NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.
Bibliography of Lewis Research Center Technical Publications Announced in 1980

May 1981
In 1980, Lewis' 1020 research authors published 427 technical publications which were announced to and reached the worldwide scientific community. This number was our typical output even though, once again, we had a slight decrease in staff. In recent years, the trend in Lewis publishing has been that each year the number of technical presentations given at seminars, society symposia, and Lewis-hosted conferences has surpassed the record set the previous year. Lewis authors publish approximately 61 percent of their research contributions in outside publications and the rest as NASA research reports. Lewis authors primarily use society proceedings, seminar presentations, and journal and transactions articles to describe their work.

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

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

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

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

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

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

George Mandel
Chief, Management Services Division
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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.
02 AERODYNAMICS

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

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

N80-10128** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COANNUULAR SUPERSONIC EJECTOR NOZZLES

Allan R. Bishop. In NASA Ames Res. Center Workshop on Thrust Augmenting Ejectors Sep 1979 p 385-396 refs (For primary document see N80-10107 01-02)
Avail NTIS HC A22/ MF A01 CSCL 01A

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

N80-11037** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL STUDY OF LOW ASPECT RATIO COMPRESSOR BLADING

(NASA-TM-79280; E-217) Avail NTIS HC A02/ MF A01 CSCL 01A

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

N80-14060** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

LASER ANEMOMETER MEASUREMENTS IN A TRANSSONIC AXIAL FLOW COMPRESSOR ROTOR

(NASA-TM-79323; E-279) Avail NTIS HC A02/ MF A01 CSCL 01A

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

N80-14061** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

MODIFICATION OF AXIAL COMPRESSOR STREAMLINE PROGRAM FOR ANALYSIS OF ENGINE TEST DATA

Jeffrey G. Williams. Nov. 1979 49 p refs (NASA-TM-79312; E-268) Avail NTIS HC A03/ MF A01 CSCL 01A

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

N80-15061** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SUMMARY OF ADVANCED METHODS FOR PREDICTING HIGH SPEED PROPELLER PERFORMANCE

(NASA-TM-81409) Avail NTIS HC A02/ MF A01 CSCL 01A

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

N80-17030** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PREDICTION METHOD FOR TWO-DIMENSIONAL AERODYNAMIC LOSSES OF COOLED VANES USING INTEGRAL BOUNDARY-LAYER PARAMETERS

Louis J. Goldman and Raymond E. Augler. Feb. 1980 43 p refs (NASA-TP-1623; E-076) Avail NTIS HC A03/ MF A01 CSCL 01A

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

N80-21285** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

HIGH SPEED TURBOPROPS FOR EXECUTIVE AIRCRAFT, POTENTIAL AND RECENT TEST RESULTS

(NASA-TM-81482; E-419) Avail NTIS HC A03/ MF A01 CSCL 01A

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

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

A three-dimensional, fully viscous computer analysis, which retains the viscous nature of the Navier-Stokes equations, was evaluated to determine its usefulness in the design of supersonic inlets. This procedure takes advantage of physical approximations to limit the high computer time and storage associated with the Navier-Stokes solutions. Computed results are presented for a Mach 3.0 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.

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 successful line overrelaxation combined with the sequential grid refinement procedure to accelerate 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 weak shocks. The program can also be used to analyze the flow around isolated aircraft propellers and helicopter rotors in hover as long as the total relative Mach number of the oncoming flow is subsonic.

Measurements of surface static pressure, flow total pressure loss, and exit air angle were obtained for two linear cascades to establish the effects of endwall profiling. Testing was conducted at an isentropic exit Mach number of 0.85. One cascade was fabricated with planar endwalls while the other had one planar and one profiled endwall. Both cascades utilized the same high pressure turbine inlet guide vane section. It was found that in terms of full passage loss the profiled endwall cascade has the superior performance. The secondary loss results obtained are reasonably well predicted by correlations developed from incompressible flow testing of similar configurations.

Inviscid flow and boundary layer calculations are compared with the test data, and overall, the agreement is found to be good. Use of the results for design purposes is briefly discussed. (Author)


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 a 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 equations are solved numerically in a fully conservative form by using an artificial time concept, a finite volume technique, rotated second-order difference, 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)


The turbulence downstream of a rapid contraction is calculated for the case when the turbulence scale can have the same magnitude as the mean-flow spatial scale. The approach used is based on the formulation of Goldstein (1978) for turbulence downstream of a contraction, with the added assumptions of a parallel mean flow at downstream infinity and turbulence calculated far enough downstream so that the nonuniformity of the mean flow field has decayed, and by treating the inverse contraction ratio as a small parameter. Consideration is given to the large-contraction ratio and classical rapid-distortion theory limits, and to results at an arbitrary contraction ratio. It is shown that the amplification effect of the contraction is reduced when the spatial scale of the turbulence increases, with the upstream turbulence actually suppressed for a contraction ratio less than five and a turbulence spatial scale greater than three times the transverse dimensions of the downstream channel. A.L.W.
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 tends to justify strongly the inadequacy of using the latter with standard boundary layer techniques to obtain viscous flow details within turbomachine rotors. Capabilities and limitations of the present method of analysis are discussed.

N80-24262* # General Dynamics/Fort Worth, Tex.  
EXPERIMENTAL INVESTIGATION OF A 0.15 SCALE MODEL OF A CONFORMAL VARIABLE-RAMP INLET FOR THE F-18 AIRPLANE Final Report  

A 0.15 scale model of a proposed conformal variable-ramp inlet for the Multirole Fighter was tested from Mach 0.8 to 2.2 at a wide range of angles of attack and sideslip. Inlet ramp angle was varied to optimize ramp angle to a function of engine airflow, Mach number, angle of attack, and angle of sideslip. Several inlet configuration options were investigated to study their effects on inlet operation and to establish the final inlet configuration. These variations were cowl sidewall cutback, cowl lip bluntness, boundary layer bleed, and first-ramp leading edge shape. Diagnostic and engine face instrumentation were used to evaluate inlet operation at various inlet stations and at the inlet/engine interface. Pressure recovery and stability of the inlet were satisfactory for the proposed application. On the basis of an engine study of one of the worst-case instantaneous distortion patterns, no inlet/engine compatibility problems are expected for normal operations.  

A.R.H.

CALCULATION OF WATER DROP TRAJECTORIES TO AND ABOUT ARBITRARY THREE-DIMENSIONAL BODIES IN POTENTIAL AIRFLOW Final Report  

A general design method was developed for steady, three dimensional, potential, incompressible or subsonic-compressible flow. In this design method, the flow field, including the shape of its boundary, was determined for arbitrarily specified, continuous distributions of velocity as a function of arc length along the boundary streamlines. The method applied to the design of both internal and external flow fields, including, in both cases, fields with planar symmetry. The analytic problems associated with stagnation points, closure of bodies in external flow fields, and prediction of turning angles in three dimensional ducts were reviewed.  

R.C.T.
An analytical technique for the prediction of fan blade flutter was evaluated by utilizing first stage fan flutter data from tests on an advanced high performance engine. The formulation includes both aerodynamic and mechanical coupling among all the blades of the assembly. Mistuning is accounted for in the analysis so that individual blade inertias, frequencies, or damping can be considered and stability was predicted by calculating a flutter determinant, the eigenvalues of which indicate the extent of susceptibility to flutter. When blade to blade differences in frequencies are considered, a stable system is predicted for the test point 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. A.R.H.


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 of 0.25 to 1.5 are reported. An additional contraction with fifth order contour was also utilized for studying the shape effect. Thirteen homogeneous and nearly isotropic test flow conditions with a range of turbulence intensities, length scales and Reynolds numbers were generated and used to examine the sensitivity of the contractions to upstream turbulence. The extent to which the turbulence is altered by the contraction depends on the incoming turbulence scales, the total strain experienced by the fluid, as well as the contraction ratio and strain rate. Varying the turbulence integral scale influences the transverse turbulence components more than the streamwise component. In general, the larger the turbulence scale, the lesser the reduction in the turbulence intensity of the transverse components. Best agreement with rapid distortion theory was obtained for large scale turbulence, where viscous decay over the contraction length is negligible, or when a first order correction for viscous decay was applied to the results. T.M.


An evaluation is made of a perturbation method devised to obtain highly accurate approximations to families of strongly nonlinear solutions which are either continuous or discontinuous, and which represent variations in some arbitrary parameter. The method first defines a unit perturbation by using two nonlinear solutions which differ from one another by a nominal change in some geometric or flow parameter. Then it employs this unit perturbation to predict a family of related nonlinear solutions over a range of parameter variation. Coordinate stretching is incorporated into this perturbation method for determining the unit perturbation account for the movemen of discontinuities and maxima of high-gradient regions due to the perturbation. Attention is given to transonic and subsonic flows. Comparisons of the perturbation results with the corresponding exact nonlinear solutions show a remarkable accuracy and range of validity of the perturbation method across the spectrum of examples considered. S.D.


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


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


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


An approximate analysis applicable to nonlinear 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 situations 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
HC A99/MF A01 CSCL 01C
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.
AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft, air navigation systems (satellite and ground based), and air traffic control.

For related information see also 17 Spacecraft Communications, Command, and Tracking and 32 Communications.


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 both hover and 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.

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(Author)

In response to recent concerns over possibly high ozone levels in the cabins of aircraft flying in the stratosphere, simultaneous measurements of the cabin and ambient ozone levels have been made as part of the NASA Global Atmospheric Sampling Program. Examples of the data taken on commercially operated Boeing 747-100 and 747SP airplanes are given for selected flights, together with summary statistics of over 5600 observations. Cabin ozone levels vary with the ambient level and, for unmodified aircraft, are higher on the 747SP than on the 747-100. Modifications to the ventilation system of the 747SP reduced cabin ozone levels by varying amounts up to a factor of 14.

(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 air (engine bleed air) as much as 50 percent. Flight test verified the predicted fuel saving of 0.8 percent.

R.C.T.
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 fixed to the case. Measurements made in this way are the equivalent of those obtained by placing three surface-normal displacement transducers at three positions on each blade of an operational rotor.

M.M.M.
07 AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

For related information see also 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

N80-10205# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AEROPROPULSION 1979
1979 464 p Proceedings of conf held at Cleveland, Ohio, 1-16 May 1979
(NASA CP 20252, E-079) Avail: NTIS HC A20/MF A01 CSCL 21E

State of the art technology in aeronautical propulsion is assessed. Noise and air pollution control techniques, advances in supersonic propulsion for transport aircraft, and composite materials and structures for reliable engine components are covered along with engine design for improved fuel consumption. For individual titles, see N80-10206 through N80-10219.

N80-10206# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIRCRAFT ENERGY EFFICIENCY (ACEE) STATUS REPORT
Donald L. Nored, James F. Dugan, Jr., Neal T. Saunders, and Joseph A. Ziemianskl in Its Aeropropulsion 1979 1979 p 1-58 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Fuel efficiency in aeronautics, for fuel conservation in general as well as for its effect on commercial aircraft operating economics is considered. Projects of the Aircraft Energy Efficiency Program related to propulsion are emphasized. These include: (1) engine component improvement, directed at performance improvement and engine diagnostics for prolonged service life; (2) energy efficient engine, directed at proving the technology base for the next generation of turbofan engines; and (3) advanced turboprop, directed at advancing the technology of turboprop powered aircraft to a point suitable for commercial airline service. Progress in these technology areas is reported.

N80-10207# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EMISSION REDUCTION
Donald A. Petrash, Larry A. Dietz, Robert E. Jones, and Edward J. Mularz in Its Aeropropulsion 1979 1979 p 39-84 (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Control of the gaseous pollutant emissions of aircraft engines is considered in terms of the emission standards for six classes of aircraft engines. Emphasis is placed on combustor design concepts to significantly reduce emissions levels and lean-burning techniques to lower flame temperature, to reduce the oxides of nitrogen in the gaseous emissions.

N80-10208# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOISE REDUCTION
Avail: NTIS HC A20/MF A01 CSCL 21E

The turbofan engine's noise-producing components are discussed in terms of efficient and economical noise reduction techniques that do not penalize the engine performance or weight significantly. Specific topics covered include fan noise, acoustic suppression, jet noise technology, combustor noise, and aircraft noise prediction.

N80-10209# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ALTERNATIVE JET AIRCRAFT FUELS
Jack Grobman in Its Aeropropulsion 1979 1979 p 129-148 refs (For primary document see N80-10205 01-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Potential changes in jet aircraft fuel specifications due to shifts in supply and quality of refinery feedstocks are discussed with emphasis on the effects these changes would have on the performance and durability of afterburner engines and fuel systems. Combustion characteristics, fuel thermal stability, and fuel pumpability at low temperature are among the factors considered. Combustor and fuel system technology needs for broad specification fuels are reviewed including prevention of fuel system fouling and fuel system technology for fuels with higher freezing points.

N80-10210# 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 N80-10205 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 components of turbine engines are covered.

N80-10211# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTATIONAL FLUID MECHANICS OF INTERNAL FLOW
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.

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.
MECHANICAL COMPONENTS


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. The research pertains to problems in both aircraft turbine engines and helicopter transmissions. R.E.S.

INSTRUMENTATION TECHNOLOGY


Avail: NTIS HC A20/MF A01 CSCL 21E

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


Avail: NTIS HC A20/MF A01 CSCL 21E

Inlet performance, nozzle performance and cooling, and afterburner performance are covered. It is concluded that nonaxisymmetric nozzles provide cleaner external lines and enhanced maneuverability, but the internal flows are more complex. Swirl afterburners show promise for enhanced performance in the high altitude, low Mach number region. K.L.

SUPERSONIC PROPULSION TECHNOLOGY


Avail: NTIS HC A20/MF A01 CSCL 21E

Performance improvements for new production and retrofit of JT9D, JT8D, and CF6 engines are reviewed. The manner in which the performance improvement concepts were selected for development and a summary of the current status of each of the 16 selected concepts are discussed. R.C.T.

VERTICAL TAKEOFF AND LANDING (VTOL) PROPULSION TECHNOLOGY


Avail: NTIS HC A20/MF A01 CSCL 21E

Fuel consumption of commercial aircraft is considered. Fuel saving and retention components for new production and retrofit of JT9D, JT8D, and CF6 engines are reviewed. The manner in which the performance improvement concepts were selected for development and a summary of the current status of each of the 16 selected concepts are discussed. R.C.T.

FLUTTER SPECTRAL MEASUREMENTS USING STATIONARY PRESSURE TRANSUDERS


Engine order sampling was used to eliminate the integral harmonics from the flutter spectra corresponding to a case-mounted static pressure transducer. Using the optical displacement

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


Avail: NTIS HC A20/MF A01 CSCL 21E

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H. Lee Beach, Jr. In *Its Aeropropulsion 1979*. 1979 p 387-408 ref (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 sub-scale 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.

Author

NBO-103043# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ATOMIZING CHARACTERISTICS OF SWIRL CAN COMBUSTOR MODULES WITH SWIRL BUST FUEL INJECTORS Robert D. Ingebo 1980 11 p refs Presented at the 25th Annual Intern Gas Turbine Conf., New Orleans, 9-13 Mar, 1980; sponsored by ASME (NASA-TM-79297; E-248) Avail: NTIS HC A02/MF A01 CSCL 21E Cold flow atomization tests of several different designs of swirl can combustor modules were conducted in a 7.6 cm diameter duct at airflow rates (per unit area) of 7.3 to 25.7 g/sq cm sec and water flow rates of 6.3 to 189 g/sec. The effect of air and water flow rates on the mean drop size of water sprays produced with the swirl bust 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 characteristic of 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 burst fuel injectors. The conditions were inlet air static pressures of 100,000 to 200,000 N/sq m at an inlet air temperature of 293 K.

Author

NBO-14121# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. STATIC TEST-STAND PERFORMANCE OF THE YF-102 TURBOFAN ENGINE WITH SEVERAL EXHAUST CONFIGURATIONS FOR THE QUIET SHORT-HAUL RESEARCH AIRCRAFT (QSHA) Jack G. McArdle, Leonard Homyak, and Allan S. Moore Nov. 1979 62 p (NASA-TP-1556; E-019) Avail: NTIS HC A04/MF A01 CSCL 21E 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 the two different-shaped core nozzles for confluent-flow configurations was determined to be satisfactory. Pressure and temperature surveys were made with a traversing probe in the exhaust-nozzle flow for some confluent-flow configurations. The 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.

A.R.H.

NBO-14123# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DYNAMIC RESPONSE OF A MACH 2.5 AXI symmetric INLET AND TURBOJET ENGINE WITH A POPPET-VALUE CONTROLLED INLET STABILITY BYPASS SYSTEM WHEN SUBJECTED TO INTERNAL AND EXTERNAL AIRFLOW TRANSIENTS Bobby W. Sanders Washington Jan. 1980 102 p refs (NASA-TP-1531; E-9413) Avail: NTIS HC A06/MF A01 CSCL 21E The throat of a Mach 2.5 inlet that was attached to a turbojet engine was fitted with a poppet-valve-controlled stability bypass system that was designed to provide a large, stable airflow range. Propulsion system response and stability bypass performance were determined 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.

Author

NBO-14124# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. TURBOJET-EXHAUST-NOZZLE SECONDARY-AIRFLOW PUMPING AS AN EXIT CONTROL OF AN INLET-STABILITY BYPASS SYSTEM FOR A MACH 2.6 AXI symmetric 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. Nozzle secondary pumping as a stability bypass exit control can provide the inlet with a large stability margin with no adverse effects on propulsion system performance.

Author

NBO-14125# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. 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 fl ametube combustor. Data collected in this study showed near linear increases in nitric oxide emissions with decreasing vaporization at equivalence ratios of 0.6. For equivalence ratios of 0.72, the degree of vaporization had very little impact 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.

Author

Takeoff and Landing aircraft engines, and to verify this technology in full-scale engine tests in 1983. The program consists of three phases: Combustor Concept Screening, Combustor Optimization Testing, and Engine Verification Testing. The development and screening of the combustion system designs for the CF6-80 engine and the JT9D-7 engine, respectively, in high-pressure sector test rigs are reported. M.M.M.

N80-14126  National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. LASER-OPTICAL BLADE TIP CLEARANCE MEASUREMENT SYSTEM

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

N80-16127  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 'tilt-rotor research aircraft' programs. In addition to these NASA programs, the Air Force AMST YC 14 and YC 15 programs were reviewed. R.E.S.

N80-15128  National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. 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. R.C.T.

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. M.M.M.

N80-15134  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 tubomachines. M.M.M.

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 indicated reattachment at the diffuser exit. A finite difference procedure for turbulent compressible flow in axisymmetric ducts was used to successfully model the HiMAT duct flow. The analysis technique was further used to estimate the initiation of separation and delineate the steady and unsteady flow regimes in similar S-shaped ducts. R.C.T.

N80-17071  National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AERODYNAMIC PERFORMANCES 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 engine geometry, water injection downstream of the compressor, and increases in gas generator speed. Results were dependent on the mode of variable geometry utilization. Over 20 percent increase in power was accomplished 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

NBO-180274‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. JTBD-7A (8P) JET ENGINE PERFORMANCE DEGRADATION TRENDS G. Paul Richter, W. J. Olsson, and N. B. Andersen 1980 24 p ref. Prepared for the 12th Congr. of the Intern. Aircraft Maintenance Eng, Exhibition and Conf., Dallas, 8-10 Apr. 1980; sponsored by Hamilton-Standard, West Concord, Mass., and Raytheon Aircraft Engine Group. West Concord, Mass. 21E The trends, and causes of engine performance deterioration were investigated. A series of installed engine calibrations (both on-the-ground and in-flight) were performed on two new Pan American World Airways 747 SP aircraft. The performance data gathered covered from before the first flight through approximately 1000 flight cycles and 8900 flight hours. To accomplish the calibrations a special instrumentation system for ground testing of installed engines over a broad power range was used along with performing concurrent in-flight engine calibrations under revenue service conditions. Results of the analysis of the data, which provide a better understanding of short and long term performance deterioration of both engines and modules are presented. J.M.S.
A hub-to-shroud and a blade-to-blade internal-flow analysis code, both inviscid and basically subsonic, were used to calculate the flow parameters over the 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.

**N80-21325**
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF SINGLE-STAGE AXIAL-FLOW TRANSONIC COMPRESSOR WITH ROTOR AND STATOR ASPECT RATIOS OF 1.19 AND 1.26 RESPECTIVELY, AND WITH DESIGN PRESSURE RATIO OF 2.06

The overall and blade-element performances of a low-aspect-ratio transonic compressor stage are presented over the stable operating flow 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 2.058 and 2.000, respectively. The stage stall margin at design speed was 10 percent.

**N80-21326**
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF UNCERTAINTIES IN TURBINE METAL TEMPERATURE PREDICTIONS

An analysis was conducted to examine the extent to which various factors influence the accuracy of analytically predicting turbine blade metal temperatures and to determine the uncertainties in these predictions for several accuracies of the influence factors. The advanced turbofan engine, gas temperatures of 1700 K and 40 atmospheres were considered along with those of a highly instrumented high temperature turbine test rig and a low temperature turbine rig that simulated the engine conditions. The analysis showed that the uncertainty in analytically predicting local blade temperature was as much as 98 K or 7.6 percent of the metal absolute temperature, with current knowledge of the influence factors. The expected reductions in uncertainties in the influence factors with additional knowledge and tests should reduce the uncertainty in predicting blade metal temperature to 28 K, or 2.1 percent of the metal absolute temperature. Author

**N80-21327**
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

GENERAL AVIATION PROPULSION
Mar. 1980 437 p refs Conf held in Cleveland, 28-29 Nov 1979 (NASA CP-2126; E-310) Avail NTIS HC A19/MF A01 CSCL 21E

Programs exploring and demonstrating new technologies in advanced aviation propulsion are considered. These programs are the quiet, clean, general aviation turboshaft (QCQAT) program, the general aviation turbine engine (GATE) study program, the general aviation propeller technology program; and the advanced rotary, diesel, and reciprocating engine programs. For individual titles, see N80-22328 through N80-22348

**N80-21328**
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

AN OVERVIEW OF NASA RESEARCH ON POSITIVE DISPLACEMENT GENERAL-AVIATION ENGINES

**N80-21329**
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

STEADY-STATE PERFORMANCE OF J85-21 COMPRESSOR AT 100 PERCENT OF DESIGN SPEED WITH AND WITHOUT INTERSTAGE RAKE BLOCKAGE

Internal compressor instrumentation blockage effects on steady state J85-21 compressor performance at 100 percent of design speed are determined. The blockage was generated by instrumented vanes for the first three compressor stages and by removal rakes for stages 4 to 9. Individual flow passage blockages ranged up to 4.5 percent with the instrumented vanes and up to 22 percent with the removable interstage rakes. At a Reynolds number index of 1.0, pressure ratio and airflow remained unchanged with insertion of the interstage rakes, but efficiency dropped 0.3 percentage point. Compressor exit profiles, compressor stage static pressure rise coefficients, turbine exit temperature, and fuel flow are also presented.

**N80-22336**
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

NEW OPPORTUNITIES FOR FUTURE, SMALL GENERAL-AVIATION TURBINE ENGINES (GATE)

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.

**N80-22335**
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

AN OVERVIEW OF NASA RESEARCH ON POSITIVE DISPLACEMENT GENERAL-AVIATION ENGINES

The research and technology program related to improved...
and advanced general aviation engines is described. Current research is directed at the near-term improvement of conventional air-cooled spark-ignition piston engines and at future alternative engine systems based on all-new spark-ignition piston engines, lightweight diesels, and rotary combustion engines that show potential for meeting program goals in the midterm 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.G.

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

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


Avail NTIS HC A19/MF A01 CSCL 21E

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

M.G.

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

NASA PROPELLER TECHNOLOGY PROGRAM

Daniel C. Mikkelson In its Gen. Aviation Propulsion Mar. 1980 p 315-325 (For primary document see N80-22327 13-07)

Avail NTIS HC A19/MF A01 CSCL 21E

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

M.G.

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

HIGH-SPEED-PROPELLER WIND-TUNNEL AEROACOUSTIC RESULTS

Robert J. Jeracki and James H. Dittmar In its Gen. Aviation Propulsion Mar. 1980 p 361-374 (For primary document see N80-22327 13-07)

Avail NTIS HC A19/MF A01 CSCL 21E

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

R.C.T.

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

ADVANCED PROPELLER AERODYNAMIC ANALYSIS

Lawrence J. Bober In its Gen. Aviation Propulsion Mar. 1980 p 375-385 (For primary document see N80-22327 13-07)

Avail NTIS HC A19/MF A01 CSCL 21E

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

R.C.T.

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

EFFECT OF THERMAL CYCLING ON Zr02-Zr03 THERMAL BARRIER COATINGS


A study was made of the comparative life of plasma sprayed Zr02-Zr03 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-ceramic coating 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 effect 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, turbine engine cost reductions required to achieve aircraft cost parity with a current spark ignition reciprocating (SIR) engine vary from 0 to 60 percent and from 6 to 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.

N80-223310* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SIGNIFICANCE OF THERMAL CONTACT RESISTANCE IN TWO-LAYER THERMAL-BARRIER-COADED 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 stabilization 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. Ruckie (Pratt and Whitney Aircraft.

Lewis Research Center, Cleveland, Ohio.

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As part of a NASA program to reduce fuel consumption of current commercial aircraft engines, methods were investigated for improving the durability of plasma sprayed ceramic coatings for use on vane platforms in the JT9D turbine engine. Increased durability concepts under evaluation include use of improved strain tolerant microstructures and control of the substrate temperature during coating application. Initial burner rig tests conducted at temperatures of 1010°C (1850°F) indicate that improvements in cyclic life greater than 20:1 over previous ceramic coating systems were achieved. Three plasma sprayed coating systems applied to first stage vane platforms in the high pressure turbine were subjected to a 100-cycle JT9D engine endurance test with only minor damage occurring to the coatings.

A.R.H.

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

R.C.T.

To enable accurate simulation of in-flight fan tone noise during ground static tests, four devices intended to reduce inflow disturbances and turbulence were tested with a JT9D-1 turbofan engine. These inflow control devices (ICD's) consisted of honeycomb/screen structures mounted over the engine inlet. The ICD's ranged from 1.6 to 4 fan diameters in size, and differed in shape and fabrication method. All the ICD's significantly reduced the BPF tone in the far-field directivity patterns, but the smallest ICD's apparently introduced propagating modes which could be recognized by additional lobes in the speeds; at supersonic fan tip speed the smallest ICD's had some measurable loss, but the largest had no loss. Data from a typical transducer show that the unsteady inflow distortion modes (turbulence) were eliminated or significantly reduced when either of the ICD's was installed. However, some steady inflow distortion modes remained. A.R.H.

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

J.M.S.

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 57.91 m/sec. At design speed and pressure ratio, the total efficiency of the turbine was 88.9 percent, which is 0.6 point lower than the design value of 89.2 percent. The corresponding mass flow was 4.0 percent greater than design. Author
TURBINE SHROUDS: HEAT TRANSFER ANALYSIS

compared to an all impingement air cooled, all metal shroud, temperature in the porous metal layer. Analysis showed that of ceramic and porous metal' layer thicknesses and of porous shroud consisting of a ceramic thermal barrier layer bonded to valve poppets and seats was investigated. Six different poppet ACTUATORS

The porous metal layer serves to mitigate the strain differences 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 on rotated type dependent differencing, successive line overrelaxation, and sequential boundary conforming grid refinement. An artificial viscosity is added in fully conservative form, and an initial guess for the potential field is applied, as determined by a two dimensional cascade analysis

N80-25329# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

STRICT AND TRANIENT PERFORMANCE OF YF-102 ENGINE WITH UP TO 14 PERCENT CORE AIRBLEED FOR THE QUIST SHORT-HAUL RESEARCH AIRCRAFT

An outdoor static test stand was used to measure the steady-state and transient performance of the YF-102 turboprop engine with core airbleed. The test configuration included a bellmouth inlet and a confluent-flow exhaust system similar in size to the quiet short-haul research aircraft (QSA) 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 QSA bleed requirements. No stability, surge, stall, overtemperature, 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.

A.R.H.

N80-28289# 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 poppet 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. E.D.K.

N80-27382# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPOSITE WALL CONCEPT FOR HIGH TEMPERATURE TURBINE SHROUDS: HEAT TRANSFER ANALYSIS


A heat transfer analysis was made of a composite wall shroud consisting of a ceramic thermal barrier layer bonded to a porous metal layer which, in tum, is bonded to a metal base. The porous metal layer serves to mitigate the strain differences between the ceramic and the metal base. Various combinations of ceramic and porous metal layer thicknesses and of porous metal densities and thermal conductivities were investigated to determine the layer thicknesses required to maintain a limiting temperature for the metal layer. Analysis showed that the composite wall offered significant air cooling flow reductions compared to an all impingement air cooled, all metal shroud.

N80-27383# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NUMERICAL CALCULATION OF TRANSONIC 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 irrational, 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 on rotated type dependent differencing, successive line overrelaxation, and sequential boundary conforming grid refinement. An artificial viscosity is added in fully conservative form, and an initial guess for the potential field is applied, as determined by a two dimensional cascade analysis

Author

N80-27385# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOSS MODEL FOR OFF-DESIGN PERFORMANCE ANALYSIS OF RADIAL TURBINES WITH PIVOTING-VANE, VARIABLE-AREA STATORS


An 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.

Author

N80-28312# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OFF-DESIGN CORRELATION FOR LOSSES DUE TO PART-SPAN DAMPERS ON TRANSONIC ROTORS


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 1.6 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.

Author

N80-29300# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AIRCRAFT RESEARCH AND TECHNOLOGY FOR FUTURE FUELS

FUTURE AVIATION FUELS OVERVIEW

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, shake oil processing, the characteristics of broadened property fuels, the effects of fuel property variations on combustor and fuel system performance, and combustor and fuel system technology for broadened property fuels. For individual titles, see N80-29301 through N80-29330.

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

FUTURE AVIATION FUELS OVERVIEW
Gregory M. Rock In Its Aircraft Res and Technol. for Future Fuels Jul. 1980 p 1-4 reff (For primary document see N80-29300 20-07)
Avail: NTIS HC A11/CF A01 CSCL 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 aircraft 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.

N80-29305# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

FUELS CHARACTERIZATION STUDIES
Avail: NTIS HC A11/CF A01 CSCL 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 ground type methods development is being approached from several directions, including aromatic fraction standards development and the elimination of standards through removal or partial removal of the alkane and aromatic fractions or through the use of whole fuel refractive index values. More sensitive methods for alkane determinations using an ultraviolet-visible detector are also being pursued. Some of the more successful gas chromatographic physical property determinations for petroleum derived fuels are the distillation curve (simulated distillation), heat of combustion, hydrogen content, API gravity, viscosity, flash point, and (to a lesser extent) freezing point.

M.G.

N80-29310# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

COMBUSTION TECHNOLOGY OVERVIEW
Avail: NTIS HC A11/CF A01 CSCL 21B

An overview of combustor technology developments required for use of broadened property fuels 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 - fuel quality effects, 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 all distributions 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.

N80-29332# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

FUELS RESEARCH: FUEL THERMAL STABILITY OVERVIEW

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 tests. 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 measurements.

The aircraft energy efficiency program within NASA is developing technology required to improve the fuel efficiency of commercial subsonic transport aircraft. One segment of this program includes engine diagnostics which is directed toward determining the sources and causes of performance deterioration in the Pratt and Whitney Aircraft JT8D and General Electric CF6 high-bypass ratio turbofan engines.

The aircraft energy efficiency program within NASA is developing technology required to improve the fuel efficiency of commercial subsonic transport aircraft. One segment of this program includes engine diagnostics which is directed toward determining the sources and causes of performance deterioration in the Pratt and Whitney Aircraft JT8D and General Electric CF6 high-bypass ratio turbofan engines.

The state of the art of SiAlOns is examined. The review includes work on phase relations, crystal structure, synthesis, fabrication, and properties of various SiAlOns. The essential features of compositions, fabrication methods, and microstructure are reviewed. High temperature flexure strength, creep, fracture toughness, oxidation, and thermal shock resistance are discussed. These data are compared to those for some currently produced silicon nitride ceramics to assess the potential of SiAlOn materials for use in advanced gas turbine engines.

Results of steady state reverse and forward to reverse thrust transient performance tests are presented. The original quiet, clean, short haul, experimental engine four segment variable fan nozzle was retested in reverse and compared with a continuous, 30 deg half angle conical exhaust. Data indicated that the significantly more stable, higher pressure recovery flow with the fixed 30 deg exhaust resulted in lower engine vibrations, lower fan blade stress, and approximately a 20 percent improvement in reverse thrust. Objective reverse thrust of 35 percent of takeoff thrust was reached. Thrust response of less than 1.5 sec was achieved for the approach and the takeoff to reverse thrust transients.

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.

The Engine Component Improvement (ECI) Project formulated to address near term improvements for current engines is described with emphasis on the development of component technologies to reduce the fuel consumption of CF6, JT8D, and JT9D engines. The technical and economical m-capability and the fuel saving systems to relate the variable, of cost on blade size. Geometries of typical 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. A B H


The results of engine performance deterioration investigations based on research, in-house 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 rubs, 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 turboshaft engines. The project is conducted through contracts 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 designs 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.

N80-32396*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LOW-PRESSURE PERFORMANCE OF ANNULAR, HIGH-PRESSURE (40 ATM) HIGH-TEMPERATURE (2840 K) COMBUSTION SYSTEM Jerrold 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 maximum 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 0.058. Combustion efficiency decreased at leaner and richer ratios than the ideal air to fuel ratio of 0.025. It 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 is also presented. Data included exhaust gas pattern factors, unburned hydrocarbon, carbon monoxide, and oxides of nitrogen emission index values, and smoke numbers. Author

N80-33410*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EXPERIMENTAL PERFORMANCE AND ANALYSIS OF 18.04-CENTIMETER-TIP DIAMETER, RADIAL-INFLOW TURBINE WITH WORK FACTOR OF 1.126 AND THICK BLADING Kerry L. McAllister and Jeffrey E. Haas Oct. 1980 21 p refs Presented 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 0.952 kg/sec and a rotational speed of 70,000 rpm. The turbine inlet temperature was 1478 K, and the turbine was designed with blades thick enough for internal cooling passages. The rotot tip diameter was limited to 105% 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 10^5 N/sq m and 322 K, respectively. Results indicated the turbine total efficiency to be 5.3 points less than design. Analysis of these results has indicated the deficit in performance to be due to internal secondary flow losses, vanes and blade surface friction losses, and trailing edge wake mixing losses. R.C.T.

A80-10033 *# Identification and dual adaptive control of a turboshaft engine. W. Merrill (NASA, Lewis Research Center, Cleveland, Ohio) and G. Leininger (Toledo, University, Toledo, Ohio). International Federation of Automatic Control, Symposium on Identification and System Parameter Estimation, 5th, Darmstadt, West Germany, Sept. 24-28, 1979, Paper, 8 p, 14 refs, Grant No. NGR-36-010-024.

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 nonlinear single spool airbreathing turboshaft engine. Using a very detailed and accurate simulation of the nonlinear 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 turboshaft engine performance. The result is a 'dual-adaptive' control law that is functionally dependent upon the sampling rate selected and environmental operating conditions. Simulation transients demonstrate the utility of the dual-adaptive design to improve on-board computer utilization while maintaining acceptable levels of engine performance. (Author)


In the late fifties the Lewis Research Center evaluated experimentally the use of hydrogen using three different turboshaft 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

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

(Author)


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

(J.P.B.)


The Engine Component Improvement (ECI) Program is NASA sponsored and is specifically directed at reducing the fuel consumption of commercial aircraft in the near-term. As part of the ECI program, a Performance Improvement (PI) effort aimed at developing fuel saving and retention components for new production and retrofit of JT9D, JT8D, and CF6 engines is underway. This paper reviews the manner in which the PI concepts were selected for development and summarizes the current status of each of the 16 NASA selected concepts.

(Author)


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 data base to aid the analysis and design development of the E3 mixed-flow exhaust system.

(Author)


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 turboshaft 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 content degraded the flexural and tensile strength 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.


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

B.J.


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


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.


The paper describes the tests of four devices intended to reduce inflow disturbances and turbulence using a JT15D-1 turbofan engine. The tests were made to simulate the in-flight fan tone noise; the inflow control devices (ICD's) consisted of honeycomb/screen structures mounted over the engine inlet. The ICD's ranged from 1.6 to 4 fan diameters in size, and were made with several fabrication methods. All the ICD's significantly reduced the BPF tone in the far-field directivity patterns; the smallest ICD's introduced 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.


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


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.


Static scale model tests were conducted to evaluate exhaust system mixers for a high bypass turbofan 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.


The General Electric CF6-50 engine nacelle was originally equipped with both fan nozzle and core nozzle thrust reversers. Many airline operators later deactivated the core reverser. Elimination of the core reverser enabled design changes to be made to help improve performance. A reduction in core nozzle length of approximately two feet was possible. This concept, defined as the Short Core Exhaust Nozzle, was evaluated in engine ground tests, including performance, acoustic, and endurance tests under the NASA/Lewis Engine Component Improvement Program. The test results verified the performance predictions from scale model tests. The Short Core Exhaust Nozzle provides an internal cruise SFC reduction of 0.9% without an increase in engine noise. The nozzle hardware successfully completed 1000 flight cycles of endurance testing with no signs of distress.


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


The paper presents a study of low aspect blading for the inlet stages of a high pressure ratio, high-speed core compressor. The basic overall design variables were stage pressure ratio and blade aspect ratio; these four stages represent two levels of total pressure ratio, two levels of rotor blade aspect ratio, and two levels of stator vane aspect ratios. Comparisons of the overall performance, radial distributions of performance parameters, diffusion factors at the near-stall conditions, blade element data, and the axial distribution of

Results of an experimental investigation of the aerodynamic performance of several annular prediffuser-combustor systems are presented. Three curved wall, dump prediffusers of different length, area ratio, and turning angle were tested with and without a simulated combustor located downstream of the prediffuser. Performance was significantly influenced by the presence of the combustor. Pressure recovery and flow losses were determined as a function of prediffuser inlet velocity profile, flow extraction at the prediffuser inlet, axial and radial location of the combustor front end, and distribution of the flow in the combustor. Axial location of the combustor was found to be the most significant parameter influencing system performance. (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 57.5 g/sq cm sec and water flow rates of 6.3 to 18.8 g/s. The effect of air and water flow rates on the mean drop size of water sprays produced with the swirl blast fuel injectors were determined. Also, from these data it was possible to determine the effect of design modifications on the atomizing performance of various fuel injectors and air swirler configurations. The trend in atomizing performance, as based on the main droplet 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 minimally processed petroleum residual fuels. The program will focus on "dry" reductions of oxides of nitrogen (NOx/x), 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 a new generation of fuel-conservative turbofan engines. A single-stage turbine required fewer cooled airfoils, a reduced number of leakage paths and no interstage seals. These advanced energy efficient engines require 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. Gregorek (Ohio State University, Columbus, Ohio), and D. C. Mikelson (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 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 CF6-50C2/E2 engine. A significant improvement in cruise power SFC of 1.8 percent was demonstrated in Sea Level test projected to altitude flight 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. Atention is given to an engine diagnostics program
sponsored by NASA Lewis Research Center which has the objectives of identifying and quantifying the levels, trends, and causes of engine performance deterioration. It is reported that as part of the program, a series of installed engine calibrations were performed on two new Pan American World Airways 747 SP aircraft. A discussion of this specific test program and the results of the analysis of the data are presented.

M.E.P.


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


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


An analysis of the effects of the hot-gas and coolant temperatures, the gas-to-blade and blade-to-coolant heat transfer coefficients, and the thermal conductances of a metal wall and a ceramic thermal-barrier coating on the prediction of local turbine-blade surface temperatures. The analysis was applied to the conditions of an advanced turboshaft 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 62 kelvins or 5.7% for ceramic-thermal-barrier-coated blades. A.T.

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


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 VSCE-5028 study engine. The carbon monoxide and unburned hydrocarbon emissions were low at all three operating conditions with combustion efficiencies in excess of 99.7 percent, as compared to the goal of 99.0 percent. Nitric oxide emissions were low at moderate but not 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 emissions of CO, NOx, and unburned hydrocarbons were negligible at all three operating conditions. (Author)

NBO-10222* # Pratt and Whitney Aircraft, East Hartford, Conn. Chemical Products Div.


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

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

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

A lightweight composite fan exit guide vane for high bypass ratio gas turbine engine application was investigated. Eight candidate material/design combinations were evaluated by NASTRAN finite element analyses. A total of four combinations were selected for further analytical evaluation, part fabrication by two vendors, and fatigue test in dry and wet condition. A core and shell vane design was chosen as the goal of an uncoated graphite core fiber was the same for all candidates. The shell material, fiber orientation, and ply configuration were varied. Material tests were performed on raw materials 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 with respect to design analysis, materials properties, inspection standards, improved durability, weight benefits, and part price of the composite fan exit guide vane. (Author)
ERRORS MEASURED ON STOL APPROACHES


An example of the 1000 series of engine data tables is base files to represent the engine and the inlet/ nozzle/ aftbody and dimensions, inlet and nozzle internal performance and drag, and an example of the 1000 series of engine data tables is presented. A.W.H.


COMPUTER CODE FOR ESTIMATING INSTALLED PERFORMANCE OF AIRCRAFT GAS TURBINE ENGINES. VOLUME 1: FINAL REPORT


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, and nacelle drag. The use of two data base files to represent the engine and the inlet/nozzle/aftbody with performance characteristics. The existing library of inlet and nacelle weight, and nacelle drag is presented. A.W.H.


COMPUTER CODE FOR ESTIMATING INSTALLED PERFORMANCE OF AIRCRAFT GAS TURBINE ENGINES. VOLUME 2: USERS MANUAL


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, and nacelle drag. A user oriented description of the input program requirements, program output, deck setup, and operating instructions is presented. A.W.H.


ADVANCED CATALYTIC COMBUSTORS FOR LOW POLUTANT EMISSIONS, PHASE 1 Final Report

W. J. Dodds Nov. 1979 159 p refs Sponsored in part by Air Force Engineering Services Center, Tyndall AFB, Flr. (Contract NAS-20820)


The feasibility of employing the known attractive and distinguishing features of catalytic combustion technology to reduce nitric oxide emissions from gas turbine engines during exhaust performance. These characteristic points determined which of nine possible injector configurations provided optimal performance at any given flight condition and injected gas conditions. Detailed examination of the thermodynamic cycle was made for representative cases and data was presented to illustrate the influence of injection upon conventional gas generator performance. The influence of nozzle loss, skin friction and flow separation, incomplete kinetic and thermal mixing, and boundary layer inlet were taken into consideration in the analysis. Correlation with existing stationary solid and jet-injector experiments showed excellent agreement between theory and experiment. It has been shown that injectors designed according to the methods described, can provide large improvement in propulsion system performance throughout the entire practical flight regime.


QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (GCSEE) ACOUSTIC AND AERODYNAMIC TESTS ON A SCALE MODEL OVER-THE-WING THRUST REVERSER AND FORWARD THRUST NOZZLE

D. L. Stimpert 18 Jan 1978 85 p refs (Contract NAS-15021)

NASA-CR-135254; R74AG504) Avail: NTIS HC A05/MF A01 CSCL 21E

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 reverser 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 acoustic considerations involved in the low source noise basic engine design and the design procedures followed in the development of the over-the-wing (OTW) nacelle. Acoustic design features include a near-sonic inlet, low fan and core pressure ratios, low fan tip speed, high and low frequency stacked core treatment, multiple thickness treatment, and fan frame and stator vane treatment.

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

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

C. L. Ruggles Jul. 1978 75 p refs (Contract NAS3-19201)

(NASA-CR-135279; R78AE206) Avail: NTIS

HC A04/MF A01 CSCL 21E

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

**R.E.S.**

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

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

Jul. 1978 49 p refs (Contract NAS3-19201)

(NASA-CR-135234; R78AE474-Vol-2) Avail: NTIS

HC A03/MF A01 CSCL 21E

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

**R.E.S.**


**FEASIBILITY OF SiC COMPOSITE STRUCTURES FOR 1964 K (2500 F) GAS TURBINE SEAL APPLICATION**

Final Report, 20 Apr. - 30 May 1979

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

(NASA-CR-135825; R78AE625) Avail: NTIS

HC A06/MF A01 CSCL 21E

The silicon carbide composites evaluated consisted of Si/SiC and sintered silicon carbide as substrates, both with attached surface layers containing BN as an additive. A total of twenty-eight candidates with variations in substrate type and density, and layer chemistry, density, microstructure, and thickness were evaluated for abradability, 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 showed that material properties were suitable for 1477 K (2200 F) gas turbine seal applications. Further improvements are needed in hot gas erosion resistance and abradability to demonstrate feasibility to 1644 K (250 F). A.R.H.


**THE CFS JET ENGINE PERFORMANCE IMPROVEMENT; NEW FRONT MOUNT**

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

(NASA-CR-159639; R79AE366) Avail: NTIS

HC A07/MF A01 CSCL 21E

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

**R.E.S.**

**N80-14128** Detroit Diesel Allison, Indianapolis, Ind.

**STUDY OF TURBOPROP SYSTEMS RELIABILITY AND MAINTENANCE COSTS** Final Report

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

(NASA-CR-135192; EDR-9132) Avail: NTIS

HC A14/MF A01 CSCL 21E

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

**R.E.S.**

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

**EXHAUST EMISSION REDUCTION FOR INTERMITTENT COMBUSTION AIRCRAFT ENGINES**

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

(NASA-CR-159757) Avail: NTIS

HC A06/MF A01 CSCL 21E

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

**R.E.S.**

**N80-14182** Acurex Corp., Mountain View, Calif. Autodata Div.

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

Alan Adler and Bas Hoeks Sep. 1979 192 p refs (Contract NAS3-20280; Acurex Proj. 6497)

(NASA-CR-159453; Acurex-78-284) Avail: NTIS

HC A09/MF A01 CSCL 09F

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


QUICK CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE SUBSYSTEM TEST REPORT


(NASA-CR-135075; R76AEG420) Avail. NTIS HC A05/MF A01 CSCL 21E

The element and subcomponent testing conducted to verify the under the wing composite nacelle design is reported. This composite nacelle consists of an intake, 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.

J. M. S.

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

QUICK CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). BALL SPLINE PITCH CHANGE MECHANISM DESIGN REPORT

Apr. 1978. 73 p refs.

(NASA-CR-134873; R77AEG327) Avail. NTIS HC A04/MF A01 CSCL 21E

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

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


(NASA-CR-134891; R75AEG368) Avail. NTIS HC A07/MF A01 CSCL 21E

Sound data which were obtained during tests of a 50.8 cm diameter, subsonic tip speed, low pressure ratio fan were analyzed. The test matrix was divided into two major investigations: (1) source noise reduction techniques; and (2) aft duct noise reduction techniques. Source noise reduction techniques were investigated which included 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 on the outer wall and constant thickness treatment on the inner wall was investigated. Variable boundary conditions such as variation in treatment panel thickness and orientation, and mixed porosity combined with variable thickness were examined. Significant results are reported.

R. C. T.


QUICK CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS TEST PROGRAM Final Report


(NASA-CR-134666; CW-WR-77-008) Avail. NTIS HC A10/MF A01 CSCL 21E

Sets of under the wing (UTW) engine reduction gears and sets of over the top (OTW) engine reduction gears were fabricated for rig testing and subsequent installation in engines. The UTW engine reduction gears which have a ratio of 2.465:1 and a design rating of 9712 kW at 3157 rpm fan speed were operated at up to 105% of speed at 60% torque and 100% speed at 125% torque. The OTW engine reduction gears which have a ratio of 2.062:1 and a design rating of 12,615 kW at 3861 rpm fan speed were operated at up to 95% speed at 50% torque and 80% speed at 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 (223,000 fpm) with a corresponding star gear spherical roller bearing DN of 850,000 OTW. Oil and star gear bearing temperatures, oil churning, heat rejection, and vibratory characteristics were acceptable for engine installation.

J. M. S.

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

QUICK CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) CLEAN COMBUSTOR TEST REPORT


(NASA-CR-134916; R75AEG449) Avail. NTIS HC A04/MF A01 CSCL 21E

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

R. C. T.

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

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS BEARING DEVELOPMENT PROGRAM Final Report


(NASA-CR-134890) Avail. NTIS HC A03/MF A01 CSCL 21E

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

R. C. T.

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

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) MAIN REDUCTION GEARS DETAILED DESIGN REPORT Final Report


(NASA-CR-134872; CW-WR-77-024) Avail. NTIS HC A10/MF A01 CSCL 21E

Lightweight turbine engines with geared slower speed fans are considered. The design of two similar but different gear ratios, minimum weight, epicyclic star configuration main reduction gears for the under the wing (UTW) and over the wing (OTW) engines is discussed. The UTW engine reduction gear has a ratio of 2.465:1 and a 100% power design rating of 9885 kW (13,256 hp) at 3143 rpm fan speed. The OTW engine reduction gear has a ratio of 2.062:1 and a 100% power design rating of 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 (QCSEE): HAMILTON STANDARD CAM/HARMONIC DRIVE VARIABLE PITCH FAN ACTUATION SYSTEM DETAIL DESIGN REPORT
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 frequency harmonic drive attached to a multiaxial spherical cam which changes blade pitch through individual cam follower arms attached to each blade trunnion. Detail design parameters of the actuation system are presented. These include the following: design philosophies, operating limits, mechanical, hydraulic and thermal characteristics, mechanical efficiencies, materials, weights, lubrication, stress analyses, reliability and failure analyses.

Author


A total of 38 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 over-speed. All tests were successfully completed. All blades planned for use in the engine were subjected to and passed a whirligig proof spin test.


The design, fabrication, and testing of two experimental high bypass geared turbofan engine 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.


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


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 frequency harmonic drive attached to a multiaxial spherical cam which changes blade pitch through individual cam follower arms attached to each blade trunnion. Detail design parameters of the actuation system are presented. These include the following: design philosophies, operating limits, mechanical, hydraulic and thermal characteristics, mechanical efficiencies, materials, weights, lubrication, stress analyses, reliability and failure analyses.

Author


General Electric Co., Cincinnati, Ohio.

Aerospace Group.


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

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

**N80-15115** General Electric Co., Cincinnati, Ohio. Aircraft Engine Group

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) SPINE PITCH-CHANGE MECHANISM WHIRLIGIG TEST REPORT**

Sep 1978 64 p refs
(Contract NAS3-18021)
(NASA-CR-135354; R77AEG394) Avail: NTIS

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). J.M.S.

**N80-15116** General Electric Co., Cincinnati, Ohio. Aircraft Engine Group

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) BOILER PLATE NACELLE AND CORE EXHAUST NOZZLE DESIGN REPORT**

Oct. 1976 104 p
(Contract NAS3-18021)
(NASA-CR-135008; R76AEG222) Avail: NTIS

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

**N80-15117** Hamilton Standard, Windsor Locks, Conn.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) WHIRL TEST OF CAM/HARMONIC PITCH CHANGE ACTUATION SYSTEM Contractor Report. 10 Nov. 1975 - 16 Feb. 1976**

Apr. 1976 208 p refs
(Contract NAS3-18021)
(NASA-CR-135140; HSER-7002) Avail: NTIS

HC A10/MF A01 CSCL 21E

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

**N80-15118** General Electric Co., Cincinnati, Ohio.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEMS TEST REPORT. VOLUME 4: ACOUSTIC PERFORMANCE**

D. L. Simporth. Feb. 1979 144 p refs
(Contract NAS3-18021)
(NASA-CR-135326; R77AEG476-Vol-4) Avail: NTIS

HC A07/MF A01 CSCL 21E

A series of acoustic tests were conducted on the over the wing engine. These tests evaluated the fully suppressed noise levels in forward and reverse thrust operation and provided insight into the component noise sources of the engine plus the suppression achieved by various components. System noise levels using the contract specified calculation procedure indicate that 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 thrust Mach number. R.E.S.

**N80-15119** General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) FINAL DESIGN REPORT**

E.A. Johnston Aug. 1978 128 p (Contract NAS3-18021)
(NASA-CR-135352; R77AEG588) Avail: NTIS

HC A07/MF A01 CSCL 21E

The detail design of the under the wing experimental composite nacelle components is summarized. Analysis of an inlet, fan bypass ducts, cowl doors, and variable fan nozzle are given. The required technology to meet propulsion system performance, weight, and operational characteristics is discussed. The materials, design, and fabrication technology for quiet propulsion systems which will yield installed thrust to weight ratios greater than 3.5 to 1 are described. R.C.T.

**N80-15120** General Electric Co., Cincinnati, Ohio. Aircraft Engine Group

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) Final Report**

William S. Willis Aug. 1979 408 p refs
(Contract NAS3-18021)
(NASA-CR-159473; R79AEG478) Avail: NTIS

HC A18/MF A01 CSCL 21E

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

**N80-15121** General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). DOUBLE-ANNULAR CLEAN COMBUSTOR TECHNOLOGY DEVELOPMENT REPORT**

D. W. Bahr, D. L. Burris, and P. E. Sable May 1979 149 p refs
(Contract NAS3-18021)
(NASA-CR-159483; R79AEG397) Avail: NTIS

HC A07/MF A01 CSCL 21E

A sector combustor technology development program was conducted to define an advanced double annular dome combustor sized for use in the quiet clean short haul experimental engine (QCSEE). A design which meets the emission goals, and combustor performance goals of the QCSEE engine program was developed. Key design features were identified which resulted in substantial reduction in carbon monoxide and unburned hydrocarbon emission levels at ground idle operating conditions, in addition to very low nitric oxide emission levels at high power operating conditions. Their significant results are reported. R.C.T.
Pitch actuation systems; fan rotor mechanical design; fan frame engine cycle and performance; fan aerodynamic design; variable following areas are discussed: acoustic design; emissions control; present...

The flight propulsion systems are also presented. The in the 'quiet, clean, short-haul experimental engine' program are ...

**REPORT, VOLUME 1**

NBO. 15123* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). PRELIMINARY ANALYSES AND DESIGN REPORT, VOLUME 1**

Oct. 1974 372 p  
(Contract NASA-130-18021)  
(NASA-CR-134838; R74AE479-Vol-1) Avail NTIS HC A16/MF A01 CSCL 21E

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

NBO. 15124* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE). PRELIMINARY ANALYSES AND DESIGN REPORT, VOLUME 2**

Oct. 1974 330 p  
(Contract NASA-130-18021)  
(NASA-CR-134839; R74AE479-Vol-2) Avail NTIS HC A15/MF A01 CSCL 21E

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

**REPORT, VOLUME 2**

NBO. 15125* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEM TEST REPORT. VOLUME 1: SUMMARY REPORT**

Jan. 1978 67 p  
(Contract NASA-130-18021)  
(NASA-CR-135323; R77AE475-Vol-1) Avail NTIS HC A04/MF A01 CSCL 21E

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

NBO. 15126* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) OVER-THE-WING (OTW) PROPULSION SYSTEM TEST REPORT. VOLUME 3: MECHANICAL PERFORMANCE**

NBO. 15130* Yale Univ., New Haven, Conn Dept of Engineering and Applied Science

**THEORY OF DEPOSITION OF CONDENSIBLE IMPURITIES ON SURFACES IMMERSED IN COMBUSTION GASES Semiannual Report, 15 Jan. - 14 Jul. 1979**

Daniel E Rosner 1979 353 p refs

The components resulting from the deposition of inorganic 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. 

R.C.T.

NBO. 15131* Yale Univ., New Haven, Conn High Temperature Chemical Reaction Engineering Lab


Daniel E Rosner Dec. 1979 10 p refs

(Grant NoG-3169)  
(NASA-CR-159753, SAR-4) Avail NTIS HC A02/MF A01 CSCL 21E

An 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 BO3-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 ribbons 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. A.R.H.

NBO. 16083* General Electric Co., Washington, D. C. Aircraft Engine Group

**DEMONSTRATION OF SHORT-HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES ON A TWENTY INCH (50.8 cm) DIAMETER FAN, VOLUME 1**

D. L. Stimpert and R. A. McFalls May 1975 131 p refs

3 Vol.  
(Contract NASA-18021)  
(NASA-CR-134949; R75AE925-Vol-1) Avail NTIS HC A07/MF A01 CSCL 21E

Tests of a 20 inch diameter, low tip speed, low pressure ratio fan which investigated aft fan noise reduction techniques are reported. These techniques included source noise reduction features of selection of vane-blade ratio to reduce second harmonic noise, spacing effects, and lowering the Mach number through a vane row. Aft suppression features investigated included porosity effects, variable depth treatment, and treatment regenerated flow noise. Initial results and selected comparisons are presented. J.M.S.
swept wing configurations were tested across a range of nozzle positions are among the parameters investigated. Straight and QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE located both under the wing and over the wing is demonstrated. The technology required for externally blown flap aircraft with engines under the wing (UTW) propulsion system installations for introduction into passenger service in the mid 1980's is included. The design, fabrication, and testing of this UTW experimental engine containing the required technology items for low noise, fuel economy, and complex system design is reported. The mechanical properties used in the nacelle design. The element tests verified that the critical panel and joint areas of the nacelle had adequate structural integrity. 


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. R.E.S.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (OCSEE) UNDER-THE-WING ENGINE DIGITAL CONTROL SYSTEM DESIGN REPORT

JUL. 1977 103 P

R.E.S.
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.

**N80-15098** General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCEE) OVER-THE-WING CONTROL SYSTEM DESIGN REPORT**

Dec 1977 249 p ref

(Contract NAA3-18021)

(NASA-CR-135253, R77AEG664) Avail: NTIS

HC A01/MA A01 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 variable pitch fan blade. The control system was designed for the propulsion system and to fail with its output device hydraulically locked into position.


**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCEE) PRELIMINARY OVER-THE-WING FLIGHT PROPULSION SYSTEM ANALYSIS REPORT**

Dec 1977 249 p ref

(Contract NAA3-18021)

(NASA-CR-135253, R77AEG664) Avail: NTIS

HC A01/MA A01 CSCL 21E

The preliminary design of the over-the-wing flight propulsion system installation and nacelle component and systems design features of a short-haul, powered lift aircraft are presented.

**N80-15085** General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCEE) UNDER-THE-WING (UTW) ENGINE BOILERPLATE NACELLE TEST REPORT, VOLUME 1: SUMMARY**

Jan 1977 249 p ref 3 Vol

(Contract NAA3-18021)

(NASA-CR-135254, R77AEG212) Vol-1 Avail: NTIS

HC A01/MA A01 CSCL 21E

The design and testing of high bypass geared turbofan engines with nacelles forming the propulsion system for an under-the-wing passenger aircraft are described. The tests demonstrated the technology required for externally blown flap aircraft for introduction into passenger service in the 1980s. 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.


**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCEE) UNDER-THE-WING (UTW) ENGINE BOILERPLATE NACELLE TEST REPORT, VOLUME 3: MECHANICAL PERFORMANCE**

Dec 1977 128 p ref 3 Vol

(Contract NAA3-18021)

(NASA-CR-135255, R77AEG212-Vol-3) Avail: NTIS

HC A07/MA A01 CSCL 21E

Results of initial tests of the under-the-wing 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 cowl cooling, fan exhaust nozzle, and digital control system.


**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCEE) COMPOSITE FAN FRAME SUBSYSTEM TEST REPORT**

Jan 1977 249 p ref 3 Vol

(Contract NAA3-18021)

(NASA-CR-135011, R76AEG233) Vol-1 Avail: NTIS

HC A04/MA A01 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 under the wing and over the wing, including technology in composite structures and digital engine controls. The element tests confirmed that the processes used in the frame design would produce the predicted mechanical properties. The subcomponent tests verified that the detail composite structures and digital engine controls are among the topics included.


**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCEE) OVER-THE-WING (OTW) BOILERPLATE NACELLE DESIGN REPORT**

May 1977 78 p ref

(Contract NAA3-18021)

(NASA-CR-135166, R77AEG300) Avail: NTIS

HC A05/MA A01 CSCL 21E
A summary of the mechanical design of the boiler plate nacelle for the CFE-60 turbofan 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 distortion test to establish the aerodynamic and acoustic requirements for nozzles and reversers of this type.

N80-10601* Pratt and Whitney Aircraft Group, West Palm Beach, Fla.
**DISTRIBUTION ANALYSIS FOR F100(3) ENGINE Final Report**
W. A. Walters 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) compressor 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.

A.H.

N80-10704* Pratt and Whitney Aircraft, East Hartford, Conn.
**EXPERIMENTAL EVALUATION OF A LOW EMISSIONS HIGH PERFORMANCE DUCT BURNER FOR VARIABLE CYCLE ENGINES (VCE) Final Report**
(Contract NAS3-20602)
(NASA CR-153694, PWA-6513-32A) Avail: NTIS
HC AO6/MF AO1 CSCL 21A

An evaluation was conducted with a three stage Vorbix duct burner to determine the performance and emissions characteristics of the concept and to refine the configuration to provide acceptable durability and operational characteristics for its use in the variable cycle engine (VCE) tested program. The tests were conducted at representative takeoff, transonic climb, and supersonic cruise inlet conditions for the VSCC-5282 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, exhaust temperature, thrust efficiency, and gaseous emissions calculations are defined. The test procedures are reviewed and the results are discussed.

A.W.H.
Six coating systems were evaluated for internal coating of decent 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.

N80-19042*§ Vought Corp., Dallas, Tex.
LOW SPEED TEST OF THE AFT INLET DESIGNED FOR A TANDEM FAN V/STOL NACELLE
(Contract NAS5-21466)
(NASA-CR-159762, TR-2-D0320/DR-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 cowl, a shaft simulator, blown-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 test 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.

N80-19113*§ 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 Sept. 1979 128 p. ref
(Contract NAS5-20578)
(NASA-CR-159714; PWA-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 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/spi 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 0.520. The aspect ratio of the second compressor was 1.22 with an overall pressure ratio of 1.324 at a design adiabatic efficiency of 88.7% with an average diffusion factor of 0.491.

N80-20221*§ Teledyne Continental Motors, Muskegon, Mich.
A 150 AND 300 KW LIGHTWEIGHT DISEL AIRCRAFT ENGINE DESIGN STUDY Final Report
Alex P. Brouwers Apr. 1980 149 p. refs
(Contract NAS5-20530)
(NASA-CR-3280; Rep/756) Avail. NTIS HC A0?/MF A01
CSCL 21A

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

PROGRAM FOR IMPACT TESTING OF SPAR-SHELL FAN BLADES, TEST REPORT
(Contract NAS5-20801)
(NASA-CR-135393, R78AE0444) 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 GCSEE-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 byjecting a stove into the path of the blade.

N80-21330*§ Pratt and Whitney Aircraft Group, East Hartford, Conn., Commercial Products Div.
MANUFACTURE OF LOW CARBON ASTROLOGY TURBINE DISK SHAPES BY HOT ISOSTATIC PRESSING, VOLUME 2, PROJECT 1 Final Report
(Contract NAS5-20072)
(NASA-CR-135410; PWA-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.

N80-21331*§ 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. ref
(Contract NAS5-19698)
(NASA-CR-159798; IITRI-M6003-53) Avail. NTIS
HC A05/MF A01 CSCL 21E

Thermal fatigue and oxidation data were obtained for 11 plasma spray coated and 13 uncoated directionally solidified single crystal MAR-M 246 blades. Blade coatings on the airfoil included several metal-oxide thermal barrier layers based on Al203, Cr203, or ZrO2. The 24 turbine blades were tested simultaneously for 3000 cycles in fluidized beds maintained at 950 and 25 C using a symmetrical 360 set thermal cycle. In 3000 cycles, only uncoated turbine blades exhibited cracking on the trailing edge near the platform; 3 of the 13 uncoated blades did not crack. Cracking occurred over the range 400 to 7250 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 spallation at the trailing edge radius after 3000 cycles. Surface general spallation on the airfoil was observed for two multilayered coatings.

Author
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. A R.H. represents a TSFC improvement of approximately 9 percent over that of current technology engines; and the engine performance FAR Part 36 conditions, are 10 to 15 ENPdB below FAA weight, and construction. The major noise, emissions, and performance goals were met. Noise levels estimated for the three other turbofan engines. A.R.H.

The three seals did have slight laminar cracks at the 85/15-40/60 completed the test successfully without severe cracking or spelling, and engine tests. Four cyclic thermal shock rig tests were conducted during the program. Three completed 1000 simulated engine thermal cycle tests and the fourth completed 500 cycles without severe cracking or spalling. Three ceramic seals were installed in a JT9D experimental engine to evaluate the effect of the engine thermal environment on the seals. All three seals completed the test successfully without severe cracking or spalling. Three of the six seals rubbed to a depth of 24 mils. Eight of the fourteen abrasive seals rubbed 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. J.M.S.

The results of the collection and analysis of historical data pertaining to the deterioration of JT9D engine performance are presented. The results of analyses of prerepair and postrepair engine test stand performance data from a number of airlines to establish the individual as well as average losses in engine performance with respect to service use are included. Analysis of the changes in mechanical condition of parts, obtained by inspection of used gas-path parts of varying age, allowed preliminary assessments of component performance deterioration levels and identification of the causative factors. These component performance estimates, refined by data from special engine back-to-back testing referenced to engine performance restoration, permitted the development of preliminary models of engine component/module performance deterioration with respect to usage. The preliminary assessment of the causes of module performance deterioration and the trends with usage are explained, along with the role each module plays in overall engine performance deterioration. Preliminary recommendations with respect to operating and maintenance practices which could be adopted to control the level of performance deterioration are presented. The needs for additional component sensitivity testing as well as outstanding issues are discussed J.M.S.


Fifty-one material systems were evaluated for potential use in turbine blade tip seal applications at 1370 C. Both ceramic blade tip inserts and ablative ceramic tip shoes were tested. Hot gas erosion, impact resistance, thermal stability, and dynamic rub performance were the criteria used in rating the various materials. Silicon carbide and silicon nitride were used, both as blade tips and abradables. The blade tip inserts were fabricated by hot pressing while low density and honeycomb abradables were sintered or reaction bonded. Author
The design of an aircraft engine capable of developing 186 kW shaft power at a 7620 m altitude is described. The 186 kW design takes into account expected new developments in aircraft designs resulting in a reassessment of the power requirements at the cruise mode operation. Based on the results of this analysis a three phase technology development program is projected resulting in production dates of 1985, 1992, and 2000.

**N80-22333** Avco Lycoming Div., Stratford, Conn.

**AVCO LYCOMING QUIET CLEAN GENERAL AVIATION TURBOFAN ENGINE**
Craig A. Wilson

186 kW shaft power at a 7620 m altitude is described. The 186 kW design takes into account expected new developments in aircraft designs resulting in a reassessment of the power requirements at the cruise mode operation. Based on the results of this analysis a three phase technology development program is projected resulting in production dates of 1985, 1992, and 2000.

**N80-22339** General Electric Co., Cincinnati, Ohio

**CF6 JET ENGINE PERFORMANCE IMPROVEMENT: NEW FAN**
W. A. Fasching May 1980 202 p

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

**N80-22311** Hamilton Standard, Windsor Locks, Conn.

**ACOUSTIC TEST AND ANALYSES OF THREE ADVANCED TURBOPROP MODELS** Final Report
Bennett M. Brooks and R. B. Metzger Jan. 1980 245 p

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. The 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.

**N80-22312** Pratt and Whitney Aircraft Group, East Hartford, Conn.


A total of two three-stage compressors were designed and tested to determine the effects of aspect ratio on compressor performance. The first compressor was designed with an aspect ratio of 0.81; the other, with an aspect ratio of 1.22. Both compressors had a hub-tip ratio of 0.915, representative of the aspect ratio design achieved a pressure ratio of 1.346 at a corrected flow of 4.28 kg/sec and an adiabatic efficiency of 86.1%. The 1.22 aspect ratio design achieved a pressure ratio of 1.314 at 4.35 kg/sec flow and 87.0% adiabatic efficiency. Surge margin to peak efficiency was 24.0% with the lower aspect ratio blading, compared with 12.4% with the higher aspect ratio blading.

**N80-22316** Williams Research Corp., Walled Lake, Mich.

**CONCEPTUAL DESIGN STUDY OF AN IMPROVED GAS TURBINE POWERTRAIN** Final Report
W. I. Chapman Mar. 1980 294 p

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

**N80-28332** Pratt and Whitney Aircraft Group, East Hartford, Conn.

**Commercial Products Div.**

**ENGINE COMPONENT IMPROVEMENT: PERFORMANCE IMPROVEMENT, JTBD-7 3.8 AR FAN Progress Report, Jan. 1978-Feb. 1979**

W. G. Gaffin 12 Jun. 1980 57 p
TORSION MODE CASCADE Final Report

The effects of reduced solidity on the realistically high reduced frequency level of 0.44. The cascade was designed to model a near tip section from a rotor which was known to have experienced supersonic torsional flutter. This single stage, low aspect ratio, compressor with a typical of an advanced core compressor front stage was tested. The test stage incorporated an inlet duct which was representative of an engine transition duct between fan and high pressure compressors. At design speed, the rotor stator stage achieved a peak adiabatic efficiency of 86.6 percent at a flow of 44.35 kg/sec and a pressure ratio of 1.8. Surge margin was 12.5 percent from the peak stage efficiency point.

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

EXPERIMENTAL AERODYNAMIC AND ACOUSTIC MODEL TESTING OF THE VARIABLE CYCLE ENGINE (VCE) TESTBED COANNULAR EXHAUST NOZZLE SYSTEM

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 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.

EXPERIMENTAL AERODYNAMIC AND ACOUSTIC MODEL TESTING OF THE VARIABLE CYCLE ENGINE (VCE) TESTBED COANNULAR EXHAUST NOZZLE SYSTEM: COMPREHENSIVE DATA REPORT

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 aero-mechanical 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.

N80-27361*# Curtis-Wright Corp., Wood-Ridge, N.J.
PERFORMANCE, EMISSIONS, AND PHYSICAL CHARACTERISTICS OF A ROTATING COMBUSTION AIRCRAFT ENGINE, SUPPLEMENT A
R. K. Lamping, 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 emissions requirements were met using the normal peripheral porting. 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 emissions requirements were met using the normal peripheral porting. 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concerning thermal stability, lubeecrity, low temperature flow, combustion, and the effect of the use of specific additives on fuel properties and performance are discussed. An assessment of available crudes and refinery capabilities is given. M.G.


The effects of broadening the specifications for JP-4 and JP-8 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 distillate fuels and extend the use of JP-8 in the United States will increase middle distillate demand and cause a slight increase in engine hot-section maintenance. It is also concluded that the maximum allowable freeze point of JP-4 or JP-8 cannot be increased without degrading system performance and safety as critical conditions are approached. M.G.


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


Advanced combustor concepts are evaluated as a means of accommodating possible future broad specification fuels. The three advanced double annular combustor concepts consisted of (1) a concept employing high pressure drop fuel nozzles for improved atomization, (2) a concept with premixing tubes in the main stage, and (3) a concept with the pilot stage on the inside and the main stage on the outside, 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 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.


A program for the determination of fuel property effects on aircraft gas turbine engine mainburners and turbines is discussed. The six engines selected as test candidates are the J79, J85, J57, FT30, FT39, and F100. Fuels election is the responsibility of the contractors with two fuels as exceptions. The petroleum JP-4 is to be used as a baseline in all tests. The shale JP-4 is to be used in nearly all tests. Fuel properties are to be correlated with combustion system performance parameters. In addition, life predictions are to be made for combustor and turbine hardware. These predictions are to be based on a typical mission for each system, measured metal temperatures and temperature gradients, and oxidation/corrosion effects. E.D.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 were evaluated. Various design modifications on the operating capability of each of the combustor concepts with experimental reference broadened specification fuels that were evaluated included perturbation of the combustor airflow schedules to alter local stoichiometric conditions, time histories revisions to the fuel injection configurations to reduce or advanced cooling concepts. R.C.T.


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

**N80-29319f** Purdue Univ., Lafayette, Ind.

**ATOZMATION OF BROAD SPECIFICATION AIRCRAFT FUELS**


The combustion 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 combustion behavior of the fuel spray/air mixture. It is shown that the fuel properties which affect the atomization behavior (viscosity, surface tension, and density) are less favorable for the broad specification fuels as compared to those for conventional fuels.

R.C.T.

**N80-29320f** Massachusetts Inst. of Tech., Cambridge.

**BOOT FORMATION AND BURNOUT IN FLAMES**


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

R.C.T.

**N80-29321f** Exxon Research and Engineering Co., Linden, N.J.

**FUEL PROPERTY EFFECTS IN STIRRED COMBUSTORS**


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

R.C.T.

**N80-29322f** Southwest Research Inst., San Antonio, Tex.

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


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), napthenes (decalin) and partially hydrogenated aromatics (tetralin); the sixth fuel emphasized final boiling point.

R.C.T.

**N80-29323f** United Technologies Research Center, East Hartford, Conn.

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


(Avail: NBS 21-1853)

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

R.C.T.

**N80-29324f** Naval Air Propulsion Test Center, Trenton, N.J.

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


Three fuels having different breakpoint temperatures were studied in the modified jet fuel thermal degradation test. 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 0.87 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 deposit formation rates for the three fuels were determined at 260°C and a relative deposit formation rate at this temperature was calculated and plotted as a function of the individual fuel's breakpoint temperature.

R.C.T.

**N80-29325f** Colorado School of Mines, Golden.

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


Avail: NTIS HC A11/MF A01 CSCL 21D

Lewis bases were extracted from a Utah COED syncrude via ligand exchange. Addition of this extract to Jet A at levels as low as 8 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 exhibited greater slopes in the presence of those nitrogen compounds producing the greater deposition rates. It is shown that despite variation in appearance the elemental composition and spectral characteristics of the deposits are affected by addition of the nitrogen compounds. The linearity of the Arrhenius plots and of a plot of Arrhenius slope versus intercept for all the compounds suggests a constancy of mechanism over the range of temperature and heterocycles studied.

R.C.T.

**N80-29326f** Boeing Military Airplane Development, Seattle, Wash.
Wash.

HIGH-FREEZING-POINT FUEL STUDIES


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

N80-29297* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) UNDER-THE-WING (UTW) COMPOSITE NACELLE TEST REPORT, VOLUME 2: ACOUSTIC PERFORMANCE


(Contract NAS3-18021)

(Associated Aerials Inc. 1979 151 p)

N80-29298* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

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

May 1975 63 p

(Contract NAS3-18021)

(ASSOCIATED AERIALS INC. 1979 151 P)

N80-29299* General Electric Co., Cincinnati, Ohio. Advanced Engineering and Technology Programs Dept.

ACOUSTIC PERFORMANCE OF A 30.8-cm (20-INCH) DIAMETER VARIABLE-PITCH FAN AND INLET. VOLUME 2: ACOUSTIC DATA Final Report


(Associated Aerials Inc. 1979 151 p)

N80-29300* Lockheed-California Co., Burbank

LOW TEMPERATURE FUEL BEHAVIOR STUDIES


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.

N80-29331* TRW, Inc., Cleveland, Ohio.

TUNGSTEN WIRE/FCCAY MATRIX TURBINE BLADE FABRICATION STUDY

P. Melnik and J. N. Fleck Dec 1979 99 p refs

(Contract NAS3-20391)

HC A06/ MF A01 FSCL 21E

The objective was to establish a viable FRS monotape technology base to fabricate a complex, advanced turbine blade. All elements of monotape fabrication were addressed. A new process for incorporation of the matrix, including bi-alloy matrices, was developed. Bonding, cleaning, cutting, sizing, and forming parameters were established. These monotapes were then used to fabricate a 4B ply solid JT9D-7F 1st stage turbine blade. Core technology was then developed and first a 12 ply and then a 7 ply shell hollow airfoil was fabricated. As the fabrication technology advanced, additional airfoils incorporated further elements of sophistication, by introducing in sequence bonded cost blocks, cross-ply, bi-metallic matrix, tip cap, trailing edge slots, and impingement inserts.

Author
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. A.R.H.

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


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


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


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 250, 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, airflow improvement, sweep, position of maximum blade loading and diameter reduction. (Author)
AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities, piloting, flight controls, and autopilots

SINGLE-STAGE ELECTROHYDRAULIC SERVOSYSTEM FOR ACTUATING ON AIRFLOW VALVE WITH FREQUENCIES TO 500 HERTZ


NASA TP-1678, E-252) Avail NTIS HC A03/MF A01 CSCL OTC

An airflow valve and its electrohydraulic actuation servosystem are described. The servosystem uses a high-power, single-stage servovalve to obtain a dynamic response beyond that of systems designed with conventional two-stage servovalves. The electrohydraulic servosystem is analyzed and the limitations imposed on system performance by such nonlinearities as signal saturations and power limitations are discussed. Descriptions of the mechanical design concepts and developmental considerations are included. Dynamic data, in the form of sweep-frequency test results, are presented and comparison with analytical results obtained with an analog computer model is made. R.K.G
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.


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

V.P.


The OTV configurations, operations and requirements planned for the period from the 1980's to the 1990's were reviewed and a propellant transfer experiment was designed that would support the needs of these advanced OTV operational concepts. An overall integrated propellant management technology plan for all NASA centers was developed. The preliminary cost estimate (for planning purposes only) is $56.7 M, of which approximately $31.8 M is for shuttle user costs.

R.K.G.

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 thruster 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. (Author)


Five specific experiments were analyzed to provide definition of experiments designed to evaluate two phase fluid behavior in low gravity. The conceptual design represents a fluid mechanics and heat transfer facility for a double rack in Spacelab. The five experiments are two phase flow patterns and pressure drop, flow boiling, liquid reorientation, and interface bubble dynamics. Hardware was sized, instrumentation and data recording requirements defined, and the five experiments were installed as an integrated experimental package. Applicable available hardware was selected in the experiment design and total experiment program costs were defined. (Author)
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 QPSK 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 02 Air Transportation and Safety and 85 Urban Technology and Transportation.

N80-20304# 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 A02/MF A01 CSCL 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 synopsisized 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 CSDL

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.

N80-18209# 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 CSCL 22B

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

J.M.S.

N80-18096# 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
Carolyn K. Purvis 1979 21 p refs Presented at the Ann. Conf. on Nucl. and Space Radiation Effects, Santa Cruz, Calif., 16-20 Jul. 1979; sponsored by IEEE
(NASA-TM-79299; E-117) Avail: NTIS HC A02/MF A01 CSCL 22B

The sensitivity of predicted equilibrium potential to 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 monoenergetic beam charging data if charging rates as well as equilibrium potentials are accurately recorded.

A.W.H.

N80-18094# 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 CSCL 22B

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

M.M.M.

N80-18095# 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 CSCL 22B

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

J.M.S.

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

MODELING OF ENVIROMENTALLY INDUCED DISCHARGES IN GEOSYNCHRONOUS SATELLITES
(NASA-TM-81598;E-581) Avail: NTIS HC A02/MF A01 CSCL 22B

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

R.C.T.


The effects of photoelectron space charge and current density on differentially charged spacecraft are studied. The steady-state potentials of a sunlight cylinder are calculated using a two-dimensional computer code with a fully self-consistent treatment of space charge and an effective surface conductivity treatment of photoelectron currents. It is found that under conditions of strong differential charging the results do not differ greatly from NASCAP results, which neglect photoheath space charge and currents. (Author)

A study of the charging and discharging characteristics of a typical geosynchronous satellite experiencing time-varying geomagnetic substorms, in sunlight, is conducted. The NASA Charging Analyzer Program (NASCAP) is used for the electric field critical field strength. It is found that while there is a minimum electron temperature for discharges to occur, the rate of discharges is dependent on particle density and duration times of the encounter. Hence, it is important to define the temporal variations in the substorm environments.


The paper uses the NASA Charging Analyzer Program (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 standard operating voltage and direct-drive voltage configurations. The computations are presented without thruster operations as well as with a simplified, simulated thruster-on representation for direct-drive configuration only. It is stressed that the computations seeking possible areas of concern in the spacecraft design are exploratory.


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


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.


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


A study is presented in which the sensitivity of predicted equilibrium potential to changes in secondary electron yield parameters is investigated using MATCHG, a simple charging code which
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’s are provided. Experimental evidence presented indicates that emission of electrons only is not effective in maintaining spacecraft potential near plasma potential for spacecraft with electrically insulating surfaces. Emission of a low energy plasma, however, is effective for this purpose. (Author)


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 photovoltaic 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)


Charged and neutral particle transport from an 8-cm mercury ion thruster to the surface 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 depositions 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 recombination/reinterception of mercury ions in magnetic fields and refraction of low energy mercury charge exchange (Group IV) ions by local electric fields, (Author)


A computer model of the three-dimensional 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)
20 SPACECRAFT PROPULSION AND POWER

- Includes main propulsion systems and components e.g., rocket engines, and spacecraft auxiliary power sources.
- For related information see also 07 Aircraft Propulsion, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

N80-13163**# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ION THRUSTER COMPONENT TESTING

The feasibility of using a heavy hydrocarbon fuel as a rocket propellant is examined. A method of predicting performance of an electron bombardment thruster is presented. The performance of various thrusters is described and compared to other fuels and to experimental test results. Experiments were done at a chamber pressure of 4137 KN/sq 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 55.9 cm (22 in). 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.

J.M.S.

N80-13164**# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
DESIGN AND EVALUATION OF HIGH PERFORMANCE ROCKET ENGINE INJECTORS FOR USE WITH HYDROCARBON FUELS

The feasibility of using a heavy hydrocarbon fuel as a rocket propellant is examined. A method of predicting performance of an electron bombardment thruster is presented. The performance of various thrusters is described and compared to other fuels and to experimental test results. Experiments were done at a chamber pressure of 4137 KN/sq 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 55.9 cm (22 in). 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.

J.M.S.

N80-14188** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
SUPERCHARGED TOPPING ROCKET PROPELLANT FEED SYSTEM

A rocket propellant feed system utilizing a bleed turbopump to supercharge a topping turbopump is presented. The bleed turbopump is 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.

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

N80-15204**# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF GaAs AND Si SOLAR CELL ARRAYS FOR EARTH ORBITAL AND ORBIT TRANSFER MISSIONS

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

R.C.T.

N80-16097**# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
UPPER STAGES UTILIZING ELECTRIC PROPULSION

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

A.W.H.

N80-17138**# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ANALYTICAL INVESTIGATION OF TWO HYDROGEN OXYGEN ROCKET ENGINE SYSTEMS FOR LOW-THRUST APPLICATION

Two hydrogen oxygen rocket engine system concepts were analyzed parametrically over a thrust range from 100 to 1000 pounds and a chamber pressure range from 175 to 1000 psia. Both concepts were regeneratively cooled with hydrogen and were pump fed by electric motor driven positive displacement pumps. Electric power was provided by either a turboalternator (turboalternator concept) or some means external to the engine system (auxiliary power concept). The 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 the 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.

N80-33365# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. COOLING OF HIGH PRESSURE ROCKET THRUST CHAMBERS WITH LIQUID OXYGEN H. G. Price 1980 15 p refs Proposed for presentation at the 16th Joint Propulsion Conf., Hartford, 30 Jun. - 2 Jul. 1980, cosponsored by AIAA, ASME and SAE (NASA-TM-81503; E-441) Avail: NTIS HC A02/MF A01 CSCL 21H An experimental program using hydrogen and oxygen as the propellants and supercritical liquid oxygen (LOX) as the coolant was conducted at 4.14 and 8.274 MN/square meters (600 and 1200 psia) chamber pressure. Data on the following are presented: the effect of LOX leaking into the combustion region through small cracks in the chamber wall; and verification of the supercritical oxygen heat transfer correlation developed from heated tube experiments; A total of four thrust chambers with throat diameters of 0.066 m were tested. Of these, three were cyclically tested to 4.14 MN/square meters (600 psia) chamber pressure until a crack developed. One had 23 additional hot cycles accumulated with no apparent metal burning or distress. The fourth chamber was operated at 8.274 MN/square meters (1200 psia) pressure to obtain steady state heat transfer data. Wall temperature measurements confirmed the heat transfer correlation. R.C.T.

N80-30382# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ANALYTICAL INVESTIGATION OF TWO HYDROGEN-OXYGEN ROCKET ENGINE SYSTEMS FOR LOW-THRUST APPLICATION Dean D. Scherer 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 turboalternator (turboalternator concept) or some means external to the engine system (auxiliary power concept). The computer program used to conduct the analyses along with the design characteristics of the major engine system components are briefly described. The feasible design range of the two hydrogen-oxygen 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

N80-30383# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LIRC REDUCED GRAVITY FLUID MANAGEMENT TECHNOLOGY PROGRAM J. C. Aydelott and E. P. Symons in APL The 1980 JANNAF Propulsion Meeting, Vol. 5 Mar. 1980 p 21-34 refs (For primary document see N80-30381 21-20) Avail: Issuing Activity CSCL 21H 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 test 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 propellant propulsion systems and the development of computer techniques for simulating reduced gravity fluid dynamic processes is reported. J.M.S.
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 tiles, see N80-33466 through N80-33475.

N80-33466 © National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SYNCHRONOUS ENERGY TECHNOLOGY PROGRAM

Robert C. Finke In its Synchronous Energy Technol. Sep. 1980 p 1-7 (For primary document see N80-33465 24-20)

Avail NTIS HC A07/ MF A01 CSCL 10B

The power program in NASA and DOD are discussed with emphasis on the technology for future large space power systems. The structure of the synchronous energy technology program is described and the technologies required for future geosynchronous power stations are defined. The output of the program is to be a series of design data documents to provide design information and to transfer the technology to the involved community. R.C.T.

N80-33470 © National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PHOTOVOLTAIC TECHNOLOGY DEVELOPMENT FOR SYNCHRONOUS ORBIT

Henry W. Brandhorst In its Synchronous Energy Technol. Sep. 1980 p 45-56 (For primary document see N80-33465 24-20)

Avail NTIS HC A07/MF A01 CSCL 10A

Accomplishments and expected benefits are summarized for the followling efforts: (1) achieving silicon solar cell efficiency of 18% at 200 micron m to 250 micron m thickness; (2) reducing silicon cell radiation damage in geosynchronous orbit after 10 years to less than 15%; (3) demonstrating coplanar back contact 50 micron m thick silicon solar cells with efficiency of 14%; (4) demonstrating the feasibility of a radiation tolerant GaAs concentrator cell; (5) achieving 30% efficient photo conversion in the laboratory; (6) defining candidate concepts for 50% efficient electromagnetic conversion; and (7) demonstrating the technology for protecting arrays capable of 300W/kg after 10 years in geosynchronous orbit. 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 thruster system characteristics was assessed for variations of propellant type, total accelerating voltage, thruster area, specific Impulse, and power system approach. The data may be used both to provide direction to technology emphasis and for preliminary estimates of electric propulsion system properties for a wide variety of application. (Author)


Ground-based tests of Hg ion thrusters have identified sputtering 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 solar cell technology of 18% efficiency, an intense current electromagnetic launcher, and the characteristics of the rail gun. A.R.H.

N80-33458 © National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SYNCHRONOUS ENERGY TECHNOLOGY

Sep 1980 144 p Symp. held in Cleveland, 29-30 Apr. 1980 (NASA-CP-2154; E-469) Avail NTIS HC A07/ MF A01 CSCL 21H

The synchronous technology requirements for large space power systems are summarized. A variety of technology areas...
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)


The characteristics of power processors strongly impact the overall performance and cost of electric propulsion systems. A program was initiated to evaluate simplifications of the thruster-power processor interface requirements. The power processor requirements are mission dependent with major differences arising for those missions which require a nearly constant thruster operating point (typical of geocentric and some inbound planetary missions) and those requiring operation over a large range of input power (such as outbound planetary missions). This paper describes the results of 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 4,137 kN/m² (600 psi) 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 65.9 cm (26 in.). 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. (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 increase 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 mass in LEO (MLEO), thrusting (trip) times, propellant type, specific impulse, and power source specific mass. It is found that the ratios of payload masses to total mass in LEO are intensive to MLEO, which allows a highly condensed presentation of the overall payload capability. Electric stages are shown capable of delivering payloads in thrusting times less than 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 magnetoplasmadynamic 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+ implanted silicon solar cell. It is reported that the responsible defect, with the energy level at +0.30 eV, has been tentatively identified as boron-oxygen-vacancy complex. In conclusion, it is shown that removal of this defect could result in significant cell recovery when annealing at temperatures well below the currently required 400°C.

M.E.P.


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


An analytical and experimental study was conducted dealing with refillmg 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. (Author)


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 concept requirements. Emphasis is placed on orbit transfer arrangements, spacecraft launch constraints, and spacecraft GEO assembly and deployment sequences. (V.T.

A80-38992 # Cooling of high pressure rocket thrust cham-


The regenerative cooling limits (maximum chamber pressure) are defined for oxygen/hydrocarbon (Methane, Propane, and RP-1) rocket engines over a thrust range of 20,000 to 600,000 lbf for a reusable life of 250 missions. Chamber pressure limits are first defined without a hot-gas wall carbon layer (unenhanced design). Cooling enhancement chamber pressure limits are then established for seven thermal barriers (carbon layer, ceramic coating, graphite liner, film cooling, zoned combustion, transpiration cooling, and a combination of two of the above). The maximum regenerative-cooled chamber pressure is attained with the oxygen/methane propellant combination. (Author)


This paper examines mid to late 1980s power management technology needs to support development of a general-purpose space platform, capable of supplying 100 to 250 KW to a variety of users in LEO. To that end, a typical Shuttle-assembled and supplied space platform is described, 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 system 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 design details which lead to technology goals including array and transmission voltage, best frequency for AC power transmission, and advantages and disadvantages of AC and DC systems for this application. Finally, system and component requirements are compared with the state of the art to identify areas where technology development is required. (Author)

N80-11137 # TRW Defense and Space Systems Group, Redondo Beach, Calif.

SPECIFIC SPACECRAFT EVALUATION: SPECIAL REPORT Special Report, 1 Nov. 1973 to 1 Jun. 1978


Charged and neutral particle transport from an 8 cm mercury ion thruster to the surfaces of the P 80-1 spacecraft and to the
Teal Ruby sensor and the ECOM 501 sensor of that spacecraft were investigated. Laboratory measurements and analyses were used to determine line-of-sight and omnidirectional particle transport modes. The recirculation of Hg (+) ions in the magnetic field of the Earth was analyzed for spacecraft velocity and Earth magnetic field vector configurations 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/recirculation/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. Results, conclusions, and future considerations are presented.

R.C.T.

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


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.

M.M.M.

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


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 pressure wave forms exhibit a second strong harmonic distortion and a variety of behaviors are possible depending on the nature of the combustion process and the parametric values involved. A one-dimensional model provides further insight into the problem by allowing a comparison of Galerkin solutions with more exact finite-difference computations.

A.R.H.

N80-13165# Tennessee Technological Univ., Cookeville.

STABILITY ANALYSIS OF A LIQUID FUEL ANNULAR COMBUSTION CHAMBER M.S. Thesis G.H. McDonald Nov. 1979 151 p refs (Grant NGR-43-003-015) (NASA-CR-159734) Available: NTIS HC A08/MF A01 CSCL

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

A.W.
and RP-1 decomposition temperature on chamber pressure limits. Chamber and nozzle design parameters are presented for the unenhanced and enhanced designs. The maximum regenerative cooled chamber pressure limits were attained with the O2/CH4 propellant combination. The O2/RP-1 designs relied on a carbon enhanced and enhanced designs. The maximum regenerative percent of the oxygen and 8 percent of the hydrogen is introduced, during pulsing. The design, fabrication, and demonstration of a 111 Newton (25 lb) thrust, integrated auxiliary propulsion system (APPS) thruster for use with LH2/LO2 propellants is described. Hydrogen was supplied at a temperature range of 22 to 33 K (40 to 125 lb) thrust, integrated auxiliary propulsion system (JAPS) during pulsing. Author E. E. Eberle and L. Kusak, D. 1979, 186 p. refs. (Contract NAS3-20273) (NASA CR 159674). (JPL/RD/79-217) Avail. NTIS HC A08/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 LH2/LO2 propellants is described. Hydrogen was supplied at a temperature range of 22 to 33 K (40 to 60 fl.) and oxygen from 89 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, triaxial injection system was designed that utilizes two 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 or nozzle design. Hot-fire evaluation of this thruster with a BLC injection distance of 2.79 cm (1.10 in.) indicated that a specific impulse value of 390 sec can be attained using a coated molybdenum thrust chamber. Pulse mode tests indicated that a chamber pressure buildup to 90 percent thrust can be achieved in a time on the order of 48 msec. Some problems were encountered in achieving ignition of each pulse during pulse trains. 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 C. H. Terwilliger and W. W. Smith, Jan. 1980, 206 p. refs (Contract NAS3-21346) (NASA CR 159735). (D180-25475-1) Avail. NTIS HC A10/MF A01 CSCL 21C.

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 interaction between the technology descriptors, program costs, and to establish the most cost-effective directions for technology advancement. The most important factor was seen to be the costs associated with the duration of the mission, and this in turn makes the development of advanced electric propulsion systems having moderate to high efficiencies (~100 percent) at intermediate ranges of specific impulse (approximately 1000 seconds) very desirable. Author M. H. Blatt, R. D. Bradshaw, and J. A. Risberg, Feb. 1980, 103 p. refs. (Contract NAS3-20029) (NASA CR 159659). (JPL/CRA-D-80003) Avail. NTIS HC A06/MF A01 CSCL 21H.

Technology areas critical to the development of cryogenic capillary devices were studied. Passive cooling of capillary devices was investigated with an analytical and experimental study of wicking flow. Capillary device refilling with settled fluid was studied using an analytical and experimental program that resulted in successful correlation of a versatile computer program with test data. The program was used to predict Centaur D-15 LO2 and LH2 start basket refilling. Comparisons were made between the baseline Centaur D-15 propellant feed system and feed system alternatives including systems using capillary devices. The preferred concepts from the Centaur D-15 study were examined for AFTOV and POTV vehicles. Mission profiles were determined to provide propellant usage timelines and the payload partials were defined. Author E. E. Eberle and L. Kusak, D. 1979, 186 p. refs. (Grant NsG-3011) (NASA-CR-159813) Avail. NTIS HC A06/MF A01 CSCL 21C.

Inert gas thrusters considered for space propulsion systems were investigated. Electron diffusion across a magnetic field was examined utilizing a basic model. The production of doubly charged ions was correlated using only overall performance parameters. The use of this correlation is therefore possible in the design stage of large gas thrusters, where detailed plasma properties are not available. Argon hollow cathode performance was investigated over a range of emission currents, with the positions of the inert, keeper, and anode varied. A general trend observed was that the maximum ratio of emission to flow rate increased at higher propellant flow rates. It was also found that the enclosed keeper enhanced maximum cathode emission at high flow rates. The maximum cathode emission at a given flow rate was associated with a noisy high-voltage mode. Although this mode has some similarities to the plume mode found at low flows and emissions, it is encountered by being initially in the spot mode and increasing emission. A detailed analysis of large, inert-gas thruster performance was carried out. For maximum thruster efficiency, the optimum beam diameter increases from less than a meter at under 2000 sec specific impulse to several meters at 10,000 sec. The corresponding range in input power varies from several kilowatts to megawatts. Author M. H. Blatt, R. D. Bradshaw, and J. A. Risberg, Feb. 1980, 206 p. refs. (Contract NAS3-21346) (NASA-CR-169658.2372.1R. 1) Avail: NTIS HC A06/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 2.4 to 4.2 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 insight into the plasma processes in the MESC discharge that will aid in the design of future thrusters. Author M. H. Blatt, R. D. Bradshaw, and J. A. Risberg, Feb. 1980, 103 p. refs. (Contract NAS3-20029) (NASA CR 159659). (JPL/CRA-D-80003) Avail. NTIS HC A06/MF A01 CSCL 21H.
Three cycles include conventional propellant turbine drives, orbit (GEO) is the use of low thrust chemical propulsion systems, and film/radiation cooling. These cycles include conventional propellant turbine drives, turbocoolant/elecric motor pump drive, and fuel cell/electric motor pump drive as well as pressure fed engines. Thrust chamber cooling analysis results are presented for regenerative/radiation and film/radiation cooling.

A. R. H.

Low thrust chemical (hydrogen/oxygen) propulsion systems configured specifically for low acceleration orbit transfer of large space systems were studied in order to provide the required additional data to better compare new, low thrust chemical propulsion systems with other propulsion approaches such as advanced electric systems. Study results indicate that it is cost-effective and least risk to combine the low thrust OTV and chemical propulsion systems to achieve the highest chamber pressure. The effects of propulsion system thrust-to-mass ratio, thrust capability of hydrogen and its low critical pressure. Regenerative/film/radiation-cooled LO2/CH4 film/radiation-cooling was found not feasible and LO2/CH4 engines were selected for further study in the system analysis. Six engine design concepts are examined.

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

N80-31469* # Martin Marietta Corp., Leasburg, Md.
LOW-THRUST CHEMICAL ORBIT TO ORBIT PROPULSION SYSTEM PROPPELLANT MANAGEMENT STUDY Progress Report, 14 Sep. 1979 - 14 Nov. 1980
Ralph H. Dergance In NASA Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol Jul 1980 p 287-310 refs (For primary document see N80-31449 22-20) (Contract NAS5-21954)
Avail NTIS HC A15/MF A01 CSCL 21H
Propellant requirements, tankage configurations, preferred propellant management techniques, propulsion system weights, and technology deficiencies for low thrust expendable propulsion systems are examined. A computer program was utilized which provided a complete propellant inventory (including boil-off for cryogenic cases), pressurant and propellant tank dimensions for a given ullage, pressurant requirements, insulation requirements, and manufacturer data. The output also includes the mass of all tanks, the mass of the insulation, engines and other components, total wet system and burnout mass; system mass fraction, total impulse and burn time.

SOLAR ROCKET SYSTEM CONCEPT ANALYSIS Final Report
Jack A. Boddy In NASA Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol Jul 1980 p 311-336 (For primary document see N80-31449 22-20) (Contract F04611-79-C-0007)
Avail NTIS HC A15/MF A01 CSCL 21H
The use of solar energy to heat propellant for application to Earth orbits/planetary propulsion systems is of interest because of its performance capabilities. The achievable specific impulse values are approximately double those delivered by a chemical rocket system, and the thrust is at least an order of magnitude greater than that produced by a mercury bombardment ion propulsion thruster. The primary advantage the solar heater thruster has over a mercury ion bombardment system is that its significantly higher thrust permits a marked reduction in mission trip time. The development of the space transportation system, offers the opportunity to utilize the full performance potential of the solar rocket. The requirements for transfer from low Earth orbit (LEO) to geosynchronous equatorial orbit (GEO) was examined as the return trip, GEO to LEO, both with and without payload. Payload weights considered ranged from 2000 to 100,000 pounds. The performance of the solar rocket was compared with that provided by L02-LH2, N204-MNH, and mercury ion bombardment systems.

Recent testing of the NASA Lewis Research Center/Hughes 8-cm Engineering Model Thruster (EMT) and Power Processing Unit has centered on two primary areas of investigation: Integration of porous-tungsten dispenser-type cathode inserts into the thruster (replacing previous inserts of rolled-tantalum-foil design) and characterization of thruster operation with the new inserts. Characterization testing of the EMT and of the new cathodes has demonstrated acceptable thruster performance and cathode ignition parameters; the only perceived change in thruster performance has been that a small amount of cathode heater power is required to maintain nominal keeper voltages. Thermal modeling of the cathode structures has facilitated design revisions which reduce this power requirement.

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

N80-33476* # Colorado State Univ Fort Collins Dept of Mechanical Engineering
A simple theoretical model which can be used as an aid in the design of the baffe 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 as required as input to the model to facilitate the use of the model in thruster design. This simplified model gave remarkably consistent results with experimental results obtained with a given thruster geometry over substantial changes in operating conditions. The model is unique to a factor of two for different thruster cathode region geometries. The design usefulness was limited by this factor of two uncertainty and by the accuracy to which the plasma parameters required as inputs to the model were specified.

A80-33476* # Colorado State Univ Fort Collins Dept of Mechanical Engineering
John R. Brophy, Jr and Paul J. Wilbur Oct 1980 78 p rems (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 baffe 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 model is unique to a factor of two for different thruster cathode region geometries. The design usefulness was limited by this factor of two uncertainty and by the accuracy to which the plasma parameters required as inputs to the model were specified.

A80-33476* # Colorado State Univ Fort Collins Dept of Mechanical Engineering
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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 L.C Resonant Inverter, Beam Supply, power components, packaging and heat pipe cooling of the 30 cm ion Engine Power Processor are described. Both the transistorized and SCR versions of the Series L.C Resonant Inverter Beam Supply are discussed. A BIMOD Ion Thruster/Power Processor Prototype Assembly is undergoing environmental and life testing. These 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

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

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.

N80-33478* Applied Medical Technology, Cleveland Heights, Ohio
TISSUE RESPONSE TO PERITONEAL IMPLANTS Final Report
George J. Picha Jun 1980 73 p refs
(NASA Order C-33350-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, multinucleated giant cell (MNGC) formation, cell to cell contact, and fibrous capsule formation. The cell responded in the case of ion etched PTFE to an altered surface morphology. However, equally interesting was the similar attachment kinetics of HEMA versus the ion etched PTFE. However, HEMA resulted in a markedly different response with no MNGC's formation, minimal to no capsule formation, and sample coverage by a uniform cell layer.

R.C.T.
COMPOSITE MATERIALS
Includes laminates.

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

NBO-11143/# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MICROMECHANICS OF INTRAPLY HYBRID COMPOSITES: ELASTIC AND THERMAL PROPERTIES
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

NBO-11144/# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TENSILE AND FLEXURAL STRENGTH OF NON-GRAPHITE SUPERHYBRID COMPOSITES: PREDICTIONS AND COMPARISONS
Equations are presented and described which can be used to predict bounds on the tensile and flexural strengths of non-graphite 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 fracture. 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

NBO-11145/# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC RESPONSE OF DAMAGED ANGLEOPLY FIBER COMPOSITES
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. A R H.

NBO-12120/# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MECHANICAL PROPERTY CHARACTERIZATION OF INTRAPLY HYBRID COMPOSITES
An investigation was conducted to characterize the mechanical properties of intraply hybrids made from graphite fiber/epoxy matrix (primary composite) 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 gauges to determine stress-strain behavior. Significant results are included. R C T.

NBO-13171/# National Aeronautics and Space Administration.
IMPROVED FIBER RETENTION BY THE USE OF FILLERS IN GRAPHITE FIBER/RESIN MATRIX COMPOSITES
A variety of matrix fillers were tested for their ability to prevent loss of fiber from graphite fiber/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 filler were measured and compared to those of composites containing no filler. K L.

NBO-14198/# National Aeronautics and Space Administration.
BURRING CHARACTERISTICS AND FIBER RETENTION OF GRAPHITE/RESIN MATRIX COMPOSITES
Graphite fiber reinforced resin matrix composites were subjected to controlled burning conditions to determine their burning characteristics and fiber retention properties. Small samples were

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burned with a natural gas fired torch to study the effects of fiber orientation and structural flaws such as holes and slits that were machined into the laminates. Larger laminate samples were burned in a modified heat release rate calorimeter. Undirectional epoxy/graphite and polyimide/graphite composites and boron powder filled samples of each of the two composite systems were burn tested. The composites were exposed to a thermal radiation of 5.3 Btu/sq ft 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.

**N80-18107** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.  
**FIRE TEST METHOD FOR GRAPHITE FIBER REINFORCED PLASTICS**  
A potential problem in the use of graphite fiber reinforced resin matrix composites is the dispersal of graphite fibers during accidental fires. Airborne, electrically conductive fibers originating from the burning composites could enter and cause shorting in electrical equipment located in surrounding areas. A test method for assessing the burning characteristics of graphite fiber reinforced composites and the effectiveness of the composites in retaining the graphite fibers has been developed. The method utilizes a modified rate of heat release apparatus. The equipment and the testing procedure are described. The application of the test method to the assessment of composite materials is illustrated for two resin matrix/graphite composite systems.  

A.R.H.

**N80-20313** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.  
**DYNAMIC MODULUS AND DAMPING OF BORON, SILICON CARBIDE, AND ALUMINA FIBERS**  
The dynamic modulus and damping capacity for boron, silicon carbide, and silicon carbide coated boron fibers were measured from 190 to 800 C. The single fiber vibration test also allowed measurement of transverse thermal conductivity for the silicon carbide fibers. Temperature dependent damping capacity data for alumina fibers were calculated from axial damping results for alumina. The damping behavior of the fiber composite measured using the transverse test indicates 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.
and the build up of residual stresses must be limited by significant boron and carbon creep rates.

**AXIAL FAILURE OF B/A1 COMPOSITES**

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


(NASA-TM-81474, E-408) Avail: NTIS HC A02/MF A01 CSCL 11D

Experimental and theoretical studies were conducted in order to understand and predict the effects of time, temperature, and stress on the axial failure modes of boron fibers and B/A1 composites. Due to the anelastic nature of boron fiber deformation, it was possible to determine simple creep functions which can be employed to accurately describe creep and fracture stress of as-produced fibers. An analysis of data on creep and strength data on 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

**ENGINE ENVIRONMENTAL EFFECTS ON COMPOSITE BEHAVIOR**


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

**A SILICON-SLURRY/ALUMINIIDE COATING**


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 blisks 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 aluminide coatings. While more expensive Pt-Al coatings and physical vapor deposited MCALY 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
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 provides 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(BA1-4V) composites were measured at room temperature and at 650 °C. At room temperature, the SN curves for the composites showed no anticipated improvement over 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(BA1-4V) 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 Si-glass or Kevlar 49 fiber composites is presented. The specimen stress-strain behavior was determined, showing that mechanical properties of intraply hybrid composites can be measured with available methods such as the tens-degree off-axis test for intralaminar shear, and conventional tensile tests for tensile, flexure, and transverse impact properties. The results also showed that combinations of high modulus graphite/S-glass/epoxy matrix composites exist which yield intraply hybrid laminates with the best 'balanced' properties, and that the translation efficiency of mechanical properties from the constituent composites to intraply hybrids may be assessed with a simple equation. (A.T.)
A method for making aluminum-mica particle composites is presented in which mica particles are stirred into molten aluminum alloys followed by casting in permanent molds. Magnesium is added either as an alloying element or in the form of particles to the surface of the alloy melts to disperse up to 3 wt% mica powders in the melts and to obtain high recoveries of mica in the castings. The mechanical properties of the aluminum alloy-mica composite decrease with increasing mica content; however, even at 2.2% it has a tensile strength of 14.22 kg/sq mm with 1.1% elongation, a compression strength of 42.61 kg/sq mm, and an impact strength of 0.30 kgm/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 in-service and strength critical applications. Finally, it is concluded that acoustooptasonic techniques provide the 'methods of choice' in this area.

M.E.P.


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


Theoretical and experimental studies are reviewed whose objective was to gain insight into and predict the effects of time, temperature, and stress on the axial failure modes of boron fibers and B/AI 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

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 calculated from axial damping results for alumina-aluminum composites. The dynamic fiber data indicate essentially elastic behavior for both the silicon carbide and alumina fibers. In contrast, the boron-based fibers are strongly anelastic, displaying frequency-dependent moduli and very high microstructural damping. The single fiber damping results were compared with a 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.

(Author)


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

(N80-10318* # Avco Systems Div., Wilmington, Mass.

IMPROVING THE STRESS RUPTURE AND CREEP OF SILICON NITRIDE Final Report

Yttria-stabilized zirconium oxide (Zyttrite) additions to pumped silicon nitride markedly improved the high temperature strength, stress rupture and creep properties of hot pressed samples. Room temperature bend strengths, however, of four (4) compositions evaluated were each about one-third lower than the NC-132 silicon nitride composition. This difference decreased with increasing temperature until at 1200 C. There was reasonable equivalence between most of the zyttrite containing compositions and NC-132 in terms of short time bend strength measurements. At 1370 C the 10 and 20 wt. % containing zyttrite compositions showed bend strengths as much as double the NC-132 material. Bend stress rupture results for 10 and 20 wt. % yttria containing compositions showed a strong stress sensitivity at the 176 MN/m² (40 Kpsi) level above 1200 C. Creep in bending measurements showed that at 1370 C, yttria containing compositions exhibited creep rates that were about two orders of magnitude lower than NC-132 material samples. All compositions appeared to follow deformation kinetics related to a visco-elastic mechanism, i.e., glassy phase diffusional creep of grain boundary sliding.

(Author)

N80-10319# United Technologies Research Center, East Hartford, Conn.

DEVELOPMENT OF SILICON NITRIDE OF IMPROVED TOUGHNESS Final Report
J. J. Brennan 2 Oct. 1979 111 p refs (NASA-CR-159676; R79-914364-12) Avail. NTIS HC A06/MF A01 CSCL 11D

The application of reaction sintered Si3N4 energy absorbing surface layers to hot-pressed Si3N4 was investigated. The surface layer was formed by in-place nitridation of silicon powder. It was found that reaction sintered Si3N4 layers of 1 mm thickness, fabricated from either -100, +200, -325 mesh Si powder and nitrided in 96% N2/4% H2 so that approximately 20-25 vol % un nitrided Si remained in the layer, resulted in a 200% increase in ballistic impact resistance of a 0.64 cm thick hot-pressed Si3N4 substrate from RT 1370 C. NCX-34 Si3N4, with MgO additive, and NCX-34 Si3N4, with Y2O3 additive, were evaluated as substrate material. The finer grain size -200 and -325 mesh nitrided Si layers were for their use in N2/H2 mixtures, rather than pure N2, resulted in a microstructure that did not substantially degrade the strength of the hot pressed Si3N4 substrate. Thermal cycling tests on the RSSN/HPSN combinations from 200 C to 1370 C for 75 cycles in air did not degrade the impact resistance nor the interfacial bonding, although a large amount of internal silica formation occurred within the RSSN layer. Mach 0.65 hr, hot gas erosion tests showed no surface recession of RSSN layers at 1200 C and slight surface recession at 1370 C.

M.M.M.

N80-12118# TRW Equipment Labs., Cleveland, Ohio.

SECOND GENERATION PMR POLYMIDE/FIBER COMPOSITES

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

R.C.T.

N80-22407# Westinghouse Research and Development Center, Pittsburgh, Pa.

SILICONE MODIFIED RESINS FOR GRAPHITE FIBER LAMINATES Final Report

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

M.G.

N80-25382# Hamilton Standard, Windsor Locks, Conn.

DIFFUSION BONDED BORON/ALUMINUM SPAR-SHELL
The average load intensity transmitted to a through crack can be reduced by having the shear modulus of the inner layers to be larger than that of the outer layers. The simulated airfoil pressings 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.

C. E. K. Carlson, J. L. Cutler, W. J. Fisher, and J. V. W. Memmott
Design and process development tasks intended to demonstrate composite blade application in large high by-pass ratio turbofan engines are described. Studies on a 30 aspect ratio steel and sand 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 R/M ror system. This second configuration requires a smaller development effort and entails less risk to translate a design into a successful product. The feasibility of metal joining large subsonic spar and shell fan blades was demonstrated. Initial aluminum alloy flame treatment indicates a distinct preference for AA6061 aluminum alloy for use as a joint material. The simulated airfoil pressings established the necessity of rigid air surfaces when joining materials of different compressive rigidities. The two aluminum alloy matrix choices both were successfully formed into blade shells. A.R.H.

Sudden Stretching of a Four Layered Composite Plate Interim Report
G. C. Sih and E. P. Chen
Mar. 1980 42 p refs (Grant Nsg-3197) (NASA-CR-159670; IFSM-80-102) Avail: NTIS HC A03/MF A01 CSCL 11D
An approximate theory of laminated plates is developed by assuming that the extensional and thickness mode of vibration are coupled. The fixed 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.

A.R.H.

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

A.R.H.


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

A.R.H.
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.
CO concentrations significantly. Finally, comparison of computed residence time and CO decreasing with secondary residence time; concentrations, with NOx concentration independent of secondary fuel nitrogen content, minimum nitrogen oxide but secondary stage residence times of 1, 2 and 3 msec and fuel nitrogen 0.6 or 0.7, primary stage residence times from 12 to 20 msec, equivalence ratios between 1.4 and 1.5, with percentage conversion of fuel nitrogen to NOx decreasing with increased fuel nitrogen content, and additional secondary dilution is observed to reduce final pollutant contents of 0.6, 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. Secondary zone residence time is not observed to affect final NOx and 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.

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 0.6 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, and 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.

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

The amplification of a Reynolds number dependent process by wave distortion and the possibility of applying 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.

The Symposium focused on deflagration to detonation transition, coal combustion, turbulent combustion interactions, kinetics, furnace combustion, inhibition and ignition, flame structure and chemistry, combustion studies, measurement techniques, fire and explosion, engine combustion, and processes and explosions. 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 flows, dissociation of nitric oxide in shock waves, pollutant emissions from partially mixed turbulent flames, energy transfer and quenching rates of laser pumped electrochemically excited alkali flames, a study of flammability limits using counterflow flames, the unidirectional process of using the CATCOM catalyst for use in catalytically supported thermal combustion has been demonstrated at 5 atm, complementing a previous 1000 hour durability study at 1 atm. Both of these studies were conducted at about 840 K air preheat temperature at a reference velocity of about 14 m/s, the adiabatic flame temperature of the fuel/air mixture was about 1530 K. The catalyst proved to be capable of low emissions operations after 1000 hours of diesel fuel aging. However, more severe deactivation occurred in the 5 atm test, this was attributed to a loss in kinetic (ignition) activity.
26 METALLIC MATERIALS

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

N60-1034A 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: R.C.T.

N60-11188 National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MECHANICAL PROPERTIES AND OXIDATION AND CORROSION RESISTANCE OF REDUCED CHROMIUM 304 STAINLESS STEEL ALLOYS

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 austenitic alloys with only 12 percent Cr compare favorably with the 18 percent Cr in 304 stainless steel. Oxidation resistance and in most cases corrosion resistance for the experimental alloys were comparable to the commercial alloy. Effective substitutes for Cr included Al, Mo, Si, Ti, and V, while Ni and Mn contents were increased to maintain an austenitic structure. R.C.T.

N60-11189 National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF THERMALLY INDUCED POROSITY ON AN AS-HIP POWDER METALLURGY SUPERALLOY

The impact of thermally induced porosity on the mechanical properties of an as-hot-iso-statically-pressed and heat treated pressing made from low carbon Astroloy was determined. Porosity in the disk-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 ranges typical of commercial jet engine designs, the rim of the porous pressing had slightly inferior fatigue life to sound pressings. A.R.H.

N60-14232 National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
IMPROVED REFRATORY 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 if 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 to the initial stages of 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

N60-14234 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

The corrosion of sodium sulfate coated cobalt alloys was measured and the results compared to the cyclic oxidation of alloys with the same composition, and to the hot corrosion of compositionally equivalent nickel-base alloys. Cobalt alloys with sufficient aluminum content to form aluminum containing scales corrode less than their nickel-base counterparts. The cobalt alloys with lower aluminum levels form CO scales and corrode more than their nickel-base counterparts which form NO scales. M.G.

N60-15234 National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
ADHESION AND FRICTION OF IRON-BASE ALLOY SHAPES IN CONTACT WITH SILICON CARBIDE IN VACUUM
Kazuhiro Miyoshi and Donald H. Buckley Jan. 1980 13 p. refs (NASA-TP-1604, E-120) Avail NTIS HC A02/MF A01 CSCL 11F

Single pass sliding friction experiments were conducted with various iron-base binary alloys (alloying elements were Ti, Cr, Mn, Ni, Rh, and W) in contact with a single crystal silicon carbide /0001/ surface in vacuum. Results indicate that atomic size and concentration of alloying elements play an important role in controlling adhesion and friction properties of iron base binary alloys. The coefficient of friction generally increases with an increase in solute concentration. The coefficient of friction increases linearly as the solute to iron atomic radius ratio increases or decreases from unity. The chemical activity of the alloying elements was also an important parameter in controlling adhesion and friction of alloys, as these latter properties are highly dependent upon the d bond character of the elements. R.C.T.

N60-15235 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 Mar-M-500, 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.

**N80-18141**

National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**SCANNING-ELECTRON-MICROSCOPE STUDY OF NORMAL- IMPINGEMENT EROSION OF DUCTILE METALS**

William A. Brainard and Joshua Salk Jan 1980 11 p refs (NASA-TP-1608, E-085) Avail NTIS HC A02/MF A01 C5CL 11F

Scanning electron microscopy was used to characterize the erosion of annealed copper and aluminum surfaces produced by both single and multiple-particle impacts. Macroscopic 3-2 mm diameter steel balls and microscopic, brittle erodent particles were projected by a gas gun system so as to impact at normal incidence at speeds up to 140 m/sec. During the impacts by the brittle erodent particles, at lower speeds the erosion behavior was similar to that observed for the larger steel balls. At higher velocities, particle fragmentation and the subsequent cutting by the radial wash of debris created a marked change in the erosion mechanism. Author

**N80-18143**

National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**SOME CONSIDERATIONS OF THE PERFORMANCE OF TWO HONEYCOMB GAS PATH SEAL MATERIAL SYSTEMS**


A standard Hastelloy-X honeycomb material and a pack aluminode coated honeycomb material were evaluated as to their performance in labyrinth seal materials for a high-speed gas turbine engine. Consideration from published literature was given to the fluid sealing characteristics of two honeycomb materials in labyrinth seal applications, and their rub characteristics, erosion resistance, and fatigue resistance, were evaluated. The increased temperature potential of the coated honeycomb material compared to the uncoated standard could be achieved without compromising the honeycomb material's rub tolerance, although there was some penalty in terms of reduced erosion resistance. Author

**N80-17199**

National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**CHEMICAL PROCESSES INVOLVED IN THE INITIATION OF HOT CORROSION OF B-1900 AND NASA-TRW VIA**


Sodium sulfate induced hot corrosion of B-1900 and NASA-TRW VIA at 900 C was studied with special emphasis on the chemical reactions occurring during and immediately after the induction period. Thermogravimetric tests were run for set periods of time after which the samples were washed with water and water soluble metal salts and/or residual sulfates were analyzed chemically. Element distributions within the oxide layer were obtained from electron microprobe X-ray micrographs. A third set of samples were subjected to surface analysis by X-ray photoelectron spectroscopy. Evolution of SO2 was monitored throughout many of the hot corrosion tests. Results are interpreted in terms of base fluxing mechanisms. Authors

**N80-17200**

National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**ANISOTROPY OF NICKEL-BASE SUPERALLOY SINGLE CRYSTALS**


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 C 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. 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. Authors

**N80-18156**

National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

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


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

**N80-18167**

National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

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


A Mach 0.3 burner rig 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,

77
and 304 stainless steel. The impurities added as aqueous solutions to the combustor were salts of sodium, potassium, vanadium, molybdenum, tungsten, phosphorus, and lead. Extent of attack was determined by metal consumption and compared to the effects of sodium alone. Vanadium, molybdenum, tungsten, phosphorus, and lead in combination with sodium all resulted in increased attack as compared with sodium alone at some temperatures, apparently due to the extension of the formation of liquid deposits. Varying the sodium-potassium ratio had little effect for ratios less than 1:3 for which reduced, but measurable, attack was observed.

N80-20370$ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
AN EXPERIMENTAL, LOW-COST, SILICON ALUMINIDE
HIGH TEMPERATURE COATING FOR SUPERALLOYS
Stanley G. Young and Daniel L. Deadmore 1980 16 p refs
To be presented at the Intern Conf on Metal Coatings, San Diego, Calif. 21-25 Apr 1980, sponsored by the Am Vacuum Soc.
(NASA TM 81455, E 3851 Avail NTIS HC AO2/MF AO1 CSCL 11F
An evaluation of a duplex silicon slurry/alummide coating is presented. The coating is cyclically tested in Mach 1 combustion gases for oxidation and thermal fatigue resistance at 1093 °C and in Mach 0.3 gases for hot-corrosion resistance at 900 °C. The base metal superalloys are V2A and B1900. The coated B1900 specimens performed much better in oxidation than similar specimens coated with alumminides and almost as well as the more expensive Pt-Al and MCrAlY (where M is Ni and/or Co). Coatings deposited by the physical vapor deposition process. The coating also provided good corrosion protection. Microprobe studies are used to characterize the coating, determine failure mechanisms, and study some of the changes due to exposure.

N80-21488$ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
APPLICATION OF SUPERALLOY POWDER METALLURGY
FOR AIRCRAFT ENGINES
In the last decade, Government/Industry programs have advanced powder metallurgy near net shape technology to permit the use of hot isostatic pressed (HIP) turbine disks in the commercial aircraft fleet. These disks offer a 30% savings of input weight and an 8% savings in cost compared to cast and wrought disks. Similar savings were demonstrated for other rotating engine components. A compressor rotor fabricated from hot die-forged HIP superalloy billets revealed input weight savings of 54% and cost savings of 35% compared to cast and wrought parts. Engine components can be produced from compositions such as Rene 85 and Astrolloy by conventional casting and forging, by forging of HIP powder billets, or by direct consolidation of powder by HIP. However, each process produces differences in microstructure and introduces different defects in the parts. As a result, their mechanical properties are not necessarily identical. Acceptance methods should be developed which recognize and account for the differences.

N80-21489$ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
AN INVESTIGATION INTO THE ROLE OF ADHESION IN
THE EROSION OF DUCTILE METALS
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 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 u/E for the porous material

R C T

N80-22464⁎ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio EFFECTS OF YTTRIUM, ALUMINUM AND CHROMIUM CONCENTRATIONS IN BOND COATINGS ON THE PERFORMANCE OF ZIRCONIA-YTTRIA THERMAL BARRIERS
A cyclic furnace study was conducted on thermal barrier systems to evaluate the effects of yttrium, chromium, and aluminum in nickel base alloy bond coatings and the effect of bond coats toughness 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

N80-23430⁎ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio PRACTICAL APPLICATIONS OF SURFACE ANALYTICAL TOOLS IN TRIBOLOGY
A brief description of many of the widely used tools is presented. Of this list, those which have the highest applicability for giving elemental and/or compound analysis for problems of interest in tribology along with being truly surface sensitive (that is less than 10 atomic layers) are presented. The latter group is criticized 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

N80-26428⁎ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio IMPROVED PFS OPERATIONS: 400-HOUR TURBINE TEST RESULTS
A pressurized fluidized bed (PFB) coal-burning reactor was used to provide hot effluent gases for operation of a small gas turbine. Preliminary tests determined the optimum operating conditions 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 criticized 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

N80-26433⁎ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio THREE DIMENSIONAL FINITE-ELEMENT ELASTIC ANALYSIS OF A THERMALLY CYCLED DOUBLE-EDGE WEDGE GEOMETRY SPECIMEN Final Report, 1 Jul. 1977 - 1 Jan. 1979
An elastic stress analysis was performed on a wedge specimen (prismatic bar with double-edge wedge cross-section) subjected to thermal cycles in fluidized beds. Five alloys (IN 100, Mar-M 200, Mar-M 302, NASA TAZ-BA, and Rene 80) subjected to the same thermal cycling condition were analyzed. This condition was alternate 3 minute immersions in fluidized beds maintained at 316°C and 1098°C (600°F and 1900°F). The analyses were performed as a joint effort of two laboratories using different models and computer programs (NASA, AND AND 103DQ). Stress, strain, and temperature results are presented.

GRA

N80-31527⁎ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio ADHERENCE OF ION BEAM SPUTTER DEPOSITED METAL FILMS ON H-13 STEEL
An electron beam bombardment argon ion source was used to sputter deposit 17 different metal and metal oxide films ranging in thickness from 1 to 8 micrometers on H-13 steel substrates. The film adherence to the substrate surface was measured using a tensile test apparatus. Comparisons in bond strength were made between ion beam, ion plating, and RF deposited films. A protective coating to prevent heat checking in H-13 steel dies used for aluminum die casting was studied. The results of exposing the coated substrates to temperatures up to 700 degrees are presented.

R K G

N80-32464⁎ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio HIGH TOUGHNESS-HIGH STRENGTH IRON ALLOY Patent
An iron alloy is provided which exhibits strength and toughness characteristics at cryogenic temperatures. The alloy consists essentially of about 10 to 16 percent by weight nickel, about 0.1 to 1.0 percent by weight aluminum, and 0 to about 3 percent by weight copper, with the balance being essentially iron. The iron alloy is produced by a process which includes cold rolling at room temperature and subsequent heat treatment. Official Gazette of the U.S. Patent and Trademark Office

N80-32486⁎ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio FRACTURE TOUGHNESS OF BRITTLE MATERIALS DETERMINED WITH CHEVRON NOTCH SPECIMENS

79
The use of chevron-notch specimens for determining the plane strain fracture toughness (K sub IC) of brittle materials is discussed. Three chevron-notch specimens were investigated: short bar, short rod, and four-point-bend. The dimensionless stress intensity coefficient used in computing K sub IC is derived for the short bar specimen from the superposition of ligament-dependent and ligament-independent solutions for the straight through crack, and also from experimental compliance calibrations. Coefficients for the four-point bend specimen were developed by the same superposition procedure, and with additional refinement utilizing the slice model of Bluhm. Short rod specimen stress intensity coefficients were determined only by experimental compliance calibration. Performance of the three chevron-notch stress intensity factor relations were evaluated by tests on hot pressed silicon nitride and sintered aluminum oxide. Results obtained with the short bar and the four-point-bend specimens on silicon nitride are in good agreement and relatively free of specimen geometry and size effects within the range investigated. Results on aluminum oxide were affected by specimen size and chevron-notch geometry, believed due to a ringing crack growth resistance curve for the material. Only tabulated results for the short bar specimen are presented in detail M.G.

ASTAR 811C
The high vacuum creep behavior of Astar 811C (78-8W-1R-07H-002E) was studied over the temperature range 850 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 rate was related to time by the Gao to exponential function, and a second exponential term was developed to describe the tertiary creep portion of the creep curve. No significant periods of secondary (linear) creep were observed. The creep curves were well expressed by a relation that includes terms for primary and tertiary creep. The initial and tertiary creep rates were obtained by differentiating the respective terms from the strain time relation and can be related to temperature by using a dual activation energy to account for lattice and dislocation core diffusion. The strain parameters were determined as power functions of the applied stress.

A.R.H.

N80-33565* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LONG-TIME CREEP BEHAVIOR OF THE NIOTIUM ALLOY C-103
The creep behavior of C-103 was studied as a function of stress, temperature, and grain size for test times to 19000 hr. Over the temperature range 827 to 1204 C and the stress range 689 to 138 MPa, only tertiary (accelerating) creep was observed. The creep strain epsilon(t) can be related to time t by an exponential relation epsilon(t) = K e raised to power (at - 1), where epsilon(0) is initial creep strain, K is the tertiary creep strain parameter, and a is the tertiary creep rate parameter. The observed stress exponent 2.87 is similar to the three power law generally observed for secondary (linear) creep of Glass I solid solutions. The apparent activation energy 374 kJ/mol is close to that observed for self diffusion of pure niobium. The initial tertiary creep rate was slightly faster for fine grained than for coarse-grained material. The strain parameter K can be expressed as a combination of power functions of stress and grain size and an exponential function of temperature. Strain time curves generated by using calculated values for K and a showed reasonable agreement with observed curves to strains of at least 4 percent. The time to 1 percent strain was related to stress, temperature, and grain size in a similar manner as the initial tertiary creep rate.
R.K.G.

N80-33565* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPROVED BOND COATINGS FOR USE WITH THERMAL BARRIER COATINGS Final Report
The potential for improving the durability of thermal barrier coatings (TBCs) being developed for coal derived fuel fired gas turbines was studied. Furnace oxidation behavior of plasma deposited bond coatings was improved by increasing the thickness from 0.010 cm to 0.015 cm and by depositing the coatings at 20 kW with argon 3.5 vol% hydrogen arc gas rather than at 11 kW with argon. The most oxidation resistant plasma deposited bond coatings were Ni-14.1Cr-10.2Ni, Ni-14.3Cr-14.4Al, 0.16Y, and Ni-15.8C-12.8Al-0.36Y on B-1900 + Hf and Ni-30.3Cr-11.1Al-0.48Y on MAR-M509. The oxidation resistant bond coatings improved TBC life when the coatings were deposited on the specimens supported on a nail bed fixture during coating.

A.R.G. 10043 * The erosion/corrosion of small superalloy turbine rotors operating in the effluent of a FBG coal combustor. G.

N80-32487* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF TWO-LAYER THERMAL BARRIER SYSTEMS ON DIRECTIONALLY SOLIDIFIED NI-AL-Mo AND COMPARATIVE EFFECTS OF ALLOY THERMAL EXPANSION ON SYSTEM LIFE
A promising two-layer thermal barrier coating system (TBS), Ni-16.4Cr-5.1Al-0.16Y/ZrO2-6.1Y2O3 (all in weight percent), was identified for directionally solidified Ni-Al-Mo (gamma'/gamma' alpha) alloys. In cyclic furnace tests at 1095 C, this system on gamma/gamma' alpha was better than Ni-16. 4Cr-5.1Al-0.16Y/ZrO2-7Y2O3 by about 50 percent. In natural gas - oxygen torch rig tests at 1250 C, the Ni-16.4Cr-5.1Al-0.16Y/ZrO2-6.1Y2O3 coating was better than the Ni-15Cr-2Y2O3 coating by 95 percent, on MAR-M59 substrates and by 60 percent on gamma/gamma' alpha substrates. Decreasing the coefficient of thermal expansion of the substrate material from 17-18 x 10 to the -6 power/C (MAR-M200 + Hf and MAR-M590) to 11Xx10 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-5.1Al-0.16Y/ZrO2-6.1Y2O3 was about 30 percent better on gamma/gamma' alpha than on MAR-M59 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.

N80-32488* 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
Seven candidate iron-base alloys for heater tube application in the Stirling automotive engine were aged for 3500 hours at 760 C in argon and hydrogen. Aging degraded the tensile and creep-rupture properties. The presence of hydrogen during aging caused additional degradation of the rupture strength in fine grain alloys. Based on current design criteria for the Mod 1 Stirling engine, N-155 and 19-9DL are the only alloys in this study with strengths adequate for heater tube service at 760 C.

N80-32498* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LONG-TIME CREEP BEHAVIOR OF THE TANTALUM ALLOY

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. Integally cast alloy 713LC and IN792 + Hf superalloy turbine rotors in a single-stage turbine with 6% 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).


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-timing mechanisms. Thruster control algorithms are also presented. The test lasted 2700 hr of a planned 3,000 hr test with a 2-series 30 cm thruster. The fast 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 startups, throttling, and variety of off-normal conditions.


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


The microstructural development of Al2O3 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 resulted from an excess number of oxygen vacancies near the oxide-metal interface. Short-circuit diffusion paths were discussed in reference to current growth stress models for oxide scales. Transient oxidations of pure, Y-doped, and Zr-doped NiCrAl was also examined. Oriented alpha-(Al,Cr)2O3 and NiAl(Cr)2O4 scales often coexisted in layered structures on all three alloys. Close-packed oxygen planes and directions in the corundum and spinel layers were parallel. The close relationships between oxide layers provided a gradual transition from initial transient scales to steady state Al2O3 growth.
etching were used to characterize the interfacial regions, and an attempt was made to correlate adherence as measured in wear tests with the chemical nature of the interface. (Author)


The isothermal oxidation of Ni-14Cr-24Al-Zr-type alloys was performed in still air at 1100, 1150, and 1200 C for times up to 200 hr. The zirconium content of the alloys varied from 0.63 atom percent Zr(at).

The oxidized surfaces were studied by optical microscopy, X-ray diffraction, and scanning electron microscopy. The base alloy was an aluminia former with the zirconium-containing alloys also developing some ZrO2. The addition of zirconium above 0.68 at% increased the rate of weight gain relative to the base alloy. Due to oxidation 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 WA vs. time data fit the parabolic model of oxidation.

The specific diffusional mechanism operative could not be identified by analysis of the calculated activation energies. Measurements of the Al2O3 scale lattice constants yielded the same values for all alloys. (Author)
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
Y. G. Kim and H. F. Merrick May 1979 37 p refs
(Contract NAS3-20093) Available NTIS HC A03/MF A01 CSCL 11F
Alloy MA 6000E was developed by the mechanical alloying process for turbine blade applications. The nominal composition of the experimental alloy is Ni-15Cr-2Mo-4W-4.5Al-2.5Ti-2Ta-
11F
The effects of crystal orientation on the mechanical properties of single crystals of the nickel-based superalloy Mar-M247 are investigated. Tensile tests at temperatures from 23 to 1093 C and stress rupture tests at temperatures from 700 to 1038 C were performed for 32 single crystals at various orientations. During tensile testing between 23 and 760 C, single crystals with high Schmid factors were found to be favorably oriented for slip and to exhibit lower strength and higher ductility than those with low Schmid factors. Crystals which required large rotations to become oriented for cross slip were observed to have the shortest stress rupture lives at 760 C, while those which required little or no rotation had the longest lives. In addition, stereographic triangles obtained for Mar-M247 and Mar-M200 single crystals reveal that crystals with orientations near the -111 had the highest lives, those near the 001 had high lives, and those near the 011 had low lives.
A.L.W.
ABRASIVE COMPRESSOR AND TURBINE SEALS, VOLUME 1
D. V. Sundberg, R. E. Dennis, and L. G. Hurst May 1979 178 p
(Contract NAS3-20073) Available NTIS HC A09/MF A01 CSCL 11A
The application and advantages of abrasive 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.
N80-15233*# Pittsburgh Univ. Pa Dept of Metallurgical and Materials Engineering
T. T. Huang and G. H. Meier 1979 70047 p refs
(Grant NsG 3214) (NASA CR 159718; SETEC MME 79 61; SAR 21) Available NTIS HC A03/MF A01 CSCL 11F
The commercial nickel base alloy, IN-738, and high purity laboratory alloys were prepared to simulate the effects of the major elements in IN-738. Results indicate that the initiation of hot corrosion attack of IN-738 and other similar alloys is the result of local penetration of molten salt through the protective oxida scale.
R.C.T.
N80-16142*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.
STRESS CORROSION CRACKING EVALUATION OF MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS
(Contract NASM-78257) Available NTIS HC A03/MF A01 CSCL 11F
The resistance of the martensitic precipitation hardening stainless steels PH13-8Mo, 15-5PH, and 17-4PH to stress corrosion cracking was investigated. Round tensile and c-ring type specimens taken from several heats of the three alloys were stressed up to 100 percent of their yield strengths and exposed to alternate immersion in salt water, to salt spray, and to a seaweed environment. The results indicate that 15-5PH is highly resistant to stress corrosion cracking in conditions H1000 and H1050 and is moderately resistant in condition H800. The stress corrosion cracking resistance of PH13-8Mo and 17-4PH stainless steels in conditions H1000 and H1050 was sensitive to mill heats and ranged from low to high among several heats included in the tests. Based on a comparison with data from seaweed environmental tests, it is apparent that alternate immersion in 3.5 percent salt water is not a suitable medium for accelerated stress corrosion testing of these PH stainless steels. A.R.H.
N80-18156*# United Technologies Research Center, East Hartford, Conn.
STUDY OF THE EFFECTS OF GASEOUS ENVIRONMENTS ON THE HOT CORROSION OF SUPERALLOY MATERIALS. Final Report
John G. Smeggi and N. S. Bornstein 5 Feb. 1980 93 p
(Contract NAS3-21376) Available NTIS HC A05/MF A01 CSCL 11F
The effect of the gaseous corrodent NaCl on the high temperature oxidation and sodium sulfate induced hot corrosion behavior of alumina formers, chromia formers, and the superalloy B-1900 was examined. Isothermal experiments were conducted at 900 C and 1050 C in air in the presence and absence of NaCl vapors. Microstructural changes in oxide morphology and increased rates of oxidation were observed when NaCl(g) was present. It is hypothesized that the accelerated rates of oxidation are the result of removal of aluminum from the scale substrate interface and the weakening of the scale substrate bonds. The aluminum removed was redeposited on the surfaces in the form of alumina whiskers. For the superalloy B-1900, alumina whiskers are also formed, and the alloy oxidizes at catastrophic rates. In the case of Ni-25Cr alloy, NaCl vapors interact with the scale depleting it of chromium. R.C.T.
A coated specimen of 262 HRC 38, 266 HRC 37 and 266 HRC 38, 40; 754; and 956. Specimens in the bare condition of systems, were cycled between fluidized beds maintained at 1130 C with a three minute immersion in each bed. The systems included alloys identified as 262 in hardness of HRC 38; 264 in hardness of HRC 38, 40 and 43; 265 HRC 39, 266 HRC 37 and 40; 754; and 956. Specimens in the bare condition of 265 HRC 39 and 266 HRC 37 survived 6000 cycles without cracking on the small radius of the double edge wedge specimen.

A coated specimen of 262 HRC 38, 266 HRC 37 and 266 HRC 38 also survived 5250 cycles without cracking. A duplicate specimens of 262 HRC 38 alloy survived 5250 cycles before cracks appeared. All the alloys showed little weight change compared to alloys tested in prior programs.

**THERMAL FATIGUE AND OXIDATION DATA OF OXIDE DISPERSION-STRENGTHENED ALLOYS**

K. E. Hofer, V. L. Hill, and V. E. Humphreys

Mar 1980 42 p refs

(Contract NAS3-17787)


Thermal fatigue and oxidation data were obtained on four specimens representing 9 discrete oxide dispersion-strengthened alloy compositions of fabricating techniques. Double edge wedge specimens, both bare metal and coated for each system, were cycled between fluidized beds maintained at 1130 C with a three minute immersion in each bed. The systems included alloys identified as 262 in hardness of HRC 38; 264 in hardness of HRC 38, 40 and 43; 265 HRC 39, 266 HRC 37 and 40; 754; and 956. Specimens in the bare condition of 265 HRC 39 and 266 HRC 37 survived 6000 cycles without cracking on the small radius of the double edge wedge specimen.

A coated specimen of 262 HRC 38, 266 HRC 37 and 266 HRC 38 also survived 5250 cycles without cracking. A duplicate specimen of 262 HRC 38 alloy survived 5250 cycles before cracks appeared. All the alloys showed little weight change compared to alloys tested in prior programs.
27 NONMETALLIC MATERIALS

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

N80-13254
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 thermochimical 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 temperatures 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 lower than those for HS-130 (hot pressed Si3N4). The high purity, fully dense, and stable grain 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.

N80-13256
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 turbine elements. The reactions were followed by X-ray diffraction analysis, BaZrO3 and 2CaO·SiO2 both reacted with PbO, V2O5, CaO, Al2O3, MgO, and Co and Ba2ZrO3 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 26 DEG TO 60 DEG IN AIR
Harold E. Sliney and Thomas P. Jacobson 1979 20 p refs (NASA-TM-79316; E-189) Avail. NTIS HC A02/MF A01 CSCL 11F

Four different compositions of self-lubricating, plasma-sprayed, composite coatings with calcium fluoride dispersed throughout cobalt alloy-silver matrices were evaluated on a friction and wear apparatus. In addition, coatings of the cobalt alloys alone and one coating with a nickel alloy-silver matrix were evaluated for comparison. The wear specimens consisted of two, diametrically opposed, flat rub shoes sliding on the coated, 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 1200 °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 900 °C compared to about 1200 °C for the nickel composite coating.

N80-16165
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MECHANISMS OF LUBRICATION AND WEAR OF A BONDED SOLID LUBRICANT FILM

To obtain a better understanding of how bonded solid lubricant films lubricate and wear (in general), the tribological properties of polynime-bonded graphite fluoride films were studied (in specific). A pin-on-disc type of testing apparatus was used; 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 occur: In the first, the film supported the load. The lubricating mechanism consisted of the shear of a thin surface layer of the film between the rider and the bulk of the film. The second occurred after the bonded film had worn to the substrate, and consisted of the shear of very thin lubricant films between the rider and flat plateaus generated on the metallic substrate asperities. The film wear mechanism was strongly dependent on contact stress. M.M.M.

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 STRESSES
Robert L. Fusaro Jan. 1980 27 p refs (NASA-TP-1584; E-9990) Avail. NTIS HC A03/MF A01 CSCL 11H

The tribological properties of polynime-bonded graphite fluoride films were studied with a pin-on-disc friction apparatus. A 440 C HT stainless steel rider with a 0.95 millimeter diameter flat area was slid against the film in order to achieve a light, closely controlled contact stress. A 1 kilogram load was applied to this flat to give a projected contact stress of 14 megapascals. Two stages of lubrication were operating. In the first stage, the film supported the load and the lubricating mechanism appeared to be the shear of a thin surface layer of the film between the rider and the bulk of the film. The second stage began after the original film was worn away, and the lubricating mechanism appeared to be the shear of very thin lubricant layers between the flat area on the rider and flat plateaus generated on the sandblasted asperities of the metallic substrate. The major difference between the lubricating mechanisms of the hemispherical and flat riders was that the flat were 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
performed in air on nine different types of polyimides applied to stresses imparted by the deformation of the soft substrate under to study the tribological properties of seven different polyimide applications than the other four. K.L.

The adherent properties of PIC-2 and PIC-5. It was concluded that as far as thermal stability and adherence are concerned, more thermally stable than the others; however, it did not possess the ability of the films to withstand the high localized tensile stresses imparted by the deformation of the soft substrate under sliding conditions. The friction coefficients obtained for six of the 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 inability of the films to withstand the high localized 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. K.L.

N80-18181† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

COMPOSITE WALL CONCEPT FOR HIGH TEMPERATURE TURBINE SHROUDS: SURVEY OF LOW MODULUS STRAIN ISOLATOR MATERIALS

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 FeNi4Al NiAl (heat treated to achieve a 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 changes in temperature, 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 damages to the ceramic. K.L.

N80-20398† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio


Sliding friction experiments, conducted with various iron base alloys (alloying elements are Ti, Cr, Mn, Ni, Rh and W) in contact with a single crystal silicon carbide /0001/ surface in vacuum are discussed. Results indicate atomic size misfit 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 an intrinsic effect involving the resistance of 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. M.G.
STABILITY WEAR AND FRICTION IN BOUNDARY LUBRICATION OF STEEL SURFACES


A friction and wear study was made at 20 C to obtain improved reproducibility and reliability in boundary lubrication testing. Ester-base and C-ester-base fluids were used to lubricate a pure iron slider in sliding contact with a rotating M-50 steel disk in a friction and wear apparatus. Conditions included loads of 1/2 and 1 kg and sliding velocities of 3.2 to 18.2 m/min in a dry air atmosphere to prevent process-induced changes in friction and wear in boundary lubrication for this apparatus were found to be 1 kg load; sliding velocities of 7.1 to 9.1 m/min (50 rpm disk speed); and use of a time stepwise test procedure. 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.

FORMATION OF POROUS SURFACE LAYERS IN REACTION BONDED SILICON NITRIDE DURING PROCESSING

N. J. Shaw and T. K. Glasgow 1979 24 p

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 nitride 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 packed in Si powder; (3) bars packed in Si3N4 powder. Packing the bars in either Si or Si3N4 powder during sintering retarded formation of the layer of large porosity. Only packing the bars in Si prevented formation of the layer during 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.

THERMAL SHOCK RESISTANCE TO PLASMA-SPRAYED CERAMIC GAS-PATH SEALS


The cyclic thermal shock resistance of several outer air, gas path seal systems for high pressure turbines was evaluated. In all these systems, plasma sprayed, yttria stabilized ZrO2 was the ceramic constituent. The most promising approaches were those that had a porous-metal, low modulus pad as a strain isolator between the ceramic layer and the dense metal substrate. Cooling pins extending into the low modulus pad significantly reduced the oxidation rate of the porous metal and the extended seal life. The thermal shock resistance of ceramic layer was improved by increasing its porosity and by precracking it before thermal shock testing. Microstructural and probe studies suggested that the long term durability of the high-pressure turbine seal systems would be adversely affected if the metal ceramic interfaces exceeded about 800 C because some metallic species would rapidly diffuse.

LOW TEMPERATURE CROSS LINKING POLYIMIDES Patent

Tito T. Serafini and Peter Delviss, inventors (to NASA) Filed 20 Jun. 1980 14 p

A way of forming a prepolymer polyimide which can be cross-linked at a relatively low temperature is disclosed. Usually a polyimide is formed by cross linking a prepolymer formed by reacting a polyfunctional ester, a polyfunctional amine, and an end-capping unit. By providing a styrene derivative end-capping unit, the prepolymer is curable at a temperature of about 175 to 245 C.

EFFECT OF W AND WC ON THE OXIDATION RESISTANCE OF YTTRIA-DOPED SILICON NITRIDE

Susan Schulz. 30 Apr. 1980 12 p

The effect of W and WC contamination on the oxidation and cracking in air of sintered Si3N4 - 8 Y2O3 ceramics at 500, 750, and 1350 C 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 WC W.
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 melilite 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 melilite phase. No intermediate temperature instability was observed in bars containing 2 w/o 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 w/o WC which was preoxidized at 1350 C had improved oxidation resistance at 750 C. The tendency to oxidation and cracking of Si3N4 - 8 Y2O3 at 750 C is concluded to be related to tungsten content of the sintered bars. M G

**N80-23518** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio


A self supporting sheet composition 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

A80-12094 **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-1B-6, B p 25 refs.

Boundary lubricating characteristics, thermal stability and oxidation-corrosion stability were determined for two types of polyimide and a perfluoropolyimide polymer. 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 Cether. 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: perfluoropolyimide triazine greater than polyether greater than C-ether greater than fluorinated polyether.

Author
Thus, polvimide bonded graphite fluoride films appear to be good candidates for solid lubrication applications where long thermal soak times are prevalent.


Results are presented for an investigation designed to characterize the microstructure of controlled nucleation thermochromal deposition (CNDT) 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 CNDT 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 CNDT shows potential for high-temperature structural applications, provided that pertinent problems are resolved.

A80-13065 * # Mechanical and chemical effects of in-texturizing 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.


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


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


Thin, sputter-deposited MoS2 films with thicknesses ranging from 2000 to 6000 A 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).


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 reduce 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.


An investigation is reported of improving the durability of plasma sprayed ceramic coatings for the vane platforms in the J79-3D turbofan engine. The program aims for reduced fuel consumption of commercial aircraft engines; the use of improved strain tolerant
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)


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 densified to 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 in 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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A.L.W.


Sintering of powder of a new composition composed of 92 wt% Si3N4, 8 wt% Y2O3, and a small amount of other oxides, was carried out in nitrogen at 1800 °C without significant scale growth. The microstructure of the sintered material was similar to that of unoxidized material. The oxidation resistance of the sintered material was found to be better than that of unoxidized material.

A.W.


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 coefficients reveal large discrepancies, in marked contrast to the good agreement obtained for polymers.

(Author)


Ease of preparation and testing are advantages unique to the chevron-notch specimen used for the determination of the plane
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/stops during rotor lift-off and touchdown and occasional short time, high speed rubs under representative loading of the engine. Some dozen coating variations of Co-graphite, Cr2O3 (by sputtering) and CrFe (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.

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 NAS3 20406)
(NASA-CR 159745, TRW-31782 6082 RU 00) Avail: NTIS
HC AOS/MF A01 CSCI 07C
A suitable method for the direct measurement of moisture concentrations after humidity/thermal exposure on state of the art epoxy and polyamide resins and their graphite and glass fiber reinforcements was investigated. Methods for the determination of moisture concentrations, profiles, moisture diffusion modeling and moisture effects on state of the art mechanical changes were examined. Carefully fabricated, precharacterized epoxy and polyamide neat resins and their AS graphite and S glass-reinforced composites were exposed to humid conditions using L-key water (10:20) at ambient and elevated temperatures. These specimens were fixture to theoretically limit the D2O permeation to a unidirectional penetration axis. The analytical techniques evaluated were (1) laser pyrolysis gas chromatography mass spectrometry, (2) solids probe mass spectrometry, (3) laser pyrolysis conventional infrared spectroscopy, and (4) infrared imaging thermovision. The most reproducible and sensitive technique was solids probe mass spectrometry. The fabricated exposed specimens were analyzed for D2O profiling after humidity/thermal conditioning at three exposure time durations.

N80-17221# Aerotherm Acurex Corp. Mountain View, Calif Aerospace Systems Div
SYNTHESIS OF IMPROVED PHENOLIC RESINS Final Report
C B Delano and A H McLeod 4 Sep 1979 115 p refs
(Contract NAS3-21368)
(NASA-CR-159724, FR-79-25(AS)) Avail: NTIS
HC AOS/MF A01 CSCI 11G
Twenty seven addition 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, allyl, acrylate, methacrylate and ethynyl derivatized phenolic oligomers were investigated. The novolac-cyanate and propargyl
novolac resins provided anerobic char yields at 800 C of 56 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 Thornel 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 strength 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 177 C. Air heat aging of the novolac-cyanate and epoxy novolac based composites for 12 weeks at 204 C showed good property retention.

(Contract No. DEN3-101, (879.13/70-20-06)
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 benefit 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.

A80-13066# State-of-the-art of SIALON 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 'SIALON'S 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 SIALONs. Also discussed are the essential features of compositions, fabrication methods, and microstructures. In addition, consideration is given to high temperature flexure 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 SIALON materials for use in advanced gas turbine engines.

591

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


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 3500 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.


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.
28 PROPELLANTS AND FUELS
Includes rocket propellants, igniters, and oxidizers, storage and handling, and aircraft fuels
For related information see also 27 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, and 44 Energy Production and Conversion

N80-13266* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
TEMPERATURE AND FLOW MEASUREMENTS ON NEAR-FREEZING AVIATION FUELS IN A WING-TANK MODEL
Robert Friedman and Francis J Stockemer 1980 18 p ref
(NASA-TM-79285, E-158) Avail NTIS HC A02/MF A01 CSCL 21D

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

K L

N80-18205* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
INITIAL CHARACTERIZATION OF AN EXPERIMENTAL REFEREE BROADENED-SPECIFICATION (ERBS) AVIATION TURBINE FUEL
George M. Prok and Gary T. Seng Jan. 1980 10 p ref
(NASA-TM-81440, E-206) Avail NTIS HC A02/MF A01 CSCL 21D

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

J M S

N80-20402* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
ATOMIC HYDROGEN STORAGE Patent

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

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

N80-21661* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
MECHANICAL IMPACT TESTS OF MATERIALS IN OXYGEN EFFECTS OF CONTAMINATION
Paul M. Oden Washington Apr 1980 36 p ref
(NASA-TM-1571, E-047) Avail NTIS HC A02/MF A01 CSCL 20K

The effect of contaminants on the mechanical impact sensitivity of Teflon, stainless steel, and aluminum in a high-pressure oxygen environment was investigated. Uncontaminated Teflon did not ignite under the test conditions. The liquid contaminants - cutting oil, motor lubricating oil, and toolmaker dye - caused Teflon to ignite. Raising the temperature lowered the impact energy required for ignition. Stainless steel was insensitive to ignition under the test conditions with the contaminants used. Aluminum appeared to react without contaminants under certain test conditions, however, contamination with cutting oil, motor lubricating oil and toolmaker dye increased the sensitivity of aluminum to mechanical impact. The grit contaminants silicon dioxide and copper powder did not conclusively affect the sensitivity of aluminum.

A R H

N80-23472* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
THE IMPACT OF FUELS ON AIRCRAFT TECHNOLOGY THROUGH THE YEAR 2000
(NASA-TM-81492, E-429) Avail NTIS HC A03/MF A01 CSCL 21D

The impact that the supply, quality, and processing costs of future fuels may have on aircraft technology is assessed. The potential range of properties for future jet fuels is discussed along with the establishment of a 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 is examined. The impact of technical and economic trade-offs within the overall fuel production-air transportation system associated with variations in fuel properties are examined.

M G

N80-25454* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
ANALYTICAL AND EXPERIMENTAL EVALUATIONS OF THE EFFECT OF BROAD PROPERTY FUELS ON COMBUSTORS FOR COMMERCIAL AIRCRAFT GAS TURBINE ENGINES
(NASA-TM-81498, E-433) Avail NTIS HC A02/MF A01 CSCL 21D

The impact of broad property fuels on the design, performance, durability, emissions, and operational characteristics of current and advanced combustors for commercial aircraft gas turbine engines were studied. The effect of fuel thermal stability on engine and airframe fuel system was evaluated. Tradeoffs between fuel properties, exhaust emissions, and combustor life were also investigated. Results indicate major impacts of broad property fuels on allowable metal temperatures in fuel manifolds and injector support, combustor cyclic durability, and somewhat lesser impacts on starting characteristics, lightoff, emissions, and smoke.

E D K

N80-27508* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
USE OF PETROLEUM-BASED CORRELATIONS AND ESTIMATION METHODS FOR SYNTHETIC FUELS
A. C. Antoine Jun. 1980 23 p ref
(NASA-TM-81533, E-485) Avail NTIS HC A02/MF A01 CSCL 21D

Correlations of hydrogen content with aromatics content, heat of combustion, and smoke point are derived for some synthetic fuels prepared from coal and oil. Comparing the results
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 of the equations that exceed the critical statistics values.

Comparison of the measured hydrogen content by the standard S13M combustion method with that by a nuclear magnetic resonance (NMR) method show 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 GROAENED PROPERTY AIRCRAFT FUELS


Possible changes in fuel properties are identified based on current trends and projections. The effect of these changes with respect to the aircraft fuel system are examined and some technological approaches to utilizing those fuels are described.

R.C.T.

NBO-29502* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SOME ADVANTAGES OF METHANE IN AN AIRCRAFT GAS TURBINE


Liquid methane, which can be manufactured from any of the hydrocarbon sources such as coal, shale biomass, and organic waste considered as a petroleum replacement for aircraft fuels.

A simple cycle analysis is carried out for a turboprop engine flying a Mach 0.8 and 10, 688 meters (35,000 ft.) altitude. Cycle performance comparisons are rendered for four cases in which the turbine cooling air is cooled or not cooled by the methane fuel. The advantages and disadvantages of involving the fuel in the turbine cooling system are discussed. Methane combustion characteristics are appreciably different from Jet A and will require different combustor designs. Although a number of similar difficult technical problems exist, a highly fuel efficient turboprop engine burning methane appears to be feasible. A R H

NBO-31821* 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.


Freezing behavior, pumpability, and temperature profiles for aviation turbine fuels were measured in a 190-litter tank, to simulate internal temperature gradients encountered in commercial airplane wing tanks. Two low-temperature situations were observed. Where the bulk of the fuel is above the specification freezing point, pumpout of the fuel removes all fuel except a layer adhering to the bottom chilled surfaces, and the unpumpable fraction depends on the fuel temperature near these surfaces. Where the bulk of the fuel is at or below the freezing point, pumpout ceases when solids block the pump inlet, and the unpumpable fraction depends on the overall average temperature.


A high pressure research combustor operating over a wide range of burner inlet conditions was used to determine the effects
The contribution of polycyclic aromatics to soot formation was equivalent to a reduction in fuel hydrogen content of about one percent. The fuel sensitivity to soot formation due to the polycyclic aromatic contribution decreased as burner inlet pressure and fuel/oil ratio increased.

R.C.T.
31 ENGINEERING (GENERAL)
Includes vacuum technology; control engineering, display engineering, and cryogenics.

N80-13317f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
EVALUATION OF CLEANERS FOR PHOTOVOLTAIC
MODULES EXPOSED IN AN OUTDOOR ENVIRONMENT
Final Report:
W D Knapp Oct 1979 17 p refs
(Contract DE-AO1-79ET-20485)
(NASA-TM-79248; E-204; DOE/NASA/20485-79/5) Avail:
NTIS HC A02/MF A01 CSCL 13H
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 detergents in cleaning encapsulated modules.

N80-16232f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
HOMOGENEOUS ALIGNMENT OF NEMATIC LIQUID
CRYSTALS BY ION BEAM ETCHED SURFACES
(NASA-TM-81378; E-283) Avail: NTIS HC A02/MF A01 CSCL 20L
A wide range of ion beam etch parameters capable of producing uniform homogeneous alignment of nematic liquid crystals on SiO2 films are discussed. The alignment surfaces were generated by obliquely incident (angles of 5 to 25 deg) argon ions with energies in the range of 0.5 to 2.0 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 ZrO2 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.

N80-15300f Massachusetts Inst of Tech., Cambridge Dept. of Materials Science and Engineering.
DIRECTIONAL SOLIDIFICATION AT ULTRA-HIGH THERMAL GRADIENT Final Report
M. C. Flemings, D. S. Lee, and M. A. Neff Jan. 1980 34 p refs
(Grant NSG-3046)
(NASA-CR-169787) Avail: NTIS HC A03/MF A01 CSCL 13H
A high gradient controlled solidification (HGC) furnace was designed and operated at gradients up to 1800 C/cm to continuously produce aluminum alloys. Rubber '0' 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.

N80-18210f Southwest Research Inst., San Antonio, Tex.
PREDICTION OF FRAGMENT VELOCITIES AND TRAJECTORIES
J. J. Kulesz, L. M. Vargas, and P. K. Moseley 19 Oct. 1979
(Contract NASA-20497) Avail: NTIS HC A09/MF A01 CSCL 20K
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.

Cryogenic air-separation process cycle variations and compression schemes are examined. They are designed to minimize net system power required to supply pressurized, oxygen-enriched air to the combustor of an MHD power plant with a coal input of 2000 MWt. Power requirements and capital costs for oxygen production and enriched air compression for enrichment levels from 13 to 50% are determined. The results are presented as curves from which total compression power requirements can be estimated for any desired enrichment level at any delivery pressure. It is found that oxygen enrichment and recuperative heating of MHD combustor air to 1400 F yields near-term power plant efficiencies in excess of 46%. A minimum power compression system requires 187 MW to supply 330 lb of oxygen per second and costs roughly 100 million dollars.
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.

A QUANTITATIVE ANALYSIS OF INTER-ISLAND TELEPHONE TRAFFIC IN THE PACIFIC BASIN REGION (PSR)

As part of NASA's continuing assessment of future communication satellite requirements, a study was conducted to quantitatively scope current and future telecommunication traffic demand in the South Pacific Archipelagos. This demand was then converted to equivalent satellite transponder capacities. Only demand in the South Pacific Archipelagos. This demand was quantitatively scope current and future telecommunication traffic elements. To illustrate the approach, the results of 30/20 GHz study about two-thirds of a satellite transponder would be needed to satisfy the base-year (1976-1977) requirement and about two-thirds of a satellite transponder would be needed to satisfy the forecasted 1985 requirement. Author


The purpose of the paper is to investigate and study in-depth market and system analysis for improving satellite communications. The analyses fall into two categories: the broad, scoping efforts intended to screen potential candidates and studies to develop viable operational system configurations and identify critical technology elements. To illustrate the approach, the results of 30/20 GHz study efforts which have been under way in the past few years are reviewed in detail. C.F.W.


This paper discusses various aspects of the 30/20 GHz wideband technology verification activities of NASA. The discussion considers the objectives, approach, system requirements, possible experiment configuration and payload, and the supporting research and technology elements. (Author)


The development of a 1978 NASA study to identify technology requirements is surveyed, and its principal conclusions, recommendations, and priorities are summarized. In addition, antenna, traveling wave tube, and solid state amplifier developments representing selected items from the current communications technology development programs at the NASA Lewis Research and Goddard Space Flight Centers are described. M.E.P.


A program plan is presented for a space 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 R&D 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 to two voice channel support to direct-to-user mode, to multiple 500 mbps trunking channel support. Advanced satellite capabilities are utilized to minimize the cost of small terminals. In a system with thousands of small terminals, this approach results in minimum system cost. Author


The baseline 30/30 GHz satellite communication system, designed for cost-effective communications in the years 1990 to 2000, incorporates on-board satellite demodulation and routing of individual 64 kbps digital voice-grade circuits. This level of routing flexibility is necessary to provide efficient communications to the large number of direct-to-user terminals (DTU) projected. The circuit interfacing hardware is distributed among all the DTU and master control stations. The switching circuitry which provides full interconnectivity between 30 to 45 thousand circuits is in the satellite. The DTU terminal cost, perhaps the largest element in the system cost, represents the largest economic value element of the system because it avoids using terrestrial signal distribution.
and routing and the charges associated with these functions. Satellite baseline design and power requirements for the system are examined.

**M.O.M.**

**NBO-1127**

**CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM, VOLUME 1**

R. Jorasch, M. Baker, R. Davies, L. Cuccia, and C. Mitchell

1 Nov 1979

169 p 3 Vol.

(Contract NAS3-21362)

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

NASA-CR-159682: MTR-3787-Vol-1

Avail: NTIS

HC A03/MF A01 CSCL 178

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.O.M.

**NBO-1127**

**CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM, VOLUME 1A:**

M. Baker, R. Davies, L. Cuccia, and C. Mitchell

1 Nov 1979

181 p refs 3 Vol.

(Contract NAS3-21362)

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

NASA-CR-159680: WDL-TR4857-Vol-1

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; (7) Values of attenuation for selected U.S. cities; and (8) Additional considerations.

M.O.M.

**NBO-1127**

**CONCEPTS FOR 18/30 GHz SATELLITE COMMUNICATION SYSTEM STUDY, EXECUTIVE SUMMARY**

R. Jorasch, M. Baker, R. Davies, L. Cuccia, and C. Mitchell

1 Nov 1979

36 p 3 Vol.

(Contract NAS3-21362)

(Contract NAS3-21366)


Avail: NTIS

HC A06/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 are presented. It was determined that K sub A band systems can incur a small communications outage during heavy rainfall periods and that reducing the outage to zero would lead to prohibitive system costs. On the other hand, the economics of scale, i.e., one spacecraft accommodating 2.5 GHz transmission bands is presented. It was determined that K sub A band systems can incur a small communications outage during heavy rainfall periods and that reducing the outage to zero would lead to prohibitive system costs. On the other hand, the economics of scale, i.e., one spacecraft accommodating 2.5 GHz transmission bands is presented.

M.O.M.

**NBO-12269**

**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)

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

NASA-CR-159703

Available: 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 side lobes 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 side lobe levels with many commercially available low cost paraboloids. The use of absorbing pads and small reflecting plates for side lobe reduction is also considered.

Author

**NBO-12265**

**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. White

Jun. 1979

406 p refs 2 Vol.

(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 example 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.

**NBO-12261**

**APPLICATION OF ADVANCED ON-BOARD PROCESSING CONCEPTS TO FUTURE SATELLITE COMMUNICATIONS SYSTEMS: BIBLIOGRAPHY**

R. L. Edelman and J. L. Katz

Jun. 1979

109 p 2 Vol.

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


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-18282**

**THE 30/20 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT. VOLUME 1: EXECUTIVE SUMMARY**

R. B. Gamble, H. R. Seltzer, K. M. Speter, and M. Westheimer

Aug. 1979

50 p 3 Vol.

(Contract NAS3-21366)

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

NASA-CR-159619

Available: 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 is separately estimated for voice, video, and data services and is also described as a function of distance traveled and city size. The satellite component of projected demand is compared with the capacity available in the C and Ku satellite bands and it is projected that new satellite technology and the implementation of Ka band transmission will be needed in the decade of the 1990's.

Author

**NBO-18283**

**THE 30/20 GHz FIXED COMMUNICATIONS SYSTEM SERVICE DEMAND ASSESSMENT. VOLUME 2: MAIN REPORT**

R. B. Gamble, H. R. Seltzer, K. M. Speter, and M. Westheimer

Aug. 1979

309 p 3 Vol.

(Contract NAS3-21366)

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

NASA-CR-159620

Available: NTIS

HC A18/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.
A review of studies forecasting the communication market in the United States is given. The applicability of these forecasts to assessment of demand for the 30/20 GHz fixed communications system is analyzed. Costs for the 30/20 satellite trunking systems are presented and compared with the cost of terrestrial communications.

J.M.S.

The total demand for voice, video, and data communications services, and satellite transmission services at the 4/6 GHz, 12/14 GHz, and 18/30 GHz frequencies is discussed. Major study objectives, overall methodology, results, and general observations about a satellite systems market characteristics and trends are summarized. M.G.

The projected cost of C and Ku band satellite systems are included. A traffic demand analysis is performed on a typical nwtropolitan city to examine service distribution trends. M.G.

The initial definition of on-board processing for an advanced satellite system architecture is based on cost, user, and technical considerations. For the given requirements and constraints, the reservation-accept packet switching and on-board switching and demodulation/remodulation baseband processing are identified. With the throughput and delay requirements as the controlled variables, the hardware complexity, separation of traffic between transmission systems, and operational discipline, occupied bandwidth, and overall user end-to-end cost are estimated for (1) random-access packet switching; and (2) reservation-accept packet switching. Other aspects of this review (eg, 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)

V.T.
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.

B.J.


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. (Author)
33 ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability, components, e.g., tunnel diodes and transistors, microcomputa-

tion, 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 MAGNET-

ICS


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).

N80-13831f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


Performance data obtained through experimental testing of a 22.4 kW traction motor using two types of excitation are presented. Ripple free dc from a motor-generator set for baseline data and pulse width modulated dc as supplied by a battery pack and chopper controller were used for excitation. For the same average values of input voltage and current, the motor power output was independent of the type of excitation. However, at the same speeds, the motor efficiency at low power output (corresponding to low duty cycle of the controller) was 5 to 10 percent average points lower on chopped dc than on ripple free dc. 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.

N80-18300# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


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

N80-20487# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


An electrolyte 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 an anode 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 electrolytically 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 lead to depurate 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

N80-21685# 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 (NASA-TM-81441; E-317) Avail: NTIS HC A02/MF A01 CSCL 09A

An update on the life testing of commercial, high current density impregnated tungsten cathodes is presented. The B-type cathodes, operated at a current density of 2 A/cm² and a cathode temperature of 1100 °C have now been run satisfactorily for more than four years. The M-cathode, at the same current density but at an operating temperature of only 1010 °C, have been tested for more than three years. The M-cathodes show no degradation in current over their present operating life whereas the current from the B-cathodes degrade about 6 percent after four years of operation.

R.E.S.
An axisymmetric, multistage, depressed collector of fixed geometric design was evaluated in conjunction with an octave bandwidth, dual mode traveling wave tube (TWT). The TWT was operated over a wide range of conditions to simulate different applications. The collector performance was optimized (within the constraint of fixed geometric design) over the range of TWT operating conditions covered. For operation of the TWT in the linear, low distortion range, 90 percent and greater collector efficiencies were obtained leading to TWT overall efficiencies of 20 to 35 percent, as compared with 2 to 5 percent with an undepressed collector. With collectors of this efficiency and minimized beam interception losses, it becomes practical to design dual mode TWT's such that the low mode can represent operation well below saturation. Consequently, the required pulse up in beam current can be reduced or eliminated, and this mitigates beam control and dual mode TWT circuit design problems. For operation of the dual mode TWT at saturation, average collector efficiencies in excess of 85 percent were obtained for both the low and high modes across an octave bandwidth, leading to a three to fourfold increase in the TWT overall efficiency. Author


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)


An accurate representation of axisymmetric fields has been devised by extending the method of ideal current loops to off-axis fields. It is assumed that the data to be simulated are available through measurements or through a solution of a boundary value problem. The method provides an algebraic expression for the fields throughout a two-dimensional region of interest and eliminates the need for the axial expansion formula in approximating off-axis fields. The use of Gaussian and other functions as alternatives to the coil function is proposed. Examples of the technique in simulating a periodic permanent magnet (PPM) focusing field are presented and compared with a Fourier analysis of the problem. (Author)


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 to an ECM TWT. The benefits of such improvements such as less input power, a smaller and lighter power supply, and easier cooling are surveyed, and it noted that it is now possible to build efficient TWT's which
rather than operating at saturation, can be very linear amplifiers. Finally, a new approach to power supplies is also covered. M.E. P.


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 ºC have been run in simulated microwave tules 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 ºC and 2 A/sq cm with no degradation in current as a constant reference anode voltage. (Author)


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 performance such as stability, audiosusceptibility, output impedance, and load transient response. (Author)


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.
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.
STREAKLINE FLOW VISUALIZATION STUDY OF A HORSESHOE VORTEX IN A LARGE-SCALE, TWO-DIMENSIONAL TURBINE STATOR CASCADE
(NASA-TM-79274; E-201) Avail: NTIS HC A02/MF A01 CSCL 20D

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. 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 move 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 across the passage near the endwall 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

N80-13403*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MARANOGONI BUBBLE MOTION IN ZERO GRAVITY
(NASA-TM-79250; E-160) Avail: NTIS HC A03/MF A01 CSCL 20D

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 solutions to solve this boundary value problem; the expansion parameter is the Marangoni number. The zeroth, first, and second order approximations for the velocity, temperature and pressure distributions in the liquid and in the bubble, and the deformation and terminal velocity of the bubble are determined. Experimental data on a gravity bubble in ethylene glycol, ethanol, and silicone oil subjected to a linear temperature gradient were obtained using the NASA Lewis zero gravity drop tower. Comparisons of the experimental data with those predicted by the zeroth order model were excellent agreement with the experimental measurements. The first and second order solutions for the bubble deformation and terminal velocity were approximate values for liquids having Prandtl numbers on the order of one, but there is a lack of appropriate data to test the theory fully.

N80-13404*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMBUSTION OF SOLID CARBON RODS IN ZERO AND NORMAL GRAVITY
(NASA-TM-79303; E-285) Avail: NTIS HC A03/MF A01 CSCL 218

In order to investigate the mechanism of carbon combustion, spectroscopic carbon rods were resistance ignited and burned in an oxygen environment in normal and zero gravity. Direct mass spectrometric cce3131 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 dropper 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 was determined as a function of time for oxygen pressures of 5, 10, 15, and 20 psia. A code 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.

N80-15364*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTER PROGRAM FOR GENERATING INPUT FOR ANALYSIS OF IMPINGEMENT-COOLED, AXIAL-FLOW TURBINE BLADE
David Rosenbaum Jan. 1980 57 p refs Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio.
(NASA-TP-1603; AVRADCOM-TR-79-34) Avail: NTIS HC A04/MF A01 CSCL 20D

A computer program, TACTGRID, was developed to generate the geometrical input for the TACT program, a program that calculates transient and steady state temperatures, pressures, and cooling flows in an impingement cooled turbine blade. Using spline curves, the TACTGRID program constructs the blade internal geometry from the previously designed external blade surface and newly selected wall and channel thicknesses. The TACTGRID program generates the TACT calculational grid, calculates length between grid points required by TACT as input, and writes the gridpoint input data set used by TACT for the blade geometry. In addition, TACTGRID produces a computer plot of each blade slice, detailing the grid and calculational stations, and thus eliminates the need for intermediate drafting.

N80-15365*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTATION OF THREE-DIMENSIONAL FLOW IN TURBOFAN MIXERS AND COMPARISON WITH EXPERIMENTAL DATA
(NASA-TP-81410; E-324) Avail: NTIS HC A02/MF A01 CSCL 20D

A three dimensional, viscous computer code was used to calculate the mixing downstream of a typical turbofan mixer geometry. Experimental data obtained using pressure and temperature rakes at the lobed nozzle exit stations was used to validate the computer results. The relative importance of turbulence in the mixing phenomenon as compared with the headwise vorticity was determined. The observations suggest that the generation of headwise vorticity plays a significant role in determining the temperature distribution at the nozzle exit plane.

N80-15366*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL SIMULATION OF SUPERSONIC INLETS USING A THREE-DIMENSIONAL VISCOUS FLOW ANALYSIS
(NASA-TM-81411; E-392) Avail: NTIS HC A02/MF A01 CSCL 20D

A three dimensional fully viscous computer analysis was conducted to determine its usefulness in the design of supersonic inlets. This procedure takes advantage of physical approximations...
to limit the high computer time and storage associated with complete Navier-Stokes solutions. Computed results are presented for a Mach 7 4 hypersonic inlet. Good agreement was obtained between theory and data for both water. Results of a mesh sensitivity study are also shown.

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 CSDL 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 exceed those of the uncoated vane.

N80-17398‡ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
VOLUME-ENERGY PARAMETERS AND TURBULENT-FLOW DENSITY FLUCTUATIONS
Robert C. Hendrick Jan 1980 28 p refs (NASA-TP-1585; E-127) Avail NTIS HC A03/MF A01 CSDL 20D
Volume-energy relations determined from an equation of state were used to group many sets of heat transfer data for liquids and gases, including the near-critical region. The volume - Gibbs energy parameter grouped these data better than did such other parameters as enthalpy, temperature, or internal energy.

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
R. James Rollbuhler and John A. Kobak Mar 1980 .37 p refs (NASA-TP-81439; E-382) Avail NTIS HC A03/MF A01 CSDL 20D
The cleanup of effluent gases from the fluidized-beds 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 particle 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 95 percent of the fly ash particles in the effluent gas are removed by using a gas-solid separator under controlled operating conditions. Gaseous pollutants in the effluent (nitrogen and sulfur oxides) are held within the proposed Federal limits by controlling the reactor operating conditions and the type and quantity of sorbent material.

N80-21708§ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
SIMILARITY TESTS OF TURBINE VANES, EFFECTS OF CERAMIC THERMAL BARRIER COATINGS
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. N80-23823* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

TOWARD THE USE OF SIMILARITY THEORY IN TWO-PHASE CHOKED FLOWS


Comparison of two phase choked flows in normalized coordinates were made between pure components and available data using a reference fluid to compute the thermophysical properties. The results are favorable. Solution of the governing equations for two LNG mixtures show some possible similarities between the normalized choked flows of the two mixtures, but the departures from the pure component loci are significant.

Author

N80-29624* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

PRELIMINARY RESULTS FROM A FOUR-WORKING SPACE, DOUBLE-ACTING PISTON, STIRLING ENGINE CONTROLS MODEL


A four working space, double acting piston, Stirling engine simulation is being developed for controls studies. The development methodology to construct two simulations, one for detailed fluid behavior, and a second model with simple fluid behavior but containing the four working space aspects and engine inertias, validate these models separately, then upgrade the four working space model by incorporating the detailed fluid behaviour model for all four working spaces. The single working space (SWS) model contains the detailed fluid dynamics. It has seven control volumes in which continuity, energy, and pressure loss effects are simulated. Comparison of the SWS model with experimental data shows reasonable agreement in net power versus speed characteristics for various mean pressure levels in the working space. The four working space (FWS) model was built to observe the 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. 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


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, dampers, bearings, and heat exchanger tubes of rectangular cross section with Borda-type inlet configurations are subject to large forces. It is noted that the reduced mass flux is independent of working fluid. A.T.


The effects of free-jet phenomena, jetting, in a 90-deg-sharp-edge inlet tube were studied. Mass-limiting flow data and calculated 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

A80-10039 * Application of the principle of similarity to fluid mechanics. R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio) and J. V. Stingers (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.


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
(Contract NAS2-21581) (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 the liquid jet, the spinning disk method, 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 sprays are assessed. These are based on the classification of

DEVELOPMENT OF A THREE-DIMENSIONAL SUPERSONIC INLET FLOW ANALYSIS Final Report
(Contract NAS2-21003) (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 inviscid flows which have a primary flow direction. The governing equations are written in general orthogonal coordinates. These equations are modified in the subsonic region of the flow to prevent the phenomenon of branching. Results are presented for the two sample cases: A Mach number equals 2.5 flow in a square duct, and a Mach number equals 3.0 flow in a research jet engine inlet. In the latter case the computational results are compared with the experimental data. A users' manual is included. (Author)

MONODISPERSE ATOMIZERS FOR AGRICULTURAL AVIATION APPLICATIONS Final Report
Larry S. Christensen and Sidney L. Steely Feb. 1980 81 p refs
(Contract NAS2-21582) (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 beam dispersed, and nonuniform swath coverage. Monodisperse atomization techniques are reviewed and a synopsis of the

N80-23589* Sigma Research, Inc., Richland, Wash.
TWO-PHASE WORKING FLUIDS FOR THE TEMPERATURE RANGE OF 50 TO 350 DEG. PHASE 2 Final Report
(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. (EDK)

N80-32888* TRW Defense and Space Systems Group, Redondo Beach, Calif.
Four thermal excursions of the Transmitter Experimental Package (TEP) were the result of the depimming of the active portion in all heat pipes in the Variable Conductance Heat Pipe System which cooled the TEP. The determined cause of the depimming of the heat pipes was the formation of bubbles of the nitrogen/helium control gas mixture in the arteries during the thaw portion of a freeze/thaw cycle of the active region of the condenser section of the heat pipe. Conditions such as suction freezeout or heat pipe turn-on, which moved these bubbles into the active region of the heat pipe, contributed to the depinning mechanism. Methods for preduding, or reducing the probability of, this type of failure mechanism in future applications of arterial heat pipes are included. (Author)

Wind tunnel experiments were carried out at Stanford between 1971 and 1977 to study the heat transfer characteristics of full-coverag film cooled surfaces with three injection angles: normal, 30 deg slant, and 30 deg x 45 deg compound-angled injection. A flat full-coverag 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.


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 photodetector scanning are used for rotating components and infrared photography for stationary components. Contact (direct) temperature and pressure measurements on rotating components are expected to be handled with an 80 channel rotary data package which mounts on and rotates with the turbine shaft at speeds up to 17,500 rpm. The data channels are time-division multiplexed and converted to digital words in the data package. A rotary transformer couples power and digital data to and from the shaft.

M.M.M.


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.

R.E.S.


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 objective of these programs is to produce more reliable sensors and to improve the safety and operating economy of future aircraft and space vehicles.

Author

N80-18385# 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 (NASA-TM-81454; E-381) Avail: NTIS HC A02/MF A01 C5L 20F

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 Gustave C. Fralick Washington May 1980 16 p refs (NASA-TP-1687; E-340) Avail: NTIS HC A02/MF A01 C5L 14B

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 (NASA-TP-1686; E-354) Avail: NTIS HC A02/MF A01 C5L 14E

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 + or -5%, plus 0.1 kPa for a typical application.

V.T.

An apparatus is described in which hydrogen atoms were trapped at temperatures down to 1.1 K in the P T field of a large volume superconducting magnet. A high sensitivity thermal detector was used to study trapping and recombination of atoms on the detector surface. The apparatus permits the application of extremely high steady state magnetic fields to study the potential effects of electron spin polarization on the stabilization of hydrogen atoms.


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.


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


Innovative features of the anemometer include: (1) a rapid and efficient data processing 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.

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 raw measurements.


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 photodiode 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 remote 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.


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 coupling and bond-layers in the acoustic path. Computer-synthesized waveforms were used to simulate a range of interface conditions encountered in ultrasonic transducer systems operating in the 20- to 80-MHz regime. The adverse effects of thin-layer multiple reflections associated with various acoustic impedance conditions are demonstrated. The information presented is relevant to ultrasonic transducer design, specimen preparation, and couplant selection.


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 was 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.

Thin film surface temperature sensors were developed. The sensors were made of platinum-palladium/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.


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 1 or 0.3 percent of point (K). This exceeds the goal of 1 percent of point. Recommendations are presented for further performance improvement.
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.

**References:**


A CESIUM TELEC EXPERIMENT AT LEWIS RESEARCH CENTER Final Report

MODIFIED FACE SEAL FOR POSITIVE FILM STIFFNESS

PATENT APPLICATION
Izhak Etzion (Technion-Israel Inst. of Technol., Haifa) and Abraham Lipshitz, inventors (to NASA) (Technion-Israel Inst. of Technol., Haifa) Filed 7 Nov. 1979 7 p. Spons. by NASA (NASA-Case-LEW-12989-1; US-Patent-AppSn-092145) Avail: NTIS HC A02/ MF A01 CSCL 11A

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 is formed in series with this face seal. Also, the clearance between the surface on the lip and the shaft is substantially the same as the spacing between the face sealing surfaces on the face seal. The clearance between the surface on the lip and the shaft is substantially the same as the spacing between the face sealing surfaces on the face seal when the shaft is rotating. The circumferential clearance seal restricts the flow of fluid from a main cavity to an intermediate cavity with a resulting pressure drop. The hydrostatic opening is strongly dependent on the face seal clearance, and the desired axial stiffness is achieved.

N80-13472* 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.R.H.

N80-13440* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SELF-ACTING LIFT-PAD GEOMETRY FOR CIRCUMFERNENTIAL SEALS: A NONCONTACTING CONCEPT

A segmented circumferential seal with lift pads for hydrodynamic action was analyzed over ranges of speed and sealed pressure. 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.

N80-15410* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMPARISON OF PREDICTED AND EXPERIMENTAL PERFORMACE OF LARGE-BORE ROLLER BEARING OPERATING TO 3.0 MILLION DN


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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 turbomachinery 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.

N80-17489# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.  
SPUR-GEAR-SYSTEM EFFICIENCY AT PART AND FULL LOAD  
Neil E. Anderson and Stuart H. Loewenthal  
Feb. 1980 42 p  
Prepared in cooperation with Army Aviation Res. and Develop. Command, Cleveland.  
(NASA-TP-1622; AVRADCOM-TR-79-46; E-061) Avail: NTIS HC A03/MF A01 CSCL 131  
A simple method for predicting the part- and full-load power loss of a spur spur gearset of arbitrary geometry supported by ball bearings is described. The analysis algebraically accounts for losses due to gear sliding, rolling traction, and windage in addition to support-ball-bearing losses. The analysis compares favorably with test data. A theoretical comparison of the component losses indicates that losses due to gear rolling traction, windage, and support bearings are significant and should be included along with gear sliding loss in a calculation of spur-gear system power loss.  

M.G.

N80-17487# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.  
PERFORMANCE SENSITIVITY ANALYSIS OF DEPARTMENT OF ENERGY-CHRYSLER UPGRADED AUTOMOTIVE GAS TURBINE ENGINE, S/N S-4  
Initial Report  
Roy L. Johnsen  
Dec. 1979 37 p refs  
(Contract EC-77-A-31-1040)  
(NASA-TM-79242; DOE/NASA/1040-79/9; E-147) Avail: NTIS HC A03/MF A01 CSCL 21A  
The performance sensitivity of a two-shaft automotive gas turbine engine to changes in performance and cycle operating parameters was examined. Sensitivities were determined for changes in turbomachinery efficiency, compressor inlet temperature, power turbine discharge temperature, regenerator effectiveness, regenerator pressure drop, and several gas flow and heat leaks. Compressor efficiency was found to have the greatest effect on system performance.  

K.L.

N80-17489# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.  
SIMPLIFIED FATIGUE LIFE ANALYSIS FOR TRACTION DRIVE CONTACTS  
Douglas A. Rohn, Stuart H. Loewenthal, and John J. Coy  
1980 30 p refs  
18-22 Aug, 1980; sponsored by ASME. Prepared in cooperation with Army Aviation Res. and Develop. Command, Cleveland.  
(NASA-TM-79199; AVRADCOM-TR-80-C-4; E-355) Avail: NTIS HC A03/MF A01 CSCL 131  
A simplified fatigue life analysis for traction drive contacts of arbitrary geometry is presented. The analysis is based on the Lundberg-Palgren 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

N80-18400# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.  
GAS PATH SEAL Patent Application  
Robert C. Bill and Robert D. Johnson, inventors (to NASA)  
Filed 20 Nov, 1979 8 p  
(NASA-Case-NPD-12131-3; US-Patent-Appl-SN-096255) Avail: NTIS HC A02/MF A01 CSCL 20A  
A gas path seal suitable for use with a turbine engine or compressor is described. A shroud wearable or abradable by the abrasion of the rotor blades of the turbine or compressor shrouds the rotor bades. A compliant backing surrounds the shroud. The backing is a yielding deformable porous material covered with a thin ductile layer. A mounting fixture surrounds the backing.  

NASA
the Nysrivis 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. Author

N80-18405f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ENDURANCE AND FAILURE CHARACTERISTICS OF MODIFIED VASCO X-2, CBS 600 AND AISI 9310 SPUR GEARS

Gear endurance tests and rolling-element fatigue tests were conducted to compare the performance of spur gears made from AISI 9310, CBS 600 and modified Vasco X-2 and to compare the pitting fatigue lives of these three materials. Gears manufactured from AISI 9310, CBS 600 and modified Vasco X-2 gears exhibited the potential of tooth fracture occurring at a tooth surface fatigue pit. Case carburization of all gear surfaces for the modified Vasco X-2 gears results in fracture at the tips of the gears. Author

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. Author

N80-18407f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONSTRAINED FATIGUE LIFE OPTIMIZATION OF A NAVYFIRIS MULTIROLLER TRACTION DRIVE

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 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. Author

N80-18408f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS AND DESIGN OF A UNIFORM-CLEARANCE, PUMPING-RING ROD SEAL FOR THE STIRLING ENGINE
J. Eton Mar. 1980 30 p refs (NASA-TM-81463; E-080) Avail NTIS HC A03/MF A01 CSCL 11A

A uniform clearance pumping ring, as opposed to the conventional taper clearance one, is described. The uniform clearance concept eliminates complex elastohydrodynamic problems and enables a simple analytical treatment to be made. An analytical expression is derived for the pumping rate showing the effect of various design parameters on the pumping ring's performance. An optimum clearance is found by which the pumping rate is maximized and a numerical example is presented to demonstrate the potential of the uniform clearance design. Author

N80-18409f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOME LIMITATIONS IN APPLYING CLASSICAL EHD FILM-THICKNESS FORMULAE TO A HIGH-SPEED BEARING

Elastohydrodynamic film thickness was measured for a 20 mm ball bearing using the capacitance technique. The bearing was thrust loaded to 90, 448, and 778 N. The corresponding maximum stresses on the inner race were 1.28, 2.09, and 2.45 GPa. Test speeds ranged from 400 to 14,000 rpm. Film thickness measurements were taken with four different lubricants: (1) synthetic paraffinic; (2) synthetic paraffinic with additives; (3) neopentylpolyol (tetra) ester; and (4) synthetic cylocalphatic hydrocarbon traction fluid. The test bearings were thrust loaded to 90, 448, and 778 N. Test temperatures were 300, 338, and 393 K. The measured results were compared to theoretical predictions and are presented. Author

N80-18410f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DAMPING IN TAPERED ANNULAR SEALS FOR AN INCOMPRESSIBLE FLUID
David P. Fleming Apr. 1980 22 p refs (NASA-TP-1646; E-124) Avail NTIS HC A02/MF A01 CSCL 11A

Damping in annular seals is calculated for an incompressible fluid. Results show that damping in tapered seals optimized for stiffness is considerably less than that in straight seals for the same minimum clearance. Damping in rotating seals can promote fractional frequency whirl. Neglecting fluid acceleration makes solution much easier, but leads to errors in calculated damping of up to 16 percent. Author

N80-18411f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CALCULATED AND EXPERIMENTAL DATA FOR A 118-mm BORE CYLINDRICAL ROLLER BEARING USING THE COMPUTER PROGRAM CYBEAN

The operating characteristics for 118 mm bore cylindrical roller bearing are examined using the computer program CYBEAN. The predicted results of inner and outer-race temperatures and heat transferred to the lubricant generally compared well with experimental data for shaft speeds to 3 million DN (25,000 rpm), radial loads to 8900 N (2000 lb), and total lubricant flow rates to 0.0102 cu m/min (2.7 gal/min). M.G.
JET-LUBRICATED 35-MILLIMETER-BORE BALL BEARING on the contact stresses, lubrication, wear, fatigue life, and gearing of Involute geometry, differential geometry, and fundamental kinematics, M.G., of an ideal spiral bevel tooth is developed based on the elements gear tooth surfaces are discussed. The parametric representation IDEAL SPIRAL BEVEL GEARS: A NEW APPROACH TO SURFACE GEOMETRY by R. L. Huston (Cincinnati Univ., Ohio) and J. C. Coy 1980 22 p refs Proposed for presentation at 3d Intern. Power Transmission and Gearing Conf., San Francisco, 18-22 Aug. 1980; sponsored by ASME (NASA-TM-81449: E-366; AVRADCOM-TR-BG-C-G) Avai: NTIS HC A02/MF A01 CSCL 131 The fundamental geometrical characteristics of spiral bevel gear tooth surface are discussed. The parametric representation of an ideal spiral bevel tooth is developed based on the elements of involute geometry, differential geometry, and fundamental gearing kinematics. A foundation is provided for the study of nonideal gears and the effects of deviations from ideal geometry on the contact stresses, lubrication, wear, fatigue life, and gearing kinematics. M.G.


FULLY PLASMA-SPRAYED COMPLIANT BACKED CERAMIC TURBINE SEAL Patent Application R. C. Bill, Inventor (to NASA) Filed 31 Mar., and Neil E. Anderson 1980 7 p (NASA-Case-LEW-13268-1: US-Patent-App1-SN-145209) Avai: NTIS HC A02/MF A01 CSCL 11A To maintain the minimum operating clearances between the blade tips and the lining of a high pressure turbine, a low temperature easily decomposable material, such as a polymer, in powder form is blended with a high temperature resistant metal powder. The two materials are simultaneously deposited on a substrate formed by the turbine casing. Alternately, the polymer powder may be added to the metal powder during plasma spraying. A ceramic layer is then deposited directly onto the metal-polymer composite. The polymer additive mixed with the metal is then completely volatilized to provide a porous layer between the ceramic layer and the substrate. Thermal stresses are reduced by virtue of the resulting porous structure which affords a cushion effect. By using plasma spraying for depositing both the powders of the metal and polymer material, as well as the ceramic powder, no brazing is required. NASA
A gas path seal suitable for use with a turbine engine or compressor is provided. A shroud wearproof or abrasion-resistant against the abrasion of the rotor blades of the turbine or compressor shrouds the rotor blades. A compliant backing surrounds the shroud. The backing is a compliant material covered with a thin ductile layer. A mounting fixture surrounds the backing. Official Gazette of the U.S. Patent and Trademark Office

**Application**

**Engine to power auxiliary equipment. Fuel and air are burned in DIESEL ENGINE CATALYTIC COMBUSTOR SYSTEM Patent NSO**

**Composite seal for turbomachinery Patent NSO**

**Section which is initially caused to rotate by the starter motor. A catalytic combustor to drive the turbine wheel of the turbine (NASA-Case-Low-12995-1; US-Patent •Appi-SN-157150)**

**Avail:**

the rotor blades. A compliant backing surrounds the shroud. The backing is a compliant material covered with a thin ductile layer. A mounting fixture surrounds the backing. Official Gazette of the U.S. Patent and Trademark Office

**Composite seal for turbomachinery Patent NSO**

**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 flap valve, compressed air from the blower section is directed to the catalytic combustor when it is heated and expanded, serving to drive the turbine wheel and also to heat the catalytic element. To start the engine, one valve is closed, combustion is terminated in the catalytic combustor, and another valve is then opened to utilize air from the blower for the air driven motor. When the engine starts, the constituents in its exhaust gas react in the catalytic element and the heat generated provides additional energy for the turbine section.**

Author

**N80-27665#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DIESEL ENGINE CATALYTIC COMBUSTOR SYSTEM Patent Application


A low compression turbocharged diesel engine is described in which the turbocharger can be operated independently of the engine to power auxiliary equipment. Fuel and air are burned in a catalytic combustor to drive the turbine wheel of the turbine section which is initially caused to rotate by the starter motor. By opening a flap valve, compressed air from the blower section is directed to the catalytic combustor when it is heated and expanded, serving to drive the turbine wheel and also to heat the catalytic element. To start the engine, one valve is closed, combustion is terminated in the catalytic combustor, and another valve is then opened to utilize air from the blower for the air driven motor. When the engine starts, the constituents in its exhaust gas react in the catalytic element and the heat generated provides additional energy for the turbine section.

Author

**N80-27665#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DYNA MICAL 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

**Starved elastohydrodynamic lubricated elliptical contacts**


A theoretical study of the influence of lubricant starvation on film thickness and pressure in hard and soft elliptical 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 are shown. The theoretical findings are compared directly with results obtained experimentally. Author

CIRCUMFERENTIAL BNAFT SEAL Patent

A circumferential shaft seal is described which comprises two sealing rings held to a rotating shaft by means of an elastomeric band. The rings are segmented and are of a rigid sealing material such as carbon or a polyimide and graphite fiber composite. Official Gazette of the U.S. Patent and Trademark Office

KINEMATIC CORRECTION FOR ROLLER SKEWING Patent

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

ROTORDYNAMIC INSTABILITY PROBLEMS IN HIGH-PERFORMANCE TURBOMACHINERY Patent
1980 493 p. refs Cont. held at College Station, 12-14 May 1980; sponsored by Texas A and M Univ., Louisville Univ., and AROD (NASA-CP-2133; E-413) Avail: NTIS HC A20/MF A01 CSCL 131

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 elastometric elements, and the use of hydrodynamic journal bearings and supports. For individual titles, see N80-29707 through N80-29733.

DAMPING IN RING SEALS FOR COMPRESSIBLE FLUIDS Patent
David P. Fleming In its Rotordyn. Instability ProbL in High-Performance Turbomachinery 1980 p 169-188 refs (For primary document see N80-29705 20-37) Avail: NTIS HC A20/MF A01 CSCL 131

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
EFFECT OF CAGE DESIGN ON CHARACTERISTICS OF
variations inside the cavitation zone, contrary to common
levels. Some photographs of the cavitation region are presented.

Tests were generated with the double outer land guided cage
assumptions of constant cavitation pressure.

region. Pressure profiles are presented showing significant pressure
showing strong reverse flow at the downstream end of the
cavitation zone of a submerged journal bearing are described,

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-

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
concave or eccentric position of the rotor and parallel or convergent tapered flow areas, data and analysis revealed that
mass flux or leak rate can be determined from a relation whose
normalizing parameters depend on the thermodynamic critical

caracteristics of conventional and
tapered high-pressure-drop simulated seals. R. C. Hendricks (NASA,

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,

Survey of ion plating sources. T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). American Vacuum

Ion plating is a plasma deposition technique where ions of the
plating 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
energies up to a maximum energy of the discharge. The various
reaction mechanisms which contribute to the exceptionally strong
adherence — formation of a graded substrate/coating interface are not
fully understood, however the controlling factors are evaluated. The
influence of process variables on the nucleation and growth
characteristics are illustrated in terms of morphological changes
which affect the mechanical and tribological properties of the
coatings. (Author)
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 radius ratio of unity. The correlations indicate that atomic size is an important parameter in controlling friction and wear of alloys. (Author)


This paper describes methods used to design elastomerically damped supports for high-speed, flexible rotor-bearing systems. The procedure consists of using a damped natural frequency analysis to identify stiffness and damping requirements for the supports over the speed range. Optimum values for these coefficients are found and unbalance response analysis is used to calculate expected rotor behavior. Equations for calculating the shear and compressive stiffness and damping of bearing-type elastomer mounts are given, as is a procedure for their application to the design of the elastomer mounts. These techniques were successfully applied to the design of damped elastomeric supports for a high-speed rotor, which traverses two bending critical speeds. Results of the testing showed that the rotor was well behaved and showed linear response to unbalance. Measured modal damping exceeded expectations and tests were conducted with both high- and low-loss elastomers, enabling the exploration of the practical range of elastomer damping capability. (Author)


Evaluation of power transmission shafting for high-speed balancing has shown that when axial torque is applied, the imbalance response is altered. An increase in synchronous excitation always occurs if the axial torque level is altered from the value used during balancing: this was the case even when the shaft was balanced with torque applied. The twisting of the long slender shaft produces a change in the imbalance distribution sufficient to disrupt the balanced state. This paper presents a review of the analytic development of a weighted least squares approach to influence coefficient balancing and a review of experimental results. The analytic approach takes advantage of the fact that the past testing has shown that the influence coefficients are not significantly affected by the application of axial torque. The 3.60-m (12 ft) long aluminum shaft, 7.62 cm (3 in.) in diameter was run through the first flexural critical speed at torque levels ranging from zero-torque to 903.8 N-m (8000 lb-in.) in 112.9 N-m (1000 lb-in.) increments. Good comparison was achieved between predicted and experimental results. (Author)


This paper describes the design and testing of an elastomer damper on a super-critical power transmission shaft. The elastomer were designed to provide acceptable operation through the fourth bending mode and to control synchronous as well as nonsynchronous vibration throughout the operating range. The design of the elastomer was such that it could be incorporated into the system as a replacement for a squeeze-film damper without a reassembly, which could have altered the imbalance of the shaft. This provided a direct comparison of the elastomer and squeeze-film dampers without having to assess the effect of shaft imbalance changes. (Author)

Existing theories of erosion of ductile metals based on cutting and deformation mechanisms predict no material removal at normal incidence which is contradictory to experience. Thus, other mechanisms may be involved. The possible role of adhesive material transfer during erosion is investigated by both single-particle impingement experiments and erosion by streams of particles. Examination of the rebounding particles as well as the eroded surfaces yields evidence of a significant adhesive mechanism for the ductile metals investigated.  (Author)


The tribological properties of polyimide-bonded graphite fluoride films were investigated. A pin-on-disc type of testing apparatus was used; four different types of ball bearing slid against a film of less than 0.25 mm diameter flat area was slid against the film such 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 lubrication 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 extruder lubricant was used in a recirculating lubricant 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 oil analysis (SOAP). Four particle types were observed: normal rubbing wear particles, spheres, nonferrous particles, and severe wear (spall) fragments.  (Author)


Four different compositions of self-lubricating, plasma-sprayed, composite coatings with calcium fluoride dispersed throughout cobalt alloy-silver matrices were evaluated on a friction and wear apparatus. In addition, coatings of the cobalt alloys alone and of one coating with a nickel alloy-silver matrix were evaluated for comparison. The wear specimens consisted of two, diametrically opposed, flat rub shoes sliding on the coated, cylindrical surface of a rotating disk. Two of the cobalt composite coatings gave a friction coefficient of about 0.25 and low wear at room temperature, 400 and 650 C. Wear rates were lower than those of the cobalt alloys alone or the nickel alloy composite coating. However, oxidation limited the maximum useful temperature of the cobalt composite coating to about 650 C compared to about 900 C for the nickel composite coating.  (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 HIP, HIP powder consolidation and by forging of HIP consolidated billets. The effect of various defects on the mechanical properties of powder parts are shown.  V.T.


A contact fatigue life analysis method for multiroller traction drives is presented. The method is based on the Lundberg-Palmgren analysis method for rolling element bearing life prediction, and also uses finite element methods to determine life factors for materials, processing, lubrication, and effect of traction. The analysis method is applied in an optimization study to the multiroller traction drive, consisting of a single-stage planetary configuration with two rows of stepped planet rollers of five rollers per row. The drive was approximately 25 centimeters in diameter by 11 centimeters long, having a nominal ratio of 15:1. The theoretically predicted drive life was 2510 hours at a nominal continuous power and speed of 74.6 kW (100 hp) and 75,000 rpm.  (Author)


The results of an analysis of the effects of spur gear size, pitch, width and ratio on total mesh power loss for a wide range of spur gears and lubricating mechanisms are presented. The results of the analysis method for rolling element bearing power loss. The analysis includes 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. The traction drive was tested for a single-stage planetary configuration with two rows of stepped planet rollers. Two versions of the drive were parametrically tested, one at speeds of 73,000 rpm and power levels to 180 kW (240 hp). Parametric tests were also conducted with the NASVYTS drive 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. (Author)


Gear endurance tests and rolling-element fatigue tests were conducted to compare the performance of spur gears made from AISI 9310, CBS 600 and modified Vasco X-2 and to compare the pitting fatigue lives of these three materials. Gears manufactured from 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 potentials of tooth fracture occurring at a tooth surface fatigue pit. Carefulization 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 low and high speeds. Increasing the speed at constant load and increasing the load at constant speed cause 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)


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 rubber 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 51SiTeltmetal underlay. Author


The potential role of superalloys, refractory alloys, and ceramics in the hottest sections of engines operating with turbine
inlet temperatures as high as 1370 C is examined. The conventional superalloys, directionally solidified eutectics, oxide dispersion strengthened alloys, and tungsten fiber reinforced superalloys are reviewed and compared on the basis of maximum turbine blade temperature capability. Improved high temperature protective coatings and special fabrication techniques for these advanced alloys are discussed. Chromium, columbium, molybdenum, tantalum, and tungsten alloys are also reviewed. Molbdenuum alloys are found to be the most suitable for mass produced turbine wheels. Various forms and fabrication processes for silicon nitride, silicon carbide, and silicon carbide acting as a support in high stress and medium stress high temperature environments.

K.L.

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


A tire and wheel assembly is described which consists of a low profile pneumatic tire with sidewalls that deflect inwardly under a load and a wheel having a narrow central channel and extended rim flanges. The extended rim flanges support the tire sidewalls under static and dynamic loading conditions to produce a combination particularly suited to aircraft applications. NASA


TESTING OF RECIPROCATING SEALS FOR APPLICATION IN A STIRLING CYCLE ENGINE J. F. Curulla and T. L. Beck Feb. 1980 76 p refs (Contract NAS3-20612) (NASA-CR-159820; DOE/NASA/012-60/1; BCAC-DS-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 sealed tested were: the Boeing Footseal, NASA Chevron polyimide seal, Bell seal, Quad seal, Tetraseal, and Dynabak seal. None of these seal configurations met the leakage goals of 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. Last seals failed due to high temperatures. Catastrophic failures were observed for a minimum number of test runs characterized by extremely high leakage rates and large temperature rises. The Bell seal attained 63 hours of run time at significantly lowered test conditions. E.D.K.

N80-22702* Kumm (Emerson L.), Tempe, Ariz.

DESIGN STUDY OF FLAT BELT CVT FOR ELECTRIC VEHICLES Emerson L. Kumm Mar. 1980 159 p refs (Contract DEN3-114; Contract EC-77-A-31-1044) (NASA-CR-159822; P-1006) Avail: NTIS HC 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 alternate application to an electric vehicle powered by an electric motor without flywheel and to a hybrid electric vehicle powered by an electric motor with an internal combustion engine was studied. E.D.K.


The development, evaluation, and optimization of a preliminary design concept for a continuously variable transmission (CVT) to couple the high-speed output shaft of an energy storage flywheel to the drive train of an electric vehicle is discussed. An existing computer simulation program was modified and used to compare the performance of five CVT design configurations. Based on this analysis, a dual-cavity toroidal drive with regenerative gearing is selected for the CVT design configuration. Three areas are identified that will require some technological development: the ratio control system, the traction fluid properties, and evaluation of the traction contact performance. Finally, the suitability of the selected CVT design concept for automobile 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.


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 test. The concepts included advanced combustors, ceramic regenerators, an integrated control system, low cost turbine material, a continuously variable transmission, power-turbine driven accessories, power augmentation, and lineless insulation in the engine housing. R.E.S.

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


Automotive gas turbine concepts with significant technological advantages over the spark ignition (SI) engine were assessed. Possible design concepts were rated with respect to fuel economy and near-term application. A program plan which outlines the development of the improved gas turbine (IGT) concept that best met the goals and objectives of the study identifies the research and development work needed to meet the goal of entering a production engineering phase by 1983. The fuel economy goal is to show at least a 20% improvement over a conventional 1976 SI engine/vehicle system. On the basis of achieving the fuel economy goal, of overall suitability to mechanical design, and of automotive mass production cost, the powertrain selected was a single-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-term 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.

N80-28662** Rocketdyne, Canoga Park, Calif.
A. Cosmar and D. J. Warren 23 May 1980 234 p refs (Contract NAS5-21008)
A high pressure, low capacity, liquid hydrogen turbopump was designed, fabricated, and tested. The design configuration of the turbopump is summarized and the results of the analytical and test efforts are presented. Approaches used to 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.D.K.

FIELD EXPERIENCES WITH ROTORDYNAMIC INSTABILITY IN HIGH-PERFORMANCE TURBOMACHINERY
H. E. Doyle In NASA, Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 3-13 (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13L
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.

N80-29708** Southwest Research Inst., San Antonio, Tex.
FIELD VERIFICATION OF LATERAL-TORSIONAL COUPLING EFFECTS ON ROTOR INSTABILITIES IN CENTRIFUGAL COMPRESSORS
J. C. Wachel and F. R. Szenasi In NASA, Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 15-34 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13L
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 coincident 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.

N80-29709** Mechanical Technology, Inc., Latham, N. Y.
PRACTICAL EXPERIENCE WITH UNSTABLE COMPRESSORS
Stig B. Malanowski In NASA, Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 35-43 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01
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 overhung (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.

N80-29710** Ingersoll-Rand Co., Easton, Pa.
ANALYSIS AND IDENTIFICATION OF SUBSYNCHRONOUS VIBRATION FOR A HIGH PRESSURE PARALLEL FLOW CENTRIFUGAL COMPRESSOR
R. G. Kirk, J. C. Nicholas, G. H. Donald, and R. C. Murphy In NASA, Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 45-63 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13L
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.

SUBSYNCHRONOUS INSTABILITY OF A GEARED CENTRIFUGAL COMPRESSOR OF OVERHUNG DESIGN
Avail: NTIS HC A20/MF A01 CSCL 13L
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.

N80-29712** Bently Nevada Corp., Minden.
Donald E. Bently In NASA, Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 95-106 (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13L
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.

N80-29713** Kobe Steel Ltd. (Japan).
ASYNCHRONOUS VIBRATION PROBLEM OF CENTRIFUGAL COMPRESSOR
Takeshi Fujikawa, Naotsugi Ishiguro, and Mitsuhiko Ito In NASA, Lewis Res. Center Rotordyn. Instability Probl. in High-Performance Turbomachinery 1980 p 109-118 refs (For primary document see N80-29706 20-37)
Avail: NTIS HC A20/MF A01 CSCL 13L
125
An unstable asynchronous vibration problem in a high pressure centrifugal compressor and the remedial actions against it are described. Asynchronous vibration of the compressor took place when the discharge pressure (Pd) was increased, after the rotor was already at full speed. The typical spectral data of the shaft vibration indicate that as the pressure Pd increases, pre-unstable vibration appears and becomes larger, and large unstable asynchronous vibration occurs suddenly (Pd - 5.49 MPa). A computer program was used which calculated the logarithmic decrement and the damped natural frequency of the rotor bearing system. The analysis of the log-decrement is concluded to be effective in preventing unstable vibration in both the design stage and remedial actions.

**N80-29714** Louisvile Univ., Ky. Mechanical Engineering Dept.
**TESTING OF TURBULENT SEALS FOR ROTODYNAMIC COEFFICIENTS**
Dara W. Childs, John B. Dressman and S. Bart Childs In NASA Lewis Res. Center. Rotodynamic Instability Prob. in High-Performance Turbomachinery 1980 p 121-138 refs Prepared in cooperation with Texas A and M Univ., College Station (For primary document see N80-29706 20-37) (Grant NaG-3200)
Avail NTIS HC A20/MF A01 CSCL 131

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.

**N80-29715** Kobe Univ., (Japan). Engineering Dept.
**EVALUATION OF INSTABILITY COEFFICIENTS OF LABYRINTH SEALS IN TURBINES OR COMPRESSORS**
Tkuskuzo Iwatsubo In NASA Lewis Res. Center Rotodynamic Instability Prob. in High-Performance Turbomachinery 1980 p 139-167 refs (For primary document see N80-29706 20-37) Avail NTIS HC A20/MF A01 CSCL 131

The effects of a force induced by the labyrinth seal on the stability of rotor systems and the factors of the seal which affect the stability are investigated. In the analysis, it is assumed that the fluid in the seal is steady and that the rotor is set vertically in order to avoid the effects of gravity force. The force induced by the seal is expressed in terms proportional to the velocity and displacement of the rotor and is deduced 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 concept. The force induced by the labyrinth seal always makes the rotor system unstable, and the tendency is marked when seal leakages are small. The resonance point of the rotor system is also affected by the labyrinth seal (the resonance point of the rotor system is removed by the seal leaking). The force induced by the labyrinth seal was measured by using a water-tunnel experimental system which was designed to measure the labyrinth seal force by using the similarity between gas and liquid flow theory.

**N80-29717** Stuttgart Univ. (West Germany). Inst. fuer Thermische Stroemungsmechanik.
**FLOW INDUCED SPIN COEFFICIENTS OF LABYRINTH SEALS FOR APPLICATION IN ROTOR DYNAMICS**
H. Benckert and J. Wachter In NASA Lewis Res. Center Rotodynamic Instability Prob. in High-Performance Turbomachinery 1980 p 189-212 refs (For primary document see N80-29706 20-37)
Avail NTIS HC A20/MF A01 CSCL 131

Flow induced aerodynamic spring coefficients of labyrinth seals are discussed and the restoring force in the deflection plane of the rotor and the lateral force acting perpendicularly to it are also considered. The effects of operational conditions on the spring characteristics of these components are examined, such as differential pressure, speed, inlet flow conditions, and the geometry of the labyrinth seals. Estimation formulas for the lateral forces due to shaft rotation and inlet swirl, which are developed through experiments, are presented. The utilization of the investigations is explained and results of stability calculations, especially for high pressure centrifugal compressors, are added. Suggestions are made concerning the avoidance of exciting forces in labyrinth.

**N80-29718** Hitachi Ltd., Tsuchihara (Japan). Mechanical Engineering Research Lab.
**HYDRAULIC FORCES CAUSED BY ANNUAR PRESSURE SEALS IN CENTRIFUGAL PUMPS**
Avail NTIS HC A20/MF A01 CSCL 131

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 ones. 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.

**N80-29719** California Inst. of Tech, Pasadena.
**A TECHNICAL PROGRAM TO MEASURE FLUID MECHANICAL WHIRL-EXCITATION FORCES IN CENTRIFUGAL PUMPS**
(Contract NAS8-33108)
Avail NTIS HC A20/MF A01 CSCL 131

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.

**N80-29720** Technical Univ. of Denmark, Copenhagen.
**EFFECT OF FLUID FORCES ON ROTOR STABILITY OF CENTRIFUGAL COMPRESSORS AND PUMPS**
Jorgen Colding-Jorgensen In NASA Lewis Res. Center Rotodynamic Instability Prob. in High-Performance Turbomachinery 1980 p 243-265 refs (For primary document see N80-29706 20-37)
Avail NTIS HC A20/MF A01 CSCL 131

A simple two dimensional model for calculating the rotodynamic effects of the impeller forces in centrifugal compressors and pumps is presented. It is based on potential flow theory with singularities. Equivalent stiffness and damping coefficients are calculated for a machine with a 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.

**N80-29721** Cornell Univ., Ithaca, N. Y.
**NON-SYNCHRONOUS WHIRLING DUE TO FLUID-DYNAMIC FORCES IN AXIAL TURBO-MACHINERY ROTORS**
Shen Fu Shen and Vinod G. Mengle In NASA Lewis Res. Center Rotodynamic Instability Prob. in High-Performance Turbomachinery 1980 p 267-284 refs (For primary document see N80-29706 20-37)
Avail NTIS HC A20/MF A01 CSCL 131

The role of fluid forces acting on the blades of an axial turborotor with regards to whirling was analyzed. The dynamic parameters of the rotor are investigated.
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 flow rate, fluid density and an increase in stiffness and external damping are all indicative for improved stability. R.C.T.


The quasi-steady 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 fluid. Results indicate that the average total damping coefficient per stage needed for stability is delta sub fluid total > 1.85. R.C.T.


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. R.C.T.

N8O-28724# Tokyo Univ. (Japan). FLUID FORCES ON ROTATING CENTRIFUGAL IMPELLER WITH WHIRLING MOTION Hidenobu Shoji and Hideo Ohashi / NASA. Lewis Res. Center Rotordyn. Instability Probl. 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 N8O-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 formulated for various values of whirl speed, number of impeller blades and angle of blades. Specific examples as well as significant results are given. R.C.T.


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. R.C.T.


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. R.C.T.


The effect of working 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 probe pulse tachometer and electronic digital counter. R.C.T.


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 axes appears to be a backward whirl at rate Omega - omega a 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. R.C.T.

N8O-28729# Politechnika Lodzka (Poland). PARAMETRIC INSTABILITIES OF ROTOR-SUPPORT SYSTEMS WITH APPLICATION TO INDUSTRIAL VENTILATORS Zdzislaw Parszewski, Janusz Krokiewski, and Krzysztof Marynowski / NASA. Lewis Res. Center Rotordyn. Instabiltiy Probl. in High-Performance Turbomachinery 1980 p 383-400 refs (For primary document see N8O-29706 20-37)

Avail: NTIS HC A20/MF A01 CSCL 131

Rotor support systems interaction with parametric excitation is considered for both unequal principal shaft stiffness (generators) and offset disc rotors (ventilators). Instability regions and types 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. 

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

INSTABILITY THRESHOLDS FOR FLEXIBLE ROTORS IN HYDRODYNAMIC BEARINGS

Two types of fixed pad hydrodynamic bearings (multiplier and pressure dam) were considered. Optimum and nonoptimum geometric configurations were tested. The optimum geometric configurations were determined by using a theoretical analysis and then the bearings were constructed for a flexible rotor test rig. It was found that optimizing bearings using this technique produces a 100% or greater increase in rotor stability. It is shown that this increase in rotor stability is carried out in the absence of certain types of instability mechanisms such as aerodynamic crosscoupling. However, the increase in rotor stability should greatly improve rotating machinery performance in the presence of such forces as well.

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-3106; Contracts DAAG29-77-C-0009; EF-76-S-01.2479)

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.

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.

N80-29733* Virginia Univ., Charlottesville.

FEASIBILITY OF ACTIVE FEEDBACK CONTROL OF ROTORDYNAMIC INSTABILITY

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.


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 to 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
Results are presented for the design and development of an upgraded engine. The design incorporated technology advancements which resulted from development testing on the Baseline Engine. The final engine performance with all retro-fitted components from the development program showed a value of 91 HP at design speed in contrast to the design value of 104 HP. The design speed SFC was 0.53 versus the goal value of 0.44. The loss in power was primarily due to missing the efficiency targets of axial bearing. Most of the SFC deficit was attributed to missed goals in the heat recovery system relative to regenerator effectiveness and expected values of heat loss. Vehicular fuel consumption, as measured on a chassis dynamometer, for a vehicle inertia weight of 3500 lbs., was 15 MPG for combined urban and highway driving cycles. The baseline engine achieved 8 MPG with a 4500 lb. vehicle. Even though the goal of 18.3 MPG was not achieved with the upgraded engine, there was an improvement in fuel economy of 46% over the baseline engine, for comparable vehicle inertia weight.

Author

DEVELOPMENT OF FLEXIBLE ROTOR BALANCING CRITERIA Final Report
Wayne W. Walter and Neville F. Rieger
(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 bases 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 data always exceeded the 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.

A.R.H.


Analytical studies of phase change effects in parallel and tapered liquid face seals are presented. An isothermal and adiabatic model of low Reynolds number flow 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.

A.T.


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 and friction effects included, is also discussed.

S.D.


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 stated 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.

M.E.P.
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-AB29-76SF-20370)
(NASA-TM-79291, DOE/NASA/20370-79/19, E-235) Avail:
NTIS HC A02/MF A01 CSCL 14D
An overview of how modern engineering and safety techniques can be used to assure the reliable and safe operation of photo voltaic 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.

N80-22714* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
SIMULATION OF TRANSDUCER-COUPLED EFFECTS ON BROADBAND ULTRASONIC SIGNALS
Alex Vary 1980 36 p.
(NASA-TM-81489, E-427) Avail:
NTIS HC A03/MF A01 CSCL 14D
The increasing use of broadband, pulse-echo ultrasonics in nondestructive evaluation, flaws and material properties has generated a need for improved understanding of the way signals are modified by coupled and bonded thin-layer interfaces associated with transducers. This understanding is most important when using frequency spectrum analyses for characterizing material properties. In this type of application, signals emanating from material specimens can be strongly influenced by 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.

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.
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.

N80-28682* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
QUANTITATIVE ULTRASONIC DETERMINATION OF ENGINEERING PROPERTIES IN METALS, COMPOSITES AND CERAMICS
Alex Vary 1980 18 p.
Presented at First Seminar on Advanced Ultrasonic Tech., Longueil, Quebec, 9-10 Jun. 1980; sponsored by National Research Council of Canada
(NASA-TM-81530; E-482) Avail: NTIS HC A02/MF A01 CSCL 14D
Ultrasonic technology from the perspective of nondestructive evaluation approaches to material strength prediction and property verification is reviewed. Emergent advanced technology involving quantitative ultrasonic techniques for materials characterization is described. Ultrasonic methods are particularly useful in this area because they involve mechanical elastic waves that are strongly modulated by the same morphological factors that govern mechanical strength and dynamic failure processes. It is emphasized that the technology is in its infancy and that much effort is still required before the techniques can be transferred from laboratory to industrial environments.


The ultrasonic nondestructive evaluation techniques discussed in 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.


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.

N80-13503 Syracuse Univ., N. Y.
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
For applications see OS Aircraft Design, Testing and Performance and 18 Spacescraft Design, Testing and Performance

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. Buzard Nov. 1979 21 p. refs
(NASA-TM-81379; E-264) Avail NTIS HC A03/MF A01 CSCL 20K

Standard round specimen fracture toughness 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

N80-15426# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
A RELATION BETWEEN SEMIEMPIRICAL FRACTURE ANALYSES AND R-CURVES
Thomas W. Orange Jan. 1980 45 p. refs
(NASA-TP-1600; E-9963) Avail NTIS HC A03/MF A01 CSCL 20K

The relations between several semiempirical fracture analyses (SEFA) and the R-curve concept of fracture mechanics are examined and the conditions for equivalence between a SEFA and an R-curve are derived. A hypothetical material is employed to study the relation analytically. Equivalent R-curves are developed for several real materials using data from the literature. For each SEFA there is an equivalent R-curve whose magnitude and shape are determined by the SEFA formulation and its empirical parameters. If the R-curve is indeed unique, then the various empirical parameters cannot be constant, and vice versa. However, for one SEFA the differences are small enough that they may be within the range of normal data scatter for real materials. Author

N80-22734# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
NONLINEAR, THREE-DIMENSIONAL FINITE-ELEMENT ANALYSIS OF AIR-COOLED GAS TURBINE BLADES
Albert Kaufman and Raymond E. 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 utilized for the analysis of impingement cooled airfoils, with and without leading-edge film cooling. Creep was the predominant damage mode (ignoring hot corrosion), particularly around film-cooling holes. Radially angled holes exhibited less creep than holes with axes normal to the surface. Beam-theory analysis of all-impingement-cooled airfoils gave fair agreement with MARC results for initial creep. Author

N80-23878# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
STATUS OF NASA FULL-SCALE ENGINE AEROELASTICITY RESEARCH

Data relevant to several types of aeroelastic instabilities were obtained using various types of turbojet and turbofan engines. In particular, data relative to separated flow (stall) flutter, choke flutter, and system mode instabilities 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.

N80-23864# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
PRACTICAL IMPLEMENTATION OF THE DOUBLE LINEAR DAMAGE RULE AND DAMAGE CURVE APPROACH FOR TREATING CUMULATIVE FATIGUE DAMAGE
S. S. Manson (Case Western Reserve Univ) and G. R. Halford Apr. 1980 50 p. refs
(NASA-TP-16157; E-387) Avail NTIS HC A03/MF A01 CSCL 20K

Simple procedures are presented for treating cumulative fatigue damage under complex loading history using either the damage curve concept or the double linear damage rule. A single equation is provided for use with the damage curve approach; each loading event providing a fraction of damage until failure is presumed to occur when the damage sum becomes unity. For the double linear damage rule, analytical expressions are provided for determining the two phases of life. The procedure involves two steps, each similar to the conventional application of the commonly used linear damage rule. When the sum of cycle ratios based on phase 1 lives reaches unity, phase 1 is presumed complete, and further loadings are summed as cycle ratios on phase 2 lives. When the phase 2 sum reaches unity, failure is presumed to occur. No other physical properties or material constants than those normally used in a conventional linear damage rule analysis are required for application of either of the two cumulative damage methods described. Illustrations and comparisons of both methods are discussed. Author

N80-27719# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
COMPARISON OF ELASTIC AND ELASTIC-PLASTIC STRUCTURAL ANALYSES FOR COOLED TURBINE BLADE AIRFOILS
Albert Kaufman Jul. 1980 15 p. refs
(NASA-TP-1679; E-241) Avail NTIS HC A02/MF A01 CSCL 20K

Elastic plastic stress strain states in cooled turbine blade airfoils were calculated by three methods for the initial takeoff transit 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 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

N80-32753# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
THE METHOD OF LINES IN THREE DIMENSIONAL FRACTURE MECHANICS

A review of recent developments in the calculation of design parameters for fracture mechanics by the method of lines (MOL) is presented. Three dimensional elastic and elasto-plastic formulations are examined and results from previous and current research activities are reviewed. The application of MOL to the appropriate partial differential equations of equilibrium leads to coupled sets of simultaneous ordinary differential equations. Solutions of these equations are obtained by the Peano-Baker and by the recurrence relations methods. The advantages and limitations of both solution methods from the computational standpoint are summarized.

R.K.G.


The paper presents simple spline-function equations for fracture mechanics calculations. A spline function is a sequence of piecewise polynomials of degree n greater than 1 whose coefficients are such that the function and its first n-1 derivatives are continuous. Second-degree spline equations are presented for 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 gives the crack length to be calculated from the slope of the load-displacement curve. For an R-curve test, equations allow the crack length and stress intensity factor to be calculated from the displacement and the displacement ratio.

A.T.


The stability of a beam subjected to compressive centrifugal forces arising from steady rotation about an axis which does not pass through the clamped end of the beam is analyzed to determine the critical rotational speeds for buckling in the in-plane and out-of-plane directions. The differential equations of motion are solved numerically using an integrating matrix method in combination with an eigenanalysis to determine the eigenvalues from which stability is assessed. The results clarify several differences which have been identified in the literature relating to the proper behavior of the critical rotational speed for buckling as the radius of rotation of the clamped end of the beam is reduced. (Author)


The method of Strainrange Partitioning is used to predict the cyclic lives of the Metal Properties Council's long time creep-fatigue intermission tests of several steel alloys. Comparisons are made with predictions based upon the Time- and Cycle-Fraction approach. The method of Strainrange Partitioning is shown to give consistently more accurate predictions of cyclic life than is given by the Time- and Cycle-Fraction approach. (Author)


A convenient procedure is described for the determination of the mechanical behavior (elastic properties and failure stresses of angle-plied fiber composite laminates using a pocket calculator. The procedure consists of simple equations and appropriate graphs of (plus or minus theta) ply combinations. The procedure can handle all types of fiber composites including hybrids. The versatility and generality of the procedure is illustrated using several step-by-step numerical examples. (Author)


The paper presents data relevant to several types of aeroelastic instabilities which have been obtained using several types of turbojet and turbofan engines. Special attention is given to data relative to separated flow (stall) flutter, fan flutter, and system mode instabilities. The discussion covers the characteristics of these instabilities, and a number of correlations are presented that help identify the nature of the phenomena. M.E.P.


Developments in the analysis of creep rupture data are reviewed with particular reference to time temperature relations for the correlation and extrapolation of creep and stress rupture data, the minimum commitment method, and successive regression methods. Some contributions to the development of time-temperature parameters are noted. V.P.

A80-45364* Vibration and buckling of rectangular plates under in-plane hydrostatic loading. R. E. 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. 543-555, 16 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 formulæ are presented which provide a simple means of determining the fundamental frequency parameter. (Author)


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 progresses from the tip of the triangular notch, the load increases to a maximum then decreases. To obtain the relation between the fracture toughness and
maximum load, calculations of Srawley and Gross for specimens with a straight-through crack were applied to the specimens with chevron notches. The specimen 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.

N80-10615** Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

EFFECT OF TIME DEPENDENT FLIGHT LOADS ON JT9D-7 PERFORMANCE DETERIORATION
A Jay and B L Lewis 21 Aug 1979 73 p refs
HC A04/MF A01 CSCL 01C

The results of a modal transient analysis of the engine/aircraft system are presented. The response of the JT9D to analytically simulated vertical gusts and landings was predicted using a NASTRAN finite element mathematical model of the JT9D/74 propulsion system. The NASTRAN finite element model of the propulsion system included engine structural models of the fan, high/low pressure rotors, as well as nacelle models of the inlet cowl, tailcone, and wing pylons. The analysis conducted predicts that an insignificant level of JT9D-7 performance deterioration would occur due to a vertical gust event 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 event. J M S.

N80-22733** Mechanical Technology, Inc., Latham, N Y.

DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING OF ELASTOMERS IN ENGINEERING APPLICATIONS, PART 6
A. Rieger, G Burgess, and E Zorzi Apr 1980 57 p refs
HC A08/MF A01 CSCL 20K

An elastomer damper was designed, tested, and compared with the performance of a hydraulic damper for a power transmission shaft. The six button Viton-70 damper was designed so that the elastomer damper or the hydraulic damper could be activated without upsetting the imbalance condition of the assembly. This permitted a direct comparison of damper effectiveness. The elastomer damper consistently performed better than the hydraulic mount and permitted stable operation of the power transmission shaft to speeds higher than obtained with the squeeze film damper. Tests were performed on shear specimens of Viton-79, Buna-N, EPDM, and Neoprene to determine performance limitations imposed by strain, temperature, and frequency. Frequencies of between 110 Hz and 1100 Hz were surveyed with imposed strains between 0.0005 and 0.01 at temperatures of 32°C, 60°C, and 80°C. A set of design curves was generated in a unified format for each of the elastomer materials.

N80-27720** Massachusetts Inst. of Tech., Cambridge.

Aeroelastic and Structures Research Lab

INSTRUCTIONS FOR THE USE OF THE CIVM-JET 4C FINITE-STRAIN COMPUTER CODE TO CALCULATE THE TRANSIENT STRUCTURAL RESPONSES OF PARTIAL AND/OR COMPLETE ARBITRARILY-CURVED RINGS SUBJECTED TO FRAGMENT IMPACT
Jose J. A. Rodal, Susan E. French, Emmett A. Witmer, and Thomas R. Stagliano Dec, 1979 38 p refs
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
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 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. 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.

N80-18538' National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
POSSIBLE METHODS FOR DISTINGUISHING IceBERGS FROM SHIPS BY AERIAL REMOT'E SENSING
Walton L. Howes Dec. 1979 36 p refs
(NASA-TM-79310; E-280) Avail: NTIS HC A03/MF A01 CSLC 08L

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.G.T.

N80-18497' National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
NUMERICAL CALCULATION OF STEADY INVISCID FULL POTENTIAL COMPRESSIBLE FLOW ABOUT WIND TURBINE BLADES

An exact nonlinear mathematical model that accounts for three-dimensional cascade effects about the inner portions of the rotor blades and compressibility effects about the tip regions of the blades was derived. An artificially time dependent version was iteratively solved by a finite volume technique involving an artificial viscosity and a three-level consecutive mesh refinement. The exact boundary conditions were applied by generating a boundary conforming periodic computation mesh. K.L.

N80-20787' National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ASSESSMENT OF SATELLITE AND AIRCRAFT MULTISPECTRAL SCANNER DATA FOR STRIP-MINE MONITORING

The application of LANDSAT multispectral scanner data to describe the mining and reclamation changes of a hilltop surface coal mine in the rugged, mountainous area of eastern Kentucky is presented. Original single band satellite imagery, computer enhanced single band imagery, and computer classified imagery are presented for four different data sets in order to demonstrate the land cover changes that can be detected. Data obtained with an 11 band multispectral scanner on board a C-47 aircraft at an altitude of 3000 meters are also presented. Comparing the satellite data with color, infrared aerial photography, and ground survey data shows that significant changes in the disrupted area can be detected from LANDSAT band 5 satellite imagery for mines with more than 100 acres of disturbed area. However, band-ratio (bands 5/6) imagery provides greater contrast than single band imagery and can provide a qualitative level 1 classification of the land cover that may be useful for monitoring either the disturbed mining area or the revegetation progress. However, if a quantitative, accurate classification of the barren or revegetated classes is required, it is necessary to perform a detailed, four band computer classification of the data. J.M.S.
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.
The efficiency of solar cells for space use is assessed. High efficiency techniques. Experimental details are given along with the results are discussed.

R.E.S.

N80-15554$^?$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**SPACE SOLAR CELLS: HIGH EFFICIENCY AND RADIATION DAMAGE**

Henry W. Brandhorst, Jr. and Daniel T. Bernardowicz
1980
12 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE (NASA-TM-81387; E-297) Avail NTIS HC A02/MF A01 CSCL 10A

The progress and status of efforts to increase the end-of-life efficiency of solar cells for space use is assessed. High efficiency solar cells, silicon solar cell radiation damage, GaAs solar cell performance and radiation damage and 30 percent devices are discussed.

R.E.S.

N80-15555$^?$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**OPEN-CIRCUIT VOLTAGE IMPROVEMENTS IN LOW RESISTIVITY SOLAR CELLS**

M. P. Godlewski, T. M. Klucher, G. A. Mazanis, and V. G. Weiher
1980
11 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE (NASA-TM-81386; E-298) Avail NTIS HC A02/MF A01 CSCL 10A

Improvements in the open circuit voltage of 0.1 ohm-cm silicon solar cells were achieved using a multistep diffusion technique. Experimental details are given along with the results of an analysis that indicate that anomalous behavior of the electron mobility in the cell base limits attainment of higher voltages.

Author

N80-15556$^?$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**BACK SURFACE REFLECTORS FOR SOLAR CELLS**

An-Ti Chai Chai 1980 10 p refs Presented at 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE (NASA-TM-81390; E-300) Avail NTIS HC A02/MF A01 CSCL 10A

Sample solar cells were fabricated to study the effects of various back surface reflectors on the device performance. They are typical 50 micrometers thick, space quality, silicon solar cells except for variations of the back contact configuration. The back surfaces of the sample cells are polished to a mirror-like finish, and have either conventional full contacts or grid finger contacts. Measurements and evaluation of various metallic back surface reflectors, as well as cells with total internal reflection, are presented. Results indicate that back surface reflectors formed using a grid finger back contact are more effective reflectors than cells with full back metallization and that Au, Ag, or Cu are better back surface reflector metals than Al.

R.C.T.

N80-15557$^?$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**LITHIUM COUNTERDOPE N/P SILICON SOLAR CELLS**

A. M. Herman (Tulane Univ.), C. K. Swartz, H. W. Brandhorst, Jr., and J. Weinberg
1980 13 p refs Presented at the 14th Photovoltaic Specialists Conf., San Diego, Calif., 7-10 Jan. 1980; sponsored by IEEE (NASA-TM-81391; E-301) Avail NTIS HC A02/MF A01 CSCL 10A

Lithium counterdoped n/p silicon solar cells were irradiated with 1 MV electrons and their post irradiation performance and low temperature annealing properties were compared to that of the 0.35 ohm-cm control cells. Cells fabricated from float zone and Czochralski grown silicon were investigated. It was found that the float zone cells exhibited superior radiation resistance compared to the control cells, while no improvement was noted for the Czochralski grown cells. Room temperature and 60 C annealing studies were conducted. The annealing was found to be a combination of first and second order kinetics for short times. It was suggested that the mechanism responsible was migration of lithium to a radiation induced defect with subsequent neutralization of the defect by combination with lithium. The effects of base lithium gradient were investigated. It was found that cells with negative base lithium gradients exhibited poor radiation resistance and performance compared to those with positive or no lithium gradients, the latter being preferred for overall performance and radiation resistance.

M.G.

N80-15558$^?$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**RADIATION DAMAGE ANNEALING MECHANISMS AND POSSIBLE LOW TEMPERATURE ANNEALING IN SILICON SOLAR CELLS**

I. Weinberg and G. K. Swartz

The defect responsible for reverse annealing in 2 ohm-cm n/p silicon solar cells was identified. This defect, with energy level at e sub v = 0.3 eV was tentatively identified as a boron oxygen vacancy complex. Results indicate that its removal could result in significant annealing for 2 ohm-cm and lower resistivity cells at temperatures as low as 200 C. These results were obtained by use of an expression derived from the Shockley-Read-Hall recombination theory which relates measured diffusion length ratios to relative defect concentrations and electron capture cross sections. The relative defect concentrations and one of the required capture cross sections are obtained from Deep Level Transient Spectroscopy. Four additional capture cross sections are obtained using diffusion length data and data from temperature dependent lifetime studies. These calculated results are in reasonable agreement with experimental data.

M.G.

N80-15560$^?$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**CANDIDATE THERMAL ENERGY STORAGE TECHNOLOGIES FOR SOLAR INDUSTRIAL PROCESS HEAT APPLICATIONS**

Edward R. Furman

A number of candidate thermal energy storage system elements were identified as having the potential for the successful application of solar industrial process heat. These elements which include storage media, containment and heat exchange are shown.

R.C.T.

N80-15561$^?$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**GLOBAL CALIBRATION OF TERRESTRIAL REFERENCE CELLS AND ERRORS INVOLVED IN USING DIFFERENT IRRADIANCE MONITORING TECHNIQUES**

Henry B. Curtis

The feasibility of global calibration of terrestrial reference
cells is discussed. A simple, accurate secondary calibration technique based on ratios of test to reference cell currents measured in natural sunlight is described. Different techniques for monitoring incident irradiance during solar cell performance measurements are also examined and assessed, including the techniques of black body detectors, calibrated reference cells, and the convoluted spectral response with solar irradiance.

M.G.

N80-16453* National Aeronautics and Space Administration Lewis Research Center. Cleveland, Ohio.

LARGE WIND TURBINE DESIGN CHARACTERISTICS AND R AND D REQUIREMENTS


Detailed technical presentations on large wind turbine research and development activities sponsored by public and private organizations are presented. Both horizontal and vertical axis machines are considered with emphasis on their structural design. For individual titles see N80-16454 through N80-16482.

N80-16455* National Aeronautics and Space Administration Lewis Research Center. Cleveland, Ohio.

DESIGN EVOLUTION OF LARGE WIND TURBINE GENERATORS

David A. Spera In its Large Wind Turbine Design Characteristics and R and D Requirements Dec 1979 p 25-33 refs (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 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. Sirocky, Jr. and Larry A. Vitera 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. Triendenberg (Purdue, Univ.) In its Large Wind Turbine Design Characteristics and R and D Requirements Dec 1979 p 375-384 refs (For primary document see N80-16453 07-44) Avail NTIS HC A20/MF A01 CSCL 10B

The potential electrical problems that may be inherent in the inertia of clusters of wind turbine generators and an electric utility network were investigated. Preliminary and limited results of an analog simulation of two MOD-2 wind generators tied to an infinite bus indicate little interaction between the generators and between the generators and the bus. The system demonstrated transient stability for the conditions considered.

A.R.H.

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

POTENTIAL PERFORMANCE IMPROVEMENT USING A REACTING GAS (NITROGEN TETROXIDE) AS THE WORKING FLUID IN A CLOSED BRAYTON CYCLE


The results of an analysis to estimate the performance that could be obtained by using a chemically reacting gas (nitrogen tetroxide) as the working fluid in a closed Brayton cycle are presented. Compared with data for helium as the working fluid, these results indicate efficiency improvements from 4 to 90 percent, depending on turbine inlet temperature, pressures, and gas residence time in heat transfer equipment.

Author

N80-16494* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

PRELIMINARY ANALYSIS OF PERFORMANCE AND LOADS DATA FROM THE 2 MEGAWATT MOD-1 WIND TURBINE GENERATOR


Preliminary test data on output power, 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 output wind speed which agrees closely with design. Blade load were measured at wind speeds up to 14 m/s and also during rapid shut downs. Peak transient loads during the most severe shutdowns are less than the design limit loads. On the inboard blade sections, fatigue loads are approximately equal to the design cyclic loads. On the outboard blade sections, however, measured cyclic loads...
cells is discussed. A simple, accurate 'secondary' calibration technique based on ratios of test to reference cell currents measured in natural sunlight is described. Different techniques for monitoring incident irradiance during solar cell performance measurements are also examined and assessed, including the techniques of black-body detectors, calibrated reference cells, and the convolution of spectral response with solar irradiance.

M.G.

Detailed technical presentations on large wind turbine research and development activities sponsored by public and private organizations are presented. Both horizontal and vertical axis machines are considered with emphasis on their structural design. For individual titles, see N80-16454 through N80-16482.

N80-16455* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DESIGN EVOLUTION OF LARGE WIND TURBINE GENERATORS David A. Spera In its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 25-33 ref (For primary document see N80-16453 07-44) Avail. NTIS HC A20/MF A01 CSCL 10B
During the past five years, the goals of economy and reliability have led to a significant evolution in the basic design—both external and internal—of large wind turbine systems. To show the scope and nature of recent changes in wind turbine designs, development of three types are described: (1) system configuration developments; (2) computer code developments; and (3) blade technology developments.

R.E.S.

N80-16469* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. STRUCTURAL ANALYSIS CONSIDERATIONS FOR WIND TURBINE BLADES David A. Spera In its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 211-224 refs (For primary document see N80-16453 07-44) Avail. NTIS HC A20/MF A01 CSCL 10B
Approaches to the structural analysis of wind turbine blade designs are reviewed. Specifications and materials data are discussed along with the analysis of vibrations, loads, stresses, and failure modes.

K.L.

N80-16470* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. BLADE DESIGN AND OPERATING EXPERIENCE ON THE MOD-0A 200 KW WIND TURBINE AT CLAYTON, NEW MEXICO Bradford S. Linscott and Richard K. Shaltens In its Large Wind Turbine Design Characteristics and R and D Requirements Dec. 1979 p 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. Srochky, Jr., and Larry A. Vitera 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.

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

Preliminary test data on output power versus wind speed, rotor blade loads, system dynamic behavior, and start-stop characteristics on the Mod-1 wind turbine generator are presented. These data were analyzed statistically and compared with design predictions of system performance and loads. To date, the Mod-1 wind turbine generator has produced up to 1.5 MW of power, with a measured power versus wind speed curve which agrees closely with design. Blade loads were measured at wind speeds up to 14 m/s and also during rapid shutdowns. Peak transient loads during the most severe shutdowns are less than the design limit loads. On the inboard blade sections, fatigue loads are approximately equal to the design cyclic loads. On the outboard blade sections, however, measured cyclic loads...
are significantly larger than design values, but they do not appear to exceed fatigue allowable loads as yet. 

R.E.S.

**N80-18564** 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. 

**N80-18559** 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. NASA 

**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 is comprised of a polyphenylene oxide polymer, an organic additive and inorganic, and organic fillers which comprise 55% by volume or less of the coating material. Preferably, at least one inorganic filler material which is reactive with the electrolyte is included to produce desirable pores in the coating. NASA 

**N80-18557** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. 

**CATALYST SURFACES FOR THE CHROMOUS/CHROMIC REDOX COUPLE Patent Application** 

Jose D. Giner (Giner, Inc.) and Kathleen J. Cahill, inventors (to NASA) (Giner, Inc.) Filed 27 Jul. 1979 15 p Spons. by NASA 

**N80-18563** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. 

**ENGINEERING EVALUATION OF A SODIUM HYDROXIDE THERMAL ENERGY STORAGE MODULE Final Report** 

Donald G. Perdue and Larry H. Gordon Feb. 1980 53 p refs Proposed for presentation at Wind Energy Conf. Boulder, Colo. 9-11 Apr. 1980; sponsored by Am. Inst. of Aeron, and Astronautics and the Midwest Res. Inst. (Contract EC-77-A-31-1034) (NASA-TM-81445; DOE/NASA/1028-80/26; E-365) Avail: is an electrically conductive, inert material plated with 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 deplate from the negative electrode and the metal coating on the electrode will act as a catalyst to increase current density. NASA 

**N80-19613** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. 

**TEETERED, TIP-CONTROLLED ROTOR: PRELIMINARY TEST RESULTS FROM MOD-0 100-kW EXPERIMENTAL WIND TURBINE** 


Results of tests conducted using the MOD-0 100 kW experimental wind turbine are evaluated. The teetered rotor significantly decreased loads on the yaw drive mechanism and reduced blade cyclic flapwise bending moments by 25 percent at the 20 percent span location when compared to the rigid hub rotor. The teetered hub performed well, but impacted the teeter stops on occasion as wind speed and/or direction varied rapidly. The tip-controlled rotor performed satisfactorily with some expected loss of control when compared to the full span pitchable blade. The performance results indicate that a review of techniques used to calculate rotor power is in order. K.L. 

**N80-19614** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. 

**INSTALLATION AND CHECKOUT OF THE DOE/NASA MOD-1 2000-kW WIND TURBINE GENERATOR** 


The Mod-1 machine was assembled without the blades, tested, and sent to the site at Boone, North Carolina for erection. The blades were transported directly to the site. A series of
checkout tests were then conducted to evaluate performance and loads. The results of these tests compared well with the design data.

NBO-19626*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS), VOLUME 1: SUMMARY Gerald J. Barna, Raymond K. Burns, and Gary D. Sagerman Jan. 1980 89 p (Contract EC-77-A-31-1062) (NASA-TM-81400; DOE/NASA/1062-80/4; E-312) Avail: NTIS HC A05/MF A01 CSCL 10B Various advanced energy conversion systems that can use coal or coal-derived fuels for industrial cogeneration applications were compared to provide information needed by DOE to establish research and development funding priorities for advanced-technology systems that could significantly advance the use of coal or coal-derived fuels in industrial cogeneration. Steam turbines, diesel engines, open-cycle gas turbines, combined cycles, closed-cycle gas turbines, Stirling engines, phosphoric acid fuel cells, molten carbonate fuel cells, and thermionic were studied with technology advancements appropriate for the 1985-2000 time period. The various advanced systems were compared and evaluated for wide diversity of representative industrial plants on the basis of fuel energy savings, annual energy cost savings, emissions savings, and rate of return on investment as compared with purchasing electricity from a utility and providing process heat with an on-site boiler. Also included in the comparisons and evaluations are results extrapolated to the national level. F.O.S.

NBO-21837*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. FLAME TRANSIENT PARAMETRIC STUDIES FOR CONTROL OF FUEL BOUND NITROGEN USING RICH-LEAN TWO-STAGE COMBUSTION Donald F. Schultz and Gary Wolfbrandt 1980 25 p refs Presented at Western States Sect. of the Combust. Inst. of Spring Meeting, Irvine, Calif., 21-22 Apr. 1980 (Contract EF-77-A-01-2593) (NASA-TM-81472; DOE/NASA/2593-80/15; E-405) Avail: NTIS HC A02/MF A01 CSCL 21B An experimental parametric study of rich-lean two-stage combustion in a flame tube is described and approaches for minimizing the conversion of fuel-bound nitrogen to nitrogen oxides in a premixed, homogeneous combustion system are evaluated. Air at 672 K and 0.48 MPa was premixed with fuel blends of propane, toluene, and pyridine at primary equivalence ratios ranging from 0.5 to 2.0 and secondary equivalence ratios of 0.5 to 0.7. Distillates of SRC-II, a coal syncrude, were also tested. The fuels were processed to vary fuel hydogen composition from 9.0 to 18.3 weight percent and fuel nitrogen composition from zero to 1.5 weight percent. Rich-lean combustion proved effective in reducing fuel nitrogen to NO sub x conversion: conversion rates up to 10 times lower than those normally produced by single-stage combustion were achieved. The optimum primary equivalence ratio, where the least NO sub x was produced, was selected to shift between 1.4 and 1.7 with changes in fuel nitrogen content and fuel hydrogen content. Increasing levels of fuel nitrogen content lowered the conversion rate, but not enough to avoid higher NO sub x emissions as fuel nitrogen increased. M.G.

NBO-22777*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. ADVANCED SCREENING OF ELECTRODE COUPLES J. Giner and K. Cahill Feb. 1980 56 p refs (Contract NAS3-20794, EC-77-A-31-1002) (NASA-CR-159738; DOE/NASA/0794-80/1) Avail: NTIS HC A04/MF A01 CSCL 10B The chromium (Cr3+ /Cr2+ 2) redox couple (electrolyte and electrode) was investigated to determine its suitability as negative electrode for the iron (Fe3+ /Fe2+ 2) chrom- ion (Cr3+ /Cr2+ 2) redox flow battery. Literature search and laboratory investigation established that the solubility and stability of aqueous acidic solutions of chromium(3) chloride and chromium(2) chloride are sufficient for redox battery application. Four categories of electrode materials were tested: namely, 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 an acceptable cathodic performance. However, the identification of lead as a good cathodic electrolysis catalyst 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 Mar. 1980 650 p refs Meeting held at Tusors Corner, Va. 3-4 Dec. 1979; sponsored by COE (NASA-CP-2125; E-428; CONF-791232) Avail: NTIS HC A09/MF A01 CSCL 10C 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 conversion 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 aqueous 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 Larry H. Gordon in Its Thermal Energy Storage Mar. 1980 p 38-41 refs (For primary document see NBO-22788 13-44) Avail: NTIS HC A09/MF A01 CSCL 10B The implementation of a program level assessment of thermal energy storage technology thrusts for the near and far term to assure overall coherent energy storage program is considered. The identification and definition of potential thermal energy storage applications, definition of technology requirements, and appropriate market sectors are discussed along with the necessary coordination, planning, and preparation associated with program reviews, workshops, multi-year plans and annual operating plans for the major laboratory tasks. J.M.S.
The NASA Redox energy storage system is described. The system is based on soluble aqueous iron and chromium chloride redox couples. The needed technology advances in the two elements (electrodes and membranes) that are key to its technological feasibility have been achieved and system development has begun. The design, construction, and test of a 1 kilowatt system integrated with a solar photovoltaic array is discussed.

R.E.S.

COMBINED CYCLE MHD-POWER PLANT APPLICATIONS
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 integrate separation plants, optimized for minimum specific power consumption and capital investment costs, for integration with MHD combined cycle power plants.

R.E.S.

INDUSTRIAL STORAGE APPLICATIONS OVERVIEW
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.

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R.E.S.

THE OPTIMIZATION AIR SEPARATION PLANTS FOR
N80-23778
The design, construction, and test of a 1 kilowatt elements (electrodes and membranes) that are key to its
temperature metallic recuperative heat exchanger to heat oxygen enriched combustion air) were comparable in both performance
to 1A ms,

R.E.S.

RUDolf A. DUSCHA

THE EFFECT OF CATALYST LENGTH AND DOWNSTREAM REACTOR DISTANCE ON CATALYTIC COMBUSTOR PERFORMANCE
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 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 range from 1230 K to 1500 K for the various conditions and configurations tested. The minimum operating temperature decreased with increasing total (catalytic-reactor-plug-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.

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R.E.S.
AN ELECTRIC VEHICLE PROPULSION SYSTEM'S IMPACT ON BATTERY PERFORMANCE: AN OVERVIEW


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 controller 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.

Pulse charging, as a method of rapidly and efficiently charging 300 amp-hour lead-acid traction cells for an electric vehicle application was investigated. A wide range of charge pulse current square waveforms were investigated and the results were compared to constant current charging at the time averaged pulse current values. Representative pulse current waveforms were: (1) positive waveform-peak charge pulse current of 300 amperes (amps), discharge pulse-current of zero amps, and a duty cycle of about 50%; (2) Romanov waveform-peak charge pulse current of 300 amps, peak discharge pulse current of 15 amps, and a duty of 50%; and (3) McCulloch waveform-peak charge pulse current of 193 amps, peak discharge pulse current of about 575 amps, and a duty cycle of 94%. Experimental results indicate that on the basis of amp-hour efficiency, pulse charging offered no significant advantage as a method of rapidly charging 300 amp-hour lead-acid traction cells when compared to constant current charging at the time average pulse current value. There were, however, some disadvantages of pulse charging in particular a decrease in charge amp-hour and energy efficiencies and an increase in cell electrolyte temperature. The constant current charge method resulted in the best energy efficiency with no significant sacrifice of charge time or amp-hour output. Whether or not pulse charging offer an advantage over constant current charging with regard to the cell charge/discharge cycle life is unknown at this time.

R.E.S.

EFFECT ON COMBINED CYCLE EFFICIENCY OF STACK GAS TEMPERATURE CONSTRAINTS TO AVOID ACID CORROSION Final Report


To avoid condensation of sulfuric acid in the gas turbine exhaust when burning fuel oils containing sulfur, the exhaust stack temperature and cold-end heat exchanger surfaces must be kept above the condensation temperature. Raising the exhaust stack temperature, however, results in lower combined cycle 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 use of various advanced energy conversion systems were compared with each other and with current technology systems for their savings in fuel energy, cost, and emission plans and on a national level. The ground rules established by NASA and assumptions made by the General Electric Company in performing this cogeneration technology alternatives study are presented. The analytical methodology employed is described in detail and is illustrated with numerical examples together with a description of the computer program used in calculating over 7000 energy conversion systems-industrial process applications. For Vol 1, see NBO:24797. R E S.

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 2.5 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 CO2 continued to be formed downstream of the catalytic reactor. At the highest equivalence ratios 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.

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 turbines can be operated satisfactorily on utility grids; (2) the structural loads can be predicted by existing codes; (3) assembly of the machine on top of the tower presents no major problem; (4) large blades 100 ft long can be transported long distances and over mountain roads; and (5) 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, tested rotor with 30% span tip control. Preliminary evaluation test results indicates that the tested 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 tested hub performed well but did impact the tester 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 1970, 17 candidate sites were identified for detailed evaluation as potential sites for installation of large, horizontal axis Wind Turbines (WT). Attention is given to the Mod-OA, a 200 kW WT located in Clayton, New Mexico. The discussion covers the meteorological data collected, some of the analyses based on these wind data as well as additional areas currently being investigated in relation to these data.

The paper 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)

A80-45722 # * Spectral effects on direct-insolation absorption of five collector coatings. G. B. Hetchikis (Texas Instruments, Inc., Dallas, Tex.), F. F. Simon (NASA, Lewis Research Center, Cleveland, Ohio), and L. C. Burnimister (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-18, T. P. 16 refs. Members, $1.50; nonmembers, $3.00. Grant No. NQ-G-3087.

Absorptance for direct insolation of back 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 ran 129 cells through charge-discharge cycles until failure; preliminary data analysis consisted of response surface estimate of life. Batteries fail through low voltage condition and an internal shorting condition: a competing failure modes analysis was made using maximum likelihood estimation for the extreme value life distribution. Extensive residual plotting and probability plotting were used to verify data quality and selection of model. A.T.


The paper describes the designs, hardware, and installations of NASA photovoltaic power systems in the village of Schuchull 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 Schuchull system has a 3.5 kW peak solar array which provides power for water pumping, a refrigerator for each family, lights, and community washing and sewing machines. The 1.8 kW 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 (VMJ) solar cell. The PMJ solar cell is internally divided into many voltage-generating regions, called unit cells, which are internally connected in series. The key to obtaining reasonable performance from this device was the separation of top surface field regions over each active unit cell area. Using existing solar cell fabricating methods, output voltages in excess of 20 volts per linear centimeter are possible. Analysis of the new device is complex, and numerous geometries are being studied which should provide substantial benefits in both normal sunlight usage as well as with concentrators. (Author)


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 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 charger circuitry for a 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 worse of the others, however, this difference could be due to an inadvertent.


A preprototype full-function 1.0 kW Redox system (2 kW peak) with 11 kW storage capacity has been built and integrated with the
NASO-10603 Energy Research Corp., Danbury, Conn.
TECHNOLOGY DEVELOPMENT FOR PHOSPHORIC ACID FUEL CELL POWERPLANT, PHASE 2 Quarterly Report
Larry Christopher, Jr., 1979 72 p Prepared for DOE
(Contract DEN3-67)
(NASA-CR-159705; DOE/NASA/0067-79-2; QR-3) Avail: NTIS HC A04/MF A01 CSCI 10A
A technique for producing an anodic inventory control membrane by spraying FEP onto a partially screened carbon paper backing (NASA-CR-159705; DOE/NASA/0067-79-2; QR-3) Avail: NTIS HC A04/MF A01 CSCI 10A

NASO-10822 General Electric Co., Schenectady, N. Y.
CONCEPTUAL DESIGN OF THERMAL ENERGY STORAGE SYSTEMS FOR NEAR-TERM ELECTRIC UTILITY APPLICATIONS, VOLUME 2: APPENDICES, SCREENING OF CONCEPTS
W. Hausz, B. J. Berkowitz, and R. C. Hare Apr. 1979 151 p refs
Volume two contains three appendices entitled: (1) Bibliography and Cross References; (2) Taxonomy: Proponents and Sources; and (3) Concept Definitions.

EXECUTIVE SUMMARY: MOD-1 WIND TURBINE GENERATOR ANALYSIS AND DESIGN REPORT Final Report
Mar. 1979 61 p
(Contracts NAS3-20508; EC-77-A-29-1010) (NASA-CR-159497; DOE/NASA/0058-79/3) Avail: NTIS HC A04/MF A01 CSCI 10A
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.

CHARACTERIZATION OF SOLAR CELLS FOR SPACE APPLICATIONS, VOLUME 10: ELECTRICAL CHARACTERISTICS OF SPECTROLAB B8F, TEXTURED, 10 OHM-CM, 300 MICRON CELLS AS A FUNCTION OF INTENSITY, TEMPERATURE AND IRRADIANCE
B. E. Anspaugh, R. G. Downing, T. F. Miyahira, and R. S. Weiss 1 Oct. 1979 38 p
(Contract NAS7-100) (NASA-CR-162422; JPL-Pub-78-15-Vol-10) Avail: NTIS HC A03/MF A01 CSCI 10A
Electrical characteristics of textured, back surface field, 10 ohm cm, 300 micron n/P silicon solar cells are presented in graphical and tabular format as a function of solar illumination intensity, temperature, and vibration. Author

ANTON PERMSELECTIVE MEMBRANE
Samuel S. Alexander, Russell B. Hodgdon, and Warren A. Waite 1979 52 p Sponsored by NASA
(Contract DEN3-1) (NASA-CR-159559; DOE/NASA/0001-79/1) Avail: NTIS HC A04/MF A01 CSCI 10A
Experimental composite membranes were synthesized on a lab scale consisting of a thin layer of anion permselective resin supported by and bonded to a porous, physically strong and conductive substrate film. These showed good selectivity and also substantially lower electrical resistivities than the homogenous candidate membranes optimized in the previous contract. A wide range of resin porosities were examined for three candidate membrane systems, CDIL, CP4L, and A3L to identify the formulation giving the best overall redox cell performance. Candidate anion membranes showed large increases in resistivity after a short time of immersion in concentrated FeCl/HC1 solution. Largely on the basis of resistance stability the CDIL formulation was selected as prime candidate and about thirty-five membranes (one foot square) were produced for experimental static and dynamic evaluation.
R.E.S.
A commercial approach to design and fabrication of an economical space power system is investigated. Cost projections are based on a 2 kW space power system conceptual design taking into consideration the capability for serviceability, constraints of operation in space, and commercial production engineering approaches. A breakdown of the system design, documentation, fabrication, and reliability and quality assurance estimated costs are detailed.

**N80-16483**

Energy Technology, Inc., Cleveland, Ohio

**STUDY OF ADVANCED RADIAL OUTFLOW TURBINE FOR SOLAR STEAM RANKINE ENGINES**

Cecil Marin and Terry Kolen. Dec 1979. 74 p refs (Contract DEN3-86) NASA 0086-79/1, ETA-1279 Available NTIS HC A04/MF A01 CSCL 10B

The performance characteristics of various steam Rankine engine configurations for solar electric power generation were investigated. A radial outflow steam turbine was investigated to determine: (1) a method for predicting performance from experimental data, (2) the flexibility of a single design with regard to power output and pressure ratio, and (3) the effect of varying the number of turbine stages. All turbine designs were restricted to be compatible with commercially available gearboxes and generator technology. A comparison 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 to maintain constant heat rejection load.

**N80-16541**


**A 15kW (NOMINAL) SOLAR THERMAL ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKINE REHEAT RECIPROCATOR SYSTEM** Final Report


An evaluation was made of the potential of a steam Rankine reheat reciprocator engine to operate at high efficiency in a point-focused distributed receiver solar thermal-electric power system. The scope of the study included the engine system and electric generator, not included was the solar collector/mirror or the steam receiver/turbine. A parametric analysis of engine conditions was completed, leading to the selection of 973 K 12.1 MPa as the steam temperature/pressure for a conceptual design. A conceptual design was completed for a two cylinder/oppoosed engine running at 100 rpm coupled to a commercially available induction generator. A unique part of the design is the use of carbon/graphite piston rings to eliminate the need for an upper cylinder lubricant. The evaluation included a system weight estimate of 230 kg at the mirror focal point with the condenser mounted separately on the ground. The estimated cost of the overall system is $1932 or $90/kW for the maximum 26 kW output.

**N80-16543**

Sundstrand Corp., Rockford, Ill.

**THE 15 kW SUB (NOMINAL) SOLAR THERMAL ELECTRIC POWER CONVERSION CONCEPT DEFINITION STUDY: STEAM RANKINE TURBINE SYSTEM** Final Report


A study to define the performance and cost characteristics of a solar powered, steam Rankine turbine system based on the focal point of a solar concentrator is presented. A two stage re-entry turbine system, which has an efficiency of 27% at a turbine inlet temperature of 732°C was used. System efficiency was defined as 60 Hertz electrical output divided by absorbed thermal input in the working fluid. Mass production costs were found to be approximately 384 dollars/kW.

**N80-17548**

Kaman Aerospace Corp., Bloomfield, Conn.

**DESIGN, FABRICATION, TEST, AND EVALUATION OF A PROTOTYPE 150-FOOT LONG COMPOSITE WIND TURBINE BLADE** Final Report


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.

**N80-17544**

Spectrofab, Inc., Sylmar, Calif.

**DEVELOPMENT OF IMPROVED WRAPAROUND CONTACTS FOR SILICON** Final Report


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

N80-18585*# Avco Corp., Wilmington, Mass.
PARAMETRIC STUDY OF POTENTIAL EARLY COM-
MERCIAL MHD POWER PLANTS
Final Report
Finn A Hals Dec. 1979 246 p refs
(Contracts DEN3-51, EF-77-A-01-2674)
(NASA-CR-158933; DOE/NASA/0051-79/1) Avail: NTIS
HC A11/MF A01 CSCL 108

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 metallic 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.

N80-18582# Grumman Aerospace Corp., Bethpage, N.Y.
ACTIVE HEAT EXCHANGE SYSTEM DEVELOPMENT FOR
LATENT HEAT THERMAL ENERGY STORAGE
Topical Report
Jun. 1978 - Feb. 1979
Joseph Alario, Robert Kosson, and Robert Haslett Jan. 1980 73 p refs
(Contracts DEN3-39; EC-77-A-31-1034)
(NASA-CR-158972; DOE/NASA/0039-79/1)
GAC-TR-1681-09) Avail: NTIS HC A04/MF A01 CSCL 10A

Various active heat exchange concepts were identified from among three generic categories: scrapers, agitators/vibrators and slurries. The most practical ones were given a more detailed technical evaluation and an economic comparison with a passive tube-shield 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-shield design.

R.E.S.

APPENDIX: MOD-1 WIND TURBINE GENERATOR
ANALYSIS AND DESIGN REPORT, VOLUME 2 Final Report
May 1979 425 p
(Contracts NASA-20088; EX-77-A-29-1010)
(NASA-CR-159486; DOE/NASA/0058-79/2-Vol-2-App) Avail:
NTIS HC A18/MF A01 CSCL 10B

The MOD-1 detail design is appended. The supporting analyses presented include a parametric system trade study, a verification of the computer codes used for rotor loads analysis, a metal blade study, and a definition of the design loads at each principal wind turbine generator interface for critical loading conditions. Shipping and assembly requirements, composite blade development, and electrical stability are also discussed.

K.L.

15 KW (NOMINAL SOLAR THERMAL ELECTRIC POWER
CONVERSION) CONCEPT DEFINITION STUDY: STEAM
RANKIN RECIPROCATOR SYSTEM
Final Report
R. Wingenback and J. Carter, Jr. June 1979 48 p refs
(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 reciprocating expander was developed for maximum thermal input power of 80 kW. The conceptual design covered two engine configurations, a single cylinder design for simple cycle operation and a two cylinder design for reheat cycle operation. The reheat expander contains a high pressure cylinder and a low pressure cylinder with steam being reheated to the initial inlet temperature after expansion in the high pressure cylinder. Power generation is accomplished with a three phase induction motor coupled directly to the expander and connected electrically to the public utility power grid. The expander, generator, water pump and control system weigh 297 kg and are dish mounted. The steam condenser, water tank and accessory pumps are ground based. Maximum heat engine efficiency is 33 percent; maximum power conversion efficiency is 30 percent. Total cost is $3,307 or $138 per kW of maximum output power.

R.E.S.

N80-19815# United Technologies Corp., South Windsor, Conn.
Power Systems Div.
ADVANCED TECHNOLOGY LIGHT WEIGHT FUEL CELL
PROGRAM
R. E. Martin 1979 52 p refs
(Contract NAS3-21257)
(NASA-CR-158907; 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 m active area single cells were constructed and tested at cell temperatures between 140 F and 200 F, current densities out to 500 ASF, and reactant pressures up to 30 psia. Cells incorporating platinum-supported-on-carbon catalyst anodes demonstrated 8,005 cell-hours of endurance operation with virtually no change in performance; 2,995 cell-hours of operation to a cyclical load profile with no apparent loss in cathode performance due to high voltage operation. Cell edge frame materials and heat treated polybenzimidazole (PBI) matrix samples were corrosion tested in 42 wt % aqueous potassium hydroxide at 250 F. Based upon the test data, PBI appears unsuitable for use as a fuel cell matrix material. Five semiconducting oxides were evaluated as cathode catalysts and as cathode catalyst supports. The candidate supports LaMnO3 and LaNiO3 appear to have development potential and merit further study.

K.L.

N80-19832# Jet Propulsion Lab., California Inst. of Tech.,
Pasadena.
ANNUAL TECHNICAL REPORT, FISCAL YEAR 1979.
VOLUME 1: EXECUTIVE SUMMARY
Annual Report
John W. Lucas 15 Jan. 1980 46 p Sponsored in part by DOE
(Contract NAS7-100)
HC A03/MF A01 CSCL 10A

Accomplishments of the Point-Focusing Distributed Receiver Technology project are presented. The following aspects of the project are discussed: information dissemination, concentrator development, receiver and heat transport network development.
The effects on life cycle costs of a number of technology areas are examined for a LEO, 500 kW 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 HC A03/MF AO1 CSCL 10C

The durability of CATCOM catalysts and catalyst supports was experimentally demonstrated in a combustion environment under simulated gas turbine engine combustor operating conditions. A test of 1000 hours duration was completed with one catalyst using no. 2 diesel fuel and operating at catalytically-supported thermal combustion conditions. The performance of the catalyst was determined by monitoring emissions throughout the test, and by examining the physical condition of the catalyst core at the conclusion of the test. Tests were performed periodically to determine changes in catalytic activity of the catalyst core. Detailed parametric studies were also run at the beginning and end of the durability test, using no. 2 fuel oil. Initial and final emissions for the 1000 hours test respectively were: unburned hydrocarbons (ppm): 0. 146, carbon monoxide (ppm): 30, 2420; nitrogen oxides (ppm): 5.7, 5.6. R.E.S.

Author HC A05/MF AO1 CSCL 10A

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 (ppm): 30, 2420; nitrogen oxides (ppm): 5.7, 5.6. R.E.S.

Author HC A08/MF AO1 CSCL 10B

The durability of CATCOM catalysts and catalyst supports the alloys during the volume change measurements, Silicon carbide phases and the volume change during phase transformation, The feasibility of using metal alloys as thermal energy storage media was investigated. The elements selected as candidate media were limited to aluminum, copper, magnesium, silicon, zinc, calcium, and phosphorus on the basis of low cost and latent heat of transformation. Several new eutectic alloys and ternary intermetallic phases were determined. A new method employing X-ray absorption techniques was developed to determine the coefficients of thermal expansion of both the solid and liquid phases and the volume change during a phase transformation. The method and apparatus are discussed and the experimental results are presented for aluminum and two aluminum-eutectic alloys. Candidate materials were evaluated to determine suitable materials for containment of the metal alloys. Graphite was used to contain the alloys during the volume change measurements. Silicon carbide was identified as a promising containment material and surface-coated iron alloys were also evaluated. System considerations that are pertinent if alloy eutectics are used as thermal energy storage media are discussed. Potential applications to solar receivers and industrial furnaces are illustrated schematically.

Author HC A09/MF AO1 CSCL 10C

Large savings can be made in industry by cogenerating electric power and process heat in single energy conversion systems rather than separately in utility plants and in process boilers. About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidates which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed-cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum-based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules for determining performance and cost in individual plants and on a national level. It was found that: (1) atmospheric and pressurized fluidized bed steam turbine systems were the most attractive of the direct coal-fired systems; and (2) open-cycle gas turbines with heat recovery steam generators and combined-cycles with NO(x) emission reduction and moderately increased firing temperatures were the most attractive of the coal-derived liquid-fired systems. R.E.S.
estimated returns, in some applications, diesels were most predicted compared to traditional on-site furnaces and utility coal with advanced fluid bed combustion or on-site gasification. Overall, fuel cells 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 intrusions were evaluated and compared to corresponding traditional values. Various cogeneration strategies were analyzed and both topping and bottoming (using industrial by-product heat) applications were included. The advanced energy conversion technology had attractive applications. Overall, fuel cells indicated the greatest fuel energy savings and emission reductions. Gas turbines and combined cycles indicated high overall annual cost savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesels were most efficient. The advanced technologies used coal-derived fuels, or coal with advanced fluid bed combustion or on-site gasification systems.

Data and information in the area of advanced energy conversion systems for industrial cogeneration applications in the 1985-2000 time period were studied. Six current and thirty-one advanced energy conversion systems were defined and combined with appropriate balance-of-plant equipment. Twenty-six industrial processes were selected 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 technology had attractive applications. Overall, fuel cells indicated reduced fuel consumption, costs, and emissions. 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COPLANAR BACK CONTACTS FOR THIN SILICON SOLAR

The performance and cost of moderate technology coal-
fi red 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
OCH/MH/steam plants were determined. Three base cases were
considered: an indirectly-fired high temperature air heater (HTAH)
subsystem delivering air at 2700 F, fired by a state of the art
atmospheric pressure gasifier, and the HTAH subsystem
was deleted and oxygen enrichment was used to obtain requisite
MHD combustion temperature. Coal gas 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 base cases
2 and 3 are recommended for conceptual design. A multiple 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.

N80-27803*# Wichita State Univ., Kans.
FEASIBILITY STUDY OF AIERON AND SCOOPER CONTROL
SYSTEMS FOR LARGE HORIZONTAL AXIS WIND TURBINES
Final Report W. H. Wentz, Jr., M. H. Snyder, and J. T. Calhoun May 1980 69 p refs
(Grant No.3-3277: Contract EX-78-I-01-1028)

The feasibility of using aileron or scoop controllers as alternatives
to pitot control for large horizontal axis wind turbines was studied.
The NASA Mod-0 100 kw machine was used as the basic for
the study. Specific performance studies were conducted for 20% chord
ailerons over the outboard 30% span, and for 10% chord
spoilers over the same portion of the span. Both control systems
utilized control deflections up to 60 deg. Results of the study show
that either ailerons or spoilers can provide the control
necessary to limit turbine power in high wind conditions. The
ailerons 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.
L.F.M.

N80-27808*# Spectrolab, Inc., Sylmar, Calif.
SCREEN PRINTING TECHNOLOGY APPLIED TO SILICON
SOLAR CELLS FABRICATION Final Report, Nov. 1977
Feb. 1979
Jay W. Thornhill and William E. Sipperly Apr. 1980 64 p refs
(Contract NAS3-159789) Avail: NTIS HC A04/MF A01 CSL 10A

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. L.F.M.

Jay W. Thornhill and W. E Sipperly Mar 1980 36 p refs
(Contract NAS3-21251)
(NASA-CR-159811) Avail: NTIS HC A03/MF A01 CSL 10A

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
1126RCB and an in house formulation 61-2-2A were all tested.
Cells with pre-dielectric thickness of 3.0-0.35 mils using
Transene 1000 as the wraparound dielectric and the procedure
outlined above showed an average efficiency of 10.7 percent.
Thinner cells were fabricated, but had an unacceptable yield and
efficiency. R.E.S.

N80-28862*# General Dynamics/Convair, San Diego, Calif.
STUDY OF POWER MANAGEMENT TECHNOLOGY FOR
ORBITAL MULTI-100KW APPLICATIONS. VOLUME 2:
(Contract NAS3-21757)

The preliminary requirements and technology advances
required for cost effective space power management systems for
multi-100 kilowatt requirements were identified. System
requirements were defined by establishing a baseline space
platform in the 250 KE Kw range and examining typical user
to a fixed pitch rotor. 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. L.F.M.

N80-28868*# Midwest Research Inst., Kansas City, Mo.
THERMAL ENERGY STORAGE SYSTEMS USING FLUIDIZED
Tom Weast and Larry Shannon Jun. 1980 209 p refs
(Contract DEN3-96: EC-77A-31-1034)

A rotary cement kiln and an electric arc furnace were chosen for evaluation to determine the applicability of a fluid bed heat exchanger (FBHX) for temperature storage (TES). Multistage shallow bed FBHX's operating at high temperature differences were identified as the most suitable for TES applications. Analysis of the two selected conceptual systems included establishing a plant process flow configuration, an operational scenario, a preliminary FBHX design, and parametric analysis. A computer model was developed to determine the effects of the number of stages, gas flow rate, bed material charge and discharge time, and parasitic power required for operation. The maximum national energy conservation potential
of the cement plant application with TES is 15.4 million barrels of oil or 3.9 million tons of coal per year. For the electric arc furnace application the maximum national conservation potential with TES is 4.5 million barrels of oil or 1.1 million tons of coal per year. Present time of day utility rates are near the breakeven point required for the TES system. Escalation of on-peak energy due to critical fuel shortages could make the FBHX/TES applications economically attractive in the future.

E.D.K.


Mid to late 1980’s power management technology needs to support development of a general purpose space platform, capable of supplying 100 to 250 KWe to a variety of users in low Earth orbit are examined. A typical, shuttle assembled and supplied space platform is illustrated, along with a group of payloads which might reasonably be expected to use such a facility. Examination of platform and user power needs yields a set of power requirements used to evaluate power management options for life cycle cost effectiveness. The most cost effective ac/dc and dc systems are evaluated, specifically to develop system details which lead to technology goals, including: array and transmission voltages, best frequency for ac power transmission, and advantages and disadvantages of ac and dc systems for the application. System and component requirements are compared with the state-of-the-art to identify areas where technological development is required.

Author


Silicon solar cells were fabricated to verify the predictions that: (1) thin n+(p+p)+ 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+(p+p) 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 assessment. Two candidates were selected for small-scale experimentation: a coated tube and shell heat exchanger and a direct contact reflux boiler. A dilute eutectic mixture of sodium nitrate and sodium hydroxide was selected as the PCM from over 50 candidate inorganic salt mixtures.

Based on a salt screening process, eight major component salts were selected initially for further evaluation. The most attractive major components in the temperature range of 250 to 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.


The technical and economic potential for high temperature (343 C, 650 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/kW-h and a power unit storage cost (CP) of $42/kW-h (1977 dollars).

A.R.H.


About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, 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.

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 technologies 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.

Cogeneneration electric power and process heat in single energy conversion systems rather than separately in utility plants and in process boilers is examined in terms of cost savings. The use of various advanced energy conversion systems are examined and compared with each other and with current technology systems for their savings in fuel energy, costs, and emissions in individual plants and on a national level. About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidate which can be made available by the 1985 to 2000 time period. The sectors considered included food, textiles, lumber, paper, chemicals, petroleum, glass, and primary metals. The energy conversion systems included steam and gas turbines, diesels, thermionics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of the cogeneration energy conversion systems (ECS's) heat and power matched to the individual industrial processes are presented. National fuel and emissions savings are also reported for each ECS assuming it alone is implemented. Two nocogeneration base cases are included: coal fired and residual fired process boilers. T.M.


The computer code for the detailed analytical model of the MK-2 stacks is described. An ERC proprietary matrix is incorporated in the stacks. The mechanical behavior of the stack during thermal cycles under compression was determined. A 3 cell stack which verified the use of wet assembly and a new acid fill procedure were fabricated and tested. Components for the 2 kW test facility were received or fabricated and construction of the facility is underway. The definition of fuel and water is used in a study of the fuel conditioning subsystem. Kinetic data on several catalysts, both crushed and pellets, was obtained in the differential reactor. A 5 cell stack of the MK-2 design was fabricated and tested. Designs for the next three stacks were selected and component fabrication initiated. A 3 cell stack which verified the use of wet assembly and a new acid fill procedure were fabricated and tested. Components for the 2 kW test facility were received or fabricated and construction of the facility is underway. The definition of fuel and water is used in a study of the fuel conditioning subsystem. Kinetic data on several catalysts, both crushed and pellets, was obtained in the differential reactor. A preliminary definition of the equipment requirements for treating tap and recovered water was developed. S.J.


Six current and thirty-six advanced energy conversion systems were defined and combined with appropriate balance of plant equipment. Twenty-six industrial processes were selected from among the high energy consuming industries to serve as a frame work for the study. Each conversion system was analyzed as a cogenerator with each industrial plant. Fuel consumption, costs, and environmental intrusion were evaluated and compared to corresponding traditional values. The advanced energy conversion technologies indicated reduced fuel consumption, costs, and emissions. Fuel energy savings of 10 to 25 percent were predicted compared to traditional 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 annual savings. Steam turbines and gas turbines produced high estimated returns. In some applications, diesels were most efficient. The advanced
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 1990s to 2000 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, thermonics, stirling, closed-cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum-based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. An attempt was made to use consistent assumptions and a consistent set of ground rules 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-PI-1: GE80ET0105-Vol-6-PI-1;

DOE/NASA/0031-80/6-PI-2: DOE/NASA/0031-80/6-PI-2

Avail. NTIS HC A21/MF A01 CSCL 108

Various advanced energy conversion systems (ECS) are compared with each other and with current technology systems for their savings in fuel energy, costs, and emissions in individual plants and on a national level. About fifty industrial processes from the largest energy consuming sectors were used as a basis for matching a similar number of energy conversion systems that are considered as candidates which can be made available by the 1995 to 2000 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, thermonics, stirling, closed cycle and steam injected gas turbines, and fuel cells. Fuels considered were coal, both coal and petroleum based residual and distillate liquid fuels, and low Btu gas obtained through the on-site gasification of coal. Computer generated reports of the fuel consumption and savings, capital costs, economics and emissions of the 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

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-PI-2: GE80ET0105-Vol-6-PI-2;

DOE/NASA/0031-80/6-Vol-6-PI-2.

Avail. NTIS HC A13/MF A01 CSCL 108

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.

Author

N80-33862* National Aeronautics and Space Administration.

Lewis Research Center, Cleveland, Ohio.

MOD-2 WIND TURBINE FARM STABILITY STUDY Final Report

E. N. Hinrichsen Jun. 1980 170 p refs

(Contracts DEN3-134: DE-AL01-79ET-20305)
45 ENVIRONMENT POLLUTION
Includes air, noise, thermal and water pollution; environment monitoring; and contamination control.

N80-13721*## National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
AN ANALYTICAL STUDY OF NITROGEN OXIDES AND CARBON MONOXIDE EMISSIONS IN HYDROCARBON COMBUSTION WITH ADDED NITROGEN, PRELIMINARY RESULTS
(Contract EF-77-A-01-2593)
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 was modeled by a fifty-seven-reaction chemical mechanism. The results for NO sub x and CO formation are given as functions of primary and secondary stage equivalence ratios and residence time.
R.E.S.

N80-14881*## National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
SULFATE AND NITRATE COLLECTED BY FILTER SAMPLING NEAR THE TROPOPAUSE
Francis M. Humenik, Erwin A. Lezberg, and Dumas A. Otterson 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 ppbm for sulfate and 0.35 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.

N80-21892*## National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPES VL0011 AND VL0013
Progress Report, 10 Jan. - 2 Oct. 1977
J. D. Holdeman, Thomas J. Dudzinski, and Marvin W. Tieferman Mar. 1979 63 p refs
(NASA-TM-81482; E-393) Avail. NTIS HC A04/ MF A01 CSCL 13B
In-situ measurements of atmospheric ozone, carbon monoxide, clouds, and related meteorological and flight information obtained during 1122 flights of aircraft VH-5B and N655PA 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.

N80-23875*## National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
ASSESSMENT OF POTENTIAL EXPOSURE TO FRIBILE INSULATION MATERIALS CONTAINING ASBESTOS
Walter S. Kim and David E. Kuivinen Apr 1980 41 p refs
(NASA-TM-81435; E-359) Avail. NTIS HC A03/ MF A01 CSCL 13B
Asbestos and the procedures for assessing potential exposure hazards are discussed. Assessment includes testing a bulk sample of the suspected material for the presence of asbestos, and monitoring the air, if necessary. Based on field inspections and laboratory analyses, the health hazard is evaluated, and abatement measures are taken if a potential hazard exists. Throughout the assessment and abatement program, all applicable regulations are administered as specified by the Environmental Protection Agency and the Occupational Safety and Health Administration.
R.E.S.

N80-27832*## National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
COORDINATED AIRCRAFT AND SHIP SURVEYS TO DETERMINE IMPACT OF RIVER INPUTS ON GREAT LAKES WATERS, REMOTE SENSING RESULTS
(NASA-TP-1694; E-172) Avail. NTIS HC A06/ MF A01 CSCL 13B
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 surface sample data are correlated resulting in 40 contour plots showing large-scale distributions 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 teletacsimilie 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 basis for developing quantitative algorithms. Predictions and field measurements of volume reflectances are presented which show the advantages 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 Rods (RBE 3.3) were given in daily fractions aiming at a total dose of 6000 Rods in 6 to 8 weeks. The treatments were well tolerated and significant palliation was achieved in 28 to 30 cases. Twelve months survival was 33 percent with a median survival of 7 months or 210 days. Treatment techniques and localization procedures are discussed.

R.E.S.
AEROSPACE MEDICINE
Includes physiological factors, biological effects of radiation, and weightlessness

N80-14864* 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)
(NASA-Case-LEW-12965-1; US-Patent-4,157,718;
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 predeter-
mined time interval. This allows maintenance of normal intraocular
pressure during glaucoma surgery. A pressure regulator of the
spring-blazed 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 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. Cwynar Jan 1980 169 p refs
NASA TP 1424 E 98101 Available NTIS HC A08/0 MF A01 CSCL 098

A computer program was developed to aid assembl E
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 the individual user's needs are consid-
ered.
61 COMPUTER PROGRAMMING
AND SOFTWARE
Includes computer programs, routines, and algorithms.

NS0-33104*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
NONANALYTIC FUNCTION GENERATION ROUTINES FOR
16-BIT MICROPROCESSORS
James F. Soeder and Maryrita Shaufl Washington Sep. 1980
66 p. refs
(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 interpola-
tion 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.

NS0-10883*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
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-364) 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.

NBS-29088 National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

CYCLES TILL FAILURE OF SILVER-ZINC CELLS WITH COMPLETING FAILURES MODES: PRELIMINARY DATA ANALYSIS
Steven M. Sidik, Harold F. Leibbeck, and John M. Bozek 1980
(NASA-TM-81556; E-517) Avail NTIS HC A03/MF A01 C5CL 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.


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.

N80-18824* // National Aeronautics and Space Administration
   Lewis Research Center, Cleveland, Ohio.
   AN AVERAGING BATTERY MODEL FOR A LEAD-ACID
   BATTERY OPERATING IN AN ELECTRIC CAR Final
   Report
   John M Bozek Dec 1979 19 p refs
   (Contract EC-77-A-31-1044)
   (NASA-TM-79321; DOE/NASA/1044-79/5; E-277) Avail
   NTIS HC AOZ/MF AO1 CSCL 128
   A battery model is developed based on time averaging the
   current or power, and is shown to be an effective means of
   predicting the performance of a lead acid battery. The effectiveness
   of this battery model was tested on battery discharge profiles
   expected during the operation of an electric vehicle following
   the various SAE J227a driving schedules. The averaging model
   predicts the performance of a battery that is periodically charged
   (regenerated) if the regeneration energy is assumed to be
   converted to retrievable electrochemical energy on a one-to-one
   basis.
   Author

A80-10035* // 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
   NCEP, WATE, LIFECYK, INSTAL, and POD DRG. A process is
   illustrated by which turbine engines can be evaluated as to fuel
   consumption, engine weight, cost and installation effects. Examples
   are shown as to the benefits of variable geometry and of the tradeoff
   between fuel burned and engine weights. Future plans for further
   improvements in the analytical modeling of engine systems are also
   described.
   C.F.W.
Approximate expressions were developed for the noise radiation from the aft duct. The results of approximate aft radiation equation compare favorably to more exact Wiener-Hopf radiation results. Refraction as well as convective effects in the multiple flow streams is considered. The peak in the radiation pattern, which occurs nearly at engine sideline, is composed of modes with relatively large cut-off ratios. This implies that aft fan radiation will be inherently more difficult to suppress than the fan inlet noise. The theoretical multimodal radiation pattern is compared to experimental data for the first two harmonics of blade passage frequency for three full scale fans at two speeds. The agreement between theory and experiment is quite good.

A.R.H.
71 ACOUSTICS

Includes sound generation, transmission and attenuation. A study of fan noise was made by using the coherence function to obtain far field spectra that were coherent with the

For noise pollution see Environment Pollution.

N80-12822* 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 were found to be superior to the conventional steady numerical analysis because of much shorter solution times and the elimination of matrix storage requirements. R.C.T.

N80-12823* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A TIME DEPENDENT DIFFERENCE THEORY FOR SOUND PROPAGATION IN DUCTS WITH FLOW
K. J. Baumeister 1979 38 p ref Presented at 98th Meeting of the Acoustical Soc. of Am., Salt Lake City, Utah, 26-30 Nov. 1979
(NASA-TM-79302; E-254) Avail: NTIS HC A03/MF A01 CSCL 20A

A time dependent numerical solution of the linearized continuity and momentum equation was developed for sound propagation in a two dimensional straight hard or soft wall duct with a sheared mean flow. The time dependent governing acoustic-difference equations and boundary conditions were developed along with a numerical determination of the maximum stable time increments. A harmonic noise source radiating into a quiescent duct was analyzed. This explicit iteration method then calculated stepwise in real time to obtain the transient as well as the steady state solution of the acoustic field. Example calculations were presented for sound propagation in hard and soft wall ducts, with no flow and plug flow. Although the problem with sheared flow was formulated and programmed, sample calculations were not examined. The time dependent finite difference analysis was found to be superior to the steady state finite difference and finite element techniques because of shorter solution times and the elimination of large matrix storage requirements. R.C.T.

N80-12824* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RECIROCITY 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. A.R.H.
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 peak 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.

**NOISE SUPPRESSION DUE TO ANNULUS SHAPING OF PRESSURE SPECTRA AND CROSS SPECTRA AT AN AREA CONVENTIONAL COAXIAL NOZZLE**

J. Goodykoontz and U. von Glahn

April 1980

27 p refs

Presented for the 99th Meeting of the Acoust. Soc. of Am., Atlanta, 21-25 Apr. 1980

(NASA-TM-81471; E-404)

Available: NTIS HC A03/MF A01 CSCL

20A

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 on only 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 yields expressions for the attenuation and dispersion of the plane wave which depends only on this single parameter. 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.

**NOISE SUPPRESSION DUE TO ANNULUS SHAPING OF AN INVERTED VELOCITY PROFILE COAXIAL NOZZLE**

J. Goodykoontz and U. von Glahn

April 1980

27 p refs

Presented for the 99th Meeting of the Acoust. Soc. of Am., Atlanta, 21-25 Apr. 1980

(NASA-TM-81460; E-389)

Available: NTIS HC A03/MF A01 CSCL

20A

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. The annulus shape (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 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.

**TIME DEPENDENT DIFFERENCE THEORY FOR SOUND PROPAGATION IN AXISYMMETRIC DUCTS WITH PLUG FLOW**

K. J. Baumeister

1980

12 p refs

Presented at 6th Aeroacoustics Conf., Hartford, Conn. 4-6 Jun. 1980; sponsored by AIAA

(NASA-TM-81501; E-438)

Available: NTIS HC A02/MF A01 CSCL

20A

The time dependent governing acoustic-difference equations and boundary conditions are developed and solved for sound propagation in an axisymmetric (cylindrical) hard wall duct with a plug mean flow and spinning acoustic modes. The analysis begins with a harmonic sound source radiating into a quiescent duct. This explicit iteration method then calculates stepwise in real time to obtain the transient as well as the steady state solutions of the acoustic field. The time dependent finite difference analysis has two advantages over the steady state finite difference and finite element techniques: (1) the elimination of large matrix storage requirements, and (2) shorter solution times under most conditions.

**PRESSURE SPECTRA AND CROSS SPECTRA AT AN AREA CONTRACTION IN A DUCTED COMBUSTION SYSTEM**

J. H. Miles and D. D. Raffoul

1980

12 p refs


(NASA-TM-81477; E-411)

Available: NTIS HC A02/MF A01 CSCL

20A

Pressure spectra and cross-spectra at an area contraction in
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 N80-23008*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. EFFECT OF INFLOW CONTROL ON INLET NOISE OF A CUT-ON FAN Richard P. Woodward and Frederick W. Glaser 1980 13 p refs Presented at 6th Aeracoustics Conf., Hartford, Conn., 4-6 Jun 1980; sponsored by AIAA (NASA-TM-81497) Avail: NTIS HC A02/MF A01 CSCL 20A The control of turbulence and other inflow disturbances in anechoic chambers for static turbulence 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-SWALLOWED HIGH-TIP-SPEED FAN (Gf-13) James G. Lucas, Richard P. Woodward, and Michael J. MacKinnon May 1980 20 p refs (NASA-TP-1668; E-202) Avail: NTIS HC A02/MF A01 CSCL 20A Forward noise and overall aerodynamic performance data are presented for a high-tip-speed fan having rotor blade airfoils designed to alter the conventional leading-edge bow shocks to weak, oblique shocks which are swallowed within the interblade channels. It was anticipated that the swallowed shocks would minimize the generation of multiple-pulse 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 Y. C. Cho and K. U. Ingard 1980 11 p refs Presented at the 6th Aeracoustics Conf., Hartford, Conn., 4-6 Jun 1980; sponsored by AIAA. Prepared in cooperation with MIT, Cambridge (NASA-TM-81481; E-141) Avail: NTIS HC A02/MF A01 CSCL 20A 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 EXPLORATORY SURVEY OF NOISE LEVELS ASSOCIATED WITH A 100Kw WIND TURBINE J. R. Balombi 1980 20 p refs Presented at the 99th Meeting of the Acoustical Soc. of Am., Atlanta, 21-25 Apr 1980 (NASA-TM-81486; E-424) Avail: NTIS HC A02/MF A01 CSCL 20A Noise measurements of a 125-foot diameter, 100 kW wind turbine are presented. The data include measurements as functions of distance from the turbine and directivity angle and cover a frequency range from 1 Hz to several kHz. Potential community impact is discussed in terms of A-weighted noise levels relative to background levels, and the intrasonic spectral content. Finally, the change in the sound power spectrum associated with a change in the rotor speed in described. The acoustic impact of this size wind turbine is judged to be minimal. M.G.

N80-25101# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. A COMPARISON BETWEEN AN EXISTING PROPELLER NOISE THEORY AND WIND TUNNEL DATA James H. Dittmar May 1980 41 p refs (NASA-TM-81519; E-464) Avail: NTIS HC A03/MF A01 CSCL 20A The noise of three supersonic helical tip speed propellers was compared with the noise predicted by an existing noise theory. Comparisons of the peak blade passage tones showed a good agreement between theory and experiment at the lowest helical tip Mach numbers tested, 0.86 and 1.00, while at higher numbers, the theory predicted higher noise levels than measured. When the differences among the propellers were considered the theory and measurement showed fairly good agreement. Directivity measurements in general showed that the measured blade passage tone data peaked further downstream than the theory predicted. At the noise design condition the harmonics appeared to fall off faster in the data than the theory indicated. E.D.K. N80-26115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. MEASURED AND PREDICTED IMPINGEMENT NOISE FOR A MODEL-SCALE UNDER THE WING EXTERNALLY BLOWN FLAP CONFIGURATION WITH A QCSEE TYPE NOZZLE D. J. McKinzie, Jr Jun. 1980 63 p refs (NASA-TM-81494; E-432) Avail: NTIS HC A04/MF A01 CSCL 20A Jet/flare interaction noise was measured and predicted for a small-scale model two-flap, under-the-wing, externally blown flap configuration equipped with and without noise suppression devices. The devices consisted of short spanwise fairings centered in relationship to the jet axis and positioned in the slots between the wing and flaps. The nozzle approximated that of the Quiet Clean Short-haul Experimental Engine (QCSEE). Takeoff noise reductions of 6 dB in the flyover and 5 dB at the sideline plane were obtained over a wide range of radiation angles. Approach noise reductions of about 5 dB were obtained only in the forward quadrant of the flyover plane; no reductions were obtained in the sideline plane. Models of several noise sources were combined analytically to form an overall noise prediction, the results from which compared favorably with the measured data. The aerodynamic and performance characteristics for these configurations were substantially the same in the takeoff attitude. However, in the approach attitude, the suppressed configuration produced a 6 percent reduction in the flow turning efficiency. Author N80-29312*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. PREDICTION OF UNSUPPRESSED JET ENGINE EXHAUST NOISE IN FLIGHT FROM STATIC DATA James R. Stone 1980 26 p refs Presented at 8th Aeracoustics Conf., Hartford, Conn., 4-6 Jun 1980; sponsored by AIAA (NASA-TM-81537; E-491) Avail: NTIS HC A03/MF A01 CSCL 20A A methodology developed for predicting in-flight exhaust noise from static data is presented and compared with experimental...
data for several unsuppressed turbojet engines. For each engine, the static data over a range of jet velocities are compared with the predicted jet mixing noise and shock-cell noise. The static engine noise over and above the jet and shock noises is identified as excess noise. The excess noise data are then empirically correlated to smooth the spectral and directivity relations and account for variations in test conditions. This excess noise is then projected to flight based on the assumption that the only effects of flight are a Doppler frequency shift and a level change given by 40 log (1 + m sub 0 cos theta), where M sub 0 is the flight Mach number and theta is the observer angle relative to the jet axis.

M.G.

N80-30154* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NUMERICAL TECHNIQUES IN LINEAR DUCT ACOUSTICS

Status Report


Both finite difference and finite element analyses of small amplitude (linear) sound propagation in straight and variable area ducts with flow, as might be found in a typical turbojet engine duct, muffler, or industrial ventilation system, are reviewed. Both steady-state and transient theories are discussed. Emphasis is placed on the advantages and limitations associated with the various numerical techniques. Examples of practical problems are given for which the numerical techniques have been applied. A R H.


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 because of much shorter solution times and the elimination of matrix storage requirements.


A time dependent numerical solution of the linearized continuity and momentum equation is developed for sound propagation in a two-dimensional straight hard or soft wall duct with a shaped mean flow. The time dependent governing acoustic-difference equations and boundary conditions are developed along with a numerical determination of the maximum stable time increments. The analysis begins with a harmonic noise source radiating into a quiescent duct. The explicit iteration method then calculates stepwise in real time to obtain the transient as well as the steady state solution of the acoustic field. Example calculations are presented for sound propagation in hard and soft wall ducts, with no flow and with plug flow. Although the problem with shaped 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.


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/detector 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 46 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.

A80-20963 * # Dispersion of sound in a combustion duct by fuel droplets and soot particles. J. H. Miles (NASA, Lewis Research Center, Cleveland, Ohio), Acoustical Society of America, Meeting, 98th, Salt Lake City, Utah, Nov. 26-30, 1979, Paper, 27 p. 22 refs.

Dispersion and attenuation of acoustic plane wave disturbances propagating in a ducted combustion system are studied. The dispersion and attenuation are caused by fuel droplet and soot emissions from a jet engine combustor. The attenuation and dispersion are due to heat transfer and mass transfer and viscous drag forces between the emissions and the ambient. Theoretical calculations show sound propagation at speeds below the isentropic sound of speed at low frequencies. Experimental results are in good agreement with the theory.


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.


This paper represents the initial quantitative comparison of inlet suppressor far-field directivity suppression with that predicted using an approximate linear design and evaluation method based upon mode cutoff ratio. The experimental data was obtained using a series of cylindrical point-reacting inlet liners on an Avco-Lycoming YF102 engine. The theoretical prediction program is based upon simplified sound propagation concepts derived from exact calculations. These indicate that all of the controlling phenomenon can be approximately related to the angles of propagation within the duct. The objective of the theory-data comparisons is to point out possible deficiencies in the approximate theory which may be corrected. After all theoretical
refinements have been made, then empirical corrections can be applied. (Author)


Insight into the inflight acoustic characteristics of high-velocity jet noise suppressor nozzles for supersonic cruise aircraft (SCA) is provided, although the suppression of jet noise over the entire range of directivity angles is of interest, the suppression of the peak noise level in the rear quadrant is frequently of the most interest. Consequently, the paper is directed primarily to the inflight effects at the peak noise level. Both single and inverted-velocity-profile multistream suppressor nozzles are considered. The importance of static spectral shape on the noise reduction due to inflight effects is stressed. (Author)

A80-35496 * Spectral structure of pressure measurements made in a combustion duct. J. H. Miles (NASA, Lewis Research Center, Cleveland, Ohio) and D. D. Raftopoulos (Toledo University, Toledo, Ohio). Acoustical Society of America, Meeting, 99th, Atlanta, Ga., Apr. 21-25, 1980, Paper. 44 p. 43 refs.

The spectral structures 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. (Author)


Previous studies have shown that increasing the annulus width of a conventional coaxial nozzle with constant bypass velocity will lower the noise level. In the present model-scale study, the annulus was shaped by an eccentric mounting of the annular nozzle with respect to the conical core nozzle. Acoustic measurements were made in the flyover plane below the widest portion of the annulus and at 90 deg and 180 deg from this point. The model-scale spectra are scaled up to engine size (1.07 m diameter) and the perceived noise levels for the eccentric and concentric coaxial nozzles are compared over a limited range of operating conditions. The implications of the acoustic benefits derived from the eccentric nozzle to practical applications are discussed. (Author)


Previous studies have shown that an inverted-velocity-profile coaxial nozzle for use with supersonic cruise aircraft produces less jet noise than an equivalent coaxial nozzle. Furthermore, decreasing the annulus height (increasing radius ratio with constant flow) results in further noise reduction benefits. In the present model-scale study, the annulus shape that is, height, was varied by an eccentric mounting of the annular nozzle with respect to a conical core nozzle. Acoustic measurements were made in the flyover plane below the narrowest portion of the annulus and at 90 deg and 180 deg from this point. The model-scale spectra are scaled up to engine size (1.07 m diameter) and the perceived noise levels for the eccentric and baseline concentric inverted-velocity-profile coaxial nozzles are compared over a range of operating conditions. The implications of the acoustic benefits derived with the eccentric nozzle to practical applications are discussed. (Author)


During performance tests of a 125-foot diameter, 100 kW wind turbine at the NASA Plum Brook Station near Sandusky, Ohio, the opportunity arose to make exploratory noise measurements and results of those surveys are presented. The data include measurements as functions of distance from the turbine, and directivity angle, and cover a frequency range from 1 Hz to several kHz. Potential community impact is discussed in terms of A-weighted noise levels relative to background levels, and the infrasonic spectral content. Finally, the change in the sound power spectrum associated with a change in the rotor speed is described. The acoustic impact of this size wind turbine is judged to be minimal. (Author)


This paper presents an analytical investigation of higher order mode propagation in a nonuniform circular duct without mean flow. An approximate wave equation is derived on the assumptions that the duct cross section varies slowly and that mode conversion is negligible. Exact closed form solutions are obtained for a particular class of converging-diverging circular duct which is here referred to as 'circular coaxial duct'. Numerical results are presented in terms of the transmission loss for 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. (Author)


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. At external suction applied to the area where the inflow control device joined the inlet produced a further reduction in blade passing tone suggesting that disturbances in the forward flow on the outside of the inlet were superimposed on the inlet boundary layer and were a significant source of tone noise. (Author)


A rigorous treatment is presented of sound radiation from circular ducts with either a hyperbolic horn or an infinite plane baffle. In the analysis hyperboloidal wave functions are used, which are defined here, for the first time, as a class of eigensolutions of the wave equation for oblate spheroidal co-ordinates. The numerical results include the complex (or reflection) coefficients and the radiation directivity for various incident wave modes.
spinning modes as well as axisymmetric modes. The solutions are valid for the whole frequency range including frequencies above and below the cut-off frequencies of the duct modes involved. (Author)


Summaries of current understandings, technological tools and remaining controversies in the field of aeroacoustics are presented, with attention also given to developments in means of noise suppression to comply with proposed and projected regulations. The solutions are considered for this nozzle. For the dual stream, 36 chute suppressor nozzle, 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.

A80-11970•# Lockheed-Georgia Co, Marietta.

STUDIES OF THE ACOUSTIC TRANSMISSION CHARACTERISTICS OF COAXIAL NOZZLES WITH INVERTED VELOCITY PROFILE, VOLUME 1: Final Report

P. D. Dean, M. Salikuddin, K. K. Ahuja, H. E. Plumbee, and P. Mungur Cleveland, Ohio NASA May 1979 186 p refs (Contract NAS3-207977)


The efficiency of internal noise radiation through annular exhaust nozzle with an inverted velocity profile was studied. A preliminary investigations was 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 to validate this methodology. The results 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 nozzle convergence angle, core extension length to annulus height ratio, and flow Mach number and temperatures were studied. The results are presented as normalized directivity plots. R.C.T.

NBO-13882•# Hamilton Standard, Windsor Locks, Conn.

ADVANCED TURBO-PROP AIRPLANE INTERIOR NOISE REDUCTION SOURCE DEFINITION Final Report

B. Magliozi and Bennett M. Brooks. Oct. 1979 90 p refs (Contract NAS3-20314)

(NASA-CR-159668) Avail: NTIS HC A05/MF A01 CSCL 20A

Acoustic pressure amplitudes and phases were measured in model scale on the surface of a rigid semi-cylinder 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 semi-cylinder 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 6dB at 90 degree incidence decreasing to no effect at grazing incidence. Comparisons of measurements with predictions made using a recently developed prop-fan noise prediction theory which includes linear and non-linear source terms showed good agreement in phase and in peak noise amplitude. Predictions of noise amplitudes and phase contours, including pressure doubling effects derived from test, are included for a full scale prop-fan installation. Author

NBO-32166•# Lockheed-Georgia Co, Marietta.

A STUDY OF THE TRANSMISSION CHARACTERISTICS OF SUPPRESSOR NOZZLES


NASA-CR-165133) Avail: NTIS HC A12/MF A01 CSCL 20A

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 annular nozzle system were also tested to provide a reference for the suppression characteristics of the system utilized 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 results were then Fourier transformed to obtain the nozzle 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 after body 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.
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
Avail US Patent and Trademark Office - CSCL 20H
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 has greater diameter than the baffle plate to provide discharge impedance and also to protect the cathode from ion flux. An anode electrode draws the electrons away from the cathode. The hollow cathode includes a tubular insert of tungsten impregnated with a low work function material to provide ample electrons. A heater is provided around the hollow cathode to initiate electron emission from the low work function material.

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


RESULTS OF DUCT AREA RATIO CHANGES IN THE NASA N80.

AIAA 201 MHD power generation experiments utilizing a cesium-seeded (NASA-TM-79308; E-264) Aval NTIS HC A02/MF A01 CSCL 201

MHD power generation experiments utilizing a cesium-seeded H2-O2 working fluid were carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments were conducted in a high field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, generator loading, B-field strength, and electrode breakdown voltage were investigated. The 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.

EXPERIMENTS ON H2-O2 MHD POWER GENERATION


Magnetohydrodynamic power generation experiments utilizing a cesium-seeded H2-O2 working fluid were carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments were conducted in a high-field strength cryomagnet facility at field strengths up to 6 tesla. The effects of power takeoff location, axial duct location within the magnetic field, generator loading, B-field strength, and electrode breakdown voltage were investigated. For the operating conditions of these experiments, it is found that the power output increases with the square of the B-field and can be limited by choking of the channel or interelectrode voltage breakdown which occurs at Hall fields greater than 50 volts/insulator. Peak power densities of greater than 100 MW/cu M were achieved. A R H.

EXPERIMENTAL RESULTS ON PLASMA INTERACTIONS WITH LARGE SURFACES AT HIGH VOLTAGES


Multikilowatt power levels for future payloads can be more efficiently generated using solar arrays operating in the kilowatt range. This implies that large areas of the array at high operating voltages will be exposed to the space plasma environment. The resulting interactions of these high voltage surfaces with space plasma environments can seriously impact the performance of the satellite system. The plasma surface interaction phenomena were studied in tests performed in two separate vacuum chambers, a 4.6 m diameter by 19.2 long chamber and a 2.0 m diameter by 27.4 m long chamber. The gasplated plasma density was approximately 1x10 to the 4th power/cm. Ten solar array panels, each with areas of 1400 sq cm were used in the tests. Nine of the solar panels were tested as a composite unit in the form of a 3x3 solar panel matrix. The results from all the tests confirmed small sample tests results: insulators were found to enhance the plasma coupling current for high positive bias and arcing was found to occur at high negative bias. A R H.
1000 K to approximately 1100 K collectors is possible using well established tungsten electrodes. Such TEC with 1800 K emitters could approach 26% efficiency at 274 W/cm² with approximately 1000 K collectors and 21.7% at 226 W/cm² with approximately 1100 K collectors. These performances require 15 and 17 eV collector work functions (not the 1 eV ultimate) with nearly negligible interelectrode losses. Such collectors correspond to tungsten electrode systems in approximately 0.5 current and approximately 6 torr cesium pressures with 1600 K to 1800 K collectors. Because higher heat rejection temperatures for TEC allow greater collector work functions, the interelectrode loss reduction becomes an increasingly important target for applications aimed at elevated temperatures. Studies of intragap modifications and new electrodes that will allow better electron emission and collection with lower cesium pressures are among the TEC-Art approaches to reduced interelectrode losses. These solutions will provide a very effective TEC to serve directly in coal-combustion products for high-temperature topping and process heating. In turn this will help to use coal and to use it well.


An experimental and analytical study of a Blumlein-type transverse fast discharge operating with He and Xe 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 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 the Xe metastable efficiencies are much larger than in He. These differences between Xe and He are accounted for by the large dissociative recombination rate of Xe compared with He.


MHD power generation experiments utilizing a cesium-seeded H2-O2 working fluid have been carried out using a diverging area Hall duct having an entrance Mach number of 2. The experiments are conducted in a high-field strength cryomagnet facility at field strengths up to 5 tesla. The effects of power takeoff location, axial duct location within the magnetic field, generator location, B field strength, and electrode breakdown voltage were investigated. For the operating conditions of these experiments it is found that the power output increases with the square of the B field and can be limited by choking of the channel or interelectrode voltage breakdown which occurs at B fields greater than 50 volts/cm.


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 3.97 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 to the 11th to 6.8 X 10 to the 12th per cu cm.

A80-12880# State Univ of New York at Buffalo Lab for Power and Environmental Studies EXPERIMENTAL AND THEORETICAL INVESTIGATION FOR THE SUPPRESSION OF THE PLASAR ARC DROP IN THE THERMIonic CONVERTER Final Report, 1 Jul. 1975 - 15 Apr. 1978 David T. Shaw Apr 1979 41 p refs (Grant No.70711) (NASA CR-159611) LAPES 79 003 Avail. NTIS HC A03/MF A01 CSDL 201 The possibility of using N2 as a gas additive for the development of thermionic stopping 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.

A80-14923* Colorado State Univ., Fort Collins, Dept. of Physics. INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLasma Annual Report Harold R. Kaufman and Raymond S. Robinson May 1979 81 p refs (Grant No.3196) (NASA CR-159731) Avail NTIS HC A05/MF A01 CSLD 201 Tests were conducted using plasma densities of approximately 10 to the 5th power - 10 to the 6th power/cu cm. Insulating materials tested were polyimide (Dapton), mica and glass. Surface-area effects were found to be substantially reduced from those previously reported at lower plasma densities. The difference in typical plasma density was felt to be the major cause of this change, although a surface effect may also be involved. At the 10 to the 5th power/cu cm plasma density range, surface effects on collection current appear limited to roughly 1 cm from the hole. A factor of several reduction of collected current was obtained with both surface scribing and 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 176
observations, that the generation of vapor is a major factor in the enhancement of collected current. A.R.H.

NBD-26181*/* Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.
Graeme Aston Jun. 1980 93 p refs
(Grant NGR-06-002-112) (NASA-CR-159849) Avail: NTIS HC A05/MF A01 CSCL 201

An experimental investigation of the physical processes governing ion extraction from a plasma is presented. The screen hole plasma sheath of a multiaperture ion accelerator system is defined by equipotential plots for a variety of accelerator system geometries and operating conditions. A sheath thickness of at least fifteen Debye lengths is shown to be typical. The electron density variation within the sheath satisfies a Maxwell Boltzmann density distribution at an effective electron temperature dependent on the discharge plasma primary to Maxwellian electron density ratio. Plasma ion flow up to and through the sheath is predominantly one dimensional and the ions enter the sheath with a modified Bohm velocity. Low values of the screen grid thickness to screen hole diameter ratio give good ion focusing and high extracted ion currents because of the effect of screen webbing on ion focusing.

Author

PLASMA PHYSICS ANALYSIS OF SERT-2 OPERATION
(Grant NsG-3011) (NASA-CR-159814) Avail: NTIS HC A04/MF A01 CSCL 201

An analysis of the major plasma processes involved in the SERT 2 spacecraft experiments was conducted to aid in the interpretation of recent data. A plume penetration model was developed for neutralization electron conduction to the ion beam and showed qualitative agreement with flight data. In the SERT 2 configuration conduction of neutralization electrons between thrusters was experimentally demonstrated in space. The analysis of this configuration suggests that the relative orientation of the two magnetic fields was an important factor in the observed results. Specifically, the opposed field orientation appeared to provide a high conductivity channel between thrusters and a barrier to the ambient low energy electrons in space. The SERT 2 neutralizer currents with negative neutralizer biases were up to about twice the theoretical prediction for electron collection by the ground screen. An experimental verification for the higher experimental values was a possible conductive path from the neutralizer plume to a nearby part of the ground screen. Plasma probe measurements of SERT 2 gave the clearest indication of plasma electron temperature, with normal operation being near 5 eV and discharge only operation near 2 eV.

E.D.K.

NBD-32223*/* Colorado State Univ., Fort Collins. Dept. of Physics.
INTERACTION OF HIGH VOLTAGE SURFACES WITH THE SPACE PLASMA Annual Report
Harold R. Kaufman and Raymond S. Robinson May 1980 50 p refs
(Grant NsG-3196) (NASA-CR-165131) Avail: NTIS HC A03/MF A01 CSCL 201

High voltage solar arrays provide spacecraft power while optimizing mass and power efficiency. Operating such arrays in the space plasma environment can result in anomalously large currents being collected through insulation defects. Two thicknesses of the insulating material were tested, with no effect found due to insulator thickness. In these tests the polyimide thickness was always much less than the pinhole diameter. The pinhole area was varied over an area range of more than 30:1. It was found that the current collected was independent of the pinhole area for hole diameters from 0.35 to 2.0 mm. Two types of adhesives were tried in two different configurations. The adhesives were chosen for their extreme difference in vacuum qualifications. Neither adhesive types nor configuration made a significant difference in current collection. The temperature of the insulating material was also varied. It was found that current collection decreased with increasing temperature. Tests were conducted to see if pinhole current collection decreased with time, as was indicated by the effects of several short tests. Current was collected for over four hours while the conductor potential was held constant at 1000 volts. A smooth decrease with time was not observed, but rather a roughly constant current collection with brief surges to high values. Tests were also conducted with the simulated solar cell biased negative. The current was found to be proportional to pinhole area.

R.K.G.

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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


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 measurement 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.

Author

A80-26182 * National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. THE PLANEAR MULTIJUNCTION CELL: A NEW SOLAR CELL FOR EARTH AND SPACE.


A 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 multijunction (VMJ) solar cell. The PMJ solar cell is internally divided into many voltage-generating regions, called unit cells, which are internally connected in series. The key to obtaining reasonable performance from this device was the separation of top surface field regions over each active unit cell area. Using existing solar cell fabricating methods, output voltages in excess of 20 volts per linear centimeter are possible. Analysis of the new device is complex, and numerous geometries are being studied which should provide substantial benefits in both normal sunlight usage as well as with concentrators. Author


A wide range of the ion beam parameters are capable of producing uniform homogeneous alignment of nematic liquid crystals on SiO2 films. The alignment surfaces were generated by obliquely incident argon ions; a smaller range of ion beam parameters was also investigated with ZrO2 films and found suitable for
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. (Author)

Three high open-circuit voltage cell designs based on 0.1 ohm-cm p-type silicon were irradiated with 1 MeV electrons and their performance determined to fluences as high as 10 to the 15th/sq cm. Of the three cell designs, radiation induced degradation was greatest in the high-low emitter (HLE) cell. The diffused and ion implanted cells degraded approximately equally but less than the HLE cell. Degradation was greatest in an HLE cell exposed to X-rays before electron irradiation. The cell regions controlling both short-circuit current and open-circuit voltage degradation were defined in all three cell types. An increase in front surface recombination velocity accompanied time dependent degradation of a HLE cell after X-irradiation. It was speculated that this was indirectly due to a decrease in positive charge at the silicon-oxide interface. Modifications aimed at reducing radiation induced degradation are proposed for all three cell types. (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)

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

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.

A.R.H.


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.

M.E.P.
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.
85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation.

For related information see 03 Air Transportation and Safety, 16 Space Transportation, and 44 Energy Production and Conversion.

N80-21200* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPPORT FOR NEAR TERM ELECTRIC VEHICLE PROPULSION SYSTEM TESTING
(NASA-TM-81495; E-400: DOE/NASA/1040-80/13) Avail. NTIS HC AO2/MF AO1 CSCL 13F

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.

N80-21201* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FUEL ECONOMY SCREENING STUDY OF ADVANCED AUTOMOTIVE GAS TURBINE ENGINES

Fuel economy potentials were calculated and compared among five 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 80 percent gains over the reference fuel economy. Fuel economy sensitivities to engine design parameter changes were also calculated for these two combinations.

N80-28254* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY RESULTS OF STEADY STATE CHARACTERIZATION OF NEAR TERM ELECTRIC VEHICLE BREADBOARD PROPULSION SYSTEM

The steady state test results on a breadboard version of the General Electric Near Term Electric Vehicle (ETV-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.

N80-30329* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A LABORATORY FACILITY FOR ELECTRIC VEHICLE PROPULSION SYSTEM TESTING
(NASA-TM-81574, DOE/NASA/1011-32; E-644) Avail. NTIS HC AO2/MF AO1 CSCL 13F

The road load simulator facility located at the NASA Lewis Research Center enables a propulsion system or any of its components to be evaluated under a realistic vehicle inertia and road load. The load is applied to the system under test according to the road load equation: \( F(\text{load}) = K_1 F_t + K_2 F_v + K_3 \sin \theta \).


The paper presents a traffic control design technique for application to large traffic networks with signalized intersections. It is shown that the design method adopts a macroscopic viewpoint to establish a new traffic modelling procedure in which vehicle platoons are subdivided into main stream queues and turning queues. Optimization of the signal splits minimizes queue lengths in the steady state condition and improves traffic flow conditions, from the viewpoint of the traveling public. Finally, an application of the design method to a traffic network with thirty-three signalized intersections is used to demonstrate the effectiveness of the proposed technique.

M.E.P.

ASSESSMENT OF THE STATE OF TECHNOLOGY OF AUTOMOTIVE STIRLING ENGINES

The current status of automotive Stirling engine technology is considered. The energy is described and the history of its evolution is reviewed. Overall engine, component, subsystem and material problem areas are identified and recommendations are made for further development and testing. Potential improvements are also identified. Projected Stirling engine/vehicle performance is compared to that of vehicles using current internal combustion 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.

N80-17916* Garrett Corp., Torrance, Calif.
ADVANCED ELECTRIC PROPULSION SYSTEM CONCEPT FOR ELECTRIC VEHICLES
Seventeen propulsion system concepts for electric vehicles were compared to determine the differences in component and battery pack to achieve the basic performance level. Design trade-offs were made for selected configurations to find the optimum component characteristics required to meet all performance goals. The anticipated performance when using nickel-zinc batteries rather than the standard lead-acid batteries was also evaluated. The two systems selected for the final conceptual design studies included a system with a flywheel energy storage unit and a basic system that did not have a flywheel. The flywheel system meets the range requirement with either lead-acid or nickel-zinc batteries and also the acceleration of zero to 89 km/hr in 15 s. The basic system can also meet the required performance with a fully charged battery, but, when the battery approaches 20 to 30 percent depth of discharge, maximum acceleration capability gradually degrades. The flywheel system has an estimated life-cycle cost of $0.045/km using lead-acid batteries. The basic system has a life-cycle cost of $0.06/km. The basic system, using batteries meeting ISOA goals, would have a life-cycle cost of $0.043/km.

An automatic shifting scheme for a two-speed transaxle for electric vehicles is described. The transaxle system was to be installed in an instrumented laboratory vehicle. Use with an electric vehicle propulsion system is described. The transaxle with which these tests were made was fabricated and described. J.M.S.

NBO-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 D13N-78; EC-77-A-31-1011)
(NASA- CR-159650; DOE/NASA/0078-79/1; WMB/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 energy to and from the flywheel appear attractive; however, development work is required to establish the safe limits of speed and energy storage for advanced flywheel designs and to achieve the optimum efficiency of energy transfer. Brushless traction motor designs using either electronic commutation schemes or dc-to-ac inverters appear to provide a practical approach to a mass producible motor, with excellent efficiency and light weight. No comparisons were made with advanced system concepts which do not incorporate a flywheel. M.G

NBO-18992** Brobeck (William M.) and Associates, Berkeley, Calif.

**AN AUTOMATICALLY-SHIFTED TWO-SPEED TRANSAXLE SYSTEM FOR AN ELECTRIC VEHICLE** Final Report Dec. 1978 - Dec. 1979

Hayden S. Gordon and Gregory V. Hassman Jan 1980 34 p refs (Contracts D13N-84; EC-77-A-31-1044)
(NASA-CR-159746; DOE/NASA/0084-79/1; WMB/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 described.

NBO-21202** Cleveland State Univ., Ohio.

**ERROR ANALYSIS IN THE MEASUREMENT OF AVERAGE POWER WITH APPLICATION TO SWITCHING CONTROLERS** Contractor Report, Oct. 1978 - Oct. 1979

(NASA-CR 159792; DOE/NASA/3222-80/1) Avail: NTIS HC A05/MF A01 CSCL 10F

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 can be minimized if 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. M.G.


**ASSESSMENT AND PRELIMINARY DESIGN OF AN ENERGY BUFFER FOR REGENERATIVE BRAKING IN ELECTRIC VEHICLES** Final Report

R. Buchholz and Anoop K. Mathur Dec. 1979 138 p (Contracts D13N-48; EC-77-C-31-1044)
(NASA-CR-159756; DOE/NASA/0048-79/1; TSCIO082-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 based on predicted range improvements, consumer acceptance, drivability, safety, reliability and durability, and initial and life cycle costs. A hydropneumatic buffer system was selected. Author


**FEASIBILITY STUDY OF SILICON NITRIDE REGENERATORS**


The feasibility of using silicon nitride as a regenerator matrix material for applications requiring inlet temperatures above 1000 C is examined. The present generation oxide ceramics are used as a reference to examine silicon nitride from a material characteristics, manufacturing, thermal stress and thermoelastic viewpoint. E.D.K.


**ADVANCED PROPULSION SYSTEM FOR HYBRID VEHICLES** Final Report

(NASA-CR-159771; DOE/NASA/0091-80/1; AlResearch 79-18430) Avail: NTIS HC A10/MF A01 CSCL 13F

A number of hybrid propulsion systems were evaluated for...
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 65 kW spark ignition heat engine, a mechanical continuously variable traction transmission, a 20 kW permanent magnet axial-gap traction motor, a variable frequency inverter, a 386 kg lead acid improved state-of-the-art battery, and a transaxle. The system was configured with a parallel power path between the heat engine and battery. It has two automatic operational modes: electric mode and heat engine mode. Power is always shared between the heat engine and battery during acceleration periods. In both modes, regenerative braking energy is absorbed by the battery.
A

ABLATION

Plasma-sprayed dual density ceramic turbine seal system

ABRASION

Abradable compressor and turbine seals, volume 1
--- for turbofan engines

ABRASION RESISTANCE

Friction and wear of plasma-sprayed coatings containing cobalt alloys from 25 deg to 650 deg in air
[ASLE PREPRINT 80-AM-6C-2] p0122 A80-43176

Development of improved high pressure turbine outer gas path seal components --- abradability and thermal cycling test results

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ABSORBERS (MATERIALS)

BT SOLAR ENERGY ABSORBERS

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Spectral effects on direct-insolation absorptance of five collector coatings
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BT CENTIFUGING STRESS

ACCELERATION STRESSES (PHYSIOLOGY)

BT DEPOSITION

ACCUMULATORS

BT SOLAR COLLECTORS

BT SOLAR REFLECTORS

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Experimental aerodynamic and acoustic model testing of the Variable Cycle Engine (VCE) tested coaxial exhaust nozzle system

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An experimental evaluation of the performance deficit of an aircraft engine starter turbine

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An advanced mixed user domestic satellite system architecture

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