENGINE PERFORMANCE IMPROVEMENT: NEW FAN W. A. Fasching May 1980 202 p (Contract NAS3-20629) (NASA-CR-159699; R79AG413) Avail: NTIS HC A10/MF A01 CSCL 21E As part of the NASA sponsored engine component improvement program, and fan package was de

N80-23311$ Hamilton Standard, Windsor Locks, Conn. ACOUSTIC TEST AND ANALYSES OF THREE ADVANCED TURBOPROP MODELS Final Report Bennett M. Brooks and F. B. Metzger Jan. 1980 245 p refe (Contract NAS3-20614) (NASA-CR-159667) Avail: NTIS HC A11/MF A01 CSCL 21E 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 the 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 near 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 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.

N80-25323# Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.


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 stage 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.


(Contract NAS3-20055) (NASA-CR-159931; 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 deg. Graphite epoxy airfoils were fabricated to achieve the realistically high reduced frequency level of 0.46. 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.

N80-25340# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

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-5515-14) 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 a 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.

N80-26300# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.


(Contract NAS3-20061) (NASA-CR-159710; PWA-5550-31) Avail: NTIS HC A05/MF A01 CSCL 21E

Aerodynamic performance and jet noise characteristics of a one sixth scale model of the variable cycle engine testbed exhaust system were obtained in a series of static tests over a range of simulated engine operating conditions. Model acoustic data were acquired. Data were compared to predictions of coannular model nozzle performance. The model, tested with and without a hardwall ejector, had a total flow area equivalent to a 0.127 meter (5 inch) diameter conical nozzle with a 0.65 fan to primary nozzle area ratio and a 0.82 fan nozzle radius ratio. Fan stream temperatures and velocities were varied from 422 K to 1089 K (760 R to 1960 R) and 353 to 600 meters per second (1158 to 1968 feet per second). Exhaust plume velocity surveys were conducted at one operating condition with and without the ejector installed. Thirty aerodynamic performance data points were obtained with an unheated air supply. Fan nozzle pressure ratio was varied from 1.8 to 3.2 at a constant primary pressure ratio of 1.6; primary pressure ratio was varied from 1.4 to 2.4 while holding fan pressure ratio constant at 2.4. Operation with the ejector increased nozzle thrust coefficient 0.2 to 0.4 percent.

B.D.

N80-26301# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.


The component detail design drawings of the one sixth scale model of the variable cycle engine testbed demonstrator exhaust system tested are presented. Also provided are the basic acoustic and aerodynamic data acquired during the experimental model tests. The model drawings, an index to the acoustic data, an index to the aerodynamic data, tabulated and graphical acoustic data, and the tabulated aerodynamic data and graphs are discussed.

B.D.
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.

**PERFORMANCE, EMISSIONS, AND PHYSICAL CHARACTERISTICS OF A ROTATING COMBUSTION AIRCRAFT ENGINE, SUPPLEMENT A**

R. K. Lampein, I. Manning, D. Myers, and B. Tjoa May 1980 74 p

(Contract NAS3-20808)

(NASA-CR-135119; CW-WR-76-028/3) Avail: NTIS HC A04/MF A01 CSCL 21E

Testing was conducted using the basic RC2-75 engine, to which several modifications were incorporated which were designed to reduce the hydrocarbon emissions and reduce the specific fuel consumption. The modifications included close-in surface gap spark plugs, increased compression ratio rotors, and provisions for utilizing either side or peripheral intake ports, or a combination of the two if required. The proposed EPA emission requirements were met using the normal peripheral porting. The specific fuel consumption for the modified RC2-75 was 283 g/kW-h at 75% power and 101 brake mean effective pressure (BMEP) and 272.5 g/kW-h at 75% power and 111 BMEP. The latter would result from rating the engine for takeoff at 285 hp and 5500 rpm, instead of 6000 rpm. E.D.K.

**CF6-6D ENGINE PERFORMANCE DETERIORATION**


(Contract NAS3-20631)

(NASA-CR-159786; R80AGE218) Avail: NTIS HC A13/MF A01 CSCL 21E

Cruise cockpit recordings and test cell performance data in conjunction with hardware inspection data from airline overhaul shops were analyzed to define the extent and magnitude of performance deterioration of the General Electric CF6-6D model engine. The studies included short-term deterioration from the long 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 10.3 million gallons. E.D.K.

**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 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 6.6 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.

**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 refinery fuel specification would not significantly alter jet fuel availability.

**A METHODOLOGY FOR LONG-RANGE PREDICTION OF AIR TRANSPORTATION**


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 utilized was 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 to 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.

**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.

The premixing dome design liner temperatures suggest that the fuel-air mixture was not as uniform as desired. M.G.

The effects of broadening the specifications for JP-4 and JP-8 fuel 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 use of high demand middle distillates fuels and extend the use of JP-8 in the United States will increase middle distillate demand and cause a slight increase in engine fuel-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 shale oil are described. Refining methods involving hydrocracking, hydro-treating, 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 on the sideout, which is the reverse of the primary concept employing high pressure drop fuel nozzles for improved atomization, and (3) a concept with the pilot stage on the inside and the main stage on the sideout, which is the reverse of the other two concepts. All of the advanced concepts show promise for reduced sensitivity to fuel 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 dome, 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 use of broad specification fuels in 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 combustion data. Correlations of other fuel properties with these and other performance parameters are presented. E.D.K.

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 combustor concepts with experimental refinement broadened specification fuel specifications that were evaluated included perturbation of the combustor airflow schedules to alter local stoichiometry, time histories revisions to the fuel injectors, and/or advanced cooling concepts. R.C.T.

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 these and other performance parameters are presented. E.D.K.
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 technical risk, R.C.T.

**NBO-29319** Purdue Univ., Lafayette, Ind.

**ATOMIZATION OF BROAD SPECIFICATION AIRCRAFT FUELS**


Avail: NTIS HC A11/MF A01 CSSJ 21D

The atomization properties of liquid fuels for the potential use in aircraft gas turbine engines are discussed. The significance of these properties are addressed with respect to the ignition and subsequent combustion 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.

**NBO-29320** Massachusetts Inst. of Tech., Cambridge.

**SOOT FORMATION AND BURNOUT IN FLAMES**


Avail: NTIS HC A11/MF A01 CSSJ 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.

**NBO-29321** 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 NBO-29300 20-07)

Avail: NTIS HC A11/MF A01 CSSJ 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.

**NBO-29322** Southwest Research Inst., San Antonio, Tex.

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


Avail: NTIS HC A11/MF A01 CSSJ 21E

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 50 test conditions with test conditions ranging over 500-1800 kPa (5-18 atm) pressure and 500-1000 K burner inlet temperature; fuel-air ratios were varied from 0.008-0.024. 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), naphthenes (decalin) and partially hydrogenated aromatics (tetralin); the sixth fuel emphasized final boiling point.

R.C.T.

**NBO-29323** 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 CSSJ 21D

The thermal stability of aircraft gas turbine fuels was investigated. The objectives were: (1) to design and build an aircraft fuel system simulator; (2) to establish criteria for quantitative 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.

**NBO-29324** Naval Air Propulsion Test Center, Trenton, N.J.

**DETERMINATION OF JET FUEL THERMAL DEPOT RATE USING A MODIFIED JFTOT**


Avail: NTIS HC A11/MF A01 CSSJ 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 8 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 deposition rate for these three fuels were determined to be 260 C, and a relative deposition rate at this temperature was calculated and plotted as a function of the individual fuel's breakpoint temperature.

R.C.T.

**NBO-29325** Colorado School of Mines, Golden.

**MECHANISMS OF NITROGEN HETERO CYCLE INFLUENCE ON TURBINE FUEL STABILITY**


Avail: NTIS HC A11/MF A01 CSSJ 21D

Lewie bases were extracted from a Utah COED syncrude via ligand exchange. Addition of this extract to Jet A at levels as low as 5 ppm N produced 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.

**NBO-29326** Boeing Military Airplane Development, Seattle,
Wash.

HIGH-FREEZING-POINT FUEL STUDIES
Avail NTIS HC A11/ MF A01 CSCL 21D

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 analyser code to permit the designer to fly various thermal exposure patterns, study fuel temperatures versus time, and determine holdup.

E.D.K.

LOW TEMPERATURE FUEL BEHAVIOR STUDIES
Francis J. Scockemer In NASA Lewis Res Center. Aircraft Res. and Technol. for Future Fuels Jul 1980 p 221-233 refs (For primary document see N80-29330 20-07)
Avail NTIS HC A11/ MF A01 CSCL 21E

Aircraft fuels at low temperatures near the freezing point. The principal objective 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.

R.C.T.
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.


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 large 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 turborev) 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 unswept 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 peaks is good. Shadowgraph measurements which show the location of typical associated wave patterns were obtained. Predicted and measured wave locations show good general 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.


Under the NASA-sponsored Energy Efficient Engine (EEE) Project, technology is being developed which will significantly reduce the fuel consumption of turbofan engines for subsonic transport aircraft. One technology concept being pursued is active control of rotor tip clearances. Attention is given to rotor tip clearance considerations and an overview of preliminary study results as well as the General Electric EEE clearance 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 441, 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, proplets, airfoil improvement, sweep, position of maximum blade loading and diameter reduction.
SINGLE-STAGE ELECTROHYDRAULIC SERVOSYSTEM FOR ACTUATING ON AIRFLOW VALVE WITH FREQUENCIES TO 500 HERTZ


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.
09 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).

N80-32404
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.
The Cryogenic Fluid Management Experiment (CFME) was analyzed to assess the feasibility and advisability of deleting the vapor-cooled shield (VCS) from the baseline CFME insulation and pressure control system. Two alternate concepts of CFME insulation and pressure control, neither of which incorporated the VCS, were investigated. The first concept employed a thermodynamic vent system (TVS) to throttle the flow through an internal wall mounted heat exchanger (HX) within the pressure vessel to decrease boiloff and pressure rise rate, while the second concept utilized a TVS without an internal heat exchanger. Only the first concept was viable. Its performance was assessed for a seven day mission and found to be satisfactory. It was also concluded that VCS development costs would be greater than for an internal HX installation. Based upon the above comparisons, the HX was recommended as a replacement for the VCS.

(Author)
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).

A80-13308 * # An electric propulsion long term test facility.

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 shakedown test of 500 hours, and facility performance during the first year of testing are presented.

NW-27403 */# General Dynamics/Convair, San Diego, Calif.
CONCEPTUAL DESIGN OF TWO-PHASE FLUID MECHANICS AND HEAT TRANSFER FACILITY FOR SPACELAB

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.
15 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-805054217) Avail: NTIS HC A16/F 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.

E.D.K.


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 OPSK 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 are outlined 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 03 Air Transportation and Safety and 85 Urban Technology and Transportation.

N90-20304# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

LaRC 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 02/MF A01 C5CL 22A

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 miniexperiments that use 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 EXPERIMENT 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 demonstrates 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 characterization 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 29 Structural Mechanics.

NBO-18200

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

CONFIGURATION EFFECTS ON SATELLITE CHARGING RESPONSE


[NASA-TM-81397; E-307] Avail. NTIS HC A02/MF A01 SCSL

The response of various spacecraft configurations to charging and discharging conditions are evaluated only for direct-drive configuration. These simulated thruster-on conditions are considered. Thruster-off simulations appear dominated by differential charging effects. Shaded insulation charges negatively result in the formation of negative surface potentials and effective surface conductivity treatments of photoelectron trajectories are indicated. A discharge process can reduce surface potentials over entire satellite, and that low density electron trajectory computations indicate that discharges generated electrons do not return to the satellite by long trajectories. Current transients predicted do not agree with available ground simulation studies indicating that additional work must be done both analytically and experimentally to understand and fully explain these discrepancies.

A.W.H.

NBO-16923

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

EFFECTS OF SECONDARY YIELD PARAMETER VARIATION ON PREDICTED EQUILIBRIUM POTENTIAL OF AN OBJECT IN A CHARGING ENVIRONMENT


[NASA-TM-79229; E-117] Avail. NTIS HC A02/MF A01 SCSL

The sensitivity of predicted equilibrium potential changes in secondary electron yield parameters was investigated using MATCHG, a simple charging code which incorporates the NASCAP material property formulations. The equilibrium potential was found to be 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. The information on the electron generated secondary yield parameters was discovered to be obtainable from monoeenergetic beam charging data if charging rates as well as equilibrium potentials of stabilization, and overall size. Results indicate that sunlight charging response is dominated by differential charging effects. The effects of photoelectron space charge and current density electron trajectory computations indicate that discharges 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.

NBO-16846

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

COMPUTED VOLTAGE DISTRIBUTIONS AROUND SOLAR ELECTRIC PROPULSION SPACECRAFT


[NASA-TM-79286; E-225] Avail. NTIS HC A02/MF A01 SCSL

The NASA Charging Analyzer Program (NASCAP) is used to conduct preliminary computations of the voltage distributions around spacecraft configurations. The simulations included solar arrays and direct-drive (-1200 volts on arrays) configurations are considered. Thruster-off simulations are computed for both operating voltage configurations; and 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 condition are evaluated only for direct-drive configuration. These simulated thruster-on conditions are evaluated only for direct-drive configuration. These simulations proposed heaters appear to alleviate surface charging. M.M.M.

NBO-18095

National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

NASCAP MODELLING COMPUTATIONS ON LARGE OPTICS SPACECRAFT IN GEOSYNCHRONOUS SUBSTORM ENvironments


[NASA-TM-81395; E-305] Avail. NTIS HC A02/MF A01 SCSL

The NASA Charging Analyzer Program (NASCAP) is used to evaluate qualitatively the possibility of such 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. Particulate 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. J.M.S.

The paper uses the NASCAP computer code to compute voltage distributions around a Solar Electric Propulsion (SEP) spacecraft as it encounters an idealized geomagnetic substorm environment. Consideration is given to both a standard operating voltage and direct-drive configuration. The computations are presented without experimental calibration of the relationship between the flight measurements and actual measurements. The experimental results are obtained from a ground simulation program to develop predictive techniques for the spacecraft design.

M. E. P.


The satellite surface potential monitor (SPSM) 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. The model also infers total surface voltages from a single point on the interior side of the spacecraft. A ground simulation program was undertaken to develop analytical techniques to monitor the response of the spacecraft to space environment conditions and to obtain experimental calibration of the relationship between the flight measurements and actual measurements. The experimental testing was conducted using monoelectronic beam irradiating samples in the dark. The results indicate that the technique used in the development of the spacecraft design are exploratory.

M. E. P.


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 suborbital 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 geostationary altitude. The electric power was provided by the spacecraft nuclear reactor space power system on a shared basis during transfer operations. Factors considered in this study included nuclear power source size, electric propulsion thruster concept, spacecraft deployment constraints, and orbital operations and safety. The results indicate that the variable 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 simulation code which has been adapted for this purpose.

54
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 monoenergetic 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)


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 space environment with a satellite at geosynchronous altitude. J. M. Sellen, Jr, and G. K. Komatsu (TRW Defense and Space Systems Group, Redondo Beach, Calif.), Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2047. 7 p. Contract No. NASA-21047.

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 II (high energy-high angle mercury charge exchange) ions and neutral mercury on solar array surfaces. Nonline-of-sight transport modes studied were redirectional/meteration of mercury ions in magnetic fields and refraction of low energy mercury charge exchange (Group IV) ions by local electric fields. (Author)


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 grids within grids. Applications of this NASA spacecraft Charging Analyzer Program (NASCAP) code to the study of a satellite photosheath and the differential charging of the SCATHA (satellite charging at high altitude) 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 escaping flux, 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)


A computer model of the three-dimensional sheath 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 voltage gradients on the collecting surfaces. (Author)
DESIGN AND EVALUATION OF HIGH PERFORMANCE LIFE TIME AND RELIABILITY OF AN ELECTRON BOMBARDMENT THRUSTER is examined. A.W.H.

DATA AND ANALYSIS OF ROCKET ENGINE INJECTORS FOR USE WITH HYDROCARBON FUELS

Electron bombardment thrusters, under development to provide both auxiliary and primary propulsion functions for a large variety of space missions are tested. Thruster design verification 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 including cathodes, vaporizers, and isolators. The performance of the cathode, vaporizer, and propellant isolaters during fatigue analyses are examined. A.W.H.

SUPERCHARGED TABBED ROCKET Propellant FEED SYSTEM

A rocket propellant feed system utilizing a bleed turbopump to supercharge a topping turbopump is presented. The bleed turbopump is of a low pressure type to meet the cavitation requirements imposed by the propellant storage tanks. The topping turbopump is of a high pressure type and develops 60 to 70 percent of the pressure rise in the propellant.

ANALYTICAL INVESTIGATION OF TWO HYDROGEN OXYGEN ROCKET ENGINE SYSTEMS FOR LOW-THRUST APPLICATION
Dean O. Scheer 1980 17 p refs Presented at JANNAF Propulsion Meeting, Monterey, Calif., 11-13 Mar. 1980

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 pumped by electric motors driving positive displacement pumps. Electric power was provided by either a turboalternator (turboballoonator concept) or some means external to the engine system (auxiliary power concept). The turboalternator concept is discussed. The computer program used to conduct the 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 various cost factors to the assumptions used is discussed. Total cost of the power system was found to be $2.46 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.

A. H.

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 G. Siller 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 pumped by electric motor driven positive displacement pumps. Electric power was provided by either a turbogenerator (turbogenerator 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 envelopes, parametric data within the feasible design range are presented.

Author

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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 facility 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.

J.M.S.

N80-30386* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

UPPER STAGES UTILIZING ELECTRIC PROPULSION
David C. Byers In APL Propulsion Meeting, Vol. 5 Mar. 1980 p 69-84 refs (For primary document see N80-30381 21-20) Avail: Issuing Activity CSCL 21H

The payload capabilities of upper stages using electric propulsion for a GEO to GEO orbit transfer mission are presented. The impact on payloads of total mass in LEO, thrusting (trip) time, propellant type, specific impulse, and power source characteristics was evaluated. Dependence upon detailed assumptions, electric stages were found capable of delivering payloads in thruster time less than 50 days with payloads always initially increasing rapidly with increasing thruster times. For the shorter thrusting (trip) times the payloads increased with increasing propellant mass and decreasing specific impulse. At very long thruster times, however, the payload increased with decreasing propellant mass and increasing specific impulse. Variation of the specific mass of the power source between 5 and 30 kg/kW caused the minimum trip times to vary about a factor of three and at short trip times strongly affected the electric stage payload capabilities.

J.M.S.

N80-31449* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

LARGE SPACE SYSTEMS/LOW-THRUST PROPULSION TECHNOLOGY

The potentially critical interactions that occur between propulsion, structures and materials, and controls for large spacecraft are considered, the technology impacts within these fields are defined and the net effect on large systems and the resulting missions is determined. Topical areas are systems/mission analysis, LSS static and dynamic characterization, and propulsion systems characterization. For individual titles, see N80-31450 through N80-31471.

N80-31452* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ELECTRIC PROPULSION TECHNOLOGY

The advanced electric propulsion program is directed towards lowering the specific impulse and increasing the thrust per unit of ion thruster systems. In addition, electrothermal and electromagnetic propulsion technologies are being developed to attempt to fill the gap between the conventional ion thruster and chemical rocket systems. Most of these new concepts are expensive and are represented by rail accelerators, ablative Teflon thrusters, MPD arcs, Free Radicals, etc. Endogenous systems such as metallic hydrogen offer great promise and are also being pursued.

A.R.H.
The synchronous energy technology program is presented 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.

Part of NASA's orbit transfer vehicle propulsion program is presented with particular emphasis on thrust system technology. The relative strengths of those interactions which enable propulsive forces are listed as well as the specific impulse of various propellants. Graphics show the linear synchronous motor of the mass driver, the principle of the direct current electromagnetic launcher, and the characteristics of the rail gun. A.R.H.

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 NBO-33466 through NBO-33475.

A.R.H.

The use of advanced electric propulsion systems will provide cost and performance benefits for future energetic space missions. A methodology to predict the characteristics of advanced electric propulsion systems was developed and programmed for computer calculations to allow evaluation of a broad set of technology and mission assumptions. The impact on overall thrust system characteristics was assessed for variations of propellant type, total accelerating impulse, and power system approach. The data may be used both to provide direction to technology emphasis and allow for preliminary estimates of electric propulsion system properties for a wide variety of application. (Author)

A.R.H.

Ground-based tests of Hg ion thrusters have identified sputter erosion of thruster components as one of the main life limiting phenomena. Subsequent measurements have revealed that sputtering rates can be affected by background gases at pressures as low as 10 to the 10th torr. With the recent interest in thin film technology, sputtering in the presence of reactive gases has been studied in great detail. This paper presents the results of many of those studies and applies them to the sputtering of electric thrusters. A model, which assumes that chisellation is the dominant mechanism, is applied to the sputtering rate measurements of the screen grid of a 30-cm thruster in the presence of nitrogen. The model utilizes inputs from a...
variety of experimental and analytical sources. The model of environmental effects on sputtering was applied to thruster conditions of low discharge voltage and a discussion of the comparison of theory and experiment is presented. (Author)


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. (Author)


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. (Author)

A80-10392 # # Reduced power processor requirements for the 30-cm diameter Hg ion thruster. V. K. Rawlin (NASA, Lewis Research Center, Cleveland, Ohio), Princeton University, AIAA, and DGLR, International Electric Propulsion Conference, 14th, Princeton, N.J., Oct. 30-Nov. 1, 1979, AIAA Paper 79-2061, 10 p. 23 refs.

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 geostationary and some inbound planetary missions) and those requiring operation over a range of input power (e.g., as outbound planetary missions). This paper describes the results of 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. (Author)


An experimental program to determine the feasibility of using a heavy hydrocarbon fuel as a rocket propellant is reported herein. A method of predicting performance of a heavy hydrocarbon in terms of vaporization effectiveness is described and compared to other fuels and to experimental test results. The work was done at a chamber pressure of 4137 KN/M (600 psia) with RP-1, JP-10, and liquefied natural gas as fuels, and liquid oxygen as the oxidizer. Combustion length effects were explored over a range of 21.6 cm (8 1/2 in.) to 85.9 cm (34 in.). Four injector types were tested, each over a range of mixture ratios. Further configuration modifications were obtained by 'teaming' each injector several times to provide test data over a range of injector pressure drop. (Author)


Cathodes, isolators, and vaporizers are critical components in determining the performance and lifetime of Mercury ion thrusters. The results of life tests of several of these components are reported. A 30-cm thruster CIV test in a bell jar has successfully accumulated over 26,000 hours. The cathode has undergone 65 restarts during the life test without requiring any appreciable increases in starting power. Recently, all restarts have been achieved with only the 44 volt keeper supply with no change required in the starting power. Another ongoing 30-cm Hg thruster cathode test has successfully passed the 10,000 hour mark. A solid-insert, 8-cm thruster cathode has accumulated over 4,000 hours of thruster operation. All starts have been achieved without the use of a high voltage ignitor. The results of this test indicate that the solid impregnated insert is a viable neutralizer cathode for the 8-cm thruster. (Author)

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 impulse, and power source specific mass. It is found that the ratios of payload masses to total mass in LEO are insensitive 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 50 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. L.M.


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 magnetoplasmadyamic accelerator, the mass driver, the laser propulsion system, and the rail gun are described. (Author)

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+1/p silicon solar cell. It is reported that this 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 (turbine alternator 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. (Author)


An analytical and experimental study was conducted dealing with refilling start baskets (capillary devices) with settled fluid. A computer program was written to include dynamic pressure, screen wicking, 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 refilling under actual mission conditions. (A.T.


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 orbiter payload arrangement, spacecraft launch constraints, and spacecraft GEO assembly and deployment sequences.

A80-38992 # Cooling of high pressure rocket thrust cham-
Teal Ruby sensor and the ECOM 501 sensor of that spacecraft were investigated. Laboratory measurements and analyses were used to determine the field-threshold and nonlinear plasma transport modes. The recirculation of Hg(+) ions in the magnetic field of the earth was analyzed for spacecraft velocity and Earth magnetic field vector characteristics which are expected to occur in near Earth, circular, high inclination orbits. For these magnetic field and orbit conditions and for expected ion release distribution functions, in both angles and energies, the recirculation/rec-interception of ions on spacecraft surfaces was evaluated. The refraction of weakly energetic ions in the electric fields of the thruster plasma plume and in the electric fields between this 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.

N80-13155# Hughes Research Labs., Malibu, Calif


R. L. Poeschel and J. R. Beattie Nov. 1979 186 p refs (Contract NAS3-21040)

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) a verification of the high-voltage propellant-flow-electrical-isolator 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.

N80-13164# Tennessee Technological Univ., Cookeville. Dept. of Engineering Science

ANALYSIS OF COMBUSTION INSTABILITY IN LIQUID FUEL ROCKETS AND CHAMBERS Ph.D. Thesis

A. R. H. Nov. 1979 119 p refs (Grant NGR-43-003-015)

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 was found that the results are very 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.

N80-13165# Tennessee Technological Univ., Cookeville

STABILITY ANALYSIS OF A LIQUID FUEL ANNULAR COMBUSTION CHAMBER M.S. Thesis

G. H. McDonald Nov. 1979 151 p refs (Grant NGR-43-003-015)

The regenerative cooling limits (maximum chamber pressure) for O2/hydrocarbon gas generator and staged combustion cycle rocket engines over a thrust range of 89,000 N (20,000 lbf) to 2,669,000 N (600,000 lbf) for a reusable life of 250 missions were defined. Maximum chamber pressure limits were first determined for the three propellant combinations (O2/CH4, O2/C2H2, and O2/2RP-1 without a carbon layer) with unheated designs. Chamber pressure cooling enhancement limits were then established for seven thermal barriers. The thermal barriers evaluated for these designs were: carbon layer, ceramic coating, graphite liner, film cooling, transpiration cooling, zoned combustion, and a combination of two of the above. All fluid barriers were assessed a 3 percent performance loss. Sensitivity studies were then conducted to determine the influence of cycle life...
N80 15202# Rocketdyne, Canoga Park, Calif
E E Eberle and L Kusak DC 1979 186 p refs (Contract NAS3 20273)
(NASA CR 159674) Avail NTIS HC A09/MF A01 CSCL 21H

The design, fabrication, and demonstration of a 111 newton (25 lb) thrust, integrated auxiliary propulsion system (APPS) thruster for use with liquid oxygen/liquid hydrogen was supplied at a temperature range of 22 to 33 K (40 to 60 °F), and oxygen from 99 to 122 K (160 to 220 °R). The thruster was designed to operate in both pulse mode and steady state modes for vehicle attitude control, space maneuvering, and as an abort backup in the event of failure of the main propulsion system. A dual sleeve, in axial injection system was designed that utilizes a 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 nozzle design Hot-fire evaluation of this thruster with a BLC injection distance of 279 cm (110 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 trans. 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

N80-18095# Boeing Aerospace Co., Seattle, Wash.
C H Terwilliger and W W Smith Jan 1980 206 p (Contract NAS3-21346)

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 inter-relationships among the technology descriptors and 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 desirable. 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 levels 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
(NASA CR-159805; XEOS-2372; IR-1) Avail NTIS HC A05/MF A01 CSCL 21C

Two 12 cm magneto-electrostatic containment (MESC) 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, MESC 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 from the hemispherical thruster tests gave insights into the plasma processes in the MESC discharge that will aid in the design of future thrusters. Author

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. Chemical rocket engine cycles and their performance characteristics are evaluated for this application. Low thrust chemical rocket engines are described, including the design characteristics of various engine types. These engine designs include conventional propellant turbine drives, turbostolent drives, 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. J. M. Shoji


Low thrust chemical (hydrogen/oxygen) propulsion systems were evaluated for use in the space transportation system. In the space transportation system (STS) will be the principal means of launching USAF spacecraft beginning in the 1980's. Since it was approved and reusability provides new opportunities for unique approaches for cost effective use of its capabilities. The STS also places additional requirements and constraints on spacecraft deployment systems that did not previously exist for expendable launch vehicles. The conceptual design of these new capabilities must be prepared by making cost-effective technologies available. Advanced propulsion technology that would provide flexibility, performance, and economic benefits to the future Air Force mission identified. Both electric propulsion systems and chemical propulsion systems are discussed. An L02/LH2 stage with a torus L02 tank and 500 lb pump-fed engine is high on the list of propulsion technology. A. R. H.


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NASA-31486

Low-thrust chemical (hydrogen/oxygen) propulsion systems were evaluated for use in the space transportation system. In the space transportation system (STS) will be the principal means of launching USAF spacecraft beginning in the 1980's. Since it was approved and reusability provides new opportunities for unique approaches for cost effective use of its capabilities. The STS also places additional requirements and constraints on spacecraft deployment systems that did not previously exist for expendable launch vehicles. The conceptual design of these new capabilities must be prepared by making cost-effective technologies available. Advanced propulsion technology that would provide flexibility, performance, and economic benefits to the future Air Force mission identified. Both electric propulsion systems and chemical propulsion systems are discussed. An L02/LH2 stage with a torus L02 tank and 500 lb pump-fed engine is high on the list of propulsion technology. A. R. H.


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The L02/LH2 stage with a torus L02 tank and 500 lb pump-fed engine is high on the list of propulsion technology. A. R. H.

NASA-31487

Low-thrust chemical (hydrogen/oxygen) propulsion systems were evaluated for use in the space transportation system. In the space transportation system (STS) will be the principal means of launching USAF spacecraft beginning in the 1980's. Since it was approved and reusability provides new opportunities for unique approaches for cost effective use of its capabilities. The STS also places additional requirements and constraints on spacecraft deployment systems that did not previously exist for expendable launch vehicles. The conceptual design of these new capabilities must be prepared by making cost-effective technologies available. Advanced propulsion technology that would provide flexibility, performance, and economic benefits to the future Air Force mission identified. Both electric propulsion systems and chemical propulsion systems are discussed. An L02/LH2 stage with a torus L02 tank and 500 lb pump-fed engine is high on the list of propulsion technology. A. R. H.

NASA-31488

Low-thrust chemical (hydrogen/oxygen) propulsion systems were evaluated for use in the space transportation system. In the space transportation system (STS) will be the principal means of launching USAF spacecraft beginning in the 1980's. Since it was approved and reusability provides new opportunities for unique approaches for cost effective use of its capabilities. The STS also places additional requirements and constraints on spacecraft deployment systems that did not previously exist for expendable launch vehicles. The conceptual design of these new capabilities must be prepared by making cost-effective technologies available. Advanced propulsion technology that would provide flexibility, performance, and economic benefits to the future Air Force mission identified. Both electric propulsion systems and chemical propulsion systems are discussed. An L02/LH2 stage with a torus L02 tank and 500 lb pump-fed engine is high on the list of propulsion technology. A. R. H.
system weights were excessive. The staged combustion cycle achieved the next highest chamber pressure but the preburner operational feasibility was in question.

**STATUS OF NICKEL-HYDROGEN CELL TECHNOLOGY**

Don R. Warnock  
In NASA, Lewis Space Flight Center (Author)  
Synchronous Energy Technol. Sep. 1980  
97-105 (For primary document see N80-33465 24-20)  
Avail NTIS HC 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 computer 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 multielement 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.

**BAFFLE APERTURE DESIGN STUDY OF HOLLOW CATHODE EQUIPPED ION THRUSTERS**

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 aperture region 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 main uncertainty about 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.
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 consistently-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 LC 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 LC 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 characteristics in turn determine configuration, performance and hence life cycle cost. (Author)
23 CHEMISTRY AND MATERIALS
(GENERAL)

Includes biochemistry and organic chemistry

A80-25900 * a Investigation into the effect of plasma pre-
treatment on the adhesion of parylene to various substrates. T. Riley,
T. C. Mahon, and K. Siebert (NASA, Lewis Research Center,
Cleveland, Ohio). Society for the Advancement of Material and
Process Engineering, Seminar on Cleaning, Finishing and Coating

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 (FEF), kapton, silicon, tantalum, titanium, and
tungsten. Without plasma treatment, 180 deg peel tests yield a few
gpm (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)

A80-28894 * Modeling and analysis of Power Processing
Systems. Y. Yu (TRW Defense and Space Systems Group, Redondo
Beach, Calif.), F. C. Y. Lee (Virginia Polytechnic Institute and State
University, Blacksburg, Va.), and J. Kolecki (NASA, Lewis Research
Center, Cleveland, Ohio). In: PESC '79; Power Electronics Specialist
Conference, San Diego, Calif., June 17-20, 1979, Record, (A80-
2889210.33) Piscataway, N.J., Institute of Electrical and Electronics

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)

A80-33478*# Applied Medical Technology, Cleveland Heights,
Ohio
TISSUE RESPONSE TO PERITONEAL IMPLANTS Final
Report
George J Picha Jun 1980 73 p refs
(NASA Order C-33550-D)
(NASA-CR-159817) Avail NTIS HC A04/MF A01 CSCL
06P

Peritoneal implants were fabricated from poly 2-OH, ethyl
methacrylate (HEMA), polyetherurethane (polytetramethylene
glycol 1000 MW, 1,4 methylene disocyanate, 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 microns wide by 100 microns 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, multinucle-
ated 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.
24 COMPOSITE MATERIALS
Includes laminates.

N80-11142# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
CORROSION RESISTANT THERMAL BARRIER COATING
Patent Application
S. R. Levine, R A. Miller, and P. E. Hodge, inventors (to NASA)
Filed 31 Oct. 1979 8 p
Avail: NTIS HC A02/MF A01 CSCL 11D
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 flames 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. NASA

N80-11143# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MICROMECHANICS OF INTRAPLY HYBRID COMPOSITES:
ELASTIC AND THERMAL PROPERTIES
C. C. Chamis and J H Sinclair Washington 1979 19 p
Engr., New York, 2-7 Dec. 1979
(NASA-TM-79253 E-164) Avail: NTIS HC A02/MF A01 CSCL 11D
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,
finitie 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 micromecha-

N80-11144# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
TENSILE AND FLEXURAL STRENGTH OF NON-GRAPHITE
SUPERHYBRID COMPOSITES: PREDICTIONS AND
COMPARISONS
1979; sponsored by Soc. for the Advancement of Material and
Process Engr.
(NASA-TM-79276 E-203) Avail: NTIS HC A02/MF A01 CSCL 11D
Equations are presented and described which can be used to
predict bounds on the tensile and flexural strengths of
non-graphitic superhybrid (NGSH) composites. These equations
are derived by taking into account the measured stress-strain
behavior, the lamination residual stresses and the sequence of
events leading to failure. The required input for using these
equations includes constituents, properties (elastic and strength),
NGSH elastic properties, cure temperature, and ply stress
influence coefficients. Results predicted by these equations are
in reasonably good agreement with measured data for strength
and for the apparent knees in the nonlinear stress-strain curve.
The lower bound values are conservative compared to measured
data. These equations are relatively simple and are suitable for
use in the preliminary design and initial sizing of structural
components made from NGSH composites. Author

N80-11145# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
DYNAMIC RESPONSE OF DAMAGED ANGLEPLY FIBER
COMPOSITES
Engr., New York, 2-7 Dec. 1979
(NASA-TM-79281, E-182) Avail: NTIS HC A02/MF A01 CSCL 11D
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 were
investigated. Two different composite systems were studied -
low modulus fiber and ultra high modulus fiber composites. The
results obtained show 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. Vibration tests may not be
sufficiently sensitive to assess concentrated local damage in
angleplied laminates. 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. Author

N80-12120# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MECHANICAL PROPERTY CHARACTERIZATION OF
INTRAPLY HYBRID COMPOSITES
C. C. Chamis, R. F. Lark, and J. H. Sinclair 1979 26 p
Presented at the Am. Soc. for Testing and Materials Symp.
Dearborn, Mich., 2-3 Oct. 1979
(NASA-TM-79306 E-261) Avail: NTIS HC A03/MF A01 CSCL 11D
An investigation was conducted to characterize the mechanical
properties of intraply hybrids made from graphite fiber/epoxy
matrix (primary composites) hybridized with varying amounts of
secondary composites made from S-glass or Kevlar 49 fibers.
The tests were conducted using thin laminates having the same
thickness. The specimens for these tests were instrumented with
strain gages to determine stress-strain behavior. Significant results
are included. Author

N80-13171# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
IMPROVED FIBER RETENTION BY THE USE OF FILLERS
IN GRAPHITE FIBER/RESIN MATRIX COMPOSITES
R. E. Giuliani and K. J. Bowles 1980 12 p
Presented for presentation at the 35th Ann. Conf. of the Reinforced
Plastics/Composites Inst., New Orleans, 4-8 Feb. 1980; sponsored by
Soc. of Plastics Ind.
(NASA-TM-79288; E-231) Avail: NTIS HC A02/MF A01 CSCL 11D
A variety of matrix fillers were 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 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

N80-14198# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
BURNING CHARACTERISTICS AND FIBER RETENTION
OF GRAPHITE/RESIN MATRIX COMPOSITES
Kenneth J. Bowles 8 Feb. 1980 14 p
Presented for presentation at the 35th Ann. Conf. of the Reinforced
Plastics/Composites Inst., New Orleans, 4-8 Feb. 1980; sponsored by
Soc. of Plastics Ind.
(NASA-TM-79314; E-271) Avail: NTIS HC A02/MF A01 CSCL 11D
Graphite fiber reinforced resin matrix composites were sub-
jected 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. Unidirectional 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/hr-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 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 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*J National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. 


Angle-ply 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 orientation on tensile properties, fracture modes, and fracture surface characteristics of the various plies. It was found that fracture modes in the plies of angle-ply laminates can be characterized by scanning electron microscope observation. The characteristics of the fracture modes 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.

A R. H.

N80-18107*J National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.


The elastic properties and failure stresses of angle-ply graphite 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.

A R. H.

N80-18106*J National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.


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 17 to 26 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 provide a weight savings of 236 N (53 lb) per engine.

A R. H.

N80-18107*J National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.


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.

A R. H.

N80-20313*J National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.


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 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.

K. L.

N80-20314*J National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.


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 layers. The model uses the previously presented method of the principal residual stresses and the filament elongation with the parameters defining deposition strain and creep. The calculated results are compared with experimental residual stress and elongation measurements made on B/C filaments. For good agreement between calculated and experimental results, the deposited boron must continue to expand after deposition, apparently due to creep.
and the build up of residual stresses must be limited by significant boron and carbon creep rates.

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-products of mass. An analysis of creep 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

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 turboprop 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 turboprop 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 are 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 aluminized 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 aluminides. While more expensive Pt-Al coatings and physical vapor deposited MCrALY 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. NASA

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 interlaminar 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 interlaminar shear strengths were also studied. Author

N80-28444** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
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. R.C.T.

N80-29431** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
POTENTIAL RELEASE 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 fire-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. Author

N80-29432** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
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
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 lends 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 U.S. Patent and Trademark Office


The low-cycle axial fatigue properties of 28 and 44 fiber volume percent SiC/Ti(BA14V) composites were measured at room temperature and at 650°C. At room temperature, the S-N curves for the composites showed no anticipated improvement over the bulk matrix behavior. Although axial and transverse tensile strength results suggest a degradation in SiC fiber strength during composite fabrication, it appears that the poor fatigue life of the composites 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)


An investigation of the mechanical properties of intraply hybrids made from graphite fiber/epoxy matrix hybridized with secondary S-glass or Kevlar 49 fiber composites is presented. The specimens stress-strain 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)


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 angularly laminated. 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 angled 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 angled laminates. Furthermore, dynamic response determined from low-velocity impact coupled with the Fast Fourier Transform and packaged in a microcomputer can be a convenient procedure for assessing low-level damage in fiber composite angularly 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)


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 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 test procedure are described. The application of the test method to the assessment of composite materials is illustrated for two resin matrix/graphite composite systems. (Author)

ABO-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...
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 the bottom 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 bearings 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.

M.E.P.


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 high-strength 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.

V.P.

A80-44236 * 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., February 1976.


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 (B4C), 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.

(Author)


Angleplied laminates of high modulus graphite/epoxy were examined in several ply configurations at various tensile loading angles to the zero ply direction to determine the effects of ply orientations on tensile properties, fracture modes, and fracture surface characteristics of the various plies. Experimental results consist of stress-strain data, selected plots, fracture stresses and strains, and scanning electron microscope (SEM) photographs of fracture surfaces. It was found that the stress-strain curves were linear to fracture, and that although fracture surface characteristics for a given fracture mode are similar to those for the same fracture mode in uniaxial specimens, no simple load angle range can be associated with a given fracture mode. It was also concluded that SEM results must be supplemented with ply stress calculations in order to identify ranges of fracture modes occurring as a function of ply orientation with respect to the load direction.

J.P.B.


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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 a 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 B/M type 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 investigated. Initial aluminum alloy aluminum alloy 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.

A balance composite blade application in large high by-pass ratio turbofan engines is developed. 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.


SUDDEN STRETCHING OF A FOUR LAYERED COMPOSITE PLATE Interim Report
G. C. Sih and E. P. Chen Mar. 1980 42 p refs
(Grant NsG-3197)
(NASA-CR-159870; IFSM-80-102) Avail. NTIS HC A03/MA A01 CSCL 110

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.


SUDDEN BENDING OF CRACKED LAMINATES Interim Report
G. C. Sih and E. P. Chen Feb. 1980 53 p refs
(Contract NsG-3197)
(NASA-CR-159860; IFSM-80-103) Avail. NTIS HC A04/MA A01 CSCL 110

A dynamic approximate laminated plate theory is developed with emphasis placed on obtaining effective solution for the crack configuration where the 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 storing 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 N80-29430# Fiber Materials, Inc., Biddeford, Maine.

FABRICATION AND EVALUATION OF LOW FIBER CONTENT ALUMINA FIBER/ALUMINUM COMPOSITES Final Report
(Contract NAS3-21371)
(NASA-CR-159571; AMDL-0001) Avail. NTIS HC A04/MA A01 CSCL 110

The mechanical fabrication of low volume percent fiber,
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 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 an 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. A.R.H.


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 in 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. S.D.


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 asbestos submerged in alkaline electrolyte was shown to be comparable with that predicted from the bulk diffusion coefficient of the zincate ion in alkali. (Author)

A80-20955* # Combustion of solid carbon rods in zero and normal gravity. C. M. Spuckler, F. J. Kohl, R. A. Miller, C. A. Stearns (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, 30 p, 11 refs.

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 CO, CO2, 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 droptower 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 psia 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. (Author)


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. S.D.


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 nonroutine. 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. V.T.

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 propane-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.

**NBS-12142** Pennsylvania State Univ., University Park

**INVESTIGATION OF CRITICAL BURNING OF FUEL DROPLETS** Final Report, 1 Sep. 1966 - 30 Jun. 1978

G M Faeth Jul 1979 87 p refs

(Grant NGR-39-009-077)

(NASA-CR-1599697) Avail. NTIS HC A04/MA A01 CSCL 21B

The general problem of spray combustion was investigated. The combustion of bipropellant droplets, combustion of hydroxene 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.

**NBS-13193** Tennessee Technological Univ. Cookeville

**DEPARTMENT 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-43-003-016)

(NASA-CR-1599732) Avail. NTIS HC A04/MA A01 CSCL 21B

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, coal combustion, turbulent combustion interactions, kinetics, furnace combustion, inhibition and ignition, flame structure and chemistry, soot formation, measurement techniques, fire and explosion, engine combustion, and precursors and explosivity.

Papers were presented on numerical modeling of the deflagration to detonation transition, the interaction between turbulence and combustion, turbulent flame propagation in premixed gases, spray evaporation in recirculating flow, dissociation of nitric oxide in shock waves, pollutant emissions from partially mixed turbulent flames, energy transfer and quenching rates of laser pumped electronically excited alkalis in flames, a study of flammability limits using counterflow flames, the unburned plume of engines with fuel consumption, and the dynamics and turbulent intensity of large hydrogen flames.

A.T.
26 METALLIC MATERIALS

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

NBS-10344 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


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

NBS-11189 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-056) Avail. NTIS HC A02/MF A01 C Sc1.11F

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 stainless steels 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, whereas Ni and Mn contents were increased to maintain an austenitic structure. R.C.T.

NBS-11189 National Aeronautics and Space Administration Lewis Research Center. Cleveland, Ohio

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


The impact of thermally induced porosity on the mechanical properties of an as-hot-isostatically-pressed and heat treated pressing made from low carbon Astroloy was determined. Porosity in the disk-shaped pressing studied ranged from 2.6 percent at the bore to 1.4 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 bore 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.

NBS-14232 National Aeronautics and Space Administration Lewis Research Center. Cleveland, Ohio

IMPROVED REFRACTORY COATINGS AND METHOD OF PRODUCING THE SAME Patent Application


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 titanium nitride and a nitride of the substrate in the interfacial region. NASA

NBS-14232 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 C Sc1.11F

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 which form NiO scales. M.G.

NBS-15235 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 C Sc1.11F

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 concentration. The coefficient of friction increases linearly as the solute to iron atomic 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.

NBS-15235 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


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 1.0 for the least corrosion resistant alloys U-700 and IN-100, near 0.8 for the moderately resistant IN-792, and close to 0.5 for 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 dopants was noted.


The influence of orientation on the tensile and stress rupture behavior of 52-Mar-M247 single crystals was studied. Tensile tests were performed at temperatures between 23 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 rank ordered according to stress rupture life for this temperature regime. Author


Black cobalt oxide coatings (high solar absorptance layer) were deposited on the layers of a dual flow emittance 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 absorbance and emittance were calculated from the measured reflectance values, before and after exposure in air at 650 C for approximately 1000 hours. Absorbance and emittance were interdependent functions of the weight of cobalt oxide. Also, these cobalt oxide/noble metal/oxide diffusion barrier coatings have absorbances greater than 0.90 and emittances of approximately 0.20 even after about 1000 hours at 650 C. Author


A Mech 0.3 burn turbine was used to determine the effects of potential coal derived liquid fuel impurity combustion of products on hot corrosion in IN-100, IN-792, IN-738, U-700, Mar M-509,
An evaluation of a duplex silicon slurry/aluminate coating is presented. The coating is cyclically tested in Mach 1 combustion gases for oxidation and thermal fatigue resistance at 1093 °C. The coating also provides good hot corrosion protection. An investigation into the role of adhesion in the erosion of ductile metals was obtained which contained iron oxide particles. Examination of the rebounding particles as well as the eroded surface yields evidence of a significant adhesive mechanism for the ductile metals investigated.
but the elastic strain range-life relation was little changed reflecting the small reduction in sigma sub u/E for the porous material.

R C T


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 chromium concentration on minimum bed particle carryover coating life. Without yttrium in the bond coatings, the zirconia coatings failed very rapidly. Increasing chromium and aluminum in the Ni-Cr-A1 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. Author


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. R C T


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 (15 to 0.05 grams/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 deplition 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
The use of chevron-notch specimens for determining the plane strain fracture toughness \( K_{ISC} \) 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 \( K_{ISC} \) 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 including the abutment model of Bluhm. Short rod specimen stress intensity coefficients were determined only by experimental compliance calibration. Performance of the three chevron-notch specimen 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 raising crack growth resistance curve for the material. Only initial results for the short bar specimen are presented in detail. M.G.

ASTAR 811C
(NASA-TP-1691, E-041) Avail NTIS CSCL 11F
The high vacuum creep behavior of Astar 811C(Ta-8W-1Re-0.7H-0.2E) 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 strain was related to time by the biexponential 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 differentiate 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.

N80-3249* * National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF TWO-LAYER THERMAL BARRIER SYSTEMS ON DIRECTIONALLY SOLIDIFIED NI-AI-Mo AND COMPARATIVE EFFECTS OF ALLOY THERMAL EXPANSION ON SYSTEM LIFE
Stephan Stecura Washington Oct. 1980 35 p refs
(NASA-TM-81604, E-463) Avail NTIS HC A03/MF A01 CSCL 11F
A promising two-layer thermal barrier coating system (TBS), Ni-16.4Cr-5.1AI-0.16Y/ZrO2-6.1Y2O3 (all in weight percent), was identified for directionally solidified Ni-Al-Mo (gamma/gamma') alpha. In cyclic furnace tests at 1098 C this system on gamma/gamma' alpha was better than Ni-16.4Cr-5.1AI-0.16Y/ZrO2-7.2Y2O3 by about 50 percent. In natural gas - oxygen torch rig tests at 1250 C, the ZrO2-Y2O3 coating was better than the ZrO2-7.2Y2O3 coating by 95 percent, on MAR-M509 substrates and by 60 percent on gamma/gamma' alpha substrates. Decreasing the coefficient of thermal expansion of the substrates material from 17-18x10 to the -6 power/C (MAR-M200 + HF and MAR-M509) to 11x10 to the -6 power/C (gamma/gamma' 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-5.1AI-0.16Y/ZrO2-6.1Y2O3 was about 30 percent better on gamma/gamma' 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

N80-3248# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

CREEP-RUPTURE BEHAVIOR OF SEVEN IRON-BASE ALLOYS AFTER LONG TERM AGING AT 760 DEG IN LOW PRESSURE HYDROGEN Final Report
Walter R. Witzke and Joseph R. Stephens Aug. 1980 40 p refs
(Contract EC-77-A-31.1040)
N80.32488* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

IMPROVED BOND COATINGS FOR USE WITH THERMAL BARRIER COATINGS Final Report
Michael A. Gedwill Sep. 1980 45 p refs
(Contract EF-77-A-01-2593)
N80.32489* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

LONG-TIME CREEP BEHAVIOR OF THE TANTALUM ALLOY
ABD-10043 * National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

The erosion/corrosion of small superalloy turbine rotors operating in the effluent of a PFBC coal combustor, G.

80

The operation of a turbine in the effluent of a pressurized fluidized bed (PFB) coal combustor presents serious materials problems. Synergistic erosion/corrosion and deposition/corrosion interactions may favor the growth of erosion-resistant oxides on blade surfaces, but brittle cracking of these oxides may be an important source of damage along heavy particle paths. Integrally cast alloy 713LC and IN793 + Hf superalloy turbine rotors in a single-stage turbine with 5% partial admission have been operated in the effluent of a PFB coal combustor for up to 164 hr. The rotor erosion pattern exhibits heavy particle separation with severe erosion at the leading edge, pressure side center, and suction side trailing edge at the tip. The erosion distribution pattern gives a spectrum of erosion/oxidation/deposition as a function of blade position. The data suggest that preferential degradation paths may exist even under the targeted lower loadings (less than 20 ppm).

S.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-time mechanisms. Thruster control algorithms are also presented. The first 2700 hr of a planned 3000 hr test with a J-series 3 cm thruster, the last 1600 hr used a functional model 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 operational 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 role 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 AI203 scales on NiCrAl alloys has been examined by transmission electron microscopy. Voids have been observed within grains in scales formed on a pure NiCrAl alloy. Both voids and oxide grains grew measurably with oxidation time at 1100 C. The size and amount of porosity decreased towards the oxide-metal growth interface. It was postulated that the voids resulting 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 was also examined. Oriented alpha-(Al,Cr)203 and NiAl(Cr)204 scales often coexisted in layered structures on all three alloys. Close-packed oxygen planes and directions in the corundum and spiral layers were parallel. The close relationships between oxide layers provided a gradual transition from initial transient scales to steady state Al203 growth.


A study of the flow strength, creep resistance and diffusion welding characteristics of the titanium alloy Ti-6AI-2Nb-1Ta-0.8Mo has been conducted. Two mill-processed forms of this alloy were examined. The forged material had been subjected 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 forged 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 effects 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-NiCrAl 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 in practice by spalling or interfacial separation. 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-xZr-type alloys was performed in still air at 1100, 1150, and 1200 C for times up to 200 hr. The zirconium content of the alloys varied from 0.063 atom percent (a/o) of the oxidized surfaces were studied by optical microscopy, X-ray diffraction, and scanning electron microscopy. The base alloy was an alumina former with the zirconium-containing alloys also developing some ZrO2. The addition of zirconium above 0.063 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 W/A vs. time data did not appear to follow the mechanism of oxidation. The specific diffusion mechanism operative could not be identified by analysis of the calculated activation energies. Measurements of the A1203 scale lattice constants yielded the same values for all alloys. (Author)


The effect of thermally induced porosity on the mechanical properties of an as heat-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 1-1/2 times greater porosity. Mechanical properties of the test ring below acceptance level are tensile reduction in area at room temperature and 539 C and time for 0.1% creep at 704 C. It is also shown that the strength, ductility, and rupture life of the rim are slightly inferior to those 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.


A duplex silicon-surflyn/aluminate coating has been developed and cyclically tested in Mach 1 combustion gases for oxidation and thermal fatigue resistance at 1093 C and Mach 0.3 gases and high-corrosion resistance at 900 C. The base alloy is AL-200. The coated B-1900 specimens were found to perform much better in oxidation than similar specimens coated with aluminides, and almost as well as the more expensive Pt-Al and Ni-Based (where M is Ni and/or Co) coatings deposited by the physical vapor deposition process. The coatings also provided good hot-corrosion protection. V.P.

A80-35902 * Stability of several oxide dispersion strengthened alloys and a directionally solidified gamma/gamma prime-alpha eutectic alloy in a thermal gradient. G. Staniek (Deutsche Forschungs- und Versuchsanstalt fur Luft- und Raumfahrt, Cologne, West Germany) and J. D. Whittenberger (NASA, Lewis Research Center, Cleveland, Ohio). Zeitschrift fur Werkstofftechnik, vol. 11, June 1980, p. 197-205. 16 refs. Research supported by the Alexander von Humboldt-Stiftung and Bundesministerium fur Forschung und Technologie.

Thermal gradient testing of three oxide dispersion strengthened alloys and two Ni-base alloys and the directionally solidified eutectic alloy, gamma/gamma prime-alpha, have been conducted. Experiments were carried out with maximum temperatures up to 1200 C and thermal gradients on the order of 100 C/mm. The oxide dispersion strengthened alloys were difficult to test because the thermal stresses promoted crack nucleation and growth; thus the ability of these alloys to maintain a thermal gradient may be limited. The stability of individual fibers in gamma/gamma prime-alpha was excellent; however, microstructural changes were observed in the vicinity of grain boundaries. Similar structures were also observed in isothermally annealed material; therefore, thermal gradients may not affect the microstructure of gamma/gamma prime-alpha in any significant manner. (Author)

N80-15233+ Pittsburgh Univ Pa Dept of Metallurgical and Materials Engineering AN INVESTIGATION OF THE INITIATION STAGE OF HOT CORROSION IN NICKEL-BASE ALLOYS

STRESS CORROSION CRACKING EVALUATION OF MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS

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

Abradable Compressor and Turbine Seals, Volume 1


N80-13218# Inco Research and Development Center, Suffern, N. Y. CHARACTERIZATION OF AN OXIDE DISPERSION STRENGTHENED SUPERALLOY, MA-6000E, FOR TURBINE BLADE APPLICATIONS Final Report

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

N80-14235+ Airesearch Mfg. Co., Phoenix, Ariz. ABRADABLE COMPRESSOR AND TURBINE SEALS, VOLUME 1


The application and advantages of abradable coatings as gas-path seals in 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.
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 fatigue 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 total fatigue 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, finer-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.

L.F.M.
27 NONMETALLIC MATERIALS

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

N80-12324# 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 bend 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 bend 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 than for GE's CVD - SiC, and considerably below those for HS-130 (hot pressed Si3N4). The high purity, fully dense, 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.

N80-12358# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIONS OF CALCIUM ORTHOSILICATE AND BARIUM ZIRCONATE 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 gas 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, as well as elements of fuels and in turbine combustion air, as well as elements of fuels and in turbine combustion air. The reactions products 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 CoO and Ba2SiO3 reacted with Fe2O3. K.L.

N80-14249# 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

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 600 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 550 C compared to about 900 C for the nickel composite coating. K.L.

N80-18165# 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-disk type of testing apparatus was used; but in addition to sliding a hemispherically tipped rider, a rider 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 plates generated on the metallic substrate asperities. The film wear mechanism was strongly dependent on contact stress. M.M.

N80-17220# 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

The tribological properties of polyimide-bonded graphite fluoride films were studied with a pin-on-disk 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.

N80-18178# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WEAR PARTICLES OF SINGLE-CRYSTAL SILICON CARBIDE IN VACUUM
Kazuhisa 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
COMPOSITE WALL CONCEPT FOR HIGH TEMPERATURE TURBINE SHROUDS: SURVEY OF LOW MODULUS STRAIN ISOLATOR MATERIALS
Robert C Bill, Gordon P Allen, and Donald W Wisander
(INASA-TM-81443, AVRADCOM-TR-80-C-7, E-363) Avail NTIS HC A03/MF A01 CSCL 11A

Plasma sprayed yttria stabilized zirconium oxide turbine seal specimens, incorporating various low modulus porous metal strain isolator pads between the zirconium oxide and a dense metal substrate, were subjected to cyclic thermal shock testing. Specimens that had a low modulus pad composed of sintered FeNiCrAlY fibermetal survived 1000 thermal shock cycles without spalling of the ceramic. A figure of merit for low modulus pad materials taking into consideration the elastic modulus, thermal conductivity, strength and oxidation resistance of the pad was proposed, and showed reasonable agreement with the thermal shock results. A potential surface distress problem on the zirconium oxide, associated with nonuniform temperature distribution and rapid stress relaxation, was examined. An approach to solving the surface distress problem through application of laser surface fusion of the zirconium oxide layer showed some promise, but improvements in the laser surface fusion process are necessary to prevent process associated damage to the ceramic.

N80-21532*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewr Research Center, Cleveland, Ohio

EFFECTS OF OXIDE ADDITIONS ON TEMPERATURE ON SINTERABILITY OF MELLED SILICON NITRIDE
Alan Arias Apr. 1980 21 p refs
(NASA-TP-1644, E-243) Avail NTIS HC A02/MF A01 CSCL 11D

Specimens of milled alpha-Si3N4 with 0 to 6.0 wt. percent oxide additions were pressure sintered at 1650° to 1820° C for 4 hours in nitrogen while covered with powdered Si3N4 + SiO2. Densities of less than or equal to 97.5 percent resulted with approximately 2.5 percent of MgO, CeO2, Y2O3, and three mixtures involving these oxides. Densities of greater than or equal to 94 percent were obtained with approximately 0.62 equivalent percent of the same additives. At most temperatures, best sinterability (density maxima) was obtained with 1.2 to 2.5 percent equivalent additive.

N80-21534*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewr Research Center, Cleveland, Ohio

ADHESION, FRICTION, AND WEAR OF BINARY ALLOYS IN CONTACT WITH SINGLE-CRYSTAL SILICON CARBIDE
Kazushia Miyoshi and Donald H Buckley
(NASA-TM-79282, E-221) Avail NTIS HC A02/MF A01 CSCL 11F

Sliding friction experiments, conducted with various iron base alloys (alloying elements are Ti, C, Mn, Ni, Rh and W) in contact with a single crystal silicon carbide /0001/ surface in vacuum are discussed. Results indicate atomic size mismatch and concentration of alloying elements play a dominant role in controlling adhesion, friction, and wear properties of iron-base binary alloys. The controlling mechanism of the alloy properties is as 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 coefficient of friction increases as the solute-to-iron atomic 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.

N80-20398*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewr Research Center, Cleveland, Ohio

TURBINE SHROUDS: SURVEY OF LOW MODULUS STRAIN ISOLATOR MATERIALS
Robert C Bill, Gordon P Allen, and Donald W Wisander
(INASA-TM-81443, AVRADCOM-TR-80-C-7, E-363) Avail NTIS HC A03/MF A01 CSCL 11A

Plasma sprayed yttria stabilized zirconium oxide turbine seal specimens, incorporating various low modulus porous metal strain isolator pads between the zirconium oxide and a dense metal substrate, were subjected to cyclic thermal shock testing. Specimens that had a low modulus pad composed of sintered FeNiCrAlY fibermetal survived 1000 thermal shock cycles without spalling of the ceramic. A figure of merit for low modulus pad materials taking into consideration the elastic modulus, thermal conductivity, strength and oxidation resistance of the pad was proposed, and showed reasonable agreement with the thermal shock results. A potential surface distress problem on the zirconium oxide, associated with nonuniform temperature distribution and rapid stress relaxation, was examined. An approach to solving the surface distress problem through application of laser surface fusion of the zirconium oxide layer showed some promise, but improvements in the laser surface fusion process are necessary to prevent process associated damage to the ceramic.

N80-18181*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewr Research Center, Cleveland, Ohio

REACTIbN SINTERED SILICON CARBIDE PREPARED FROM WET ATTUITION-MILLED SILICON
Thomas P Herball, Thomas K. Gsalko, and Nancy J Shaw
(NASA-TM-81428, E-329) Avail NTIS HC A02/MF A01 CSCL 11G

Silicon powder wet milled in heptane was dried, compacted into test bar shape, helium-sintered, and then reaction bonded in nitrogen-4 volume percent argon at 1400° C for 2 hours. The bond strengths averaged approximately 250 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.

N80-18183*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewr Research Center, Cleveland, Ohio

COMPARISON OF THE WEIGHT LOSS AND ADHERENCE OF NINE DIFFERENT POLYIMIDE FILMS THERMALLY AGED AT 315 C AND 360 C IN AIR
Robert L Fusaro Mar. 1980 34 p refs
(NASA-TM-81381, E-286) Avail NTIS HC A03/MF A01 CSCL 07D

Thermal exposure experiments at 315 and 350° C were performed in air on nine different types of polyimides applied to thin 304 stainless steel foils. The tests were conducted to determine which polyimide was the most thermally stable and adherent when subjected to long exposure times at elevated temperatures. One polyimide designated PIC-7 was found to be more thermally stable than the others, however, it did not possess the adherent properties of PIC-2 and PIC-5. It was concluded that as far as thermal stability and adherence are concerned, five of the polyimides are more suitable for high temperature applications than the other four.

N80-19283*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Lewr Research Center, Cleveland, Ohio

COMPARISON OF THE TRIBOLOGICAL PROPERTIES At 25 C OF SEVEN DIFFERENT POLYIMIDE FILMS BONDED TO 301 STAINLESS STEEL
Robert L Fusaro Feb. 1980 25 p refs
(NASA-TM-81413, E-328) Avail NTIS HC A02/MF A01 CSCL 11G

A pin-on-disk type of friction and wear apparatus was used to study the tribological properties of seven different polyimide films bonded to AISI 301 stainless steel disks at 25 C. It was found that the substrate material was extremely influential in determining the lubricating ability of the polyimide films. All seven films spoiled in less than 1000 cycles of sliding. This was believed to be caused by poor adhesion to the 301 stainless steel or the instability of the films to withstand the high local tensile stresses imparted by the deformation of the soft substrate under sliding conditions. The friction coefficients obtained for six of the polyimides varied between 0.21 to 0.32 while one varied between 0.32 to 0.39.
Wear rates and coefficients of friction were constant following friction coefficients were determined under boundary conditions. Compared with those from previous studies where a single 25 min period was used, satisfactory test conditions for studying friction and wear in boundary lubrication for this apparatus were obtained with loads of 1/2 and 1 kg and sliding velocities of 3.6 to 18.2 m/min in a dry air atmosphere and stepwise time intervals from 1 to 250 min for wear measurements. The wear rate results were compared with those from previous studies where a single 25 min test period was used. Highly reproducible steady-state wear rates and steady-state friction coefficients were determined under boundary conditions. Wear rates and coefficients of friction were constant following initially high values during run-in periods.

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. Isostatically 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 baked in Si powder; (3) bars baked 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 nitriding. 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.

Multipass sliding friction experiments were conducted with various iron base binary alloys in contact with a single crystal silicon carbide surface in vacuum. Results indicate that the atomic size and concentration of alloy elements play important roles in controlling the transfer and friction properties of iron base binary alloys. Alloys having high solute concentration produce more transfer than do alloys having low solute concentration. The coefficient of friction during multipass sliding generally increases with an increase in the concentration of alloying element. The change of friction with succeeding passes after the initial pass also increases as the solute to iron, atomic radius ratio increases. The effect of W and WC on the oxidation resistance of yttria-doped silicon nitride is examined. A mixture of Si3N4 - 8Y2O3, milled with alumina balls, was divided into four portions. Three portions were doped with 2 w/o WC W, and 4 w/o W 87
respective difference in order to simulate combustion during milling. The fourth portion was undoped and used on a control. The addition of W or WC did not affect the phase relationships in the system, as all bars with or without additions contained mellite as the major Si-Y-O-N phase after sintering. At 750°C, instability (rapid oxidation and cracking) of W-doped bars appears to have occurred as a result of oxidation of the tungsten containing mellite phase. No intermediate temperature instability was observed in bars containing 2 wt % WC or in bars with no additive. Specimens exposed at 1350°C had good oxidation resistance due to the formation of a protective silica oxide layer. A specimen containing 4 wt % W which was preoxidized at 1350°C had improved oxidation resistance at 750°C. The tendency to oxidation and cracking of Si3N4 - 8Y2O3 at 750°C is concluded to be related to tungsten content of the sintered bars. M G


The densification and oxidation behavior of Si3N4 - 8Y2O3 prepared from three different starting powders were studied. Bars of SN 402, SN 502, and CP 85/15 were sintered for 3 to 4 hours at 1750°C. A second set was hot pressed at 1750°C. The microstructures were studied by transmission electron microscopy and scanning electron microscopy, densities were determined, and the phase compositions were greatly influenced by the starting powder morphology and impurity content. Although SN 402 exhibited the maximum weight loss, the highest sintered and hot pressed densities were obtained with CP 85/15. All powders had both equiaxed and elongated grains. Sintered bars were composed of beta silicon nitride and melinite. In contrast, hot pressed bars contained beta silicon nitride, H-phase, and J-phase, but no melinite. Yttria distribution in sintered bars was related to the presence of cation impurities such as Ca, Fe, and Mg. A limited oxidation study at 750°C in air showed no instability in these Si3N4 - 8Y2O3 specimens, regardless of startin powder. Author


The contributions of individual resin components to total resin weight loss in 600°F air aged Celion 600/PMR-15 polyimide composites were determined from the overall resin weight loss in the composite by chemically separating the PMR-15 matrix resin into its monomeric components. The individual resin components were also analyzed by spectroscopic techniques in order to elucidate curing and degradation mechanisms of the PMR-15 matrix resin. The isothermal weight loss of the individual resin components during prolonged 600°F thermo-oxidative aging of the composite was correlated to the changes observed in the Fourier Transform infrared spectra and Fourier Transform nuclear magnetic resonance spectra of the individual resin components. The correlation was used to identify the molecular site of the thermo-oxidative changes in PMR-15 polyimide matrix resin during 600°F curing of the prolonged 600°F thermo-oxidative aging. Author


A self supporting sheet structure comprising a water soluble, noncrosslinked polymer such as polyvinyl alcohol which is capable of being crosslinked by reaction with hydrogen atom radicals and hydroxyl molecule radicals is contacted with an aqueous solution having a pH of less than 8 and containing a dissolved salt in an amount sufficient to prevent substantial dissolution of the noncrosslinked polymer in the aqueous solution. The aqueous solution is then irradiated with ionizing radiation to form hydrogen atom radicals and hydroxyl molecule radicals and the irradiation is continued for a time sufficient to effect crosslinking of the water soluble polymer to produce a water insoluble polymer sheet structure. The method has particular application in the production of battery separators and electrode envelopes for alkaline batteries.

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

A80-12089 Boundary lubrication, thermal and oxidative stability of a fluorinated polyether and a perfluoropolyether triazine. W. R. Jones, Jr. (NASA, Lewis Research Center, Cleveland, Ohio) and C. E. Snyder, Jr. (NASA, Lewis Research Center, Cleveland; USAF, Materials Laboratory, Wright-Patterson AFB, Ohio), American Society of Lubrication Engineers, Annual Meeting, 34th, St. Louis, Mo., Apr. 30-May 3, 1979, Preprint 79-AM-1B-1, 8 p. 25 refs. Boundary lubricating characteristics, thermal stability and oxidation-corrosion stability were determined for a fluorinated polyether and a perfluoropolyether triazine. A ball-on-disc apparatus, a tensimeter and oxidation-corrosion apparatus were used. Results were compared to data for a polyphenyl ether and a C-ether. The polyether and triazine yielded better boundary lubricating characteristics than either the polyphenyl ether or C-ether. The polyphenyl ether had the greatest thermal stability (443°C) while the other fluids had stabilities in the range 389 to 397°C. Oxidation-corrosion results indicated the following order of stabilities: perfluoropolyether triazine greater than polyphenyl ether greater than C-ether greater than fluorinated polyether.

A80-12094 Effect of thermal aging on the tribological properties of polyimide films and polyimide-bonded graphite fluoride films. R. L. Fusaro (NASA, Lewis Research Center, Cleveland, Ohio) American Society of Lubrication Engineers, Annual Meeting, 34th, St. Louis, Mo., Apr. 30-May 3, 1979, Preprint 79-AM-3B-1, 10 p, 10 refs. The effect of thermal aging on the weight loss, adherence, friction and wear of polyimide films and polyimide-bonded graphite fluoride films applied to 440C-HT stainless steel disks and to 304L stainless steel disks of various surface conditions is investigated. The friction and wear of the polyimide films and the polyimide-bonded graphite fluoride films are determined. The wear and friction behavior is found to be strongly dependent on the surface condition of the stainless steel disks. The wear and friction behavior of the polyimide films and the polyimide-bonded graphite fluoride films is found to be quite sensitive to the thermal aging conditions.
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 adherence 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 thermochemical deposition (CNTD) 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 CNTD process, ultrafine-grained SiC is deposited on tungsten wires as substrates, with superior surface smoothness and without the macrocolumnar growth commonly observed in conventional CVD materials. The results suggest that the high-purity, fully dense, and stable grain size SiC material produced by CNTD shows potential for high-temperature structural applications, provided that pertinent problems are resolved. S.D.

A80-13065 ** Mechanical and chemical effects of in-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 norbornenyl endcap and the amine, were detected in a resin solution aged for three days. Two commercial prepregs exhibited fingerprints similar to that of laboratory material, but three others contained additional components corresponding to higher esters and amides. (Author)


Silicon powder wet milled in hexane was dried, compacted into test bar shape, helium-sintered, and then reaction bonded in nitrogen-4 vol% hydrogen. As nitrided bond strengths averaged approximately 240 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 NiCrAlY 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 heating 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 JF30 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 burn time test 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 JT9D 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, 2 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 reveals 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.


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The coefficients of friction have been determined for some metallic glasses using a simple 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 values 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 that 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-nitrided 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 this 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 cold pressed. (Author)
formation so that they can be used in the as fired condition. A refractory glass composition (81023 x 6.5 CaO MgO x 115:02) was used to join and seal component parts by a brazing technique which formed strong recuperator 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.

N80-15264* TRW Defense and Space Systems Group. Redondo Beach Calif

ANALYSES OF MOISTURE IN POLYMERS AND COMPOSITES
L E Ryan and R W Vaughan 11 Jan 1980 99 p refs
(Contract NASA 20406) (NASA-CR-159745. TRW-31782 6082 RU 00) Avail NTIS HC A05/MF A01 CSCL 07C

A suitable method for the direct measurement of moisture concentrations after humidity/thermal exposure on state of the art epoxy and polyimide resins and their graphite and glass fiber reinforcements was investigated. Methods for the determination of moisture concentrations, profiles, moisture diffusion modeling and moisture induced dimensional changes were examined. Carefully fabricated, precharacterized epoxy and polyimide neat resins and their AS graphite and S glass-reinforced composites were exposed to humid conditions using I-heavy water (D2O) at ambient and elevated temperatures. These specimens were fixtures 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
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.

N80-17221* AeroTherm Acurex Corp. Mountain View, Calif

SYNTHESIS OF IMPROVED PHENOLIC RESINS Final Report
C B Delano and A H. McLeod 4 Sep 1979 115 p refs

Twenty seven additional cured phenolic resin compositions were prepared and tested for their ability to give char residues comparable to state-of-the-art phenolic resins. Cyanate, epoxy, acrylate, methacrylate and ethynyl derivatized phenolic oligomers were investigated. The novolac-cyanate and propargyl-novolac resins provided aneural char yields at 800 C of 58 percent. A 59 percent char yield was obtained from modified epoxy novolac. A phosphonitrilic derivative was found to be effective as an additive for increasing char yields. The novolac-cyanate, epoxy-novolac and methacrylate-epoxy-novolac systems were investigated as composite matrices with Thernol 300 graphite fiber. All three resins showed good potential as composite matrices. This free radical cured methacrylate-epoxy-novolac graphite composite provided short beam shear strengths at room temperature of 93.3 MPa (13.5 ksi). The novolac-cyanate graphite composite produced a short beam shear strength of 74 MPa (10.7 ksi) and flexural strength of 1302 MPa (189 ksi) at 777 C. Air heating of the novolac-cyanate and epoxy novolac based composites for 12 weeks at 204 C showed good property retention.

N80-26448* Mechanical Technology, Inc., Latham, N.Y.

HIGH TEMPERATURE SELF-LUBRICATION COATINGS FOR AIR LUBRICATED FOIL BEARINGS FOR THE AUTOMOTIVE GAS TURBINE ENGINE Final Report
Bharat Bhushan 1 Jul. 1980 232 p refs

Coating combinations were developed for compliant surface bearings and journals to be used in an automotive gas turbine engine. The coatings were able to withstand the sliding start/stop during rotor lift off and touchdown and exceptional short time, high speed rubs under representative loading of the engine. Some dozen coating variations of Co-C graph set, Cr2O3 (by sputtering) and Ce2O3 (plasma sprayed) were identified. The coatings were optimized and they were examined for stoichiometry, metallurgical condition, and adhesion. Sputtered Cr2O3 was most adherent when optimum parameters were used and it was applied on an annealed (soft) substrate. Metallic binders and interlayers were used to improve the ductility and the adhesion.


THE 3500 HOUR DURABILITY TESTING OF COMMERCIAL CERAMIC MATERIALS Interim Report

A two year durability testing program to evaluate four commercially available ceramic materials under simulated automotive gas turbine combustor discharge conditions was conducted. Conditions included extended cyclic thermal exposures up to 2500 F and 3500 hours. Selected for evaluation were Norton NCX-34 hot pressed silicon nitride, AirResearch RBN 101 reaction bonded silicon nitride. Barbourum pressureless sintered SiC and British Nuclear Fuels Ltd. Refel reaction sintered silicon carbide marketed by Pure Carbon Co. These materials initially were exposed to 350 hours/1750 cycles at 1200 and 1270 C (2200 and 2500 F). Subsequent exposure to 1050, 2100, and 2900 hours were performed on the materials maintaining 50 percent of baseline strength after the initial exposure. Additional evaluations of exposed bars included dimensional changes, weight changes, density, porosity, sintering damping capacity changes, scanning electron microscope fractography and X-ray diffraction.

(Contract No. DEN3-101, IS705-M7402-05) A program plan on a NASA-Lewis funded program is presented, in which effectiveness of thick ceramic coatings in preventing hot corrosion and in providing thermal insulation to gas turbine engine components are to be investigated. Preliminary analysis of the benefits of the thermal insulating effect of this coating on decreasing cooling air and simplifying component design appears very encouraging. The program is in the preliminary stages of obtaining starting materials and establishing procedures. Numerous graphs, tables and photographs are included. S.D.

A80-13066 * # State-of-the-art of SICAION materials. S. Dutta (NASA, Lewis Research Center, Cleveland, Ohio), NATO, AGARD, Specialist Meeting on Ceramics for Turbine Engine Applications, Cologne, West Germany, Oct. 7-12, 1979, Paper. 21 p. 41 refs.

The state of the art of SICAIONs is reviewed, noting that the term has become a generic one applied to Si3N4 based materials. Attention is given to work on phase relations, crystal structure, synthesis, fabrication, and properties of various SICAIONs. Also discussed are the essential features of compositions, fabrication methods, and microstructures. In addition, consideration is given to high temperature flowre strength, creep, fracture toughness, oxidation, and thermal shock resistance. Finally, these data are compared to those for some currently produced silicon nitride ceramics to assess the potential of SICAIION materials for use in advanced gas turbine engines.

M.E.P.

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 buttun 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 AIREsearch 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 3600 hr. The four materials selected for evaluation were Norton NCX-34 hot pressed silicon nitride, AIREsearch 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 360 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)
INITIAL CHARACTERIZATION OF AN EXPERIMENTAL TEMPERATURE AND FLOW MEASUREMENTS ON NEAR-hydrotreated catalytic gas oil, is a hypothetical representation of experimental referee broadened specification aviation turbine fuel. Aviation turbine fuels were measured in a 190-liter tank chill to be presented at the 25th Intern Gas Turbine Conf, New Orleans, Sep-13 Feb. 1980, sponsored by ASME.


FREEZING AVIATION FUELS IN A WING-TANK MODEL, Lewis Research Center, Cleveland, Ohio.

K anomalous 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.


Characterization data and a hydrocarbon compositional analysis are presented for a research test fuel designated as an experimental referee 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.

CHARACTERIZATION OF AN EXPERIMENTAL FUEL FOR THE IMPACT OF CONTAMINATION ON THE FREEZING BEHAVIOR, PAUL M. ORDIN May 1980 36 p refs (NASA-TP-1571, 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 contaminant silicon dioxide and copper powder did not conclusively affect the sensitivity of aluminum.


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 data base 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 fuels and the simulation of technical and economic trade-offs within the overall fuel production-air transportation system associated with variations in fuel properties are examined.


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.

Correlations of hydrogen content with aromatics contents, heat of combustion, and smoke point are derived for some synthetic fuels prepared from coal and oil syncrudes. Comparing the results
of the aromatics content with correlations derived 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 comparison of the calculated and measured NMR hydrogen contents shows 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 BROADENED 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 is 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 10,568 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

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. (Author)


FUEL QUALITY COMBUSTION ANALYSIS Final Report

A high pressure research combustor operating over a wide range of burner inlet conditions was used to determine the effects

C -2
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.

R.C.T.

LABORATORY MEASUREMENTS IN A TURBULENT, SWIRLING FLOW Final Report

David P. Houlé Nov. 1979 52 p refs

(Grant NoG-3076) Avail: NTIS HC A04/MF A01 CSCL 21D

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 the downstream pollutant formation was studied. It was found that the amount of soot formed in particular is sensitive to flow aerodynamically clean the configuration of the burner is upstream of the injector swirl vanes. The effect of pressure 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.

F.O.S.

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.

Autonignition Characteristics of Aircraft-Type Fuels

Louis J. Spadaccini and John A. TeVeidec Jun. 1980 88 p refs

(Contract NAS3-20066) Avail: NTIS HC A05/MF A01 CSCL 21D

The ignition delay characteristics of Jet A, JP 4, and a diesel fuel were measured. The data indicate that for lean mixtures, ignition delay times decrease with increasing equivalence ratio. It was also noted that physical (apparatus dependent) phenomena, such as mixing (i.e., length and number of injection sites) and airstream cooling (due to fuel heating, vaporization and convective heat loss) can have an important effect on the ignition delay. R.K.G.


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 tetrafluor, produced more soot than would be expected from a hydrogen content correlation for typical petroleum based fuels. The fuels containing napthenes, 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 1%. The fuel sensitivity to soot formation due to the polycyclic aromatic contribution decreased as burner inlet pressure and fuel/air ratio increased.

(Author)
31 ENGINEERING (GENERAL)

Includes vacuum technology; control engineering; display engineering; and cryogenics.


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 are much less affected. Organic hydrocarbon solvents or abrasives were found to be about five times more effective than mild cleaning agents. Periodic cleaning was measured after washing with detergents, abrasive soap, and hydrocarbon solvents, including detergents in a variety of chemical environments, 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 are much less affected. Organic hydrocarbon solvents or abrasives were found to be about five times more effective than mild detergents in cleaning encapsulated modules. Author


A wide range of ion beam etch parameters capable of producing uniform homogeneous alignment of nematic liquid crystals on Si02 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 2.0 KeV, 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 (2.0 KeV, 0.2 mA sq cm, 5 to 10 deg and 1 to 5 min.) were also investigated with Zr02 films and found suitable for homogeneous alignment. Extinction ratios were very high (1000), twist angles were small (c or = 3 deg) and tilt-bias angles very small (c or = 1 deg). Preliminary scanning electron microscopy results indicate a parallel oriented surface structure on the ion beam etched surfaces which may determine alignment. Author


A high gradient controlled solidification (HGC) furnace was designed and operated at gradients up to 1800 C/cm to continuously produce aluminum alloys. Rubber 'O' rings for the water cooling chamber were eliminated, while still maintaining water cooling directly onto the solidified metal. An HGC unit for high temperature ferrous alloys was also designed. Successful runs were made with cast iron, at thermal gradients up to 500 C/cm. K.L.


Analytical techniques are described which predict: (1) the velocities of two unequal fragments from bursting cylindrical pressure vessels; (2) the velocity and range of portions of vessels containing a fluid which, when the vessel ruptures, causes the fragment to accelerate as the fluid changes from the liquid to the gaseous phase; and (3) the ranges of fragments subjected to drag and lift forces during flight. Numerous computer runs were made with various initial conditions in an effort to generalize the results for maximum range in plots of dimensionless range versus dimensionless velocity. R.E.S.
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 quantify the requisite 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 then converted to equivalent satellite transponder capacities. Only NSO-32610


The purpose of the paper is to investigate and study in-depth market and system analysis for improving satellite communications. This paper is 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 the 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.


A program plan is presented for a space communication 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 R50 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, designated 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.

NBO-11277si Ford Aerospace and Communications Corp., Palo Alto, Calif.

CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM, VOLUME 1: APPENDIX Final Report
R. Jorsch, R. Baker, R. Davies, L. Cuccia, and C. Mitchell
1 Nov 1979 169 p 3 Vol.

(Contract NAS3-21362)


Concepts for 18/30 GHz satellite communication systems are presented. Major terminal trunking as well as direct-to-user configurations were evaluated. Critical technologies in support of millimeter wave satellite communications were determined.

M.M.M.

NBO-11278si Ford Aerospace and Communications Corp., Palo Alto, Calif.

CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM, VOLUME 1A: APPENDIX Final Report
R. Jorsch, R. Baker, R. Davies, L. Cuccia, and C. Mitchell
1 Nov 1979 181 p refs 3 Vol.

(Contract NAS3-21362)

(NASA-CR-159660-1A, WDL-TR8457-1A) Avail: NTIS HC A09/MF A01 CSCL 178

The following are appended: (1) Propagation phenomena and attenuation models; (2) Models and measurements of rainfall patterns in the U.S.; (3) Millimeter wave propagation experiments; (4) Comparison of theory and experiment; (5) A practical rain attenuation model for CONUS; (6) Space diversity; (3) Millimeter wave propagation patterns in the 6.5GHz; (3) Millimeter wave propagation attenuation models; (2) Models and measurements of rainfall.

NBO-11279si Ford Aerospace and Communications Corp., Palo Alto, Calif.

CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM STUDY, EXECUTIVE SUMMARY
M. Baker, R. Davies, L. Cuccia, and C. Mitchell
1 Nov 1979 36 p 3 Vol.

(Contract NAS3-21362)

(NASA-CR-159680; WDL-TR8457) Avail: NTIS HC A03/MF A01 CSCL 178

An examination of a multiplicity of interconnected parameters ranging from specific technology details to total system economic costs for satellite communication systems at the 18/30 GHz transmission bands is presented. It was determined that K sub s and K sub a systems can incur a small communications outage during very heavy rainfall periods and that reducing the outage to zero would lead to prohibitive system costs. On the other hand, the economics of scale, ie, one spacecraft accommodating 2.5 GHz of bandwidth coupled with multiple beam frequency reuse, leads to significant economies of scale, ie, one spacecraft accommodating 2.5 GHz of bandwidth coupled with multiple beam frequency reuse, leads to significant economies of scale.

M.M.M.

NBO-12269si Case Western Reserve Univ., Cleveland, Ohio Dept. of Electrical Engineering and Applied Physics

LOW SIDELobe LEVEL LOW-COST EARTH STATION ANTENNAS FOR THE 12 GHz BROADCASTING SATELLITE SERVICE
R. E. Collin and L. R. Gabel
Sep. 1979 117 p refs

(Contract NAS3-21365)

(NASA-CR-159703) Avail: NTIS HC A06/MF A01 CSCL 178

An experimental investigation of the performance of a 1.22 m and 1.83 m diameter paraboloid antennas with an f/D ratio of 0.38 and using a feed developed by Kumar is reported. It is found that sidelobes below 30 dB can be obtained only if the paraboloids are relatively free of surface errors. A theoretical analysis of clam shell distortion shows that this is a limiting factor in achieving low sidelobe levels with many commercially available low cost paraboloids. The use of absorbing pads and small reflecting plates for sidelobe reduction is also considered.

Author


APPLICATION OF ADVANCED ON-BOARD PROCESSING CONCEPTS TO FUTURE SATELLITE COMMUNICATIONS SYSTEMS
J. L. Katz, M. Hoffman, S. L. Kota, J. M. Ruddy, and B. F.

(Contract F19628-79-C-0001; AF Proj. 8680)

(NASA-CR-159682; MTR-3787-Vol-1) Avail: NTIS HC A18/MF A01 CSCL 178

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.


APPLICATION OF ADVANCED ON-BOARD PROCESSING CONCEPTS TO FUTURE SATELLITE COMMUNICATIONS SYSTEMS: BIBLIOGRAPHY
R. L. Edelman and J. L. Katz

(Contract F19628-79-C-0001; AF Proj. 8680)

(NASA-CR-159684; MTR-3787-Vol-2) Avail: NTIS HC A06/MF A01 CSCL 178

Abstracts are presented of a literature survey of reports concerning the application of signal processing concepts. Approximately 300 references are included.

R.C.T.

NBO-18282s# International Telephone and Telegraph Corp., New York.

THE 30/20 GHz FIXED COMMUNICATIONS SYSTEMS SERVICE DEMAND ASSESSMENT. VOLUME 1: EXECUTIVE SUMMARY
R. B. Gamble, H. R. Saltzner, K. M. Speter, and M. Westheimer

(Contract NAS3-21366)

(NASA-CR-159619) Avail: NTIS HC A03/MF A01 CSCL 178

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 and 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

NBO-18283s# International Telephone and Telegraph Corp., New York.

THE 30/20 GHz FIXED COMMUNICATIONS SYSTEMS SERVICE DEMAND ASSESSMENT. VOLUME 2: MAIN REPORT
R. B. Gamble, H. R. Saltzner, K. M. Speter, and M. Westheimer

(Contract NAS3-21366)

(NASA-CR-159620) Avail: NTIS HC A14/MF A01 CSCL 178

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

SERVICE DEMAND ASSESSMENT. VOLUME 3: ANNEX

T. Gabriszeski, P. Reiner, J. Rogers, and W. Terbo


(Contract NAS3-21359)
(NASA-CR-159548) Avail: NTIS HC A15/MF A01 CSCL 17B

The initial definition of on-board processing for an advanced satellite communications system to service domestic markets in the 1990's is discussed. An exemplar system with both RF on-board switching and demodulation/remodulation baseband processing is used to identify important issues related to system implementation, cost, and technology development. Analyses of spectrum-efficient modulation, coding, and system control techniques are summarized. Implementations for an RF switch and baseband processor are described. Among the major conclusions listed is the need for high gain satellites capable of handling tens of simultaneous beams for the efficient reuse of the 2.9 GHz 30/20 frequency band. Several scanning beams are recommended in addition to the fixed beams. Low power solid state 20 GHz GaAs FET power amplifiers in the SW range and a general purpose digital baseband processor with gigahertz logic speeds and megabits of memory are also recommended.

V.T.


A domestic satellite system architecture that can efficiently and economically accommodate a wide variety of disparate user classes is described and a baseline system configuration identified. With such a technique, both the efficiency of TDMA operation and the operational terminal flexibility of FDMA can be simultaneously achieved.


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 recovery (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)
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, microcomputerization, and integrated circuitry. For related information see also 60 Computer Operations and Hardware and 76 Solid-State Physics.

N80-11327f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HEAT PIPE COOLING OF POWER PROCESSING MAGNETICS

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).

N80-12381f 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 operation was independent of the type of excitation. However, for the same average values of input voltage and current, the motor efficiency at low power output was about 1% higher than the ripple free dc case. The chopped dc, locked rotor torque was approximately 1 to 3 percent greater than the ripple free dc torque for the same average current. J.M.S.

N80-18300f 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 round 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 whenever direction the rotor turns the probes present the same physical resistance and affords the same electrical conductivity as a connection between the probe and the rotor. Author.

N80-18302f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THERMONIC CADTHODE 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.

N80-19425f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COUPLED CAVITY TRAVELING WAVE TUBE WITH VELOCITY TAPERING Patent Application

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 as 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

N80-20487f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CATALYST SURFACES FOR THE CHROMIOUS/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 between the electrodes causing the anode to deplate 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

N80-21689f 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
Peter Ramins and Thomas A. Fox Washington Apr. 1980 16 p refs

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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. (Author)

NEW ASTRONOMY -Astronomy of the new generation.


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. (Author)

A80-22598 * National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A80 22598 9 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 an improved power supply are suggested. E.D.K.


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 approximately double the efficiency of the critical amplifier TWT. Attention is given to a quick method of computing the expected improvement at 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
rather than operating at saturation, can be very linear amplifiers. Finally, a new approach to power supplies is also covered.


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.
(Contracts NAS7-100: JPL-055223)
(NASA-CR-162432) Avail: NTIS HC A05/MF A01 CSCL 09C

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 impant-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.


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.
(NASA-CR-159778; DOE/NASA/0130-80/1) Avail: NTIS HC A05/MF A01 CSCL 09C

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.


Describing-function techniques and averaging methods have been employed to characterize a multiloop switching buck regulator by three functional blocks: power stage, analog signal processor, and pulse modulator. The model is employed to explore possible forms of pole-zero cancellation and the adaptive nature of the control to filter parameter changes. Analysis-based design guidelines are provided including a suggested additional RC-compensation loop to optimize regulator performances such as stability, audiosusceptibility, output impedance, and load transient response. (Author)

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34 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.

STREAMLINE FLOW VISUALIZATION STUDY OF A HORSESHOE VORTEX IN A LARGE-SCALE, TWO-DIMENSIONAL TURBINE STATOR CASCADE


Neutral 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. Inlet 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 airpassage 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: K.L.

N80-13403* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

MARANGONI 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 gradient were obtained using the NASA Lewis zero gravity drop tower. Comparisons with experimental results for bubble deformation and bubble 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.

Author: 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 cco, cco, cco was used in the normal gravity tests to obtain 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 droptower 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, 20 psi was obtained for three different rod diameters. It was found that this ratio was inversely proportional to both the oxygen pressure and the rod diameter.

Author: K.L.

N80-16361* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR GENERATING INPUT FOR ANALYSIS OF IMPINGEMENT-COOLED, AXIAL-FLOW TURBINE BLADE


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 are length between grid points required by TACT as input, and prepares the namelist 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 calculation stations, and thus eliminates the need for intermediate drafting.

Author: J.M.S.

N80-16364* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COMPUTATION OF THREE-DIMENSIONAL FLOW IN TUBE FAN 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 under pressure and temperature tests 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 with 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.

Author: K.L.

N80-16365* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

NUMERICAL SIMULATION OF SUPersonic INLETS USING A THREE-DIMENSIONAL VISCOUS FLOW ANALYSIS


A three dimensional, fully viscous computer analysis was utilized to determine the usefulness of the design of supersonic inlets. The 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 7.4 hypersonic inlet. Good agreement was obtained between theory and data for both water. Results of a mesh sensitivity study are also shown K L

N80-17397* 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-TP-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

N80-17398* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

VOLUME-ENERGY PARAMETERS AND TURBULENT-FLOW DENSITY FLUCTUATIONS


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 - Gibbs energy parameter grouped these data better than did such other parameters as enthalpy, temperature, or internal energy. K L

N80-20532* 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 90 percent of the fly ash particles in the effluent gas are removed by using a gas-solids 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.

N80-21706* 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. Vanes were 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.

N80-24673* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

HEAT EXCHANGER AND METHOD OF MAKING Patent


A heat exchanger 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

N80-24677* 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

N80-27632* 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
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 regions. 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.

N80-23622* 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, STIRRING ENGINE CONTROLS
MODEL


A four working space, double acting piston, stirring engine simulation is being developed for controls studies. The development method is 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 inlets. Validate these models separately, then upgrade the four working space model by incorporating the detailed fluid behavior 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 behavior of the whole engine. The drive dynamics and vehicle inertia effects are simulated. To reduce calculation time, only three spaces are used in each working space and the gas temperature are fixed in 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 concaves centering lines. As was discharged from a duct, located on the tunnel side wall behind the plate, through a canted aft 30 deg honeycomb vent into the free stream. Data for the analysis of the Titan forward skirt compartment venting during ascent through the atmosphere were 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 coefficient 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

A80-10030 * Critical mass flux through short Borda type inlets of various cross sections.

Mass flux 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 as found in seals, domers, 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.

A.T.

A80-10037 * Frej jet phenomena in a 90 deg sharp edge inlet geometry.

The effects of free-jet phenomena, jetting, in a 90-deg-sharp-edge inlet tube were analyzed. 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 saturation 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.


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 adequately 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 obtaining such a transformation to calculate two phase critical mass flow through a nozzle. (Author)


Evolution of a rotating fluid 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 qualitative 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.


Evolution of a rotating flow in the vicinity of a surface calculated. 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 qualitative 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 in 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 away from 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 temperature 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 develeoped for the 2.4 kW beam supply of a 30-cm ion thruster. System development yielded a mass reduction of 40% (1.76 kg) and a lower mean cooling 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 chord airfoil in the turbulent mainstream 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.


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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 Final Report, Oct. 1978 - Sep. 1979 K W. Lee, A. A. Putnam, J. A. Gieseke, M. N. Golovin, and J. A. Hale 18 Sep. 1979 106 p. refs (Contract NAS3-21581) (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 operation concerning chemical liquids used in agricultural aviation are (Contract NAS3-21581)The governing equations are written in general orthogonal coordinates. These equations are modified in the subsonic region, and ultrasonic atomization are the techniques discussed. Conceptually designed spray nozzles for generating monodisperse sprays are assessed. These are based on the classification of the drops using centrifugal force, on using two opposing liquid jet arcs, and on operating a spinning disk at an overloaded flow. Performance requirements for the designs are described and estimates of the operational characteristics are presented. A.W.H.

N80-14356"# Scientific Research Associates, Inc., Glastonbury, Conn. DEVELOPMENT OF A THREE-DIMENSIONAL SUPERSONIC INLET FLOW ANALYSIS Final Report R. C. Buggeln, H. McDonald, R. Levy, and J. P. Kreskovsky 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 include 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

N80-19450"# FGW Associates, Inc., Tullahoma, Tenn. 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 A06/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, 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. V. Saasaki 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.

N80-32888"# TRW Defense and Space Systems Group, Redondo Beach, Calif. DEPRIMING OF ARTERIAL HEAT PIPES: AN INVESTIGATION OF CTSS THERMAL EXCURSIONS Final Report, Sept. 1978 - Aug. 1980 D. Antoniuk and D. K. Edwards 20 Aug. 1980 214 p. refs (Contract NAS3-21740) (NASA-CR-165153; TRW-34129-6001-UT-00) Avail. NTIS HC A10/MF A01 CSCL 20D Four thermal excursions of the Transmitter Experim... Package (TEP) were the result of the depriming of the active section 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 thawing cycle of the inactive 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 precluding, or reducing the probability of, this type of failure mechanism in future applications of arterial heat pipes are included. Author

A80-42176"# Full-covering film cooling. I - Comparison of heat transfer data for three injection angles. M. E. Crawford (MIT, Cambridge, Mass.), W. M. Kay, and R. J. Moffat (Stanford University, Stanford, Calif.). American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 10-15, 1980, Paper 80-GT-43. 6 p. 15 refs. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-14336. Wind tunnel experiments were carried out at Stanford between 1971 and 1977 to study the heat transfer characteristics of full-covering film cooled surfaces with three injection angles: normal, 30 deg slant, and 30 deg x 45 deg compound-angled injection. A flat full-covering 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)
35 INSTRUMENTATION AND PHOTOGRAPHY

Includes remote sensors, measuring instruments and gages, detectors, cameras and photographic supplies; and holography.

For aerial photography see 43 Earth Resources. For related information see also 06 Aircraft Instrumentation, and 19 Spacecraft Instrumentation.

N80-14374# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

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 photoelectric 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.

N80-17422# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FATIGUE STRENGTH TESTING EMPLOYED FOR EVALUATION AND ACCEPTANCE OF JET-ENGINE INSTRUMENTATION PROBES


The fatigue type testing performed on instrumentation rakes and probes intended for use in the air flow passages of jet engines during full scale engine tests is outlined. A discussion of each type of test performed, the results that may be derived and means of inspection is included.

N80-17423# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPTICAL SENSORS FOR AERONAUTICS AND SPACE


A review of some NASA and DOD programs to develop optical sensors with fiberoptics for instrumentation and control is presented. Fiberoptic 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 objection of these programs is to produce more reliable sensors and to improve the safety and operating economy of future aircraft and space vehicles.

N80-18365# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FIBER OPTIC SENSORS FOR MEASURING ANGULAR POSITION AND ROTATIONAL SPEED

Robert J. Baumbick, Mar. 1980 13 p

Two optical sensors, a 360 deg rotary encoder and a tachometer, were built for operation with the light source and detectors located remotely from the sensors. The source and detectors were coupled to the passive sensing heads through 3.65 meter fiber optic cables. The rotary encoder and tachometer were subjected to limited environmental testing. They were installed on an air breathing engine during recent altitude tests. Over 100 hours of engine operation were accumulated without any failure of either device.

K.L.

N80-24595# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DYNAMIC BEHAVIOR OF A BEAM DRAG-FORCE ANEMOMETER

Gustav C. Fralick Washington May 1980 16 p refs

A cantilevered beam with strain gages attached to the fixed ends and the minimax technique were used in an experiment conducted to determine the dynamic behavior of a drag-force anemometer in high frequency, unsteady flow. In steady flow the output of the anemometer is proportional to stream velocity head and flow angle. Fluid mechanics suggests that, in unsteady flow, the output would also be proportional to the rate of change of fluid velocity. It was determined that effects due to the rate of change of fluid velocity are negligible for the probe geometry and frequencies involved.

A.R.H.

N80-25635# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTERIZED VIDEO DENSITOMETRY METHOD FOR RAPID ANALYSIS OF INFRARED PHOTOGRAPHIC IMAGES

Ernest Roberts, Jr., Frederick D. Calfo, and Frank G. Pollack Jan. 1980 13 p refs

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 photographic 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, centripetal acceleration, and pressure. Test results showed no failures of transducers or mountings and indicated an uncertainty of unsteady pressure measurement of approximately +0.6 kPa for a typical application.

V.T.

N80-30884# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COST EFFECTIVE MONITORING OF ENVIRONMENTAL AND OPERATIONAL CHARACTERISTICS OF SPACECRAFT POWER SYSTEMS

Charles E. Wilson Feb. 1980 16 p refs

A cost effective technique for monitoring the environment and operational characteristics of spacecraft power systems is presented. The technique, which involves data collection and analysis, has been used to evaluate spacecraft during on-orbit operations. The technique is described and the results of its use are presented.

D.J.

N80-39396# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

APPLICATION OF AERODYNAMIC AND THERMAL MEASUREMENTS TO OPERATIONAL BOUNDARIES OF THE LING-TIAN VIEHICLE

H. T. Schaefer Sep. 1980 16 p refs

Aerodynamic and thermal measurements were taken at operational conditions for the Ling-Tian vehicle. These conditions were extrapolated to the environment of the LTL-1 and LTL-2 vehicles. The results of these extrapolations were used to determine the operational boundaries of these vehicles.

D.J.

N80-39397# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

APPLICATION OF THE SATELLITE INSTRUMENTATION TO THE SATELLITE INSTRUMENTATION AND SPACECRAFT SIMULATION PROJECTS

H. T. Schaefer Sep. 1980 16 p refs

The satellite instrumentation is described and its application to simulation projects is presented. The results of these applications are also discussed.

D.J.

An apparatus is described in which hydrogen atoms were trapped at temperatures down to 1.1 K in the 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.  

V.P.


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 subsystem. 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)

V.P.


Innovative features of the anemometer include: (1) a rapid and efficient data acquisition system, (2) 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)

V.T.


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)

V.P.


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 aero propulsion 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. (Author)

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. (Author)

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 80-channel rotary data package which mounts on and rotates with the turbine shaft at speeds up to 17,000 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.


This report outlines the fatigue type testing 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.


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.

N80-14375* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFICIENT LASER ANEMOMETER FOR INTRA-ROTOR FLOW MAPPING IN TURBOMACHINERY

J. Anthony Powell, Anthony J. Strojiksz, and Richard G. Seasholtz


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 that is 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.

N80-17425* Pratt and Whitney Aircraft, East Hartford, Conn.

THIN FILM TEMPERATURE SENSOR

H. F. Grant and J. S. Przybyszewski


Thin film surface 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.

N80-31777* United Technologies Research Center, East Hartford, Conn.

DESIGN, FABRICATION AND TESTING OF AN OPTICAL TEMPERATURE SENSOR

W. W. Morley, W. H. Glenn, R. O. Decker, and W. C. McClurg


The laboratory breadboard optical temperature sensor based on the temperature dependent absorptive characteristics of a rare earth (europium) doped optical fiber. The principles of operation, materials characterization, fiber and optical component design, 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 + or - 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.
37 MECHANICAL ENGINEERING

Includes auxiliary systems (non-power), machine elements and processes, and mechanical equipment.

N80-12414*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
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 pressure drop. The hydrostatic opening is strongly dependent on the face seal clearance, and the desired axial stiffness is achieved.

N80-13473*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION INTO THE EFFECT OF PLASMA PRE-TREATMENT ON THE ADHESION OF PARYLENE TO VARIOUS SUBSTRATES

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.W.H.

N80-13403*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELF-ACTING LIFT-PAD GEOMETRY FOR CIRCUMFERENTIAL SEALS: A NONCONTACTING CONCEPT

A segmented circumferential seal with lift pads for hydrodynamic action was analyzed over ranges of speed and sealed pressures. Performance predictions, which predicted noncontact operation for speeds as high as 600 revolutions per second at sealed pressures to 86 N/sq cm, are discussed. Performance tests were performed on the seals and compared with the performance predictions.

A.W.H.

N80-124403*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF PREDICTED AND EXPERIMENTAL PERFORMANCE OF LARGE-BORE ROLLER BEARING OPERATING TO 3.0 MILLION DN

Harold H. Cae and Frederick T. Huller Jan. 1980 20 p refs (NASA-TP-1599; E-063) Avail: NTIS HC A02/MF A01 CSCL 131

Bearing inner and outer race temperatures and the amount of heat transferred to the lubricant were calculated by using the computer program CYBEAN. The results obtained were compared with previously reported experimental data for a 118 mm bore roller bearing that operated at shaft speeds to 25,500 rpm, radial loads to 8,900 N (2000 lb), and total lubricant flow rates to 0.0102 cu m/min (2.7 gal/min). The calculated results compared well with the experimental data.

Author

N80-18340*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TRIBOLOGICAL PROPERTIES OF SILICON CARBIDE IN METAL REMOVAL PROCESSES


Material properties are considered as they relate to adhesion, friction, and wear of single crystal silicon carbide in contact 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. The adhesion, 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, 10-110, and/or 11-210 planes.

J.M.S.

N80-16341*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF WEAR-DEBRIS FROM FULL-SCALE BEARING FATIGUE TESTS USING THE FERROGRAPH


The ferrograph was used to determine the types and 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 tetrastearic lubricant was used in a recirculating lubrication system containing a 49 mm 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 failures were detected by accelerometers in this test set. In general, the ferrograph was more sensitive (up to 23 hr) in detecting spall initiation than other accelerometers or the normal spectrographic oil analysis. Four particle types were observed: normal rubbing wear particles, spheres, nonferrous particles, and severe wear (spall) fragments.

Author

N80-16342# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF COMPUTER-OPTIMIZED TAPERED-ROLLER BEARINGS TO 2.4 MILLION DN

The performance of 120.65 mm bore high speed design tapered roller bearings was investigated 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 turbomachines 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.
the Nasvytis drive retrofitted to an automotive gas turbine engine. The drives exhibited good performance with a nominal peak efficiency of 94 to 96 percent and a maximum speed loss due to creep of approximately 3.5 percent. 

ENDURANCE AND FAILURE CHARACTERISTICS OF MODIFIED VASCO X-2, CBS 600 AND AISI 9310 SPUR GEARS


The drives exhibited statistically equivalent lives to 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, 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. 

N80-18406f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF GEOMETRY AND OPERATING CONDITIONS ON SPUR GEAR SYSTEM POWER LOSS


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 speeds, torques, and oil viscosities 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 fine pitched gears had higher peak efficiencies but low 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. 

N80-18407f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONSTRAINED FATIGUE LIFE OPTIMIZATION OF A NASVYTIS MULTIROLLER TRACTION DRIVE


A contact fatigue life analysis method for multiroller traction drives is presented. The method is based on the Lundberg-Palgren analysis method for rolling element bearing life prediction, and also uses life adjustment 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 7500 rpm.
A.J.

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Application engine to power auxiliary equipment. Fuel and air are burned in a catalytic combustor. To start the engine, one valve is opened to direct compressed air from the blower and expander to drive the turbine wheel and also to heat the catalytic element. By opening a flapper valve, the air driven motor starts the engine. The constituents in its exhaust gas react in the catalytic combustor and the heat generated provides additional energy for the turbine section. Abrasion of the rotor blades of the turbine or compressor should be prevented. A compliant backing surrounds the rotor blades. A mounting fixture surrounds the backing.

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

DIESEL ENGINE CATALYTIC COMBUSTOR SYSTEM Patent

Applicant: Lloyd W. Ream, inventor (to NASA) Filed 6 Jun, 1980 10 p NTIS HC A02/MF A01 CSCL 21A

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 exposed, serving to drive the turbine wheel and also to heat the catalytic element. To start the engine, one valve is opened and combustion is initiated 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.

DYNAMIC ANALYSIS OF NONCONTACTING FACE SEALS Patent Application


The dynamic behavior of a noncontacting coned face seal is analyzed taking into account various design parameters and operating conditions. The primary seal ring motion is expressed by a set of nonlinear equations for three degrees of freedom. These equations, which are solved numerically, allow identification of two dimensionless groups of parameters that affect the seal dynamic behavior. Stability maps for various seals are presented. These maps contain a stable-to-unstable transition region in which the ring wobbles at half the shaft frequency. The effect of various parameters on seal stability is discussed and an empirical expression for critical stability is offered. Author

FULLY FLOODED ELASTOHYDRODYNAMIC LUBRICATED ELLIPTICAL CONTACTS Patent


Emphasis is on fully flooded, elastohydrodynamic lubricated, elliptical contacts. A fully flooded conjunction is one in which the film thickness is not significantly changed when the amount of lubricant is increased. A brief description of the relevant equations used in the elastohydrodynamic lubrication of elliptical contacts is given. The most important practical aspect of the elastohydrodynamic theory is the determination of the minimum film thickness within the contact. The maintenance of a fluid film of adequate magnitude is an essential feature of the correct operation of lubricated machine elements. The results presented show the influence of contact geometry on minimum film thickness as expressed by the ellipticity parameter and the dimensionless speed, load, and materials parameters. Film thickness equations are developed for materials of high elastic modulus, such as metal, and for materials of low elastic modulus, such as rubber. In addition to the film thickness equations that are developed, plots of pressure and film thickness are presented. These theoretical solutions for film thickness have all the essential features of previously reported experimental observations based on optical interferometry. Correlation between theory and experiments is also presented. L.F.M.

STARVED ELASTOHYDRODYNAMIC LUBRICATED ELLIPTICAL CONTACTS Patent


A theoretical study of the influence of lubricant starvation on film thickness and pressure in hard and soft elastohydrodynamic contacts is presented. From the results for both hard and soft EHL contacts a simple and important dimensionless inlet boundary distance is specified. This inlet boundary defines whether a fully flooded or a starved condition exists in the contact. Furthermore it is found that the film thickness for a starved condition could be written in dimensionless terms.
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 in contact with each other by means of a surrounding elastomeric band. The rings are segmented and are of a rigid sealing material such as carbon or a polyimide and graphite fiber composite. Official Gazette of the U.S. Patent and Trademark Office


A theory of kinematic stabilization of rolling cylinders is developed for high-speed cylindrical roller bearings. This stabilization requires race and roller crowning to produce changes in the rolling geometry as the roller shifts axially. These changes put a reverse skew in the rolling elements by changing the rolling taper. Twelve basic possible bearing modifications are identified in this paper. Four have single transverse convex curvature in the rollers while eight have rollers with compound transverse curvature composed of a central cylindrical band of constant radius surrounded by symmetric bands with both slope and transverse curvature. Author

N80-28706* 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 ARID (NASA-CP-2133; E-413) Avail: NTIS HC A2O/MF A01 CSCL 13I

Diagnostic and remedial 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 rotordynamic 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. Author


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


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 distinguishes 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 output. 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 separately located on the same side of the displacer member or may be separated by the diaphragm member. Official Gazette of the U.S. Patent and Trademark Office
EFFECT OF CAGE DESIGN ON CHARACTERISTICS OF
variations inside the cavitation zone, contrary to common
levels. Some photographs of the cavitation region are presented
showing strong reverse flow at the downstream end of the
cavitation zone of a submerged journal bearing are described,
Author

M.E.P.

A80-13068 * // NASA gear research and its probable effect on
rotorcraft transmission design. E. V. Zaretzky, 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 rotorcraft 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-
neers. Lubrication Conference, Dayton, Ohio. Oct. 16-18, 1979,
ASLE Preprint 79-LC-38-2, 6 p. 11 refs. 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
centrifugal or eccentric position of the rotor and parallel or
cossergent tapered flow passages, data and analyses reveal that
mass flux or leak rate can be determined from a relation whose
normalizing parameters depend on the thermodynamic critical
constant of the working fluid and an average flow area expressed in
terms of the inlet and exit cross-sectional areas. 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
part. (Author)

A80-14734 * // 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,
19 refs. Sliding 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

A80-10040 * // Survey of ion plating sources. T. Spalvins
(NASA, Lewis Research Center, Cleveland, Ohio). American Vaccum
2-5, 1979, Paper. 23 p. 30 refs. 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 exceptionallu 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. (Author)

A80-35098 * // National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio. OBSERVATION OF PRESSURE VARIATION IN THE
CAVITATION REGION OF SUBMERGED JOURNAL
bearings. I. Etsion and L. P. Ludwig 1980 27 p refs Proposed for
presentation at the Lubrication Conf., New Orleans, 11-14 Oct
1981; sponsored by the ASME (NASA-TM-81582; E-555) Avail. NTIS HC A03/ MF A01 CSCL
131 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 inside the cavitation zone, contrary to common
assumptions of constant cavitation pressure. Author

A80-35749 * // National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio. EFFECT OF CAGE DESIGN ON CHARACTERISTICS OF
HIGH-SPEED-JET-LUBRICATED 36-MILLIMETER-SORE
131 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 (350 F). Successful operation of the
test bearing was accomplished up to 2.5 million DN. 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. Author

A80-10040 * // Survey of ion plating sources. T. Spalvins
(NASA, Lewis Research Center, Cleveland, Ohio). American Vaccum
2-5, 1979, Paper. 23 p. 30 refs. 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 exceptionallu 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. (Author)
They increase as the atomic ratio increases or decreases linearly from the atomic radius ratio and the decreasing rates of change of coefficient of friction and groove height with increasing solute content. These rates of change are minimum at a solute to iron atomic radius ratio of unity.

Members, $1.50; nonmembers, $3.00, NASA-sponsored research.


This paper describes a method used to design elastically 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 elastomer 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.


This paper presents the results of a program of analysis and test to determine the dynamic properties of elastomer cartridge bearings. These 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 vibration-driven tests were two rectangular cross-section, continuous rings, 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.


A review of various types of seal locations in a gas turbine 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 temperatures to attain low porosity metallic gas path seal materials. A.T.

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 polyimide-bonded graphite fluoride films were investigated. A sin-on-disk type of testing apparatus was used; flat admittance to sliding a hemispherically tipped rider, a rider with a 0.95-mm-diameter flat area was 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 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. (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 failures were detected by accelerometers in this test set. In general, the Ferrograph was more sensitive (up to 23 h) in detecting spall initiation than either accelerometers or the normal spectrographic analysis. (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 both, 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 coated by overrode. However, in the maximum useful temperature of the cobalt composite coating to about 650 C compared to about 900 C for the nickel composite coating. (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. (Author)


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 assessment 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 with rollers per row. The drive was approximately 25 centimeters in diameter by 11 centimeters long, having a nominal ratio of 16.1. 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 and oil viscosities 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 Nasvitys 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, one at maximum power levels to 73,000 rpm and power levels to 180 kW (240 hp). Parametric tests were also conducted with the Nasvitys drive

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 of tooth fracture occurring at a tooth surface fatigue pit. Careful selection of all gear surfaces for the modified Vasco X-2 gears results in fracture at the tips of the gears.

(Author)


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 high and low speeds. 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.

(Author)


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.

(Author)


The feasibility of silicon carbide composite structures was evaluated for 1644 K gas turbine seal applications. The silicon carbide composites evaluated consisted of Si/SiC Silcomp (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.

J.M.S.


Dual density, plasma sprayed ceramic coating systems were investigated for possible application as abradable turbine tip seal systems in small gas turbine engines. Abradability, erosion resistance, internal leakage, and microstructural characterization were investigated for polyester and cenosphere filled zirconium oxide composites. Results indicate the polyester system is more abradable but displays significantly less erosion resistance than the cenosphere system. It is also stated that the absence of significant blade tip damage during abradability testing of both systems suggests additional effort may result in a more nearly optimum balance of abradability and erosion resistance.

M.G.


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-1Fe) with and without a 515B Feltmetal underlayer.

Author
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, molybdenum, tantalum, and tungsten alloys are also reviewed. Molybdenum alloys are found to be the most suitable for gas turbine wheel and various forms of fabrication processes for silicon nitride, silicon carbide, and SIALON's are investigated for use in hightemperature environments.

K.L.

N80-18402* National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

IMPROVED TIRE/WHEEL CONCEPT Patent Application

Philip M. Harper, Sr., Inventor (to NASA) (Boeing Commercial Airplane Co., Seattle, Wash.) Filed 12 Dec. 1979 12 p

Sponsored by NASA (NASA-Case-LAR-11695-2; US-Patent-Appl-SN-103836) Avail: NTIS HC A02/MF A01 CSCL 01C

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

(Sponsored by NASA) (NASA-CR-159820; DOE/NASA/1201-80/1; BCAC-DE-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 Footaseal, NASA Chevon polynide 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 PA, rod speed of 7.19 m/sec peak, and seal environmental temperature of 408 K for 1500 hours. All tests 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.

N80-22703* 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-1000) Avail: NTIS HC A05/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 and smaller design output torques. The suitability of the flat belt CVT for application to an electric vehicle powered by an electric motor without a flywheel and to a hybrid electric vehicle powered by an electric motor with an internal combustion engine was studied. E.D.K.


DESIGN STUDY OF TOROIDAL TRACTION CVT FOR ELECTRIC VEHICLES Final Report

A. E. Raymond, James Kraus, and Daniel D. Bell Jan 1980 161 p refs

(Contracts DEN3-117; EC-77-A-31-1044) (NASA-CR-159803; DOE/NASA/1017-80/1; Rep 80-16762) Avail: NTIS HC A05/MF A01 CSCL 13I

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 full-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.

N80-24620* Chrysler Corp., Detroit, Mich.

BASELINE AUTOMOTIVE GAS TURBINE ENGINE DEVELOPMENT PROGRAM Final Report

C. E. Wagner, ed, and R. C. Pampreen, ed. Apr. 1979 182 p refs

(Sponsored by NASA) (Contracts EY-76-C-02-2749; EC-77-A-31-1040) (NASA-CR-159870; DOE/NASA/2749-79/1-Vol-1; COO-2749-42) Avail: NTIS HC A05/MF A01 CSCL 21A

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 a 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 filamentless insulation in the engine housing. R.E.S.

N80-24621* Chrysler Corp., Detroit, Mich.

CONCEPTUAL DESIGN STUDY OF AN IMPROVED AUTOMOTIVE GAS TURBINE POWERTRAIN Final Report

C. E. Wagner, ed, and R. C. Pampreen, ed. June 1979 196 p refs

(Contracts DS-AC02-76CS-52749) (NASA-CR-159872; DOE/NASA/2749-79/3-Vol-3; COO-2749-40) Avail: NTIS HC A05/MF A01 CSCL 21A

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, overall suitability to mechanical design, and of automotive mass production cost, the powertrain selected was a single-shaft 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
1350 C to achieve near-maximum fuel economy. A.R.H.


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 tests efforts are presented. Approaches used to pin point 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.O.K.


Two field situations illustrate the consequences of rotordynamic instability in centrifugal compressors. One involves the re injection of produced gas into a North Sea oil formation for the temporary extraction of crude. The other describes on-shore compressors used to deliver natural gas from off-shore wells. The problems which developed and the remedies attempted in each case are discussed. Instability problems resulted in lost production, extended construction periods and costs, and heavy maintenance expenditures. The need for effective methods to properly identify the problem in the field and in the compressor design stage is emphasized. M.G.


Lateral and torsional vibration data obtained on a centrifugal compressor train which had shaft instabilities and gear failures is examined. The field data verifies that the stability of centrifugal compressors can be adversely affected by coincidence of torsional natural frequencies with lateral instability frequencies. The data also indicates that excitation energy from gear boxes can reduce stability margins if energy is transmitted either laterally or torsionally to the compressors. The lateral and torsional coupling mechanisms of shaft systems is discussed. The coupling mechanisms in a large industrial compressor train are documented and the potential effect on rotor stability is demonstrated. Guidelines are set forth to eliminate these potential problems by minimizing the interaction of torsional and lateral responses and their effect on rotor stability. M.G.


Using analytical mathematical modeling techniques for the system components, an attempt is made to gauge the destabilizing effects in a number of compressor designs. In particular the overhang (or cantilevered) compressor designs and the straddle-mounted (or simply supported) compressor designs are examined. 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. M.G.


The summary of a complete analytical design evaluation of an existing parallel flow compressor is presented and a field vibration problem that manifested itself as a subsynchronous vibration that tracked at approximately 2/3 of compressor speed is reviewed. The comparison of predicted and observed peak response speeds, frequency spectrum content, and the performance of the bearing-seal systems are presented as the events of the field problem are reviewed. Conclusions and recommendations are made as to the degree of accuracy of the analytical techniques used to evaluate the compressor design. 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 whip). 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 category of forward circular whip 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 \( P_d \) was increased, after the rotor was already at full speed. The typical spectral data of the shaft vibration indicate that as the pressure \( P_d \) increases, pre-unstable vibration appears and becomes larger, and large unstable asynchronous vibration occurs suddenly \( (P_d = 5.69 \text{MPa}) \). 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.

**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.

**Evaluation of Instability Forces of Labyrinth Seals in Turbines or Compressors**


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 to 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 concepts. The force induced by the labyrinth seal always makes the rotor system unstable, and the tendency is marked when seal leakages are small. 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.

**Hydraulic Forces Caused by Annular Pressure Seals in Centrifugal Pumps**


The hydraulic forces caused by annular pressure seals 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.

**Effect of Fluid Forces on Rotor Stability of Centrifugal Compressors and Pumps**


The details of a test program for the measurement of the unsteady forces on centrifugal impellers are discussed. Various hydrodynamic flows are identified as possible contributors to these destabilizing forces.

**Flow Induced Aerodynamic Spring Coefficients of Labyrinth Seals**


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 vanless volute formed as a logarithmic spiral. It is shown that for certain operating conditions, the impeller force has a destabilizing effect on the rotor.

**Non-Synchronous Whirling Due to Fluid-Dynamic Forces in Axial Turbo-Machinery Rotors**


The role of fluid forces acting on the blades of an axial turboshaft 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 backward whirl was indicated when the phase shifting of the rotor wake effect was ignored.

A parametric study of the dynamic stability boundary revealed that a reduction in blade stagger angle, mass Row rate, fluid damping coefficient per stage needed for stability is delta sub n with respect to a system rotating supercritically at rate Omega - omega sub n, is investigated, the destabilizing effect of rotating damping was investigated, and offset disc rotors (ventilators). Instability regions and types of instability are computed in the first case, and parametric excitation systems with application to industrial ventilation is considered for both unequal principal shaft stiffness (generators) and offset disc rotors (ventilators). Instability and conditions of instability are computed in the first case, and parametric

VIBRATION EXCITING MECHANISMS INDUCED BY FLOW IN TURBOMACHINE STAGES


The quasisteady computer analysis of the perturbed centrifugal impeller passage flow was reviewed. A total of 115 stage calculations were used to define the fluid damping coefficient, delta sub f sub fluid, results indicate that the average total damping coefficient per stage needed for stability is delta sub f sub fluid > 1.85.

SELF-EXCITED ROTOR WHIRL DUE TO TIP-SEAL LEAKAGE FORCES


The limitations in the performance of turbomachines which arise as a result of selfexcited vibration were investigated. Bearing 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 form the leakage losses and from rotating flow in radial gaps.

FLUID FORCES ON ROTATING CENTRIFUGAL IMPELLER WITH WHIRLING MOTION

Hidenobu Shoji and Hideo Ohashi / In NASA. Lewis Res. Center Rotordyn, Instability Prob. in High-Performance Turbomachinery 1980 p 317-328 refs Sponsored in part by the Japanese Ministry of Education and by Hitachi Ltd. (For primary document see N80-29706 20-37) Avail: NTIS HC A20/MF A01 CSCL 131

Fluid forces on a centrifugal impeller, whose rotating axis whirls with a constant speed, were calculated by using unsteady potential theory for various values of whirl speed, number of impeller blades and angle of blades. Specific examples as well as significant results are given.

LIMIT CYCLES OF A FLEXIBLE SHAFT WITH HYDRODYNAMIC JOURNAL BEARINGS IN UNSTABLE REGIMES

R. David Brown and Henry F. Black / In Institute Rotordyn, Instability Prob. in High-Performance Turbomachinery 1980 p 331-343 refs (For primary document see N80-29706 20-37) Avail: NTIS HC A20/MF A01 CSCL 131

A symmetric 3 mass rotor supported on hydrodynamic bearings is described. An approximate method of representing finite bearings is used to calculate bearing forces. As the method sums forces from a number of independent circular lobes lemon 3 and 4 lobe bearings are taken into account. The calculations are based on an axial groove bearing. Linear analysis precedes nonlinear simulation of some unstable conditions. The demonstration 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.

ON THE ROLE OF OIL-FILM BEARINGS IN PROMOTING SHAFT INSTABILITY: SOME EXPERIMENTAL OBSERVATIONS

R. Holmes / In NASA. Lewis Res. Center Rotordyn, Instability Prob. in High-Performance Turbomachinery 1980 p 345-367 refs (For primary document see N80-29706 20-37) Avail: NTIS HC A20/MF A01 CSCL 131

The occurrence of oil whirl instability in rigid and flexible rotor systems was investigated. The effect of various bearing parameters on the oil whirl frequency and amplitude of rigid and flexible shafts supported on fluid film bearings was also studied.

EXPERIMENTAL RESULTS CONCERNING CENTRIFUGAL IMPELLER EXCITATIONS


The effect of rotating fluid on the dynamics of an impeller with radial vanes was investigated. The impeller was supported vertically from a very flexible quill shaft in order to produce a low critical speed, and to allow the fluid dynamic effects on the impeller to predominate. The shaft was supported from ball bearings, so that there was no possibility of oil whip from fluid film bearings as a destabilizing influence. The impeller was run both in the atmosphere, and submerged in working fluids contained in a cylindrical housing, open at the top. Variable speed was obtained with a dc gearmotor drive unit. The speed was measured with a proximity pulse tachometer and electronic digital counter.

Massachusetts Inst. of Tech., Cambridge.

PHYSICAL EXPLANATIONS OF THE DESTABILIZING EFFECT OF DAMPING IN ROTATING PARTS

Stephen H. Crandall / In Institute Rotordyn, Instability Prob. in High-Performance Turbomachinery 1980 p 389-382 refs (For primary document see N80-29706 20-37) 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 stationary damping 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.

Politechnika Lodzka (Poland).

PARAMETRIC INSTABILITIES OF ROTOR-SUPPORT SYSTEMS WITH APPLICATION TO INDUSTRIAL VENTILATORS


Rotor support systems interaction with parametric excitation is considered for both unequal principal shaft stiffness (generators) and offset disc rotors (ventilators). Instability and conditions of instability are computed in the first case, and parametric
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.

N80-29730* Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.

INSTABILITY THRESHOLDS FOR FLEXIBLE ROTORS IN HYDRODYNAMIC BEARINGS

Paul E. Allaire and Ronald D. Flock In NASA. Lewis Res. Center Rotordyn. Instability Probl, in High-Performance Turbomachinery 1980 p 403-427 refs (For primary document see N80-29706 20-37) (Grant NsG-3177: Contract DE-AC01-78ET-13151: Grant RC-A-77-6C)

Two types of fixed pad hydrodynamic bearings (multiplate and pressure dam) were considered. Optimum and nonoptimum geometric configurations were tested. The optimum geometric configurations were determined by using 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 cross-coupling. However, the increase in rotor stability should greatly improve rotating machinery performance in the presence of such forces as well.

R.C.T.

N80-29731* Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.

STABILIZATION OF AERODYNAMICALLY EXCITED TURBOMACHINERY WITH HYDRODYNAMIC JOURNAL BEARINGS AND SUPPORTS

Lloyd E. Barrett and Edgar J. Gunter In NASA. Lewis Res. Center Rotordyn. Instability Probl, in High-Performance Turbomachinery 1980 p 429-452 refs (For primary document see N80-29706 20-37) (Grant NsG-3105; Contracts DAA29-77-C-0009: EF-76-C-01-2479)

Avail: NTIS HC A20/MF A01 CSCL 13I

A method of analyzing the first mode stability and unbalance response of multimass flexible rotors is presented whereby the multimass system is modeled as an equivalent single mass modal model including the effects of rotor flexibility, general linearized hydrodynamic journal bearings, squeeze film bearing supports and rotor aerodynamic cross coupling. Expressions for optimum bearing and support damping are presented for both stability and unbalance response. The method is intended to be used as a preliminary design tool to quickly ascertain the effects of bearing and support changes on rotor-bearing system performance.

R.C.T.

N80-29732* Mechanical Technology, Inc., Latham, N. Y.

USE OF ELASTOMERIC ELEMENTS IN CONTROL OF ROTOR INSTABILITY


The dynamic characteristics of elastomeric supports are discussed. Stiffness and damping characteristics for elastomers of various geometries including O-rings, buttons loaded in compression, and rectangular elements loaded in shear are presented. The effects of frequency, temperature, and amplitude are illustrated, as well as the effects of material and geometry. Empirical design methods are illustrated, and several examples are presented where elastomers have successfully controlled both synchronous and nonsynchronous vibrations.

R.C.T.

N80-29733* Virginia Univ., Charlottesville.

FEASIBILITY OF ACTIVE FEEDBACK CONTROL OF ROTORDYNAMIC INSTABILITY


Avail: NTIS HC A20/MF A01 CSCL 13I

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.


SMALL PASSENGER CAR TRANSMISSION TEST; FORD C4 TRANSMISSION Final Report


A 1979 Ford C4 automatic transmission was tested per a passenger car automatic transmission test code (SAE J651b) which required drive performance, coast performance, and no load test conditions. Under these test conditions, the transmission attained maximum efficiencies in the mid-eighty percent range for both drive performance tests and coast performance tests. The major results of this test (torque, speed, and efficiency curves) are presented. Graphs map the complete performance characteristics for the Ford C4 transmission.

A.R.H.


SMALL PASSENGER CAR TRANSMISSION TEST; CHEVROLET LUV TRANSMISSION Final Report


A 1978 Chevrolet LUV manual transmission tested per the applicable portions of a passenger car automatic transmission test code (SAE J651b) which required drive performance, coast performance, and no load test conditions. Under these test conditions, the transmission attained maximum efficiencies in the upper ninety percent range for both drive performance tests and coast performance tests. The major results of this test (torque, speed, and efficiency curves) are presented. Graphs map the complete performance characteristics for the Chevrolet LUV transmission.

A.R.H.

N80-32719* Mechanical Technology, Inc., Latham, N. Y.

DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING OF ELASTOMERS IN ENGINEERING APPLICATIONS, PART 7


An elastomer shear damper was designed, tested, and compared with the performance of the T 55 power turbine supported on the production engine roller bearing support. The Viton 70 shear damper was designed so that the elastomer damper could be interchanged with the production T 55 power turbine roller bearing support. The results show that the elastomer shear damper permitted stable operation of the power turbine at the maximum operating speed of 16,000 rpm.

Author

N80-32718* Chrysler Corp., Detroit, Mich.

UPGRADED AUTOMOTIVE GAS TURBINE ENGINE DESIGN AND DEVELOPMENT PROGRAM, VOLUME 2 Final Report

C. E. Wagner, ed. and R. C. Pampreen, ed. Jun. 1979 348 p
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 retrofitted 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 loss in power was primarily due to missing the baseline engine achieved 8 MPG with a 4500 Ib. 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.

**N80-32720**
Rochester Inst. of Tech., N.Y.
**DEVELOPMENT OF FLEXIBLE ROTOR BALANCING CRITERIA** Final Report
(Grant NsG-3072)
(NASA-CR-159506) Avail: NTIS HC A06/MF A01 CSCL 131

Several studies in which analytical procedures were used to obtain balancing criteria for flexible rotors are described. General response data for a uniform rotor in damped flexible supports were first obtained for plain cylindrical bearings, tilting pad bearings, axial groove bearings, and partial arc bearings. These data formed the basis for the flexible rotor balance criteria presented. A procedure by which a practical rotor in bearings could be reduced to an equivalent uniform rotor was developed and tested. It was found that the equivalent rotor response was always exceeded to practical rotor response by more than sixty percent for the cases tested. The equivalent rotor procedure was then tested against six practical rotor configurations for which data was available. It was found that the equivalent rotor method offered a procedure by which balance criteria could be selected for practical flexible rotors, using the charts given for the uniform rotor.

**A80-14739**

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 are 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 for 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.

**A80-14760**

An analysis and a series of computerized calculations were carried out to explore competing prototype design concepts of a shaft and two taper-roller bearings systems to support the high-speed input pinion of an advanced commercial helicopter transmission. The results were used to evaluate designs both for a straddle arrangement where the pinion gear is located between the bearings and for a cantilever arrangement where the pinion is outboard of the two bearings. Effects of varying parameters including applied gear load, preload, wall thickness, interference fits, bearing spacing and pinion gear location on system rigidity, load distribution and bearing rating life were assessed. A comparison of the bearing load distributions for these designs demonstrated that the straddle more equally distributes both radial and axial loads. The performance of these designs over a range of shaft rotational speeds, with lubrication friction effects included, is also discussed.

**A80-14761**

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 ANalyzes), 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.

**A80-35574**

A progress report on the Advanced Gas Turbine Powertrain System Development Project being performed under contract from NASA Lewis is presented. The goals and objectives of the project are described noting that funds from the DOE, Office of Transportation Programs are used to sponsor the project. Among the demonstration objectives are attaining a fuel economy of 42.5 miles per gallon in a 1985 Pontiac Phoenix, multifuel capability, and emission levels within the federal standards. Design objectives examined include competitive reliability and life as well as competitive initial and life cycle costs. Finally, it is stressed that high risk and key elements in this advanced powertrain project are the development of ceramic turbine engine components and the aerodynamic development of small size turbine components.
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
(Contract DE-AB29-75SF-20730) (NASA-TM-79291, DOE/NASA/20370-79/19, E-235) Avail NTIS HC A02/MF A01 CSCL 14D

An example of 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 TRANSDUCER-COUPPLANT EFFECTS ON BROADBAND ULTRASONIC SIGNALS
(NASA-TM-81489, E-427) Avail NTIS HC A03/MF A01 CSCL 14D

The increasing use of broadband, pulse-echo ultrasonics in nondestructive evaluation 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 analysis 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 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
Alex Vary 1980 21 p refs To be presented at the Conf. on Mech. of Nondestructive Testing, Blacksburg, Va., 10-12 Sep. 1980
(NASA-TM-81523; E-467) Avail: NTIS HC A02/MF A01 CSCL 14D

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

N80-28822# 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.

E D K


The ultrasonic nondestructive evaluation techniques discussed in the present 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 energy transfer properties of a material.

V P


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

N80-13503 Syracuse Univ., N. Y.

MODELLING OF CRACK TIP DEFORMATION WITH FINITE ELEMENT METHOD AND ITS APPLICATIONS Ph.D. Thesis Chuang-Yeh Yang 1979 125 p
Avail: Univ. Microfilms Order No. 7925610

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. Dissert. Abstr.
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 A03/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 armed 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 SEMIPRINCIPAL FRACTURE ANALYSES AND R-CURVES

Thomas W. Orange Jan. 1980 45 p refs
(NASA-TP-1600: E-96963) Avail NTIS HC A03/MF A01 CSCL 20K

The relations between several semiprincipal 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. Gaugler 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. 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

N80-23678# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

STATUS OF NASA FULL-SCALE ENGINE AEREOELASTICITY RESEARCH


Data relevant to several types of aeroelastic instabilities were obtained using several types of turbojet and turbofan engines. In particular, data relative to separated flow (stall) flutter, choke flutter, and system mode instability are presented. The unique characteristics of these instabilities are discussed, and a number of correlations are presented that help identify the nature of the phenomena. R.E.S.

N80-23684# 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-8117: 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

N80-23719# 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


The paper presents simple spline-function equations for fracture mechanics calculations. A spline function is a piecewise polynomial 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 presented 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 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.


The stability of a beam subjected to compressive centrifugal forces arising from a 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 interservice 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 angled fiber composite laminates using a pocket calculator. The procedure consists of simple equations and appropriate graphs of (plus or minus theta) p/y 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 turboprop engines. Special attention is given to data relative to separated flow (stall), lock-on, critical rotational speed for buckle in the Enplane and out-of-plane directions, and system mode instabilities. The discussion covers the characteristics of those instabilities, and a number of correlations are presented that help identify the nature of the phenomena.


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. Kielb (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. 543-566. 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

133
maximum load, calculations of Srawley and Gross for specimens with a straight-through crack were applied to the specimens with chevron notches. For 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)


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/turbin e cases, and high/low pressure turbines, as well as the nacelle, tailcone, and wing pylon. The analysis conducted pred ets 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-flight-life event. J M S.


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-79, Buna-N, EPDM, and Neoprene to determine performance limitations imposed by strain, temperature, and frequency. Frequencies of between 100 Hz and 1100 Hz were surveyed with imposed strains between 0.0005 and 0.08, at temperatures of 32 C, 65 C, and 80 C. A set of design curves was generated in a unified format for each of the elastomers.


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 4B computer code and (2) the CIVM-JET 4C computer code 'with the use of the modified input instructions' attached hereto.

L.F.M.


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 deformable 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.

E D K.
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.
43 EARTH RESOURCES
Includes remote sensing of earth resources by aircraft and spacecraft, photogrammetry, and aerial photography.
For instrumentation see 35 Instrumentation and Photography.

N80-15539
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

POSSIBLE METHODS FOR DISTINGUISHING ICEBERGS FROM SHIPS BY AERIAL REMOTE 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 these 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 ININVISCID 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 disturbed 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; geophysical conversion; hydroelectric power; and 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.

SOME TECHNIQUES FOR REDUCING THE TOWER SHADOW OF THE DOE/NASA MOD-0 WIND TURBINE TOWER Final Report

Richard R. Burley, Joseph M. Savino, Lee H. Wagner, and James H. Diedrich Sep 1979 129 p refs (Contract DE-AB29-76-T20370)

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.

NASA-LEWIS CLOSED-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.

N80-12552\# National Aeronautics and Space Administration.

A PHOTOVOLTAIC POWER SYSTEM IN THE REMOTE AFRICAN VILLAGE OF TANGAYE, UPPER VOLTA

William J. bifano, Anthony F. Ratcliff, and James E. Martz 11 Dec 1979 17 p UNITAR Conf, on Long-Term Energy Resources, Montreal, 26 Nov. - 7 Dec 1979

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.

N80-13623\# National Aeronautics and Space Administration.

MODIFIED POWER LAW EQUATIONS FOR VERTICAL WIND PROFILES


Equations are presented for calculating power law exponents from wind speed and surface roughness data. Results are evaluated by comparison with wind profile data measured at a variety of sites.

Author

N80-13624\# National Aeronautics and Space Administration.

LOW NOX(III) HEAVY FUEL COMBUSTOR PROGRAM


The 'low nitrogen oxides heavy fuel combustor' program is described. 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, improved combustor durability, and satisfactory combustion of minimally processed petroleum residual fuels. Other technology advances sought include: fuel flexibility for operation with petroleum distillates, blends of petroleum distillates and residual fuels, and synfuels (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.

R.E.S.

N80-14472\# National Aeronautics and Space Administration.

SELF-RECONFIGURING SOLAR CELL SYSTEM Patent


A self-reconfiguring solar cell array is disclosed wherein some of the cells are switched so that they can be either in series or in shunt within the array. This feature of series or parallel switching of cells allows the array to match the load to achieve maximum power transfer. Automatic control is used to determine the conditions for maximum power operation and to switch the array into the appropriate configuration necessary to transfer maximum power to the load.

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

N80-14493\# National Aeronautics and Space Administration.

STATUS OF THE DOE/NASA CRITICAL GAS TURBINE RESEARCH AND TECHNOLOGY PROJECT


Activities performed in order to provide an R&T data base for utility gas turbine systems burning coal-derived fuels are described. Treatment focused on combustor, turbine, and system performance and includes design and effectiveness of combustor, turbine, and system performance. The data base includes over 1000 points from over 150 combustors, over 50 turbines, and over 10 systems.

R.E.S.
The efficiency of solar cells for space use is assessed. High efficiency is indicated by an analysis that suggests anomalous behavior of the electron mobility in the cell base limits attainment of higher voltages. Silicon solar cells were achieved using a multistep diffusion process. Actual cells were fabricated from float zone material exhibiting superior radiation resistance. 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 the mechanism of radiation 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 gradients 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.

A.R.H.

SILICON SOLAR CELLS

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.

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 data are given along with the results of an analysis that indicates anomalous behavior of the electron mobility in the cell base limits attainment of higher voltages.

Author

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.

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 blackbody detectors, calibrated reference cells, and the convolution of spectral response with solar irradiance. M.G.

**N80-16454**
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.

**N80-16465**
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-OA 200 kW WIND TURBINE AT CLAYTON, NEW MEXICO**
Bradford S. Linscott and Richard K. Shawon 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-OA 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. Siroom, 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-O 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. Triezenberg (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 generator 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**
Robert J. Stockl Dec 1979 23 p. refs (Contract EX-76-4-29-1060) (NASA-7M 79322 DOE/NASA/1060-79/3) Avail NTIS HC A02/MF A01 CSCL 10B
The results of an analysis of possible performance improvements that could be obtained by using a chemically reacting gas (nitrogen tetroxide) as the working fluid in a closed Brayton cycle are presented. 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 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...
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.

N80-16463* 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 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-OA 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-OA 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. Sroicky, 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-O 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

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A.R.H.

N80-16490* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

POTENTIAL 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

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are significantly larger than design values, but they do not appear to exceed fatigue allowable loads as yet.

**N80-18554** 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.**

**N80-18555** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FLEXIBLE FORMLATED 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.**

**N80-18556** 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.**

**N80-18557** 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
checkout tests were then conducted to evaluate performance and loads. The results of these tests compared well with the design data. K.L.

NBO-19626* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS), VOLUME 1: SUMMARY


The optimum primary equivalence ratio, where the least NO suboxides in a premixed, homogeneous combustion system are achieved, was determined. Increased levels of fuel nitrogen were evaluated. Air at 672 K and 0.48 MPa was premixed with fuel hydrogen content. Increasing levels of fuel nitrogen was found to slightly increase NO suboxides output, while varying the fuel hydrogen content had no significant effect.

NBO-21837* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

FLAME TUBE PARAMETRIC STUDIES FOR CONTROL OF FUEL BOUND NITROGEN USING RICH-LEAN TWO-STAGE COMBUSTION


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 propane, toluene, and pyridine at primary equivalence ratios ranging from 0.5 to 1.5. Secondary equivalence ratios of 0.5 to 2.0, and temperature ratios of 0.7, for the dual-stage combustion, were also tested. The results show that, for optimal NO suboxides output, the fuel nitrogen composition is more effective than the temperature ratio, 0.9 to 1.3 percent of fuel nitrogen content, as opposed to the temperature ratio of 7 to 18 percent.

NBO-22777* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ADVANCED SCREENING OF ELECTRODE COUPLES


The chromium (Cr3+/Cr2+ i) redox couple (electrolyte and electrode) was investigated to determine its suitability as a negative electrode for the iron (Fe3+/Fe2+) redox couple. Literature search and laboratory investigation established 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 evaluated: 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 of 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-22789 through NBO-22829.

NBO-22790* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PROGRAM DEFINITION AND ASSESSMENT OVERVIEW


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, synthoil, solvent-refined coal, donor solvent, zinc chloride hydrocracking, co-steam, and flash pyrolysis. Some typical ranges of data for coal-derived low Btu gases are also presented.

R.E.S.
**INDUSTRIAL STORAGE APPLICATIONS OVERVIEW**

Rudolph A. Duscha In its Thermal Energy Storage Mar. 1980 p 85-94 ref. (For primary document see NBO-22788 13-44) avail. NTIS HC A09/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.

**COMBINED CYCLE MHD-POWER PLANT APPLICATIONS**


(Contracts A02/MF A01 CSCL 10B)

Some of the design approaches being employed during a current supported study directed at developing an improved 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.

**THE EFFECT OF CATALYST LENGTH AND DOWNSTREAM REACTOR DISTANCE ON CATALYTIC COMBUSTOR PERFORMANCE**

David Anderson 1980 24 p refs Presented at the 4th Workshop on Catalytic Combust., Cincinnati, 14-15 May 1980; sponsored by EPA

(Contract EC-77-A-31-1040)

(ASSA-TM-8197: DOE/NASA/1040-80/14; E-409) Avail. NTIS HC A02/MF A01 CSCL 10B

A study was made to determine the effects on catalytic combustor performance which resulted from independently varying the length of a catalytic reactor and the length available for gas-phase reactions downstream of the catalyst. Monolithic combustion catalysts from three manufacturers were tested in a combustion test rig with no. 2 diesel fuel. Catalytic reactor lengths of 2.5 and 5.4 cm, and downstream gas-phase reaction distances of 7.3, 12.4, 17.5, and 22.5 cm were evaluated. Measurements of carbon monoxide, unburned hydrocarbons, nitrogen oxides, and pressure drop were made. The catalytic-reactor pressure drop was less than 1 percent of the upstream total pressure for all test configurations and test conditions. Nitrogen oxides and unburned hydrocarbons emissions were less than 0.25 g NO2/kg fuel and 0.6 g HC/kg fuel, respectively. The minimum operating temperature (defined as the adiabatic combustion temperature required to obtain carbon monoxide emissions below a reference level of 13.6 g CO/kg fuel) ranged from 1220 K to 1500 K for the various conditions and configurations tested. The minimum operating temperature decreased with increasing total catalytic-reactor-plus-downstream-gas-phase-reactor-zone residence time but was independent of the relative times spent in each region when the catalytic-reactor residence time was greater than or equal to 1.4 ms. R.E.S.
controllers with series traction motors resulted in a significant...

AN ELECTRIC VEHICLE PROPULSION SYSTEM'S IMPACT
described.

R.E.S.,

oxygen enriched plant as the first commercial MHD plant is...

THERMAL ENERGY STORAGE

The performance of two types of batteries, lead-acid and nickel-zinc, was measured as a function of the charging and discharging demands anticipated from electric vehicle propulsion systems. The benefits of rapid high current charging were mixed: although it allowed quick charges, the energy efficiency was reduced. For low power (overnight) charging the current wave shapes delivered by the charger to the battery tended to have no effect on the battery cycle life. The use of chopper speed controllers with series traction motors resulted in a significant reduction in the energy available from a battery whenever the motor operates at part load. The demand placed on a battery by an electric vehicle propulsion system containing electrical regenerative braking confirmed significant improvement in short term performance of the battery.

R.E.S.

ELEC, Vehicle Exposition and Cont, St. Louis, 20-22 May 1980

Charging 300 amp-hour lead-acid traction cells when compared to constant current charging at the time average pulse current. The constant current charge method resulted in the best energy efficiency compared to that achievable by a combined cycle burning a sulfur-free fuel. The maximum difference in efficiency between the use of sulfur-free and fuels containing 0.8 percent sulfur is found to be less than one percentage point. The effect of using a ceramic thermal barrier coating (TBC) and a fuel containing sulfur is also evaluated. The combined-cycle efficiency gain using a TBC with a fuel containing sulfur compared to a sulfur-free fuel without TBC is 0.6 to 1.0 percentage points with air-cooled gas turbines and 1.6 to 1.8 percentage points with water-cooled gas turbines.

Author

The wind resource is such that wind energy generation has the potential to save 6-7 quads of energy nationally. Thus, the Federal Government is sponsoring and encouraging the development of cost effective and reliable wind turbines. One element of the Federal Wind Energy Programs, Large Horizontal Axis Wind Turbine Development, is managed by the NASA Lewis Research Center for the Department of Energy. There are several ongoing wind system development projects oriented primarily toward utility application within this program element. In addition, a comprehensive technology program supporting the wind turbine development projects is being conducted. An overview is presented of the NASA activities with emphasis on application of large wind turbines for generation of electricity by utility systems Author

NBO-29882*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. RAPPORTEUR REPORT: MHD ELECTRIC POWER PLANTS


Five US papers from the Proceedings of the Seventh International Conference on MHD Electrical Power Generation at the Massachusetts Institute of Technology are summarized. Results of the initial parametric phase of the US effort on the study of potential early commercial MHD plants are reported and aspects of the smaller commercial prototype plant termed the Engineering Test Facility are discussed. The alternative of using a disk geometry generator rather than a linear generator in baselined MHD plants is examined. Closed-cycle as well as open-cycle MHD plants are considered. A.R.H.

NBO-29883*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. GAS PHASE OXIDATION DOWNSTREAM OF A CATALYTIC COMBUSTOR


Effect of the length available for gas-phase reactions downstream of the catalytic reactor on the emission of CO and unburned hydrocarbons was investigated. A premixed, pre-vaporized propane/air feed to a 12 cm diameter catalytic reactor test section was used. The catalytic reactor was made of four 2.5 cm long monolithic catalyst elements. Four water cooled gas sampling probes were located at positions between 0 and 22 cm downstream of the catalytic reactor. Measurements of unburned hydrocarbon, CO, and CO2 were made. Tests were performed with an inlet air temperature of 800 K, a reference velocity of 10 m/s, pressures of 3 and 600,000 Pa, and fuel air equivalence ratios of 0.14 to 0.24. For very lean mixtures, hydrocarbon emissions were high and CO continued to be formed downstream of the catalytic reactor. At the highest equivalence ratio tested, hydrocarbon levels were much lower and CO was oxidized to CO2 in the gas phase downstream. To achieve acceptable emissions, a downstream region several times longer than the catalytic reactor could be required. R.K.G.

NBO-32858*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LARGE WIND TURBINES: A UTILITY OPTION FOR THE GENERATION OF ELECTRICITY

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 regions 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 turbine 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) 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 indicates 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 is 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. M.E.P.


The paper deals with a 400-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.


The paper comments on published and projected thermionic-energy-conversion (TEC) performance trends. This commentary includes graphs and an appendix relating TEC performance parameters, plots of predicted 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 (SRQA) approach developed for the first large wind turbine generator project, MOD-OA. The SRQA 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 Tangaye, 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)

A80-45772 * # Spectral effects on direct-insolation absorbance of five collector coatings. G. B. Hotchkiiss (Texas Instruments, Inc., Dallas, Tex.), 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. 6-8, 1979, ASME Paper HT-1978-4. 7 p., 10 refs. Membranes, $1.50; nonmembers, $3.00. Grant No. NQ-3087.

Absorptance 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. Absorptance 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 run 129 cells through charged-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. A.T.


The paper describes the designs, hardware, and installations of NASA photovoltaic power systems in the village of Schuchuli in Arizona and Tangaye 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 Schuchuli system has 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 Tangaye system provides power for pumping, flour milling, and lights in the milling building. Both are standalone systems operated by local personnel, and they are monitored by NASA to measure design adequacy and refine future designs. A.T.


A new family of high-voltage solar cells, called 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 junction (VM) 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)


Five amp-hour nickel-zinc cells were life cycled to evaluate four different charge methods. Three of the four waveforms investigated were 120 Hz full wave rectified sinusoidal (FWRS), 120 Hz silicon controlled rectified (SCR), and 1 kHz square wave (SW). The fourth, a constant current method, was used as a baseline of comparison. Three sealed Ni-Zn cells connected in series were cycled. Each series string was charged at an average e/20 rate, and discharged at a e/2.5 rate to a 75% rated depth. Results indicate that the relatively inexpensive 120 Hz FWRS charger appears feasible for charging 5 amp-hour nickel-zinc cells with no significant loss in average cycle life when compared to constant current charging. The 1-kHz SW charger could also be used with no significant loss in average cycle life, and suggests the possibility of utilizing the existing electric vehicle chopper controller circuitry for an onboard charger. There was an apparent difference using the 120 Hz SCR charger compared to the others, however, this difference could be due to an inadvertent severe overcharge, which occurred prior to cell failure. The remaining two positive pulse charging waveforms, FWRS and 1 kHz, did not improve the cycle life of 5 amp-hour nickel-zinc cells over that of constant current charging. (Author)


A preprototype full-function 1.0 kW Redox system (2 kW peak) with 11 kW storage capacity has been built and integrated with the...

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 phosphoric acid and graphite/phenolic resin composites in H3PO4 at 185°C show specific surface etching. Carbonization of graphite/phenolic bipolar plates is achieved without blistering.

N90-10603 B General Electric Co., Schenectady, N. Y.


Volume two contains three appendices: (1) Bibliography and Cross References; (2) Taxonomy: Proponents and Sources; (3) Concept Definitions. DOE

N90-10622 B General Electric Co., Schenectady, N. Y.


Activities leading to the detail design of a wind turbine generator having a nominal rating of 1.8 megawatts are reported. Topics covered include (1) system description; (2) structural dynamics; (3) stability analysis; (4) mechanical subassemblies design; (5) power generation subsystem; and (6) control and instrumentation subsystem. A.R.H.

N90-10659 B Jet Propulsion Lab., Calif. Inst. of Techn., Pasadena


Electrical characteristics of textured, back surface field, 10 ohm cm, 300 microm H/P silicon solar cells are presented in graphical and tabular format as a function of solar illumination intensity, temperature, and Author
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.

N80-14843# 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 DEN3-86) (NASA-CR-158663; DOE/NASA/0086-79/1; EPI-1279) Avail. NTIS HC A04/MF A01 CSCL 108

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. On the basis of a parametric analysis of several methods and control schemes for the steam Rankine engine shows that from an efficiency and control simplicity 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 15kWe (NOMINAL) SOLAR THERMAL ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKINE REHEAT RECIPROCATOR SYSTEM Final Report
H. Fuller, R. Demler, E. Poulin, and P. Dantowitz Jun. 1979 63 p refs
(Contracts DEN3-62; EX-76-A-29-1060) (NASA-CR-158663; DOE/NASA/0086-79/1; NAS-7645) Avail. NTIS HC A04/MF A01 CSCL 108

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 generator/receiver. A parametric analysis of several conditions was completed leading to the selection of 973 K (121 MPa) as the steam temperature/pressure for a conceptual design. A concept design was completed for a two cylinder opposed engine directly coupled to a commercially available induction generator. A unique part of the design is the use of carbon/graphite piston rings to float maintaining constant heat rejection load.

A.R.H.

N80-17548# Kaman Aerospace Corp., Bloomfield, Conn.
DESIGN, FABRICATION, TEST, AND EVALUATION OF A PROTOTYPE 150-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 108

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, testing, and quality assurance are discussed.

A.W.H.

N80-17544# Spectralab, Inc., Sylmar, Calif.
DEVELOPMENT OF IMPROVED WRAPAROUND CONTACTS FOR SILICON Final Report
Jay W. Thornhill Dec. 1979 41 p refs
(Contracts NAS3-20605) (NASA-CR-159748) Avail. NTIS HC A03/MF A01 CSCL 10A

A developmental process for fabricating 2 X 4 cm back surface field silicon solar cells featuring wraparound contacts and screen printed dielectric isolation is described. The process...
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

N80-18559# Avco Corp., Wilmington, Mass.
PARAMETRIC STUDY OF POTENTIAL EARLY COMMERCIAL MHD POWER PLANTS Final Report
Finn A. Hals Dec 1979 246 p. refs
(Contracts DEN3-51; EF-77-A-01-2874)
(NASA-CR-159833; DOE/NASA/0051-79/1) Avail: NTIS HC A17/MF A01 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 temperature in a tubular type metal recuperative heat exchanger which is part of the bottoming plant heat recovery system. Comparative 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 advanced 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.

N80-18558# Grumman Aerospace Corp., Bethpage, N.Y.
(Contracts DEN3-39; EC-77-A-31-1034)
(NASA-CR-159726; DOE/NASA/0039-79/1)
(GAC-TR-1618-09) Avail: NTIS HC A04/MF A01 CSCL 10A

Various active heat exchange concepts were identified from among three generic categories: scrapers, suction/vacuum 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 molten salt droplets are injected into a cooler countercflowing stream of liquid metal carrier fluid and (2) a rotating drum scraper in which molten salt is sprayed onto the circumference of a rotating drum, which contains the fluid salt is sprayed onto the circumference of a rotating drum, which contains the fluid heat sink in an internal annulus near the surface. A fixed scraper 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.

APPENDIX: MOD-1 WIND TURBINE GENERATOR ANALYSIS AND DESIGN REPORT, VOLUME 2 Final Report
May 1979 425 p. refs
(Contracts 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 kW active area single cells were constructed and tested at cell temperatures between 140 F and 200 F. Current densities of 3.000 mA/cm^2 at 50 volts were achieved. The performance of a 3 kW cell was 97% of the expected performance for this temperature range. The performance and reliability of the 3 kW cell were 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.
R.E.S.

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 10A

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 dis 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.

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 kW active area single cells were constructed and tested at cell temperatures between 140 F and 200 F. Current densities of 3.000 mA/cm^2 at 50 volts were achieved. The performance of a 3 kW cell was 97% of the expected performance for this temperature range. The performance and reliability of the 3 kW cell were 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.
R.E.S.

N80-19632# Jet Propulsion Lab., California Inst. of Tach., Pasadena.
ANNUAL TECHNICAL REPORT, FISCAL YEAR 1979, VOLUME 1: EXECUTIVE SUMMARY Annual Report
(Contract NAS7-100)
(NASA-CR-159715; JPL-Pub-79-12-1 Vol-1) Avail: NTIS 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.
The completed solar cells F.O.S. beam annealing to minimize thermal process-induced defects in furnace annealing techniques, and utilization of pulsed electron beam to investigate the effects of bandgap narrowing caused by high annealing and simultaneous SiO₂ growth. One key element was the approach based on ion implantation in 0.1- to 0.3-micron-thick single crystal silicon solar cells. As a result of the implantation, the circuit voltage of low resistivity silicon solar cells are improved. The approach was based on ion implantation in 0.1- to 0.3-micron-thick single crystal silicon solar cells. The results were reviewed by specialists from outside the Mod-1 program, and corrective action taken wherever recommended.

The results of a 14 month program to improve the open-circuit voltage of low resistivity single crystal silicon solar cells indicated that the free piston solar Stirling engine-linear alternator can be manufactured at a reasonable price cost (direct labor plus material) of $2,500 per engine in production quantities of 25,000 units per year. Opportunity for significant reduction of cost was also identified.

Three first-generation Brayton cycle engine types were studied for solar application: 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.

Over forty concepts were examined for storage media, forms of containment, and cycle configurations for conversion to electricity. An extensive analysis and screening process resulted in selecting two coal-fired and two nuclear plants for detail conceptual design. The coal plants utilized peak-power turbines and the nuclear plants varied the feedwater extraction to change power output. It was shown that the performance and costs of even the best of these systems could not compete in near-term utility applications with cycling coal plants and typical gas turbines available for peaking power. Lower electricity costs, greater...
its cost does not increase significantly. DOE LIMMARY DESIGN REPORT. VOLUME 1: EXECUTIVE SUMMARY

Cycling coal plants for greater than 1500 hours of peaking or Wash. f by gas turbines for less than 1500 hours if oil is available and MOD-2 WIND TURBINE SYSTEM CONCEPT AND PRE-
flexibility of operation, and other benefits can be provided by 11190-24765•41’ Boeing Engineering and Construction, Seattle, performance and hence life cycle cost. Author HC A03/MF AO1	 CSCL 10C

baseline design are determined by the array materials and masses. (Grant NsG-3184; Contract EC-77-A-31-1034) For example, the thermal characteristics of the C. Ernest Birehenall	 Apr. 1980	 29 p	 refs technologies are then varied and their relationships to life cycle estimated in detail. The baseline system requirements and design Engineering. system conceptual design is developed and the life cycle costs quantified, For example, the thermal characteristics of the C. Ernest Birehenall	 Apr. 1980	 29 p	 refs

1979 - May 1990 The configuration development of the MOD-12 wind turbine	 iP. W. Richardson, F. Q. Miller, and M. B. ... is currently being developed liquid-fired systems, R.E.S. as the most promising electrical energy converter to meet near-future needs. R.E.S.

SOLAR THERMAL POWER SYSTEMS POINT-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 about life cycle cost. Tests were performed periodically to determine changes in catalytic activity of the catalyst. 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, 2420: nitrogen oxides (vppm):5.7, 5.6. R.E.S.


The accomplishments of the Point-Focusing Distributed Receiver Technology Project during fiscal year 1979 are detailed. Present studies involve designs of modular units that collect and concentrate solar energy via highly reflective, parabolic-shaped dishes. The concentrated energy is then converted to heat in a working fluid, such as hot gas. In modules designed to produce heat for industrial applications, a flexible line conveys the heated fluid from the module to a heat transfer network. In modules designed to produce electricity the fluid carries the heat directly to an engine in a power conversion unit located at the focus of the concentrator. The engine is mechanically linked to an electric generator. A Brayton-cycle engine is currently being developed as the most promising electrical energy converter to meet near-future needs. R.E.S.
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 intrusion 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 industrial 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. R.E.S.


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 systems-industrial process combinations are presented. R.E.S.


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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 OCMHD/steam plants were determined. Three base cases were considered: an indirectly-fired high temperature air heater (HTAH) subsystem delivering air at 2700°F, firing by a state of the art atmospheric pressure gasifier, and the HTAH subsystem was deleted and oxygen enrichment was used to obtain requisite MHD combustion temperature. Combustion to 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. J.M.S.


The feasibility of using anileron or spacer 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 outward 30% span, and for 10% chord spacers 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 spacers 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 3.8 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 failsafe flyweight actuator for overspeed protection in the event of a hydraulic system failure.


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 storage under conditions of high temperature and high humidity.


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 1126R8B and an in house formulation 61-2-2A were all tested. Cells with pre-dielectric thickness of 3.0-0.3-5.0 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. R.E.S.
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 breaker 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.

N80-29845# General Dynamics/Convair, San Diego, Calif. Study of power management technology for orbital multi-100kWe applications. Volume 3: requirements. J. W. Mildeke 15 Jul. 1980 37 p refs 3 Vol. (Contract NAS3-21757) (NASA-CR-159834; GDC-ASP-80-015) Avail: NTIS HC A03/MF A01 CSCL 10B 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 characteristics and also attendant system costs. For large TSUs (1A; DOE/NASA/0031-80/6-Pt-1A; GE80ETO105-Vol-6-Pt-1A; JPL-PUB-80-35) Avail: NTIS HC A05/MF A01 CSCL 10C

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 would 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/discharge cycle has an energy unit storage cost (CE) of $2.63/kWh-t and a power unit storage cost (Cp) of $42/kWh (in 1977 dollars). A.R.H.

N80-29852# Communications Satellite Corp., Clarksburg, Md. Thin film radiation-resistant solar cell feasibility study. Final Report J. F. Allison, R. A. Arndt, and A. Meulenberg, Jr. Jun. 1980 70 p refs 10A (Contract NASA-21280) (NASA-CR-159871) Avail: NTIS HC A04/MF A01 CSCL 10A Silicon solar cells were fabricated to verify the predictions that: (1) thin n+-p+ 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+ 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 exchanger modules for future applications to solar and conventional utility power plants were discussed. Alternative mechanisms of active heat exchange concepts were analyzed for use with heat of fusion 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 refinement. 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 350 C appeared to be NaNO3, NaNO2, and NaOH. Sketches of the two active heat exchange concepts selected for test are given. R.K.G.


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 fuels 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.


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COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 2: INDUSTRIAL PROCESSES Final Report

W. F. Knightly May 1980 296 p

COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS). VOLUME 3: ENERGY CONVERSION SYSTEM CHARACTERISTICS Final Report

Jan. 1980 283 p refs

Six current 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 high overall annual savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesel were most efficient. The advanced technologies used coal derived fuels, or coal with advanced fluid bed combustion or on site gasifications. Data and information for both current and advanced energy conversion technology are presented. Schematic and physical descriptions, performance data, equipment cost estimates, and predicted emissions are included. Technical developments which are needed to achieve commercialization in the 1985-2000 period are identified. 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 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-cyclde 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-Pr-1; G80ET0105-Vol-6-Pr-1; DOE/NASA/0031-B0-6(A6)) NTIS HC A21/MF A01 CSLC 10B

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-cyclde 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 and emissions savings are also reported for each ECS assuming it alone is power matched to use consistent assumptions and a consistent set of ground rules specified by NASA for determining performance and cost.

Author

N80-33861# General Electric Co., Schenectady, N.Y.

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

(Contract DEN3-31)

(NASA-CR-159770-Pr-2; G80ET0105-Vol-6-Pr-2; DOD/NASA/0031-B0-6(Vol-6-Pr-2)) NTIS HC A13/MF A01 CSLC 10B

Computer generated data on the performance of the energy conversion system are presented. Performance parameters included fuel consumption and savings, capital costs, economics, and emissions of residual fired process boilers.

T.M.

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-AI01-79ET-20305)

156
ENVIRONMENT POLLUTION
Includes air, noise, thermal and water pollution; environment monitoring; and contamination control.

NBO-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 ratio and residence time.

R.E.S.

NBO-14581* 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 ppbv for sulfate and 0.36 ppbm for nitrate. For the summer-fall group, stratospheric mixing ratios averaged 0.13 ppbm and 0.25 ppbm for sulfate and nitrate, respectively. Winter-spring group tropospheric mass mixing ratios averaged 0.08 ppbm for sulfate and 0.10 ppbm for nitrate, while summer-fall group tropospheric mixing ratios averaged 0.05 ppbm for sulfate and 0.08 ppbm 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.

NBO-21892* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

In-situ measurements of atmospheric ozone, carbon monoxide, clouds, and related meteorological and flight information obtained during 1122 flights of aircraft VH-EBE and N85SPA from January 10 through October 2, 1977 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.

NBO-23875* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ASSESSMENT OF POTENTIAL EXPOSURE TO FRIABLE 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 analysis, 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.

NBO-27832* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
COORDINATED AIRCRAFT AND SHIP SURVEYS FOR DETECTING 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 effluents 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, Menomonee 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 quantitatively 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 telefacsimile for the transmission of imagery.

J.M.S.


The paper discusses the quantitative interpretation of Great Lakes remote sensing water quality data. Remote sensing using color information must take into account (1) the existence of many different organic and inorganic species throughout the Great Lakes, (2) the occurrence of a mixture of species in most locations, and (3) spatial variations in types and concentration of species. The radiative transfer model provides a potential method for an orderly analysis of remote sensing data and a physical method for developing quantitative algorithms. Predictions and field measurements of volume reflectances are presented which show the advantage of using a radiative transfer model. Spectral absorptance and backscattering coefficients for two inorganic sediments are reported.

A.T.
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.

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 26 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.

N80-14884* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

INTRA-OCULAR PRESSURE NORMALIZATION TECHNIQUE
AND EQUIPMENT Patent
Edward F. Baehr, Inventor (to NASA) Issued 12 Jun. 1979
5 p. Filed 31 Aug. 1977 Supersedes N77-30738 (15 - 21,
p 2839)
US Patent and Trademark Office CSCL 088

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. The 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
INFORM: AN INTERACTIVE DATA COLLECTION AND DISPLAY PROGRAM WITH DEBUGGING CAPABILITY

David S. Cynar
Jan 1980 169 p refs
NASA TP 1424 E 98101 Avail NTIS HC A08/MF A01 CSCL 098

A computer program was developed to aid assembly language programmers of min 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 individual user's needs are considered.
61 COMPUTER PROGRAMMING AND SOFTWARE
Includes computer programs, routines, and algorithms.

NONANALYTIC FUNCTION GENERATION ROUTINES FOR 16-BIT MICROPROCESSORS
(NASA-TM-81586, E-565) Avail NTIS HC A04/MF A01 CSCL 09B
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. Gauntner Feb. 1980 23 p. refs
(NASA-TM-81453; E-384) Avail NTIS HC A02/MF A01 CSCL 09B
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.

CYCLES TILL FAILURE OF SILVER-ZINC CELLS WITH COMPLETING FAILURES MODES: PRELIMINARY DATA ANALYSIS
Steven M. Sidik, Harold F. Leibbeck, and John M. Bozek 1980
(NASA-TM-81556; E-517) Avail. NTIS HC A03/MF A01 CSCL 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)
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.

A80-160035* Computerized systems analysis and optimization
of aircraft engine performance, weight, and life cycle costs.
L. H. Fishbach (NASA, Lewis Research Center, Flight Performance
Section, Cleveland, Ohio), NATO, AGARD, Symposium on the Use
of Computers as a Design Tool, Munich, West Germany, Sept. 3-8,
1979, Paper 20 p, 16 refs.
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, LIFECYCL, 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.
71 ACoustics

Includes sound generation, transmission and attenuation.
For noise pollution see Environment Pollution.

N80-12822f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

TIME-DEPENDENT DIFFERENCE THEORY FOR NOISE PROPAGATION IN A TWO-DIMENSIONAL DUCT
(NASA-TM-79298; E-249; 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 was found to be superior to the conventional steady numerical analysis because of much shorter solution times and the elimination of matrix storage requirements.

N80-12823f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ACOUSTIC CONSIDERATIONS OF FLIGHT EFFECTS ON JET NOISE SUPPRESSOR NOZZLES
(NASA-TM-81386; E-294) Avail: NTIS HC A03/MF A01 CSCL 20A

The inflight acoustic characteristics of high velocity jet noise suppressor nozzles for supersonic cruise aircraft were reviewed. The inflight effects at the peak noise level were discussed. Both single and inverted velocity profile multistream suppressor nozzles were considered. The importance of static and spectral shape on the noise reduction due to inflight effects was stressed.

N80-12824f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

RECIPROCITY PRINCIPLE IN DUCT ACOUSTICS
(NASA-TM-79300; 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.
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 inert 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 for the original concentric bypass nozzle. Acoustic 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 model for acoustic plane wave propagation in a combustion duct through a confined, flowing gas containing soot particles is presented. The model takes into account only heat transfer between the gas and soot particles. As a result, the model depends only on a single parameter which can be written as the ratio of the soot particle thermal relaxation time to the soot particle mass fraction. The model was used to calculate pressure spectra in a combustion duct. The results were compared with measured spectra. For particular values of the single free parameter, the calculated spectra resemble the measured spectra. Consequently, the model, to this extent, explains the experimental measurements and provides some insight into the number and type of particles.

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.

A model jet/free-jet simulated-flight tests. The effects of nozzle size, jet velocity, jet temperature, and flight are included.

A model for acoustic plane wave propagation in a combustion duct through a confined, flowing gas containing soot particles is presented. The model takes into account only heat transfer between the gas and soot particles. As a result, the model depends only on a single parameter which can be written as the ratio of the soot particle thermal relaxation time to the soot particle mass fraction. The model was used to calculate pressure spectra in a combustion duct. The results were compared with measured spectra. For particular values of the single free parameter, the calculated spectra resemble the measured spectra. Consequently, the model, to this extent, explains the experimental measurements and provides some insight into the number and type of particles.
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. Author

**N80-23098**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**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 turbine 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. 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. M.G.

**N80-23100**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**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 airfoil 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-guainone-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. Author

**N80-23101**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**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 cosh 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 cosh duct. F.O.S.

**N80-23102**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**AN EXPLANATORY SURVEY OF NOISE LEVELS ASSOCIATED WITH A 1000kW 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 is described. The acoustic impact of this size wind turbine is judged to be minimal. M.G.
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 cos theta), where M is the flight Mach number and theta is the observer angle relative to the jet axis.

M.G.


On the basis of static zero/acoustic data obtained at model scale, the effect of exhaust nozzle size on flyover noise is evaluated at full scale for different STOL-OTW nozzle configurations. Three types of nozzles are evaluated: a circular deflector nozzle mounted on the wing, a slot/deflector nozzle mounted on the wing, and a slot nozzle mounted on the wing. The nozzle exhaust plane location, measured from the wing leading edge was varied from 10 to 40 percent of the wing chord (flaps retracted). Flap angles of 20 deg (takeoff) and 60 deg (approach) are included in the study. Initially, perceived noise levels (PNL) are calculated as a function of flyover distance at 152 m altitude. From these plots static EPNL values, defined as flyover relative noise levels, then are obtained as functions of nozzle size for equal aerodynamic performance (lift and thrust). On the basis of these calculations, the acoustic benefits attributable to nozzle size relative to a given wing chord size are assessed.

(Author)


Although the problem with sheared flow has been formulated and programmed, sample calculations have not yet been examined. So far, the time dependent finite difference analysis has been 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.

(Author)


A time-dependent numerical formulation is 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 are developed along with the maximum stable time increment. Example calculations are presented for sound attenuation in hard- and soft-wall ducts. The time-dependent analysis has been found to be superior to the conventional steady numerical analysis of shock wave reflection. The solution times and the elimination of matrix storage requirements.

(Author)
refinements have been made, then empirical corrections can be applied. 


Insight into the inflight acoustic characteristics of high-velocity jet noise suppressor nozzles for supersonic cruise aircraft (SCA) is provided. Although the supression of jet noise over the entire range of directivity angles is of interest, the supression 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 multistream suppressor nozzles are considered. The importance of static spectral shape on the noise reduction due to inflight effects is stressed. 

A80-35486 * Spectral structure of pressure measurements made in a combustion duct. J. H. Miles (NASA, Lewis Research Center, Cleveland, Ohio) and D. D. Raptopoulos (Toledo University, Toledo, Ohio). Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper. 17 p. 5 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 discussed. Experimental results are compared with theory. 


Previous studies have shown that increasing the annulus width of a conventional coaxial nozzle with constant bypass velocities 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. 


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. 


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. 


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 coaxial duct. 


A cut-on, high tip speed fan stage was acoustically tested with three configurations of an inflow control device in the NASA Lewis anechoic 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. The 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. 


Grant No. NGR-02-010-085. 

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 the corresponding duct cut-off frequencies. For 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; jet noise and fan noise; jet noise and fan noise prediction; and experimental methods. Author


The efficiency of internal noise radiation through annular exhaust nozzles 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. Author


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 semi-cylinder 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 9 dB at 90 deg incidence of a fuselage on the sound pressure amplitudes. These effects were found to be 6 dB at 90 degrees incidence, decreasing to 0dB at 90 deg incidence. Comparison 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

A80-32186 * # Lockheed-Georgia Co., Marietta.


The internal noise radiation characteristics for a single stream 12-lobe 24 tube suppressor nozzle and for a dual stream 36 chute suppressor nozzle were investigated. An equivalent single round conical nozzle and an equivalent coaxial nozzle system were also tested to provide a reference to the internal nozzle. A technique utilizing a high voltage spark discharge as a 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 noise transmission coefficient and the power transfer function. These transmission parameters for the 12-lobe, 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 simulated 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 semiequilibrium model of the acoustic behavior of fibrously 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 the sound field propagation direction. A.R.H.

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
A source of hydrogen ions is disclosed and 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.


RESULTS OF DUCT AREA RATIO CHANGES IN THE NASA N80. LEWIS H2.02 COMBUSTION MHD EXPERIMENT were conducted in a high field strength cryomagnet facility at AIAA considered. 201 MHD power generation experiments utilizing a cesium-seeded H2.02 working fluid ware 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 testa. The effects of power takeoff location, generator loading, B-field strength, and electrode breakdown voltage were investigated. The effect of area ratio, multiple loading of the duct, and duct location within the magnetic field are considered. R.C.T.

EFFECT OF VELOCITY OVERSHOOT ON THE PERFORMANCE OF MAGNETOHYDRODYNAMIC SUBSONIC DIFFUSERS

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. R.C.T.

COMMMENTS ON TEC TRENDS

A technology assessment of thermionic energy conversion research and technology is presented. R.E.S.

An experimental and analytical study of a Blumlein-type transverse fast discharge operating with He and Xe are presented. An electro optical 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 metastables and 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 He and Xe are accounted for by the large dissociative recombination rate of Xe compared with He. A.R.H.


MHD power generation experiments utilizing a cesium-seeded H2O2 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 was 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/cm. [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 10 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 densities range from 2.1 x 10^11 to the 11th to 6.8 x 10^10 to the 12th per cu cm. (Author)


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


Tests were conducted using plasma densities of approximately 10 to the 5th power - 10 to the 6th power/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/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
An experimental investigation of the physical processes governing ion extraction from a plasma is presented. The screen hole plasma sheath of a multipurpose 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 predominately 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
FORM UL TIONS HIGH VOLTAGE SOLAR CELLS


Technical considerations, preliminary results, and fabrication details are discussed for a family of high-voltage planar multijunction (PMJ) solar cells which 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. 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.


Four types of sensors were used to make both dynamic and time-averaged flow measurements in a cold turbine rig to determine the magnitude of errors in time-averaged total-pressure measurements at a station 5 1/2 blade chords downstream from the rotor. The errors turned out to be negligible. The sensors and their intended use are discussed.


The interfacial shear strength of the metal-insulator system has been studied by means of the coefficient of static friction of copper, nickel, or gold contacts on sapphire in ultrahigh vacuum. The effect on contact strength of adsorbed oxygen, nitrogen, chlorine, and carbon monoxide on the metal surfaces is reported. It was found that exposures as low as 1 L of O2 on Ni produced observable increases in contact strength, whereas exposures of 3 L of O2 lead to a decrease in contact strength. These results imply that submonolayer concentrations of these species at the interface of a thin Ni film on A203 should affect film adhesion similarly. The atomic mechanism by which these surface or interface phases affect interfacial strength is not yet understood.
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. (Author)


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 an 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. (Author)


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 initiation phase of a propagating discharge in electron-irradiated dielectrics. (Author)
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 principle 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)
ADMINISTRATION AND MANAGEMENT
Includes management planning and research.

MATRIX MANAGEMENT FOR AEROSPACE 2000
(NASA-TM-81509, E-447) Avail: NTIS HC A02/MF A01 CSCL 05A

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.

MATRIX MANAGEMENT FOR AEROSPACE 2000
J. F. McCarthy, Jr. (NASA, Lewis Research Center, Cleveland, Ohio).

The matrix management approach to program management is described, showing that it is an organized approach to 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 to attain an uncompromised complete coverage of the program management effort. It is demonstrated that beginning 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 is examined to establish how it is to be implemented and how it relates to all other processes.
ECONOMICS AND COST ANALYSIS

Includes cost effectiveness studies.

COST EFFECTIVE TECHNOLOGY ADVANCEMENT DIRECTIONS FOR ELECTRIC PROPULSION TRANSPORTATION SYSTEMS IN EARTH-ORBITAL MISSIONS


(A9SA-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.


The technical 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. A.M.S.


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 gasoline, had 65 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


The steady state test results on a breadboard version of the General Electric Electric Vehicle (GETV-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.


A 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 inertia and road loads. The load is applied to the system under test according to the road load equation: F(ina) = K1F1 + K2F2 + K3 V + K4qdV/dt + K5 sin theta. The coefficient of each term in the equation can be varied over a wide range with vehicle inertial representative of vehicles up to 7500 pounds simulated by means of flywheels. The required torque is applied by the flywheels, 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 horsepower.


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 modeling procedure in which vehicle platoon 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.


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 engine 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.

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. 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. The basic system has a life-cycle cost of $0.08/km. The basic system, using batteries meeting ISOA goals, would have a life-cycle cost of $0.043/km.

**N80-18991** Brobeck (William M.) and Associates, Berkeley, Calif.  
**STUDY OF ADVANCED ELECTRIC PROPULSION SYSTEM CONCEPT USING A FLYWHEEL FOR ELECTRIC VEHICLES**  
**Final Report**  
Francis C. Younger and Heinz Lackner Dec. 1979 231 p refs  
(Contracts DEN3-78; EC-77-A-31-1011)  
(NASA-CR-155650; DOE/NASA/0078-79/1; WM6/A-4500-131-3-R1) Avail. NTIS HC A11/MF A01 CSCL 10B

Advanced electric propulsion system concepts with flywheels for electric vehicles are evaluated and it is predicted that advanced systems can provide considerable performance improvement over existing electric propulsion systems with little or no cost penalty. Using components specifically designed for an integrated electric propulsion system avoids the compromises that frequently lead to a loss of efficiency and to inefficient utilization of space and weight. A propulsion system using a flywheel power energy storage device can provide excellent acceleration under adverse conditions of battery degradation due either to very low temperatures or 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 or dc-to-ac inverters appear to provide a practical approach to a mass producible motor, with excellent efficiency and light weight. No comparisons were made with advanced system concepts which do not incorporate a flywheel.

**N80-18992** Brobeck (William M.) and Associates, Berkeley, Calif.  
**AN AUTOMATICALLY-SHIFTED TWO-SPEED TRANAXLE SYSTEM FOR AN ELECTRIC VEHICLE**  
**Final Report**  
Hayden S. Gordon and Gregory V. Hassman Jan. 1980 34 p refs  
(Contracts DEN3-84; EC-77-A-31-1044)  
(NASA-CR-159746; DOE/NASA/0084-79/1; WM8/A-131-4-R2) Avail. NTIS HC A03/MF A01 CSCL 13F

An automatic shifting scheme for a two speed transaxle for use with an electric vehicle propulsion system is described. The transaxle system was to be installed in an instrumented laboratory propulsion system of an ac electric vehicle drive train. The transaxle which had been fabricated is also described.

**N80-21202** Cleveland State Univ., Ohio.  
**ERROR ANALYSIS IN THE MEASUREMENT OF AVERAGE POWER WITH APPLICATION TO SWITCHING CONTROLERS**  
**Contractor Report**  

James E. Madsen Mar. 1980 84 p refs Sponsored by NASA  
(Contract EC 77-A-31-1044)  
(NASA-CR 159792; DOE/NASA/3222-80/1) Avail. NTIS HC A05/MF A01 CSCL 10B

Power measurement errors due to the bandwidth of a power meter and the sampling of the input voltage and current of a power meter were investigated assuming sinusoidal excitation and periodic signals generated by a model of a simple chopper system. Errors incurred in measuring power using a microcomputer with limited data storage were also considered. The behavior of the power measurement error due to the frequency responses of first order transfer functions between the input sinusoidal voltage, input sinusoidal current, and the signal multiplier was studied. Results indicate that this power measurement error is minimized when the frequency responses of the first order transfer functions are identical. The power error analysis was extended to include the power measurement error for a model of a simple chopper system with a power source and an ideal shunt motor acting as an electrical load for the chopper. The behavior of the power measurement error was determined as a function of the chopper's duty cycle and back EMF of the shunt motor. Results indicate that the error is large when the duty cycle or back EMF is small. Theoretical and experimental results indicate that the power measurement error due to sampling of sinusoidal voltages and currents becomes excessively large when the number of observation periods approaches one-half the size of the microcomputer data memory allocated to the storage of either the input sinusoidal voltage or current.

**ASSESSMENT AND PRELIMINARY DESIGN OF AN ENERGY BUFFER FOR REGENERATIVE BRAKING IN ELECTRIC VEHICLES**  
**Final Report**  
(Contracts DEN3-48; EC-77-C-31-1044)  
(NASA-CR-159756; DOE/NASA/0048-79/1; TSCI0082-FR) Avail. NTIS HC A07/MF A01 CSCL 13F

Energy buffer systems, capable of storing the vehicle energy during braking and reusing this stored energy during acceleration, were examined. Some of these buffer systems when incorporated in an electric vehicle would result in an improvement in the performance and range under stop and go driving conditions. Buffer systems considered included flywheels, hydropneumatic, pneumatic, spring, and regenerative braking. Buffer ranking and rating criteria were established. Buffer systems were rated based on predicted range improvements, consumer acceptance, driveability, safety, reliability and durability, and initial and life cycle costs. A hydropneumatic buffer system was selected.
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 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 60 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.
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