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Bibliography of Lewis Research Center Technical Publications Announced in 1982

April 1983
PREFACE

In 1982, Lewis Research Center's 934 research authors published 378 technical publications which were announced to and reached the worldwide scientific community. This number was almost the same as last year's 364 publications. The number of reports published per person per year has decreased slightly. In 1982, Lewis authors published approximately 61 percent of their research contributions in outside publications and the remainder as NASA research reports. Lewis authors primarily use society proceedings, seminar presentations, journal articles, and transactions to describe their work. Many have received awards for their contributions; among them are the following:

The 1982 Lewis Distinguished Paper Award was presented to Gary M. Johnson for his paper entitled "Surrogate-Equation Technique for Simulation of Steady Inviscid Flow."

In 1982, Marvin Goldstein, Lewis' Chief Scientist, was presented two prestigious awards. He received the Aeroacoustics Award for his important contributions to the theories of fan, jet, and jet-surface interaction noise including his comprehensive treatise Aeroacoustics, that has become a standard reference in the field and was published by McGraw-Hill. M. Goldstein also was presented the Pendray Aerospace Literature Award for outstanding literature contributions in aeroacoustics and unsteady aerodynamics which have significantly advanced those sciences and produced key elements in the design of high-speed fans and compressors for modern aircraft engines.

In 1982, 296 contractor-authored research reports were produced, a decrease from the previous year's output of 312. In addition, 21 patent applications were filed and 19 patents were issued.

All the publications in this collection were announced in the 1982 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, Publications Division
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AN EXPERIMENTAL STUDY OF AIRFOIL ICING CHARACTERISTICS


A full scale general aviation wing with a NACA 63 sub 2 A415 airfoil section was tested to determine icing characteristics for representative rime and glaze icing conditions. Measurements were made of ice accretion shapes and resultant wing section drag coefficient levels. It was found that the NACA 63 sub 2 A415 wing section was less sensitive to rime and glaze icing encounters for climb conditions.

E.A.K.

ADVANCED TECHNOLOGY FOR CONTROLLING POLLUTANT EMISSIONS FROM SUPERSONIC CRUISE AIRCRAFT

Robert A. Duerr and Larry A. Diehl In NASA. Langley Research Center Supersonic Cruise Res. 1979, Pt. 1 Mar, 1980 p 539-548 (For primary document see N84-17981 09.01) Avail: NTIS HC A23/MF A01 CSCL 13B

Gas turbine engine combustor technology for the reduction of pollutant emissions is summarized. Variations of conventional combustion systems and advanced combustor concepts are discussed. Projected results from far term technology efforts aimed at applying the premixed vaporized and catalytic combustion techniques to aircraft combustion systems indicate a potential for significant reductions in pollutant emission levels.

M.G.

BIBLIOGRAPHY OF NASA PUBLISHED REPORTS ON GENERAL AVIATION, 1976 TO 1981


This bibliography lists 476 documents which relate to all heavier-than-air fixed wing aircraft exclusive of military types and those used for commercial air transport. An exception is the inclusion of commuter transport aircraft types within the general aviation category. NASA publications included in this bibliography are: conference publications (CP), reference publications (RP), technical memorandums (TM), technical notes (TN), technical papers (TP), and contractor reports (CR). In addition, papers and articles on NASA general aviation programs published by technical societies (AIAA, SAE, etc.) are included, as well as those listed in NASA's Scientific and Technical Aerospace Reports (STAR) Journal. Author and subject indexes are also provided to facilitate use of the bibliography.

T.M.

ENGINE TECHNOLOGY

Anthony C. Hoffman In NASA. Langley Research Center Elec. Flight Systems Feb, 1982 p 235-240 (For primary document see N82-19134 10.01) Avail: NTIS HC A12/MF A01 CSCL 21E

Materials used in a presentation on development of engine technology for electric flight systems are presented. Component and system technology issues, NASA's role, and flight test requirements are outlined.

J.D.H.
results show that blade sweep was important in achieving net efficiencies near 80 percent at Mach 0.8 and reducing near-field cruise noise by dB. Lifting line and lifting surface aerodynamic analysis codes are under development and some initial lifting line results are compared with propeller force and probe data. Some initial laser velocimeter measurements of the flow field velocities of an 8-bladed 45 deg swept propeller are shown. Experimental aeroelastic results indicate that cascade effects and blade sweep strongly affect propeller aeroelastic characteristics. Comparisons of propeller near-field noise data with linear acoustic theory indicate that the theory adequately predicts near-field noise for subsonic tip speeds but overpredicts the noise for supersonic tip speeds. Potential large gains in propeller efficiency of 7 to 11 percent at Mach 0.8 may be possible with advanced counter-rotation propellers.

B.W.


The design of supersonic nozzles is becoming increasingly complex as conflicting requirements for low noise, higher efficiency, and wider operating range are driving the designer toward more variable geometry and multiple stream flows. Analysis techniques must be modified and expanded to take into account these additional complexities and still retain the rapid computational rate necessary for optimization and design studies. A nozzle analysis must handle more flow streams, more complex geometries, and more highly distorted initial profiles. This paper discusses some modifications to a method for calculating the performance characteristics of supersonic ejector nozzles and demonstrates the improvement in results the modifications provide.

(Author)


The Aircraft Energy Efficiency (ACEE) Program was established by NASA to improve the fuel efficiency of commercial transport aircraft and thereby to reduce the amount of fuel consumed by the air transportation industry. One of the final items developed by the program is an improved fairing which is the aft closure for the thrust reverser actuators on the JT8D nacelles on DC-9 aircraft. The reduced-drag fairing uses, in the interest of weight savings, an advanced composite construction. The composite material contains Kevlar 49 fibers in a PMR-15 matrix. Attention is given to the aerodynamic configuration, the material system, and aspects of fabrication development.

G.R.
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.

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**LOW SPEED TESTING OF THE INLETS DESIGNED FOR A TAMDEN-FAN V/STOL NACELLE**


(NASA-TM-82725, E-1031, AIAA-81-2627) Avail. NTIS HC A02/MF A01 CSCL 01A

An approximately 0.25 scale model of a tandem fan nacelle, designed for a subsonic V/STOL aircraft, was tested in a Lewis wind tunnel. Model variables included long and short intake cowl and the addition of exterior strakes to the short intake cowling. Inlet pressure recoveries and distortion were measured for a double slotted inlet and thick lip inlet. Results can be summarized as:

1. The VPR and VIGV systems were the most promising.
2. Both systems attained significant implications for the inlet, and (3) both systems attained good performance and is considered suitable for the intended V/STOL application.

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**A SUMMARY OF V/STOL INLET ANALYSIS METHODS**


(NASA-TM-82725, E-1027) Avail. NTIS HC A02/MF A01 CSCL 01A

Recent extensions and applications of the methods are emphasized. They include the specification of the Kutta condition for a slotted inlet, the calculation of suction and tangential blowing, the determination of interaction of flow distortions, such as gusts and wakes with blade rows of advance type fans and compressors having high tip Mach numbers. A typical disturbance was assumed to have harmonic time dependence and was described, at a far upstream location, in three orthogonal spatial coordinates by a double Fourier series. It was convected at supersonic relative to a linear cascade described as an unrolled annulus. Conditions were selected so that the component of this velocity parallel to the axis of the turbomachine was subsonic, permitting interaction between blades through the upstream as well as downstream flow media. A strong, nearly normal shock was considered in the blade passages which was allowed curvature and displacement. The flows before and after the shock were linearized relative to uniform mean velocities in their respective regions. Solution of the descriptive equations was by adaption of the Wiener-Hofp technique, enabling a determination of distortion patterns through and downstream of the cascade as well as pressure distributions on the blade and surfaces. Details of interaction of the disturbance with the in-passage shock were discussed, influences of amplitude, wave length, and phase of the disturbance on lifts and moments of cascade configurations were presented. Numerical results are clarified by reference to an especially orderly pattern of upstream vertical motion in relation to the cascade parameters.

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**THE EFFECT OF ROTOR BLADE THICKNESS AND SURFACE FINISH ON THE PERFORMANCE OF A SMALL AXIAL FLOW TURBINE**


(NASA-TM-82764; E-1085) Avail. NTIS HC A02/MF A01 CSCL 01A

Current computational methods for analyzing flows in turbomachinery and other related internal propulsion components are presented. The methods are divided into two classes. The inviscid methods deal specifically with turbomachinery applications. Viscous methods deal with general flows as well as viscous flows in turbomachinery passages. Viscous methods are categorized into time potential, streamline function, and Euler approaches. Various grids used in association with these procedures are also discussed.

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**ANALYTIC INVESTIGATION OF EFFECT OF END-WALL CONTOURING ON STATOR PERFORMANCE**


(NASA-TM-82747; E-1063) Avail. NTIS HC A02/MF A01 CSCL 01A

Low speed wind tunnel tests were conducted to assess four methods for attaining thrust modulation for V/STOL aircraft. The four methods were:

1. Fan speed control,
2. Fan nozzle exit area change,
3. Variable pitch rotor (VPR) fan, and
4. Variable inlet guide vanes (VIGV).

The interrelationships between inlet and thrust modulation system were also investigated using a double slotted inlet and thick lip inlet. Results can be summarized as:

1. The VPR and VIGV systems were the most promising,
2. Changes in blade angle to obtain changes in fan thrust have significant implications for the inlet, and
3. Both systems attained good performance and are considered suitable for the intended V/STOL application.

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than the exit area. Comparisons are made with previously published experimental data. This sets up a parametric analysis of the effect contour geometry on the efficiency of a highly loaded axial stator are given. The maximum stator efficiency gain is about 0.8 percentage point, and this represents a 22 percent reduction in stator losses. The degree to which andwall conditions reduces the forces driving secondary flows was also examined. The driving forces for both cross channel and radial secondary flow were reduced. T.M.

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**N82-15020** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. COMPARISON OF TWO AND THREE DIMENSIONAL FLOW COMPUTATIONS WITH LASER ANEMOMETER MEASUREMENTS IN A TRANSonic COMPRESSOR ROTOR Rodrick R. Osima and Anthony J. Stratist 1982 16 p refs Proposed for presentation at the 27th Gas Turbine Conf., London, 18-22 Apr. 1982; sponsored by ASME (NASA-TM-82777; E-1007) Avail: NTIS HC A02/MF A01 CSDL 01A

A procedure for using an efficient axisymmetric code to generate downstream pressure input for more costly Euler codes is discussed. Two and three dimensional inviscid solutions for the flow within a transonic axial compressor rotor at design speed are compared to laser anemometer measurements at maximum flow and near stall operating points. Computational details of the 2-D axisymmetric stream function solution and the 3-D full Euler solution are described. Relative Mach number contours, shock location, and shock strength as measured and as predicted by the 3-D code are compared. Downstream of the rotor the inviscid computations agree with each other but predict higher pressure ratio than those measured. Euler codes require a downstream pressure as input. Since that pressure controls the computed mass flow and shock system, it must be consistent with an inviscid solution. E.A.K.

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The application of color coding techniques used in processing remote sensing imagery to analyze and display fluid flow data is discussed. A minicomputer based color film recording and color CRT display system is described. High quality, high resolution images of two-dimensional data are produced on the CRT screen. Three dimensional data, in large volume, are used to generate color motion pictures © which time is used to represent the third dimension. Several applications and examples are presented. System hardware and software is described. M.G.

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The thrust, specific fuel consumption, and relative merits of the tandem fan and the dual reverse flow front fan propulsion systems for a subsonic V/STOL/VTOL are compared. Consideration is given to; fan pressure ratio, fan air burning, and variable core supercharging. The special propulsion system components required are described, namely; the deflecting front inlet/nozzle, the aft subsonic inlet, the reverse pitch fan, the variable core supercharger and the low pressure forward burner. The potential benefits for these unconventional systems are indicated. Author

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**N82-24185** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EXPERIMENTAL AND ANALYTICAL RESULTS OF TANGENTIAL BLOWING APPLIED TO A SUBSONIC V/STOL INLET Richard R. Butley and Danny P. Hwang 1982 18 p refs Proposed for presentation at the 18th Joint Propulsion Conf., Cleveland, 21-23 Jun. 1982; sponsored by AIAA, SAE and ASME (NASA-TM-82847; E-1217; NAS 1.15:82847) Avail: NTIS HC A02/MF A01 CSDL 01A

Engine inlets for subsonic V/STOL aircraft must operate over a wide range of conditions without internal flow separation. Experimental and analytical investigations were conducted to evaluate the effectiveness of tangential blowing to maintain attached flow to high angles of attack. The inlet had a relatively thin lip with a blowing slot located either on the lip or in the diffuser. The height and width of these slots was varied. Experimentally determined flow separation boundaries showed that lip blowing achieved higher angle of attack capability than diffuser blowing. This capability was achieved with the largest circumferential extent and either of the two slot heights. Predicted (analytical) separation boundaries showed good agreement except at the highest angles of attack. S.L.

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Various three dimensional inlet models were calculated based on the potential flow model. Results are presented in the forms of surface static pressure, flow angularity, surface flow pattern, and inlet flow field. It is indicated that the extension of the lower lip can reduce the adverse pressure gradient and increase the flow separation bound. E.A.K.

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**N82-26234** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LASER ANEMOMETER MEASUREMENTS IN AN ANNUAL CASCADE OF CORE TURBINE VANES AND COMPARISON WITH THEORY Louis J. Goldman and Richard G. Seashultz Jun. 1982 47 p refs (NASA-TP-2018; E-876; NAS 1.60:2018) Avail: NTIS HC A03/MF A01 CSDL 01A

Laser measurements were made in an annular cascade of stator vanes operating at an exit critical velocity ratio of 0.78. Velocity and flow angles in the blade to blade plane were obtained at every 10 percent of axial chord within the passage and at 1/2 axial chord downstream of the vanes for radial positions near the hub, mean and tip. Results are presented in both plot and tabulated form and are compared with calculations from an inviscid, quasi three dimensional computer program. The experimental measurements generally agreed well with these theoretical calculations, an indication of the usefulness of this analytic approach. Author

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**N82-26240** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. AERODYNAMIC PERFORMANCE OF HIGH TURNING CORE TURBINE VANES IN A TWO DIMENSIONAL CASCADE John R. Schwab 1982 20 p refs Presented at the 18th Joint Propulsion Conf., Cleveland, 21-23 Jun. 1982; sponsored by AIAA, SAE and ASME (NASA-TM-82894; E-1272; NAS 1.15:82894) Avail: NTIS HC A02/MF A01 CSDL 01A

Experimental and theoretical aerodynamic performance data are presented for four uncooled high turning core turbine vanes with exit angles of 74.9, 75.0, 77.5, and 79.6 degrees in a two dimensional cascade. Data for a more conservative 67.0 degree vane are included for comparison. Correction of the experimental aftermix kinetic energy results to a common 0.10 centimeter trailing edge thickness yields a linear trend of increased loss from 0.020 to 0.025 as the vane exit angle increases from 67.0 to 79.6 degrees. The theoretical losses show
a similar trend. The experimental and theoretical vane surface velocity distributions generally agree within approximately five percent, although the suction surface theoretical velocities are generally higher than the experimental velocities as the vane exit angle increases. S.L.

N82-28241*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**PERFORMANCE OF A 2D-CD NONAXISYMMETRIC EXHAUST NOZZLE ON A TURBOPROPEL ENGINE AT ALTITUDE**

David M. Straight 1982 28 p refs Presented at 18th Joint Propulsion Conf., Cleveland, 21-23 June. 1982; sponsored by AIAA, SAE and ASME.

(NASA-TM-82868; NAS 1.15:82868) Avail: NTIS HC A02/MF A01 CSCL 01A

Baseline thrust and cooling data obtained with a 2D-CD versatile research exhaust nozzle mounted on a turboprop engine in an altitude chamber are presented. The tests covered a range of nozzle pressure ratios, nozzle pressure ratios, nozzle throat areas, and internal expansion area ratios. The thrust data obtained show good agreement with theory and scale model results after correcting the data for leakage and bypass cooling flows. Additional work is needed to improve predictability of cooling performance. B.W.

N82-28247*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**COMPUTER PROGRAM FOR CALCULATING FULL POTENTIAL TRANSONIC, QUASI-THREE-DIMENSIONAL FLOW THROUGH A ROTATING TURBOMACHINERY BLADE ROW**

Charles A. Farrell Jun. 1982 57 p refs (NASA-TP-2030; E-1013; NAS 1.60:2030) Avail: NTIS HC A04/MF A01 CSCL 01A

A fast, reliable computer code is described for calculating the flow field about a cascade of arbitrary two dimensional airfoils. The method approximates the three dimensional flow in a turbomachinery blade row by correcting for stream tube convergence and radius change in the throughflow direction. A fully conservative solution of the full potential equation is combined with the finite volume technique on a body fitted periodic mesh. The instructions required to set up and use the code are included. The name of the code is QSONIC. A numerical example is also given to illustrate the output of the program. M.E.

N82-28249*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**A SUMMARY OF VSTOL INLET ANALYSIS METHODS**

Danny P. Hwang and John M. Abbarb 1982 17 p refs To be presented at the 12527; NAS 1.15:82868) Avail: NTIS HC A02/MF A01 CSCL 01A

For abstract see AB2-16902

N82-28250*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**COMPARISON OF LASER ANEMOMETER MEASUREMENTS AND THEORY IN AN ANNULAR TURBINE CASCADE WITH EXPERIMENTAL ACCURACY DETERMINED BY PA CENTER, ENGR. RESEARCH, OHIO**


(NASA-TM-82680; E-1228; NAS 1.15:82680) Avail: NTIS HC A02/MF A01 CSCL 01A

Three experimental measurements of the velocity components in the blade to blade (axial tangential) plane were obtained with an axial flow turbine stator passage and were compared with calculations from three turbomachinery computer programs. The theoretical results were calculated from a quasi three dimensional inviscid code, a three dimensional inviscid code, and a three dimensional viscous code. Parameter estimation techniques and a particle dynamics calculation were used to assess the accuracy of the laser measurements, which allow a rational basis for comparison of the experimental and theoretical results. The general agreement of the experimental data with the results from the two inviscid computer codes indicates the usefulness of these calculation procedures for turbomachinery blading. The comparison with the viscous code, while generally reasonable, was not as good as for the inviscid codes. S.L.

N82-28251*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

**VELOCITY GRADIENT METHOD FOR CALCULATING VELOCITIES IN AN AXISYMMETRIC ANNULAR DUCT**

Theodore Katonis Jul. 1982 23 p refs

(NASA-TP-2029; E-1104; NAS 1.60:2029) Avail: NTIS HC A02/MF A01 CSCL 01A

The velocity distribution along an arbitrary line between the inner and outer walls of an annular duct with axisymmetric swirling fluid is calculated. The velocity gradient equation is used with an assumed variation of meridional streamline curvature. Upstream flow conditions can vary between the inner and outer walls, and an assumed total pressure distribution can be specified. S.L.

A82-19776 * # Three-dimensional flow calculations including boundary layer effects for supersonic Inlets at angle of attack. J. Vadyak, J. D. Hoffman (Purdue University, West Lafayette, IN), and A. Bishop (NASA, Lewis Research Center, Wind Turbine Division, Flight Div., Cleveland, OH). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, Paper 82-0061. 13 p, 23 refs. Grant No. NSG-3311.

An analysis is presented for calculating the steady three-dimensional flow field in supersonic mixed-compression Inlets at incidence. A zonal modeling approach is employed to obtain the solution. The supersonic core flow is computed using a second-order pentahedral bicharacteristic algorithm. The bow shock wave and the reflected Internal shock train are determined using a three-dimensional discrete shock fitting procedure. The boundary layer flow adjacent to both the centerbody and the cowl is computed using a second-order implicit finite difference method. The flow in a shock wave-boundary layer Interaction region is computed using an integral formulation. The culmination of the present research effort is the development of a production-type computer program capable of analyzing flow in a variety of mixed-compression aircraft Inlets. Numerical results and experimental correlations are presented to illustrate application of the analysis. (Author)

A82-35195 *# Experimental and analytical results of tangential blowing applied to a subsonic VSTOL inlet. R. R. Burley and D. L. Hwang (NASA, Lewis Research Center, Cleveland, OH); AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA Paper 82-1062 12 p, 9 refs. (Previously announced in STAR as N82-24165)


The use of tangential blowing from a row of holes in an aft facing step is found to provide good control of the ramp boundary layer, normal shock interaction on a fixed geometry Inlet over a wide range of inlet mass flow rates. Ramp Mach numbers of 1.36 and 1.96 are investigated. The blowing geometry is found to have a significant effect on system performance at the highest Mach number. The use of high-temperature air in the blowing system, however, has only a slight effect on performance. The required blowing rates are significantly high for the most severe test conditions. In addition, the required blowing coefficient is found to be proportional to the normal shock pressure rise. C.R.

Experimental and theoretical aerodynamic performance data are presented for
four uncooled high turning core turbine vanes with exit angles of 74.8, 75.0, 77.5,
and 78.6 degrees in a two-dimensional cascade. Data for a more conservative
67.0 degree vane are included for comparison. Correlation of the experimental
afterburn kinetic energy losses to a common 0.100 centimeter trailing edge thick-
ness yields a linear trend of increased loss from 0.020 to 0.025 as the vane exit
angle increases from 67.0 to 78.6 degrees. The theoretical losses show a similar
trend. The experimental and theoretical vane surface velocity distributions gener-
amely agree within approximately five percent, although the suction surface
theoretical velocities are generally higher than the experimental velocities as the
vane exit angle increases.

(Author)

AB8-37037* # Three-dimensional shock structure in a transonic flutter
cascade. D. R. Boldman, A. E. Buggele, and A. J. Decker (NASA, Lewis Re-
5 refs.
Rapid double-pulse holography was employed to obtain detailed, two-dimen-
sional images of the shock formation during simulated flutter in a transonic flowfield.
The experiment comprised a linear cascade of airfoils externally oscillated in
motion and view tangentially at the shock surface. Three biconvex airfoils were
subjected to shock-pitching motion about the midchord axis at a frequency of
0.53 while immersed in a Mach 0.81 flow. Failure to produce observable shocks
led to use of choked flow with a Mach number near one, of which 50 holograms
were taken. The images revealed a narrow shock surface with a complex varia-
tion in the shock properties. The method is concluded to be useful for examining
transonic flowfield shocks in the presence of airfoil flutter.
M.S.K.

AB8-40821* # A summary of V/STOL inlet analysis methods. D. P. Hunsperger and J. M. Abbott (NASA, Lewis Research Center, Cleveland, OH). In
International Congress on Aeronautical Sciences, Congress, 13th and AIAA
Aircraft Systems and Technology Conference, Seattle, WA, August 22-27, 1982,
Proceedings, Volume 1, (AB8-40876 20-01) New York, American Institute of
The methods used to analyze the aerodynamic performance of V/STOL inlets
at the NASA Lewis Research Center are briefly described. Recent extensions
and applications of the method are emphasized. They include the specification
of the Kutta condition for a slotted inlet, the calculation of suction and tangential
blowing for boundary layer control, and the analysis of auxiliary inlet geometries.
A comparison is made with experiment for the slotted inlet and also for tangential
blowing. Finally, an optimum inlet diffuser velocity distribution is developed.

AB8-11041* # Flow Research, Inc., Kent, Wash.
CALCULATIONS OF TRANSONIC POTENTIAL FLOW OVER
CASCADES Final Report
(Contract NAS3-22129)
cosl OIA
Transonic flow through a cascade was studied by using the
full potential equation and the finite volume method of Jameson
and Courch. The C-type computational grid is generated by an
electrostatic analogy and simple shearing transformation. The
solution algorithm includes an option of using either an artificial
density or an artificial viscosity formulation of the dissipative
term. Using the developed code, flows through a cascade of
NACA 0012 airfoils and flows through a cascade of shockless
blades were computed. It is found that the resolved flow through
the shockless blade is accurately predicted, the artificial density
formulation shows more tolerance to the mesh irregularity, and
the C-type mesh does not extend very far upstream for a small
pitch-card ratio.
T.M

AB8-16044* # Universities Space Research Association.
COLUMBIA, Md.
CAS22 - FORTRAN PROGRAM FOR FAST DESIGN AND
ANALYSIS OF SHOCK-FREE AIRFOIL CASCADES USING
FITICTIOUS-GAS CONCEPT Final Report
Djordje S. Dulikravich and Helmut Sobieczky (DFVLR-Inr. fuer
Theoretische Stramungsmechanik, Goettingen, West Germany)
(Contract NAS3-22932)
(NASA-CR-35070) Avail: NTIS HC A04/MF A01
cosl OIA
A user-oriented computer program, CAS22, was developed
that is applicable to aerodynamic analysis and design of existing
and new two-dimensional airfoils. This FORTRAN program can be used: (1) as an analysis code
for full-potential, transonic, shocked or shock-free cascades
(2) as a design code for shock-free cascades that uses Sobie-
eczky's fictitious-gas concept; and (3) as a shock-free design
code followed automatically by the analysis code as a form of
the newly obtained cascade shape provides for an entirely
shock-free transonic flow field. A four-level boundary-conforming
grid of an O type is generated. The shock-free design is performed
by implementing Sobieczky's fictitious-gas concept of elliptic
continuation from subsonic into supersonic flow domains.
Recomposition inside each supersonic zone is performed by the
method of characteristics in the r-phase plane by using
lentisotropic gas relations. Besides converting existing cascade
shapes with multiple shocked supersonic regions into shock-free
cascades, CAS22 can also unchoke previously choked cascades
and make them shock free.
A.R.H.

AB8-17122* # McDonnell-Douglas Corp., St. Louis, Mo.
TESTS OF A D VENTED THRUST DEFLECTING NOZZLE
BEHIND A SIMULATED TURBOFAN ENGINE Final Report
(Contract NAS3-21733)
HC A07/MF A01
cosl OIA
A D vented thrust deflecting nozzle applicable to subsonic
V/STOL aircraft was tested behind a simulated turbofan engine
in the vertical thrust stand. Nozzle thrust, fan operating
characteristics, nozzle entrance conditions, and static pressures
were measured. Nozzle performance was measured for variations
in exit area and thrust deflection angle. Six core nozzle configura-
tions, the effect of core exit axial location, mismatched core,
and fan stream pressure ratio, and yaw angle were evaluated. Core nozzle configuration affected performance
at normal and engine cut operating conditions. Highest vectored
nozzle performance resulted for a given exit area where core
and fan stream pressure were equal. It is concluded that high
nozzle performance can be maintained at both normal and engine
out conditions through control of the nozzle entrance Mach number with a variable exit area.

AB8-18180* # United Technologies Research Center, East
Hartford, Conn.
AN EXPERIMENTAL INVESTIGATION OF GAPWISE
PERIODICITY AND UNSTEADY AERODYNAMIC RESPONSE
IN AN OSCILLATING CASCADE. VOLUME 2: DATA
REPORT. PART 1: TEST AND MODE 1 DATA Final
Report
(Contract NAS2-22018)
(NASA-CR-165457- Vol-2-Pr-1: R81-51461B-28-Vol-2-Pr-1)
Avail: NTIS HC A16/MF A01
cosl OIA
Tests were conducted a linear cascade of airfoils oscillating
pitch to measure the unsteady pressure response on selected
blade along the leading edge plane of the cascade, over the
chord of the center blade, and on the sidewall in the plane of
the leading edge. The tests were conducted for all 96 combinations
2 mean camberline incidence angles 2 pitching amplitudes 3
reduced frequencies and 6 interblade phase angles. The pressure
data were reduced to Fourier coefficient form for direct comparison,
and were also processed to yield integrated loads and particularly,
the aerodynamic damping coefficient. Data obtained during the
test program, reproduced from the printout of the data reduction
program are compiled. A further description of the contents
of this report is found in the text that follows.

AB8-16184* # Pennsylvania State Univ., University Park. Dept.
of Aerospace Engineering.
NUMERICAL ANALYSIS AND FORTRAN PROGRAM FOR
THE COMPUTATION OF THE TURBULENT WAKES OF
TURBOMACHINERY ROTOR BLADES, ISOLATED AIRFOILS
AND CASCADE OF AIRFOILS Final Report - Ph.D. Thesis
1982 171 p. refs
(Grant NsG-3012)
HC A08/MF A01
cosl OIA
Turbulent wakes of turbomachinery rotor blades, isolated
airfoils, and a cascade of airfoils were generated both numerically
and experimentally. Low subsonic and incompressible wake flows
were examined. A finite difference procedure was employed in the numerical analysis utilizing the continuity, momentum, and turbulence closure equations in the rotating, curvilinear, and nonorthogonal coordinate systems. The curvilinear coordinate system was developed to improve the accuracy and efficiency of the numerical calculation. Three turbulence models were employed to obtain closure of the governing equations. The first model was comprised of turbulence equations for the turbulent kinetic energy and the rate of energy dissipation, and the second and third models were comprised of equations for the rate of turbulent kinetic energy dissipation and Reynolds stresses, respectively. The second model handles the convection and diffusion terms in the Reynolds stress transport equation collectively, while the third model handles them individually. The numerical results demonstrate that the second and third models provide accurate predictions, but the computer time and memory storage can be considerably saved with the second model.

B.W.
Blade-to-blade calculation. Numerical calculations were made for an axial annular turbine cascade and a transonic, centrifugal impeller with splitter vanes. The subsonic turbine cascade computation was generated in blade-to-blade surface to evaluate the accuracy of the blade-to-blade mode of marching. Calculated blade pressures at the hub, mid, and 1/2 radius of the cascade agreed with measurements. The transonic impeller computation was conducted to test the newly developed locally mass flux conservative cross-sectional code. Both blade-to-blade and cross sectional modes of calculation were implemented for this problem. A triplet point shock structure was computed in the inducer region of the impeller. In addition, time-averaged shroud static pressures generally agreed with measured shroud pressures. It is concluded that the blade-to-blade computation produces a useful engineering flow field in regions of subsonic relative flow; and cross-sectional computation, with a locally mass flux conservative continuity equation, is required to compute the shock waves in regions of supersonic relative flow.

N82-24168# Ohio State Univ, Columbus. Dept. of Aeronautical and Astronautical Engineering.


A methodology was developed to predict the growth of rime ice, and the resulting aerodynamic penalty on unprotected, subcritical, airfoil surfaces. The system of equations governing the trajectory of a water droplet in the airfoil flowfield is developed and a numerical solution is obtained to predict the mass flux of super cooled water droplets freezing on impact. A rime ice shape is predicted. The effect of time on the ice growth is modeled by a time-stepping procedure where the flowfield and droplet mass flux are updated periodically through the ice accretion process. Two similarity parameters, the trajectory similarity parameter and accumulation parameter, are found to govern the accretion of rime ice. In addition, an analytical solution is presented for Langmuir's classical modified inertia parameter. The aerodynamic evaluation of the effect of the ice accretion on airfoil performance is determined using an existing airfoil analysis code with empirical corrections. The change in maximum lift coefficient is found from an analysis of the new ice cell. The drag correction needed due to the severe surface roughness is formulated from existing ice cell ice and rough airflow data. A small scale wind tunnel test was conducted to determine the change in airfoil performance due to a simulated rime ice shape.

Author

N82-26229# United Technologies Research Center, East Hartford, Conn.


Tests were conducted on a linear cascade of airfoils oscillating in which to measure the unsteady pressure response on selected blades along the leading edge plane of the cascade, over the chord of the center blade, and on the sidewall in the plane of the leading edge. The pressure data were reduced to Fourier coefficients from the direct computation, and were also processed to yield integrated loads and, particularly, the aerodynamic damping coefficient. Results from the unsteady Verdon/Caspar theory for cascaded blades with nonzero thickness and camber was compared with the experimental measurements. The three primary results are: (1) from the leading edge plane blade data, the cascade was judged to be periodic in unsteady flow over the range of parameters tested; (2) the interblade phase angle was found to be the single most important parameter affecting the stability of the oscillating cascade blades; and (3) the real blade theory and the experiment were in excellent agreement for the several cases chosen for comparison. A.R.H.

N82-26230# Massachusetts Inst of Tech, Cambridge Gas Turbine and Plasma Dynamics Lab.


A FORTRAN-IV computer program was developed for the calculation of the inviscid transonic/supersonic flow field in a fully three dimensional blade passage of an axial compressor rotor or stator. Rotors may have dampers (part span shrouds). MacCormack's explicit time marching method is used to solve the unsteady Euler equations on a finite difference mesh. This technique captures shocks and smears them over several grid points. Input quantities are blade row geometry, operating conditions and thermodynamic quantities. Output quantities are three velocity components, density and internal energy at each mesh point. Other flow quantities are calculated from these variables. A short graphics package is included with the code, and may be used to display the finite difference grid, blade geometry and static pressure contour plots on blade to blade calculation surfaces or blade suction and pressure surfaces. The flow in a low aspect ratio transonic compressor was analyzed and compared with high response total pressure probe measurements and gas fluorescence static density measurements made in the MIT blowdown wind tunnel. A FORTRAN-IV computer program was developed and tested with the comparisons data that the computed flow fields accurately model the measured shock wave locations and overall aerodynamic performance.

B.W.

N82-26237# Purdue Univ, Lafayette, Ind. Thermal Sciences and Propulsion Center.


Three dimensional aerodynamic data, required to validate and/or indicate necessary refinements to inviscid and viscous analyses of the flow through turbomachinery blade rows, are discussed. Instrumentation and capabilities for pressure measurement, probe insertion and traversing, and flow visualization are reviewed. Advanced measurement techniques including Laser Doppler Anemometers, are considered. Data processing is reviewed. Predictions were correlated with the experimental data. A flow visualization technique using helium filled soap bubbles was demonstrated.

Author

N82-26239# Universities Space Research Association, Columbia, Md.


A fast computer program, GRID3C, was developed for accurately generating periodic, boundary conforming, three dimensional, consecutively refined computational grids applicable to realistic axial turbomachinery geometries. The method is based on using two functions to generate two dimensional grids on coaxial axisymmetric surfaces positioned between the centerbody and the outer radial boundary. These boundary fitted grids are of the C type and are characterized by quasi-orthogonality and geometric periodicity. The built in nonorthogonal coordinate stretchings and shearings cause the grid clustering in the regions of interest. The stretching parameters are part of the input to GRID3C. In its present version GRID3C can generate and store a maximum of four non dimensional grids. The output grid coordinates can be calculated either in the Cartesian or in the cylindrical coordinate system.

Author
A fast computer program, GRID3C, was developed to generate multilevel three-dimensional C-type periodic, boundary conforming grids for the calculation of realistic turbomachinery and propeller flow fields. The technique is based on two analytic functions that conformally map a cascade of semi-infinite slits to a cascade of doubly infinite strips on different Riemann sheets. Up to four consecutively refined three-dimensional grids are automatically generated and permanently stored on four different computer tapes. Grid nonorthogonality is introduced by a separate coordinate shearing and stretching performed in each of three coordinate directions. The grids are easily clustered closer to the blade surface, the trailing and leading edges and the hub or shroud.

Calculation of the Flow Field Including Boundary Layer Effects for Supersonic Mixed Compression Inlets at Angles of Attack

Joseph Vadyak and Joe D. Hoffman
July 1982
406 p refs (Grant No. NAG-3811)

The flow field is a subsonic mixed compression aircraft inlet at angles of attack. A zonal modeling technique is employed to calculate the solution which divides the flow field into different computational regions. The computational regions consist of a supersonic core flow, boundary layer flows adjacent to both the foreshock/centerbody and cowl contours, and flow in the shock wave boundary layer interaction regions. The zonal modeling analysis is described and some computational results are presented. The governing equations for the supersonic core flow form a hyperbolic system of partial differential equations. The equations for the characteristic surfaces and the compatibility equations applicable along these surfaces are derived. The characteristic surfaces are the stream surfaces, which are surfaces composed of streamlines, and the wave surfaces, which are surfaces tangent to shock waves. The compatibility equations are expressed as directional derivatives along streamlines and bicharacteristics, which are the lines of tangency between a wave surface and a Mach cone.

Three Dimensional Flow Measurements in a Turbine Scroll

W. Tabakoff, B. V. R. Vittal, and B. Wood
July 1982
55 p refs (Grant NAG-326)

A study was conducted to determine experimentally the flow behavior in combined scroll nozzle assembly of a radial inflow turbine. Hot film anemometry technique was used to measure the three-dimensional flow velocity in the scroll. The through flow and secondary flow velocity components are measured at various points in three scroll sections.

Characteristics of the Flow in the Annulus-Wall Region of an Axial-Flow Compressor Blade Passage

R. M. Davino
(Pennsylvania State University, University Park, PA).

Three-dimensional characteristics of the mean velocity and turbulence structure in the annulus-wall region of a moderately loaded compressor rotor have been investigated experimentally by employing triaxial hot-wire probes. Results are presented which indicate that the flow within and downstream of the blade passage is highly complex due to the interaction of the annulus-wall boundary layer, blade boundary layers, tip leakage flow, and passage secondary flow. An understanding of the reported viscous flow interactions is important for establishing improved aerodynamic design criteria and efficiency, for predicting noise levels, and for determining the stall, surge, vibration, and flutter characteristics of turbomachinery.

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This paper reports the experimental study of the three-dimensional characteristics of the mean velocity of the rotor wake inside the annulus- and hub-wall boundary layers. The measurements were taken with a rotating three-sensor hot wire behind the rotor. This set of measurements probably represents the first set of comprehensive measurements taken inside the annulus- and hub-wall boundary layers. The wake was surveyed at several radial locations inside the boundary layer region and at several axial locations. Interaction of the wake with the annulus-wall boundary layer, secondary flow, tip-leakage flow, and the trailing vortex system results in slower decay and larger width of the wake. The presence of a strong vortex and its merger with the wake is also observed. The end-wall boundary layers and the secondary flow were found to have a substantial effect on both the decay characteristics and the profile of the wake. These and other measurements are reported and interpreted in this paper. (Author)


This study was carried out to understand the effects of blade loading and rotation on the rotor end wall flow structure, including the wake. The measurements were taken with a stationary three sensor hot wire located at the exit of a compressor rotor. The data was ensemble averaged to derive all the three components of velocity and six components of stresses at the exit. Measurements were made at two different rotational speeds (1753 and 1010 rpm) and at two differing blade loadings at several radii near the hub and the annulus wall. The wake decay in the annulus wall region is found to be much more rapid than the mid span regions. Furthermore, both the loading and rotation of the blade have appreciable influence on the end wall flow and wake structure. Interaction of the annulus and hub wall boundary layers (and secondary flow resulting from these) have appreciable influence on the wake structure in the endwall regions. (Author)


Results of a wind tunnel test to evaluate the performance of an airfoil with simulated rime ice are presented with theoretical comparisons. A NASA 65A143 airfoil was tested in the OSU 6 x 22 inch Transonic Airfoil Wind Tunnel at a Reynolds number near three million and Mach numbers from 0.20 to 0.80. The model was tested in four configurations to determine the aerodynamic effects of the roughness and shape of a rime ice accretion. The simulated rime ice shape was obtained analytically using a time-stepping dry ice accretion computer code. Lift, drag, moment coefficients, and pressure distributions for the clean and simulated rime ice cases are reported. The measured degradation in airfoil performance is compared to an analytical method which uses existing airfoil analysis computer codes with empirical corrections for the surface roughness. A discussion of the empirical surface roughness correction and uses of other airfoil computer methods is included. (Author)


Asymmetric flows inside curved ducts of rectangular as well as polar cross section are analyzed using the Navier-Stokes equations in terms of the axial velocity and vorticity and the cross-stream flow function. Numerical solutions of the three second-order coupled elliptic partial differential equations governing this flow are obtained efficiently using the coupled alternating-direction implicit (ADI) method as well as the multigrid strongly-implicit (SI) scheme. For the flow configuration studied, the ADI method is found to be more sensitive to the time steps used than is the SI scheme. Use of the multigrid-coupled-strongly-implicit (MG-SI) scheme makes it possible to efficiently obtain fine-grid solutions for configurations having strong secondary flow. It is shown that, for this asymmetric curved-duct flow, the similarity parameter of significance is the Dean's number K rather than the Reynolds number Re. Results are obtained for curved ducts with square cross sections for K up to 900, which here corresponds to Re = 9,000 for this internal flow configuration. C.R.


The finite volume scheme of Jameson (1977) is used to calculate potential flow around a propeller rotating at high speed. An H-type mesh is generated and used successfully in the calculations. A test calculation with a thick blade cross section shows that the present code is capable of computing the propeller flow at the advance Mach number 0.8. The possible physical mechanisms which may play an important role in the propeller aerodynamics are discussed. V.L.


A finite element algorithm for the solution of two-dimensional, steady Euler equations is presented which, through a Closch-type transformation for the velocity vector, gives the conservation mass equation with one primary variable and two additional equations for the convection of two new variables. The accuracy and efficiency of this scheme is discussed, and the second-order accuracy
attained in the analysis of the convection of the vorticity is demonstrated together with the efficient treatment of rotational and irrotational flow subregions. A sample problem is used to show the accuracy of the numerical scheme and its convergence characteristics.

G.C.


Attention is given to a research project which has the goal to develop a two-stage slugging gasifier-combustor in the form of a high-intensity combustor, taking into account a suitable aerodynamic design of the second stage nozzle which will prevent the separation of the boundary layer over the turbine section. The specific objectives of the present investigation are to test the effect of various entrance-nozzle geometries, flow rates, swirl number, and distribution in the first and second stages upon the corresponding flowfield in the second stage. Special emphasis is given to the avoidance of boundary layer separation as the flow turns from axial to radial direction into the MHD disk generator.

G.R.


Measurements of the subsonic flow in the rotor passage of a single stage axial flow compressor were made to study the nature of the flow field and to verify the existing numerical codes. The density and pressure fields were measured across the entire rotor passage at six axial locations and at five radial locations. A five-hole probe, rotating with the rotor, was used to measure the three components of velocity and total pressure. The experimental results are compared with the predictions from Katsanis and McNally's computer program. The agreement between the two is good for most of the cases. (Author)


The paper is concerned with an experimental study undertaken to measure the density and radial velocity profiles across the entire rotor blade. The measurements were carried out using a miniature 'X'-configuration hot wire probe at various chordwise and radial locations on both surfaces of the blade. The streamwise and radial velocity profiles as well as the corresponding intensity components are interpreted and correlated. The validity of conventional velocity profiles such as the law of the wall for the streamwise profile and the hodograph plot for the cross flow profile are examined. The measured values of boundary-layer gross properties are compared with the predictions based on a momentum-integral technique. (Author)


A rotating three-sensor, hot-wire probe has been used along with rotor blade static pressure measurements to investigate the complex inviscid and viscous effects in the annulus wall flowfield, including the three components of mean velocity, turbulence intensity, and turbulence stress inside the rotor blade passage. It is found that the tip leakage flow originates near quarter-chord, with peak values occurring near mid-chord. The leakage flow, which is in the form of a jet within the blade row, is augmented by the blade rotation and travels further away from the suction surface than that observed in stationary blade rows and cascades. The leakage flow tends to roll up between the mid-passage and the pressure surface near the tip region, the vortex formation does not occur within the passage in this particular case.


A stationary two-sensor hot-wire probe has been used in combination with an ensemble averaging technique to measure the flow in the tip clearance region of a compressor rotor with emphasis on the leakage flow development inside the tip clearance region and at the exit of the rotor. It is found that the presence of interaction of leakage flow, annulus boundary layer, and the scraping vortex is the dominant feature at mid-chord position. The rotation of the blade augments the leakage flow, resulting in the movement of the leakage jet toward the mid-passage. The blade-to-blade distribution of properties is shown to be highly nonuniform, except in the downstream and upstream regions.


To model the impingement cooled mid-chord region of gas turbine inlets, an initial crossflow is present. The present experimental study shows the experimenter's experimental determined flow distributions for jet arrays with ten spanwise rows of holes, which range from uniform to highly nonuniform. The jet flow after impingement is constrained to exit in a single direction along the channel formed by the jet office plate and the impingement plate. The streamwise distributions and crossflow velocities are presented for ratios of the initial crossflow rate to the total jet flow rate ranging from zero to unity. For crossflow to jet velocity ratios greater than a value somewhat less than unity, jet exit discharge coefficients do not remain constant, but decrease significantly, showing a secondary dependence on x/d, where d is the channel height and d is the jet hole diameter.


The turbulence properties in the annulus wall region of an axial flow compressor rotor was measured using a triaxial, hot-wire probe rotating with the rotor. The flow was surveyed across the entire passage at five axial locations (loading of axial chord, 1/4 chord, 1/2 chord, 3/4 chord, and the trailing edge location) and at six radial locations in a low-speed compressor rotor. The data derived include all three components of turbulence intensity and three components of turbulence stress.

A comprehensive interpretation of the data with emphasis on flows related to rotation, leakage flow, annulus wall boundary layer, and blade boundary layer interactions is included. All the components of turbulent intensities and stresses are found to be high in the leakage-flow mixing region. The radial component of intensities and stresses is found to be much higher than the corresponding streamwise components. The turbulent spectra clearly reveal the decay process of the inlet-guide-vane wake within the rotor passage. (Author)


A numerical technique to predict the viscous behavior in the three-dimensional domain of rotating and stationary blade passages is presented. The analysis is based on the generalized momentum and the conservation of momentum equations. An approach is taken to combine the three momentum equations and the continuity equation into two sets of vorticity transport-stream function equations.
These equations are expressed along families of arbitrarily defined orthogonally intersecting surfaces placed within the blade passage. Unlike the stream surfaces, the axial surfaces allow fluid to flow across the blade passage. The numerical code employs a nonorthogonal body fitted coordinate system on each of the intersecting surfaces. The solution process involves the iterative combination of the solutions on the two families of intersecting surfaces for a complete solution. The results of flow in thin blade stationary and rotating polar ducts is presented.


A model has been developed and demonstrated for the direct measurement of aerodynamic damping in a transonic compressor. The method is based on the inverse solution of the structural dynamic equations of motion of the blade-disk system. The equations are solved inversely to determine the forces acting on the system. If the structural dynamic equations are transformed to modal coordinates, the damping can be measured for blade-disk modes, and related to a reduced frequency and interblade phase angle. This method of damping determination was demonstrated using a specially instrumented version of the MIT Transonic Compressor run in the MIT Blowndown Compressor Test Facility. No regions of aerelastic instability were found. In runs at the testing point, the rotor was aerodynamically excited by a controlled two-per-revolution fixed upstream disturbance. The disturbance was sharply terminated midway through the test. Analysis of the data in terms of multiblade modes led to a direct measurement of aerodynamic damping for three interblade phase angles.


A model has been developed and verified for blade-disk-shaft coupling in rotors due to the in-plane rigid body modes of the disk. An analytic model has been developed which couples the in-plane rigid body vibrations of the rotor with the blade bending modes. Bench resonance tests were carried out on the MIT Compressor Rotor, typical of research rotors with flexible blades and a thick rigid disk. When the rotor was carefully tuned, the structural coupling of the blades by the disks was confined to zero and one nodal diameter modes, whose modal frequencies were greater than the blade bending frequency. In the case of the tuned rotor, and in two cases where severe mistuning was intentionally introduced, agreement between the predicted and observed natural frequencies is excellent. The analytic model was then extended to include the effects of constant angular rotation of the disk.


Stahara et al. (1978) have considered the use of an approximation technique which employs two or more nonlinear base solutions determined by the full computational method to predict entire families of related nonlinear solutions. The present investigation provides results for several applications of that method which demonstrate both its accuracy and its utility for engineering applications. Attention is given to the perturbation concept and methods, aspects of coordinate straining, aspects of analytical formulation, and an application to surface propellers. In a discussion of the results, single and multiple parameter perturbations are considered along with a combination of the approximation method with optimization procedures. The results show that it is possible to combine in certain cases large savings in computational cost with improved optimization.


Necessary improvements to a paper on the flow of a dusty gas by Datta and Mishra (1980) are presented. Particular attention is given to the importance of particle phase compressibility and the hyperbolic nature of the particle momentum conservation equation which prohibits downstream (wall) boundary conditions for the solid phase. Fundamental differences between particle and ordinary flow boundary layers are discussed, and the correct conservation equations are written.


An investigation of the unsteady disturbances of a fixed frequency within a radial duct rotating at a set speed is presented. The flow is assumed to be compressible, inviscid, and of a fluid which is a perfect gas. Equations are developed for the steady and the unsteady parts of the flow in cylindrical coordinates. The unsteady disturbances are expressed by Fourier decomposition in angular position, distance into the duct, and in time. It is found that a resonance is possible when the frequency of flow disturbances is twice the shaft rotation frequency, considering only the radial and tangential disturbances and not the radial and circumferential disturbances. The particular point at which the resonance occurs indicates the occurrence is due to the Coriolis force, which is only present in the radial and tangential directions. It is noted that the Coriolis force can only be present in open-ended ducts, such as those found in centrifugal compressors.


The problem of a thin airfoil subject to simple harmonic disturbances in a uniform subsonic free stream is solved by extension of a technique developed earlier for a stationary strip vibrating in a uniform fluid. Explicit expressions are given for the lift and moment, acoustic directivity pattern, and total acoustic power for arbitrary upwash and, in particular, for the 'elementary disturbances': plunge, pitch, and a stationary transverse gust. Numerical results for a simple skewed gust are presented and compared to the high-frequency asymptotic theory of Martinez and Wildnall.


An application of the finite element method is presented in order to study the flow through a two-dimensional channel including the choked and nearly-choked flow conditions. The mathematical procedure provides a combined treatment of potential and Euler equations, where the steady Euler equations are solved through the integration of a pseudo-time system which is equivalent to a relaxa-

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03 AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.
For related information see also 16 Space Transportation and 35 Urban Technology and Transportation.

ORIGINAL PAGE IS OF POOR QUALITY
05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

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

N82-110452*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SELECTED BIBLIOGRAPHY OF NACA-NASA AIRCRAFT ICING PUBLICATIONS
(NASA-TM-81651; E-668) Avail: NTIS HC E15/MF A01 CSCL 01C

A summary of NACA-NASA icing research from 1940 to 1980 is presented. It includes: the main results of the NACA icing program from 1940 to 1950; a selected bibliography of 132 NACA-NASA aircraft icing publications; a technical summary of each document cited in the selected bibliography; and a microfiche copy of each document cited in the selected bibliography T.M.


It is noted that the rising cost of aviation fuel has necessitated the development of a new approach to upper air forecasting for flight planning. It is shown that the spatial resolution of the present weather forecast models used in fully automated computer flight planning is an important accuracy-limiting factor, and it is proposed that man be put back into the system, although not in the way he has been used in the past. A new approach is proposed which uses the application of man-computer interactive display techniques to upper air forecasting to retain the fine scale features of the atmosphere inherent in the present data base in order to provide a more accurate and cost-effective flight plan. It is pointed out that, as a result of NASA research, the hardware required for this approach already exists. C.R.


A theoretical model has been established which is applicable to both propeller and helicopter systems that determines the effect of rime ice accretion on the thrust coefficient, power coefficient, and efficiency as a function of time in a natural icing condition. Theoretical comparisons have been made with experimentally determined decrease in propeller thrust coefficient and efficiency for five natural icing conditions with good agreement. The present analytical model is also applicable to the helicopter case, where the method predicts radial and azimuthal rotor blade ice shapes in addition to torque rise as a function of time in a natural icing condition. (Author)


ICING TUNNEL TESTS OF A COMPOSITE POROUS LEADING EDGE FOR USE WITH A LIQUID ANTI-ICE SYSTEM
David L. Kohiman Sep. 1981 21 p refs
(Grant NAG3-711)
(NASA-CR-164966; KU-FRL-464-3) Avail: NTIS HC A02/MF A01 CSCL 01C

The efficacy of liquid ice protection systems which distribute a glycol-water solution onto leading edge surfaces through a porous skin was demonstrated in tests conducted in the NASA Lewis icing research tunnel using a composite porous leading edge panels. The data obtained were compared with the performance of previously tested stainless steel leading edge with the same geometry. Results show: (1) anti-ice protection of a composite leading edge is possible for all the simulated conditions tested; (2) the glycol flow rates required to achieve anti-ice protection were generally much higher than those required for a stainless steel panel; (3) the low reservoir pressures of the glycol during test runs indicates that more uniform distribution of glycol, and therefore lower glycol flow rates, can probably be achieved by decreasing the porosity of the panel; and (4) significant weight savings can be achieved in fluid ice protection systems with composite porous leading edges. The resistance of composite panels to abrasion and erosion must yet be determined before they can be incorporated in production systems. A.R.H.

N82-33375*# Douglas Aircraft Co., Inc., Long Beach, Calif.

ADVANCED TURBOPROP TESTBED SYSTEM STUDY Final Report
I. M. Goldsmith Jul. 1982 255 p refs
(Con't act NAS3-52347)
(NASA-CR-167895; NAS 1.26:167895; ACEE-22-FR-1699A) Avail: NTIS HC A12/MF A01 CSCL 01C

The proof of concept, feasibility, and verification of the advanced propfan and of the integrated advanced propfan aircraft are established. The use of existing hardware is compatible with having a successfully expedited testbed ready for flight. A propfan testbed aircraft is definitely feasible and necessary for verification of prop fan/prop fan aircraft integrity. The Allison T701 is most suitable as a propulsion and modification of existing engine and propeller controls are adequate for the testbed. The airframer is considered the logical overall systems integrator of the testbed program. S.L.


The progress toward development of a computer model suitable for predicting icing behavior on airfoils over a wide range of environmental conditions and airfoils shapes is reported. The LEWICE program was formulated to solve a set of equations which describe the physical processes which occur during accretion of ice on an airfoil, including heat transfer in a time-dependent mode, with the restriction that the flow must be describable by a two-dimensional flow code. Input data comprises the cloud liquid water content, mean droplet diameter, ambient air temperature, air velocity, and relative humidity. A potential flowfield around the airfoil is calculated, along with the droplet trajectories within the flowfield, followed by local values of water droplet collection efficiency at the impact points. Both glaze and rime ice conditions are reproduced, and comparisons with test results on icing of circular cylinders showed good agreement with the physical situation. M.S.K.

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AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

For related information see also 19 Spacecraft Instrumentation and 35 Instrumentation and Photography.

Aircraft gas turbine performance and efficiency are related to airfoil tip clearance. The possibility has been considered to obtain optimum performance and efficiency by reducing clearance to a safe minimum with the aid of a closed-loop tip clearance control system, which utilizes a tip clearance sensor. The use of optical sensing methods appears to represent a potential solution to the tip clearance measurement problem. Principles of sensor operation are discussed along with dimensional considerations and diffraction limitations. A description is presented of the study of the feasibility of a certain sensor, taking into account the test rig system, the optical components, and the mounting tube. Attention is also given to the operation of the feasibility-study sensor, performance estimations, the optical fiber bundle, light beam refraction, and aspects of aircraft engine implementation.
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.

N82-13143* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EFFECT OF FUEL-AIR-RATIO NONUNIFORMITY ON EMISSIONS OF NITROGEN OXIDES Valerie J. Lyons Nov. 1981 14 p refs (NASA-TP-1798; E-648) Avail: NTIS HC A02/MF A01 CSCL 21E

The inlet fuel-air ratio nonuniformity is studied to determine how nitrogen oxide (NOx) emissions are affected. An increase in NOx emissions with increased fuel-air ratio nonuniformity for average equivalence ratios less than 0.7 and a decrease in NOx emissions for average equivalence ratios near stoichiometric is predicted. The degree of uniformity of fuel-air ratio profiles that is necessary to achieve NOx emissions goals for actual engines that use lean, premixed, prereacted combustion systems is determined.

S.L.


A real time propulsion system model technique suitable for use in man-in-the-loop simulator studies was developed. This technique provides the system accuracy, stability, and transient response required for integrated aircraft and propulsion control system studies. A Pegasus/Harrier propulsion system was selected as a baseline for developing mathematical modeling and simulation techniques for VSTOL. Initially, static and dynamic propulsion system characteristics were modeled in detail to form a nonlinear aerothermodynamic digital computer simulation of a Pegasus engine. From this high fidelity simulation, a real time propulsion model was formulated by applying a piece-wise linear state variable methodology. A hydromechanical and water injection control system was also simulated. The real time dynamic model includes the detail and fidelity required for the evaluation of control system parameters and steady and unsteady component time histories over a limited flight envelope. The model was programmed for interfacing with a Harrier aircraft simulation. Typical propulsion system simulation results are presented.

M.D.K.


A broad overview of the scope of research presently being supported by NASA in aircraft propulsion is presented with emphasis on Lewis Research Center activities related to civil air transports, CTOL and VSTOL systems. Aircraft systems work is performed to identify the requirements for the propulsion system that enhance the mission capabilities of the aircraft. This important source of innovation and creativity drives the direction of propulsion research. In a companion effort, component research of a generic nature is performed to provide a better basis for design and provides an evolutionary process for technological growth that increases the capabilities of all types of aircraft. Both are important.

A.R.H.

N82-14006* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. GAS TURBINE CERAMIC-COATED-POROUS METAL CORE Albert F. Kasak (AVRACOM Research and Technology Labs., Cleveland), Curt H. Liebert, Robert F. Handschuh, and Lawrence P. Ludwig Dec. 1981 14 p refs Sponsored in part by U.S. Army Aviation Research and Development Command, St. Louis (NASA-TP-1942; AVRADCOM-TR-81-C7; E-732) Avail: NTIS HC A02/MF A01 CSCL 21E

Analysis and flow experiments on a ceramic-coated-porous-metal vane concept indicated the feasibility, from a heat transfer standpoint, of operating 'at a high-temperature (2500°F) gas turbine cascade facility. The heat transfer and pressure drop calculations provided a basis for selecting the ceramic thickness (0.008 in.) which was found to be the dominant factor in the overall heat transfer coefficient. Also an approximate analysis of the heat transfer in the vane trailing-edge revealed that with trailing-edge ejection the ceramic thickness could be reduced to (0.01 in.) in this portion of the vane.

B.W.


A method for automating compressor blade design using numerical optimization, and applied to the design of a controlled diffusion stator blade row is presented. A general purpose optimization procedure is employed, based on conjugate directions for locally unconstrained problems and on feasible directions for locally constrained problems. Coupled to the optimizer is an analysis package consisting of three analysis programs which calculates blade geometry, inviscid flow, and blade surface boundary layers. The optimizing concepts and selection of design objective and constraints are described. The procedure for automating the design of a two dimensional blade section is discussed, and design results are presented.

E.A.K.


A code for computing the aerodynamic design of a multistage axial-flow compressor and, if desired, the associated blade geometry input for internal flow analysis codes is presented. Compressible flow, which is assumed to be steady and axisymmetric, is the basis for a two-dimensional solution in the meridional plane with viscous effects modeled by pressure loss coefficients and boundary layer blockage. The radial equation of motion and the continuity equation are solved with the streamline curvature method on calculation stations outside the blade rows. The annulus profile, mass flow, pressure ratio, and rotative speed are input. A number of other input parameters specify and control the blade row aerodynamics and geometry. In particular, blade element centerlines and thicknesses can be specified with fourth degree polynomials for two segments. The output includes a detailed aerodynamic solution and, if desired, blade coordinates that can be used for internal flow analysis codes. Author


16 ORIGINAL PAGE IS OF POOR QUALITY
The combustion process in a reverse-flow combustor suitable for a small gas turbine engine was investigated to evaluate the effect of fuel injector type on performance and emissions. Fuel injector configurations using pressure-atomizing, split-flow, air blast, and air-assist techniques were compared and evaluated on the basis of performance obtained in a full-scale experimental combustor operated at inlet conditions corresponding to takeoff, cruise, low power, and idle and typical of an 18:1-pressure-ratio turbine engine. Major differences in combustor performance and emissions characteristics were experienced with each injector type even though the aerodynamic configuration was common to most combustor models. Performance characteristics obtained with the various fuel injector types could not have been predicted from bench-test injector spray characteristics. The effect of the number of operating fuel injectors on performance and emissions is also presented.

Author:

EFFECTS OF FAN INLET TEMPERATURE DISTURBANCES ON THE STABILITY OF A TURBOFAN ENGINE

The effects of steady-state and time-dependent fan inlet total temperature disturbances on the stability of a TF30-P-1 turbofan engine were determined. Disturbances were induced by a gaseous-hydrogen-fueled burner system installed upstream of the fan inlet. Data were obtained at a fan inlet Reynolds number index of 0.50 and at a low-pressure-rotor corrected speed of 80 percent of military speed. All tests were conducted with a 90 deg extent of the fan inlet circumference exposed to above-average temperatures. T.M.
ANALYTICAL INVESTIGATION OF NONRECOVERABLE STALL

A lumped parameter model of the TF34 engine is formulated to study nonreversible stall. Features of the model include forward and reverse flow, radial flow in the fan, and variable corrected speed. The purpose of the study is to point out those parameters to which recoverability is highly sensitive but are not well known. Experimental research may then be directed toward identification of the parameters in that category. Compressor performance in the positive flow region and radial flow in the fan are shown to be important but unknown parameters determining recoverability. Other parameters such as compressor performance during reverse flow and in-stall efficiency have relatively small impact on recoverability.

THÉ ROLE OF MODERN CONTROL THEORY IN THE DESIGN OF CONTROLS FOR AIRCRAFT TURBINE ENGINES

Accomplishments in applying Modern Control Theory to the design of controls for advanced aircraft turbine engines were reviewed. The results of successful research programs are discussed. Ongoing programs as well as planned or recommended future thrusts are also discussed.

STRUCTURAL DYNAMICS OF SHROUDED, HOLLOW FAN BLADES WITH COMPOSITE IN-LAYS

Structural and dynamic analyses are presented for a shrouded, hollow titanium fan blade designed for future use in aircraft turbine engines. The blade was modeled and analyzed using the composite blade structural analysis computer program (COBSTRAN); an integrated program consisting of mesh generators, composite mechanics codes, NASTRAN, and pre- and post-processors. Vibration and impact analyses are presented. The vibration analysis was conducted with COBSTRAN. Results show the effect of field on twist, and blade camber. Bird impact analysis was performed with the multi-mode blade impact computer program. This program uses the geometric model and modal analysis from the COBSTRAN vibration analysis to determine the gross impact response of the fan blades to bird strikes. The structural performance of this blade is also compared to a blade of similar design but with composite in-lays on the outer surface. Results show that the composite in-lays can be selected (designed) to substantially modify the mechanical performance of the shrouded, hollow fan blade.

STGTK: A COMPUTER CODE FOR PREDICTING MULTISTAGE AXIAL FLOW COMPRESSOR PERFORMANCE BY A MEANLINE STAGE STACKING METHOD

A FORTRAN computer code is presented for off-design performance prediction of axial-flow compressors. Stage and compressor performance is obtained by a stage-stacking method that uses representative velocity diagrams at rotor inlet and outlet and momentum radii. The code has options for calculation of non-dimensional stage characteristics; (2) adjustment of stage characteristics for off-design speed and blade setting angle; (3) adjustment of rotor deviation angle for off-design conditions; and (4) SI or U.S. customary units. Correlations from experimental data are used to model real flow conditions. Calculations are compared with experimental data.

FUTURE PROPULSION OPPORTUNITIES FOR COMMUTER AIRPLANES

Commuter airplane propulsion opportunities are summarized. Consideration is given to advanced technology conventional turboprop engines, advanced propellers, and several unconventional alternatives: regenerative turboprops, rotaries, and diesels. Advanced versions of conventional turboprops (including propellers) offer 15-20 percent savings in fuel and 10-15 percent in DOC compared to the new crop of 1500-2000 SHP engines currently in development. Unconventional engines could boost fuel savings to 30-40 percent. The conclusion is that several important opportunities exist and, therefore, powerplant technology need not plateau.

REAL TIME PROPULSION SYSTEM SIMULATION
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Emissions of carbon dioxide, total oxides of nitrogen, unburned hydrocarbons, and carbon monoxide from an F100 afterburning two spool turbofan engine at simulated flight conditions are reported. Tests were run at Mach 0.8 at altitudes of 10.97 and 13.71 km (36,000 and 45,000 ft), and at Mach 1.2 at 13.71 km (45,000 ft). Emission measurements were made from intermediate power (nonafterburning) through maximum afterburning, using a single point gas sample probe traversed across the horizontal diameter of the exhaust nozzle. The data show that emissions vary with flight speed, altitude, power level, and radial position across the nozzle. Carbon monoxide emissions were low for intermediate and partial afterburning power. Unburned hydrocarbons were near zero for most of the simulated flight conditions. At maximum afterburning, there were regions of NOx deficiency in regions of high CO. The results suggest that the low NOx levels observed in the tests are a result of interaction with high CO in the thermal converter. CO2 emissions were proportional to local fuel air ratio for all test conditions. T.M.

EXHAUST EMISSIONS SURVEY OF A TURBOFAN ENGINE FOR FLAME HOLDER SWIRL TYPE AUGMENTORS AT SIMULATED ALTITUDE FLIGHT CONDITIONS Lewis Research Center, Cleveland, Ohio

Emissions of carbon dioxide, total oxides of nitrogen, unburned hydrocarbons, and carbon monoxide from an F100 afterburning two spool turbofan engine at simulated flight conditions are reviewed. The following topics are discussed on several advanced intermittent combustion engines emphasizing lightweight diesels and rotary stratified charge engines. The current state-of-the-art is evaluated for lightweight, aircraft suitable versions of each engine. This information is used to project the engine characteristics that can be expected on near-term and long-term time horizons. The key enabling technology requirements are identified for each engine on the long-term time horizon. E.A.K.

THRUST REVERSER FOR A LONG DUCT FAN ENGINE Patent

Author

REAL TIME PRESSURE SIGNAL SYSTEM FOR A ROTARY ENGINE Patent Application

Author

DEVELOPMENT POTENTIAL OF INTERMITTENT COMBUSTION (I.C.) AIRCRAFT ENGINES FOR COMMUTER TRANSPORT APPLICATIONS

Author

OCBEE UNDER-THE-WING ENGINE ACOUSTIC DATA

Author

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simulate an installation on a short-haul transport aircraft. The engine acoustic configuration was varied to give 14 test configurations. All of the acoustic test results from the OTW program are Lewis presented as 1/3-octave-band sound pressure level (SPL) tabulations for all of the test points and some narrow-band spectra and 1/3-octave-band data plots for selected conditions. T.M.

N82-29324*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
GCESS OVER-THE-WING ENGINE ACOUSTIC DATA
Henry E Bloomer and Irvin J. Loeffler May 1982 28 p, refs (NASA-TM-82708; E-990; NAS 1.15 82708) Avail: NTIS HC A03/MF A01 CSCL 21E
The over the wing (OTW) quiet, clean, short haul experimental engine (GCSEE) was tested at the NASA Lewis Engine Noise Test Facility. A boiler plate (nonflight weight), high throat Mach number, acoustically treated inlet and a shaped OTW exhaust nozzle with variable position side doors were used in the tests along with wing and flap segments to simulate an installation on a short haul transport aircraft. All of the acoustic test data from 10 configurations are documented in tabular form. Some selected narrow band and 1/3 octave band plots of sound pressure level are presented. Author

N82-31329*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
VENTURI NOZZLE EFFECTS ON FUEL DROP SIZE AND NITROGEN OXIDE EMISSIONS
Susan M Johnson Aug. 1982 17 p, refs (NASA-TP-2028; E-1029; NAS 1.60:2028) Avail: NTIS HC A02/MF A01 CSCL 21E
The effect of a venturi nozzle on the Sauter mean diameter of a water spray produced by a simplex pressure atomizing injector in a swirling airflow was determined. A Malvern particle and droplet size distribution analyzer, Type S.T. 1800, was used to measure D sub 32 of the water sprays. The water spray was studied at ambient temperature (293 K) and atmospheric pressure. The venturi reduced D sub 32 by an average of 30 percent when installed with a simplex injector and air swirler. The venturi improved atomization of the injector spray by increasing relative air velocity. The small drop size enhanced vaporization and therefore decreased oxides of nitrogen in a combustor. The decrease in drop size provided by the addition of a venturi explains the results obtained in a previous small scale research combustor wherein NOx emission indices decreased as a result of this hardware modification. S.L.

N82-32365*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ACTIVE CLEARANCE CONTROL SYSTEM FOR A TURBOMACHINE Patent
An axial compressor is provided with a cooling air manifold surrounding a portion of the shroud, and means for bleeding air from the compressor to the manifold for selectively flowing it in a modulating manner axially along the outer side of the stator/shroud to cool and shrink it during steady-state operating conditions so as to obtain minimum shroud/rotor clearance conditions. Provision is also made to selectively divert the flow of cooling air from the manifold during transient periods of operation so as to alter the thermal growth or shrink rate of the stator/shroud and result in adequate clearance with the compressor rotor. Official Gazette of the U.S. Patent and Trademark Office

N82-33388# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. ROTO-TIP CLEARANCE EFFECTS ON OVERALL AND BLADE-ELEMENT PERFORMANCE OF AXIAL-FLOW TRANSONIC FAN STAGE
Royce D. Moore Sep. 1982 87 p, refs (NASA-TP-2049; E-559; NAS 1.60:2049) Avail: NTIS HC A05/MF A01 CSCL 21E
The effects of tip clearance on the overall and blade-element performance of an axial flow transonic fan stage are documented. The 50-centimeter-diameter fan was tested at four tip clearances (nonrotating) from 0.061 to 0.178 centimeter. The calculated radial growth of the blades was 0.040 centimeter at design conditions. The decrease in overall stage performance with increasing clearance is attributed to the loss in rotor performance. For the rotor the effects of clearance on performance parameters extended to about 70 percent of blade span from the tip. The stage still margin based on an assumed operating line decreased from 15.3 to 0 percent as the clearance increased from 0.061 to 0.178 centimeter. Author

Analysis was made of the heat transfer and pressure drop through turbine vanes made of a sintered, porous metal coated with a thin layer of ceramic and convection cooled by spanwise flow of cooling air. The analysis was made for gas conditions of approximately 10 and 40 atm and 1044 K and with turbine vanes made of felt-type porous metals with relative densities from 0.2 and 0.6 and ceramic coating thicknesses of 0.02% to 0.254 mm. (Author)

The thrust, specific fuel consumption, and relative merits of the tandem fan and the dual reverse flow front fan propulsion systems for a supersonic V/STOL aircraft are discussed. Consideration is given to: fan pressure ratio, fan air burning, and variable core supercharging. The special propulsion system components required are described, namely: the reflecting front inlet/nozzle, the reversed flow subsonic inlet, the reverse pitch fan, the variable core supercharger and the low pressure forward burner. The potential benefits for these unconventional systems are indicated. (Author)

A Pegasus-Harrier propulsion system is selected as a baseline for developing mathematical modeling and simulation techniques for VSTOL. Initially, static and dynamic propulsion system characteristics are modeled in detail to form a nonlinear aerothermodynamic digital computer simulation of a Pegasus engine. From this high fidelity simulation, a real-time propulsion model is formulated by applying a piecewise linear state variable methodology. A hydro...
mechanical and water injection control system is also simulated. It is noted that the real-time dynamic model includes the detail and flexibility required for evaluating control parameters and propulsion component limits over a limited flight envelope.

A82-19337 * # Aerelastic characteristics of a cascade of mistuned blades in subsonic and supersonic flows. R. E. Kleib (NASA, Lewis Research Center, Structure: Dynamics Section, Cleveland, OH) and E. Reif (NASA, Lewis Research Center, Cleveland; Toledo, University, Toledo, OH), American Society of Mechanical Engineers, Design Engineering Technical Conference, Hartford, CT, Sept. 20-23, 1981, Paper 81-DET-122, 12 p. 19 refs. Members, $2.00; nonmembers, $4.00.

An investigation of the effects of mistuning on flutter and forced response of a cascade in subsonic and supersonic flows is presented. The aerodynamic and structural coupling between the bending and torsional modes and the aerodynamic coupling between the blades are included. The mistuning always has a beneficial effect on flutter. Additionally, the results indicate that frequency mistuning may have either a beneficial or an adverse effect on forced response, depending on the engine order of the excitation and Mach number.

A82-20291 * # Dilution jet behavior in the turn section of a reverse flow combustor. S. M. Riddlebaugh (NASA, Lewis Research Center, Cleveland, OH), L. Greber (Case Western Reserve University, Cleveland, OH), and A. Lipshitz, American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, Paper 82-0192, 13 p. Measurements of the temperature field produced by a single jet and a row of dilution jets issued into a reverse flow combustor are presented. The temperature measurements are presented in the form of consecutive normalized temperature profiles, and jet trajectories. Single jet trajectories were swept toward the inner wall of the turn, whether injection was from the inner or outer wall. This behavior is explained by the radially inward velocity component necessary to support rotational flow through the turn. Comparison between experimental results and model calculations showed poor agreement due to the model's not including the radial velocity component. A widely spaced row of jets produced trajectories similar to single jets at similar test conditions, but as spacing ratio was reduced, penetration was reduced to the point where the dilution jet flow attached to the wall.


The utility of advanced structural analysis and life prediction techniques was evaluated for the life assessment of a commercial air-cooled turbine blade with a history of tip cracking. Three-dimensional, nonlinear finite element structural analyses were performed for the blade geometry. The computed strain-temperature history of the critical location was imposed on a uniaxial strain controlled test specimen to evaluate the validity of the structural analysis method. Experimental results indicated higher peak stresses and greater stress relaxation than the analytical predictions. Life predictions using the Strainrange Partitioning and Frequency Modified approaches predicted 1200 to 4420 cycles and 2700 cycles to crack initiation, respectively, compared to an observed life of 3000 cycles.


A study of the effects of secondary air addition on the stability and emissions of a gas turbine combustor has been performed. Tests were conducted with two types of flameholders and varying amounts of dilution air addition. Results indicate that NOx decreases slightly with increasing dilution air injection, whereas CO is independent of the amount of dilution air and is related to the gas temperature near the walls. The axial location of the dilution air addition has no effect on the performance or stability. Results also indicate that the amount of secondary air entrained by the flameholder recirculation zone is dependent on the amount of dilution air and flameholder geometry.


(Previously announced in STAR as N82-22919)

A82-34089 * # NASA Broad Specification Fuels Combustion Technology program - Pratt and Whitney Aircraft Phase I results and status. P. R. Lohmann (United Technologies Corp., Commercial Products Div., East Hartford, CT), and J. S. Fear (NASA, Lewis Research Center, Aircraft Propulsion, Fuel Div., Cleveland, OH), AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA Paper 82-1088, 12 p. 11 refs. In connection with increases in the cost of fuels and the reduced availability of high quality petroleum crude, a modification of Specification Fuels Combustion Technology program was formulated by NASA. A program is being conducted to develop the technology required to utilize fuels and flameholders in air-cooled gas turbine engine combustors. The first phase of this program consisted of the experimental evaluation of three different combustor concepts to determine their potential for meeting several specific performance and emissions goals, when operated on broadened property fuels. The three concepts were: a single annular combustor; a double annular combustor; and a short single annular combustor with variable geometry. All of these concepts were sized for the General Electric CF6-80 engine. A total of 24 different configurations of these concepts were evaluated in a high pressure test facility, using JP-10 test fuels having hydrogen contents between 11.8 and 14.1%. Fuel effects on combustor performance, durability and emissions, and combustor design features to offset these effects were demonstrated.


An experimental program to investigate hardware configurations which attempt to minimize carbon formation and soot production without sacrificing performance
in small gas turbine combustors has been conducted at the United Technologies Research Center. Four fuel injectors, embodying either airlift atomization, pressure atomization, or fuel vaporization techniques, were combined with nozzle air swirlers and injector sheeting, and evaluated at test conditions which included and extended beyond standard small gas turbine combustor operation. Extensive testing was accomplished with configurations embodying either a spill return or a T-vaporizer injector. Minimal carbon deposits were observed on the spill return nozzle for tests using either Jet A or EPBS test fuel A more extensive film of soft West Germany) and D. S. Dulikravich and extended beyond standard small gas turbine combustor operation. Extensive air swifter and injector sheaths, and evaluated at test conditions which included emissions levels depended on the combustor fluid mechanics (especially the mixing rates near the injector), the atomization quality of the injector and the fuel hydrogen content.


This paper describes a systematical computational procedure to find configuration changes necessary to modify the resulting flow past turbomachinery cascades, channels and nozzles, to be shock-free at prescribed transonic operating conditions. The method is based on a finite area transonic analysis technique and the fictitious gas approach. This design scheme has two major areas of application. First, it can be used for design of supercavitating cascades, with applications mainly in compressor blade design. Second, it provides subsonic inlet shapes including sonic surfaces with suitable initial data for the design of supercavitated (accelerated) exits, like nozzles and turbine cascade shapes. This last, accurate and economical method, with a proven performance for applications to three-dimensional flows is illustrated by some design examples. (Author)


(Preliminary announced in STAR as N82-14094)


(Preliminary announced in STAR as N82-13146)


(Preliminary announced in STAR as N82-13114)


(Preliminary announced in STAR as N82-22066)


The ability of the helicopter to function efficiently at zero flight speed is counterbalanced by a limitation to rather low forward flight speeds. An ability to fly efficiently at high speeds would provide very significant improvements in rotorcraft productivity and safety. The achievement of such improvements would require the development of a suitable integrated power plant for both the vertical and horizontal flight modes. The engine should be a shaft output engine in the vertical flight mode, and the propulsor can be a fan or propeller. A description is presented of a program concerned with the demonstration of a convertible turboshaft/turbofan engine. The program is nominally directed toward the demonstration of a propulsion system for an X-wing aircraft. However, the principles being investigated are applicable to any convertible turboshaft/turbofan engine application. At the current early stage of the program, no barrier problems have become apparent, and interesting possibilities for high speed rotorcraft flight are envisaged.

G.R.

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The effects of coating TBC on a CF6-50 stage 2 high-pressure turbine blade were analyzed with respect to changes in the mean bulk temperature, cooling air requirements, and high-cycle fatigue. Localized spallation was found to have a deleterious effect on low-cycle fatigue life. Few blade design concepts were developed to take optimum advantage of TBCs. Process and material development work and rig evaluations were undertaken which identified the most promising combination as ZrO2 containing W/v/o Y2O3 applied by air plasma spray onto a N22Cr-10Al-1Y bond layer. The bond layer was applied by a low-pressure, high-velocity plasma spray process onto the base alloy. During the initial startup cycles the blades experienced localized leading edge spallation caused by foreign objects. T.M.

The core compressor exit stage study program develops rear stage blading designs that have lower losses in their endwall boundary layer regions. The test data reported here are for the best stage configuration consisting of Rotor-B running with Stator-B, as described. The technical approach of this efficiency improvement program utilizes a low speed research compressor. Tests were conducted in two ways: (1) to use four identical stages of blading to obtain test data in a true multistage environment and (2) to use a single stage of blading to compare with the multistage test results. The effects of increased rotor tip clearances and circumferential groove casing treatment are evaluated.

E.A.K.

The advanced concept was compared to a baseline parameter synthesis technique. The advanced concept was shown to be a viable concept for detecting, isolating, and accommodating sensor failures for the gas turbine applications. M.G.

E.A.K.
ERBS FUEL ADDENDUM: POLLUTION REDUCTION TECHNOLOGY PROGRAM SMALL JET AIRCRAFT ENGINES, PHASE 3 Final Report
T. W., Bruce, F. G. Davis, T. E. Kuhn, and H. C. Mongia [1982] 47 p refs (Contract NAS3-20819)
(NASA-CR-165387; AlResearch-21-3619) Avail: NTIS HC A03/MF A01 CSCL 21E
A Model TF731-2 engine with a low emission, variable geometry combustion system was tested to compare the effects of operating the engine on Commercial Jet-A turbine fuel and experiment reference broad specification (ERBS) fuel. Low power emission levels were essentially identical while the high power NOx emission indexes were approximately 15% lower with the ERBS fuel. The exhaust smoke number was approximately 50% higher with ERBS at the takeoff thrust setting; however, both values were still below the EPA limit of 40 for the Model TF731 engine. Primary zone liner wall temperature ran an average of 25 K higher with ERBS fuel than with Jet-A. The possible adoption of broadened properties fuels for gas turbine applications is suggested. E.A.K.

N82-16080$^\#$ United Technologies Research Center, East Hartford, Conn.
RESEARCH AND DEVELOPMENT PROGRAM FOR NONLINEAR STRUCTURAL MODELING WITH ADVANCED TEMPERATURE-DEPENDENT CONSTITUTIVE RELATIONSHIP: Phase 5 Final Report
Kevin P. Walker; 25 Nov. 1981 187 p refs (Contract NAS3-22055)
Results of a 20-month research and development program for nonlinear structural modeling with advanced temperature constitutive relationships are reported. The program included: (1) the evaluation of a number of viscoplastic constitutive models in the published literature; (2) incorporation of three of the most appropriate constitutive models into the MARC nonlinear finite element program; (3) calibration of the three constitutive models against experimental data using Hastelloy-X material; and (4) application of the most appropriate constitutive model to a three dimensional finite element analysis of a cylindrical combustor liner louver test specimen to establish the capability of the viscoplastic model to predict component structural response. M.D.K.

N82-16081$^\#$ Pratt and Whitney Aircraft Group, East Hartford, Conn.
STUDY OF CONTROLLED DIFFUSION STATOR BLADING, 1. AERODYNAMIC AND MECHANICAL DESIGN REPORT
E. Canale, U. C. Chisholm, D. Lee, and D. A. Spear; Jan. 1981 97 p refs (Contract NAS3-22008)
(NASA-CR-165500; PWA-5698-28) Avail: NTIS HC A05/MF A01 CSCL 21E
Pratt & Whitney Aircraft is conducting a test program for NASA in order to demonstrate that a controlled-diffusion stator provides low losses at high loadings and Mach numbers. The technology has shown great promise in wind tunnel tests. Details of the design of the controlled diffusion stator vanes and the multiple-circular-arc rotor blades are presented. The stage, including stator and rotor, was designed to be suitable for the first-stage of an advanced multistage, high-pressure compressor. Author

CF6 JET ENGINE PERFORMANCE IMPROVEMENT: HIGH PRESSURE TURBINE ROUNDNESS
W. D. Howard and W. A. Fasching; Jan. 1982 136 p refs (Contract NAS3-20829)
(NASA-CR-165555; RB2AE1115) Avail: NTIS HC A05/MF A01 CSCL 21E
An improved high pressure turbine stator reducing fuel consumption in current CF6-50 turbofan engines was developed. The feasibility of the roundness and clearance response improvements was demonstrated. Application of these improvements will result in a cruise SFC reduction of 0.25 percent for new engines. For high temperature engines, the improved roundness and response characteristics results in an 0.5 percent reduction in cruise SFC. A basic life capability of the improved HP turbine stator in over 800 simulated flight cycles without any sign of significant distress is shown. E.A.K.

N82-18221$^\#$ Garrett Turbine Engine Co., Phoenix, Ariz.
COOLED VARIABLE-AREA RADIAL TURBINE TECHNOLOGY PROGRAM Final Report
G. D. Large and L. J. Meyer; Jan. 1982 303 p refs (Contract NAS3-22004)
(NASA-CR-165408) Avail: NTIS HC A14/MF A01 CSCL 21E
The objective of this study was a conceptual evaluation and design analyses of a cooled variable-area radial turbine capable of maintaining nearly constant high efficiency when operated at a constant speed and pressure ratio over a range of flows corresponding to 50-100 percent maximum engine power. The results showed that a 1589K (2400 F) turbine was feasible that would satisfy a 4000-hour duty cycle life goal. The final design feasibility is based on 1986 material technology goals. A peak aerodynamic stage total efficiency of 0.88 was predicted at 100 percent power. Two candidate stators were identified: an articulated trailing-edge and a locally movable sidewall. Both concepts must be experimentally evaluated to determine the optimum configuration. A follow-on test program is proposed for this evaluation. Author

N82-21193$^\#$ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
COLD-AIR PERFORMANCE OF A 74.21-cm-TIP-DIAMETER AXIAL FLOW POWER TURBINE WITH VARIABLE-AREA STATOR DESIGNED FOR A 75-KW AUTOMOTIVE GAS TURBINE ENGINE Final Report
Kerry L. McLain, Milton G. Kolskey, and Robert Y. Wong; Feb. 1982 33 p refs (Contract DE-A101-77CS-51040)
(NASA-TM-82644; E-889; NAS 1.15:82644; DOE/NASA/51040-20) Avail: NTIS HC A03/MF A01 CSCL 21E
An experimental evaluation of the aerodynamic performance of the axial flow, variable area stator power turbine stage for the Department of Energy supported automotive gas turbine engine was conducted in cold air. The interstage transition duct, the variable area stator, the rotor, and the exit diffuser were included in the evaluation of the turbine stage. The measured total blading efficiency was 0.086 less than the design value of 0.85. Large radial gradients in flow conditions were found at the exit of the interstage duct that adversely affected power turbine performance. Although power turbine efficiency was less than design, the turbine operating line corresponding to the steady state road load power curve was within 0.02 of the maximum available stage efficiency at any given speed. Author

N82-21196$^\#$ Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
ENERGY EFFICIENT ENGINE SHROUDED, HOLLOW FAN BLADE TECHNOLOGY REPORT
C. J. Michael; Dec. 1981 81 p refs (Contract NAS3-20646)
The Shrouded, Hollow Fan Blade Technology program was structured to support the design, fabrication, and subsequent evaluation of advanced hollow and shroudless blades for the Energy Efficient Engine fan component. Rockwell International was initially selected to produce hollow airfoil specimens employing the superplastic forming/diffusion bonding (SPF/DB) fabrication technique. Rockwell demonstrated that a titanium hollow structure could be fabricated utilizing SPF/DB manufacturing methods. However, some problems such as sharp internal cavity radii and unsatisfactory secondary bonding of the edge and root details prevented production of the required quantity of fatigue test specimens. Subsequently, TRW was selected to (1) produce hollow airfoil test specimens utilizing a laminate-core/ hot isostatic press/diffusion bond approach, and (2) manufacture full-size hollow prototype fan blades utilizing the technology that evolved from the specimen fabrication effort. TRW established elements of blade design and defined laminate-core/hot isostatic
press/diffusion bonding fabrication techniques to produce test specimens. This fabrication technology was utilized to produce full size hollow fan blades in which the HiPed parts were cambered/twisted/isothermally forged, finished machined, and delivered to Pratt & Whitney Aircraft and NASA for further evaluation.

Author


CFS JET ENGINE DIAGNOSTICS PROGRAM: HIGH PRESSURE COMPRESSOR CLEARANCE INVESTIGATION

M. A. Redomski Jctn. 1982 48 p ref

(Contract NAS3-20631)

(NASA-CR-165580; NAS 1:26:165580; R82AE1879) Avail: NTIS HC A03/MF A01 CSCL 21E

The effects of high pressure compressor clearance changes on engine performance were experimentally determined on a CF6 core engine. The results indicate that a one percent reduction in normalized average clearance, expressed as a fraction of airfoil length, improves compressor efficiency by one percent. Compressor clearances are reduced by the application of rotor bore cooling, insulation of the stator casing, and use of a low coefficient of expansion material in the stator stages. This improvement amounts to a reduction of normalized average clearance of 0.78 percent relative to CF6-60 compressor, which is equivalent to an improvement in compressor efficiency of 0.78 percent. J.M.S.


George L. Huggins and David R. Ellis Sep. 1981 133 p refs

(Contract NAS3-22221)

(NASA-CR-165564; NAS 1:26:165564; Cessna-AD-217) Avail: NTIS HC A07/MF A01 CSCL 21E

The NASA Advanced Aviation Comparative Engine/Airframe Integration Study is initiated to help determine which of four promising concepts for new general aviation engines for the 1990's should be considered for further research funding. The engine concepts included rotary, diesel, spark ignition, and turboprop powerplants: a conventional state-of-the-art piston engine was used as a baseline for the comparison. Computer simulations of the performance of single and twin engine pressurized aircraft designs were used to determine how the various characteristics of each engine interacted in the overall process. Comparisons were made of how each engine performed relative to the others when integrated into an airframe and required to fly a transportation mission.

Author

N82-22284* Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

ENERGY EFFICIENT ENGINE EXHAUST MIXER MODEL TECHNOLOGY


(Contract NAS3-22220)


An exhaust mixer test program was conducted to define the technology required for the Energy Efficient Engine Program. The model configurations of 1/10 scale were tested in two phases. A parametric study of mixer design options, the impact of residual low pressure turbine swirl, and integration of the mixer with the structural pylon of the engine were investigated. The improvement of the mixer itself was also studied. Nozzle performance characteristics were obtained along with exit profiles and oil smear photographs. The sensitivity of nozzle performance to tailpipe length, lobe number, mixer penetration, and mixer modifications like scalloping and cutbacks were established. Residual turbine swirl was found detrimental to exhaust system performance and the low pressure turbine system for Energy Efficient Engine was designed so that no swirl would enter the mixer. The impact of mixer/plug gap was also established, along with importance of scalloping, cutbacks, hoods, and plug angles on high penetration mixers.

M.D.K.

N82-22285* Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

ADVANCED LOW-EMISSIONS CATALYTIC-COMBUSTOR PROGRAM, PHASE 1 Final Report


(Contract NAS3-20821)


Six catalytic combustor concepts were defined, analyzed, and evaluated. Major design considerations included low emissions, performance, safety, durability, installations, operations and development. On the basis of these considerations the two most promising concepts were selected. Refined analysis and preliminary design work was conducted on these two concepts. The selected concepts were required to fit within the combustor chamber dimensions of the reference engine. This is achieved by using a dump diffuser discharging into a plenum chamber between the compressor discharge and the turbine inlet, with the combustors overlaying the diffuser and the rear of the compressor. To enhance maintainability, the outer combustor case for each concept is designed to translate forward for accessibility to the catalytic reactor, liners and high pressure turbine area. The catalytic reactor is self-contained with air-cooled canning on a stainless mounting. Both selected concepts employed integrated engine-starting approaches to raise the catalytic reactor up to operating conditions. Advanced liner schemes are used to minimize required cooling air. The two selected concepts respectively employ fuel-rich initial thermal reaction followed by regeneratively and subsequently fuel lean catalytic reaction of carbon monoxide, and, fuel lean thermal reaction of some fuel in a continuously operating pilot combustor with fuel lean catalytic reaction of remaining fuel in a radially-staged main combustor.

Author

N82-22287* United Technologies Research Center, East Hartford, Conn.

INVESTIGATION OF Soot AND CARBON FORMATION IN SMALL GAS TURBINE COMBUSTORS Final Report

T. J. Rosfjord Apr. 1982 54 p refs

(Contract NAS3-22524)

(NASA-CR-167853; NAS 1.26:167853; UTRC-R82-91537-16) Avail: NTIS HC A04/MF A01 CSCL 21E

An investigation of hardware configurations which attempt to minimize carbon and soot-production without sacrificing performance in small gas turbine combustors was conducted. Four fuel injectors, employing either airblast atomization, pressure atomization, or fuel vaporization techniques were combined with nozzle air swiders and injector sheaths. Eight configurations were screened at sea-level takeoff and idle test conditions. Selected configurations were focused upon in an attempt to quantify the influence of combustor pressure, inlet temperature, primary zone operation, and combustor loading on soot and carbon formation. Cycle tests were also performed. It was found that smoke emission levels depended on the combustor fluid mechanics, the atomization quality of the injector and the fuel hydrogen content.

R.J.F.

N82-22288* Beech Aircraft Corp., Wichita, Kans.

ADVANCED GENERAL AVIATION ENGINE/AIRFRAME INTEGRATION STUDY

Leon A. Zmroczek Mar. 1982 131 p refs

(Contract NAS3-22220)


A comparison of the in-airframe performance and efficiency of the advanced engine concepts is presented. The results indicate that the proposed advanced engines can significantly improve the performance and economy of general aviation airplanes. The engine found to be most promising is the highly advanced version of a rotary combustion (Wankel) engine. The low weight and fuel consumption of this engine, as well as its small size, make it suited for aircraft use.

T.M.

N82-22349* Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.

COMPUTER MODELING OF FAN-EXIT-SPLITTER SPACING EFFECTS ON F100 RESPONSE TO DISTORTION Final Report

M. Shaw and R. W. Murdoch Mar. 1982 115 p refs
The distortion response of the F100(3) engine was effected by the fan exit splitter sensitivity. The sensitivity for a proximate splitter fan is calculated to be slightly greater than a remote fan exit splitter configuration. The sensitivity for a proximate by the fan exit splitter configuration with identical airfoils. Predicted response was based upon a multiple segment parallel compressor model modified to include a bypass ratio representation that affects the performance characteristics of the last rotor and intermediate case struts. The predicted distortion response required an accurate definition of row pre- and post-stall undistorted operation.

Author

N82-23247# Notre Dame Univ., Ind. Dept. of Electrical Engineering.

Michael K. Sain 1981 140 p refs (Grant NsG-3048)
(NASA-CR-168894; NAS 1.26:168894; TPR-12) Avail: NTIS HC A07/MF A01 CSCL 21E

Research centered on basic topics in the modeling and feedback control of nonlinear dynamical systems is reported. Of special interest were the following topics: (1) the role of series descriptions, especially insofar as they relate to questions of scheduling, in the control of gas turbine engines; (2) the use of algebraic tensor theory as a technique for parameterizing such descriptions; (3) the relationships between tensor methodology and other parts of the nonlinear literature; (4) the improvement of interactive methods for parameter selection within a tensor viewpoint; and (5) study of feedback gain representation as a counterpart to these modeling and parameterization ideas. Author

N82-23248# Pratt and Whitney Aircraft Group, East Hartford, Conn.

ANALYSIS OF HIGH LOAD DAMPERS Final Report
(Contract NASA-22518)
(NASA-CR-165503; NAS 1.26:165503; PWA-5779-10) Avail: NTIS HC A07/MF A01 CSCL 21E

High load damping requirements for modern jet engines are discussed. The design of damping systems which could satisfy these requirements is also discussed. In order to evaluate high load damping requirements, engines in three major classes were studied: large transport engines, small general aviation engines, and military engines. Four damper concepts applicable to these engines were evaluated: multi-ring, cartridge, curved beam, and viscous friction. The most promising damper concept was selected for each engine and performance was assessed relative to conventional dampers and in light of projected damping requirements for advanced jet engines. B.W.

N82-24202# Garrett Turbine Engine Co., Phoenix, Ariz.

STUDY OF ADVANCED PROPULSION SYSTEMS FOR SMALL TRANSPORT AIRCRAFT TECHNOLOGY (STAT) PROGRAM Final Report
(Contract NAS3-21997)
(NASA-CR-165610; NAS 1.26:165610; Garrett-21-3911) Avail: NTIS HC A06/AF A01 CSCL 21E

Definitions of takeoff gross weight, performance, and direct operating cost for both a 30 and 50 passenger airplane were established. The results indicate that a potential direct operating cost benefit, resulting from advanced technologies, of approximately 20 percent would be achieved for the 1980 engines. Of the numerous design features that were evaluated, only maintenance-related items contributed to a significant decrease in direct operating cost. Recommendations are made to continue research and technology programs for advanced component and engine development. T.M.

N82-25282* # Pennsylvania State Univ., University Park. Lab. of Turbomachinery.

THREE DIMENSIONAL MEAN VELOCITY AND TURBULENCE CHARACTERISTICS IN THE ANNUUS WALL REGION OF AN AXIAL FLOW COMPRESSOR ROTOR PASSAGE
R. Deavin and B. Lakshminarayana May 1982 262 p refs (Grant NsG-3212)
(NASA-CR-169003; NAS 1.26:169003; PSU/TURBO-82-2) Avail: NTIS HC A12/MF A01 CSCL 21E

The experiment was performed using the rotating hot-wire technique within the rotor blade passage and the stationary hot-wire technique for the exitflow of the rotor blade passage. The measurements reveal the effect of rotation and subsequent flow interactions upon the rotor blade flowfield and wake development in the annulus-wall region. The flow near the rotor blade tips is found to be highly complex due to the interaction of the annulus-wall boundary layer, the blade boundary layers, the leakage flow, and the secondary flow. Within the passage, this interaction results in an appreciable radial inward flow as well as a defect in the mainstream velocity near the mid-passage. Turbulence levels within this region are very high. This indicates a considerable extent of flow mixing due to the viscous flow interactions. The size and strength of this loss core is found to grow with axial distance from the blade trailing edge. The nature of the rotor blade exit-flow was dominated by the wake development. T.M.

N82-25283# Pennsylvania State Univ., University Park. Lab. of Turbomachinery.

INVESTIGATION OF THE TIP CLEARANCE FLOW INSIDE AND AT THE EXIT OF A COMPRESSOR ROTOR PASSAGE
A. Pandya and B. Lakshminarayana May 1982 147 p refs (Grant NsG-3212)
(NASA-CR-169004; NAS 1.26:169004; PSU/TURBO-82-3) Avail: NTIS HC A07/MF A01 CSCL 21E

The nature of the tip clearance flow in a moderately loaded compressor rotor is studied. The measurements were taken inside the clearance between the annulus-wall casing and the rotor blade tip. These measurements were obtained using a stationary two-cell hot-wire probe in combination with an ensemble averaging technique. The flowfield was surveyed at various radial locations and at ten axial locations, four of which were inside the blade passage in the clearance region and the remaining six outside the passage. Variations of the mean flow properties in the tangential and the radial directions at various axial locations were derived from the data. Variation of the leakage velocity at different axial stations and the annulus-wall boundary layer profiles from passage-averaged mean velocities were also estimated. B.W.


COST/BENEFIT STUDIES OF ADVANCED MATERIALS TECHNOLOGIES FOR FUTURE AIRCRAFT TURBINE ENGINES: MATERIALS FOR ADVANCED TURBINE ENGINES
M. Stearns and L. Wilbers May 1982 49 p (Contract NAS3-20074)
(NASA-CR-167849; NAS 1.26:167849) Avail: NTIS HC A03/MF A01 CSCL 21E

Cost benefit studies were conducted on six advanced materials and processes technologies applicable to commercial engines planned for production in the 1985 to 1990 time frame. These technologies consisted of thermal barrier coatings for combustion and high pressure turbine airfoils, directionally solidified eutectic high pressure turbine blades, (both cast and fabricated), and mixtures, tail cones, and piping made of titanium-aluminum alloys. A fabricated titanium fan blisk, an advanced turbine disk alloy with improved low cycle fatigue life, and a long-life high pressure turbine blade abrasive tip and ceramic shroud system were also analyzed. Technologies showing considerable promise as to benefits, low development costs, and high probability of success were thermal barrier coating, directionally solidified eutectic turbine blades, and abrasive-tip blades/ceramic-shroud turbine systems. R.J.F.
HOT SECTION COMPONENTS Final Report
G. J. Meyers May 1982 123 p refs
(Contract NAS3-22550)
(NASA-CR-167896; NAS 1.26:107896; PWA-5772-23) Avail: NTIS HC A06/MF A01 CSCL 21E

The application of several fracture mechanics parameters to predicting the crack propagation life of turbine engine hot section components was evaluated. An engine survey was conducted to determine the locations where conventional fracture mechanics approaches may not be adequate to characterize crack behavior. Both linear and nonlinear fracture mechanics analyses of a cracked annular combustor liner configuration were performed (isothermal and variable temperature crack propagation tests were performed on Hastelloy X combustor liner material. The crack growth data was reduced using the stress intensity factor, the strain intensity factor, the J integral. Fracture mechanics approaches may not be adequate to near stage blading. This report presents statistical information relating to the number of gas turbine engine rotor failures which occurred in commercial aviation service use. The predominant failure involved blade fragments, 82.4 percent of which were contained. Although fewer rotor rim, disk, and seal failures occurred, 33.3%, 100% and 50% respectively were uncontained. Sixty-five percent of the 16' mwr failures occurred during the takeoff and climb stages of flight.

Pennsylvania State Univ., University Park
(Grant Nsg-3306)
(NASA-CR-3563; NAS 1.26 3563) Avail: NTIS HC A05/MF A01 CSCL 21E

The flow, atomization and spreading of flashing injector flowing liquids containing dissolved gases (jet/air) as well as superheated liquids (Freon-11) were considered. The use of a two stage expansion process separated by an expansion chamber, was found to be beneficial for thermal and separated flow models provided good predictions of injector flow properties. Conventional correlations for drop sizes from pressure atomized injectors were successfully modified, using the separated flow model to prescribe injector exit conditions, to correlate drop size measurements. Additional experimental results are provided for spray angle and combustion properties of sprays from flashing injectors. Author

Pratt and Whitney Aircraft Group, East Hartford, Conn.
PERFORMANCE DETERIORATION DUE TO ACCEPTANCE TESTING AND FLIGHT LOADS; JT9D JET ENGINE DIAGNOSTIC PROGRAM Final Report, 22 Jan. 1982 147 p refs
(Contract NAS3-20832)
(NASA-CR-165572; NAS 1.26:165572; PWA-5512-87) Avail: NTIS HC A07/MF A01 CSCL 21E

The results of a flight loads test of the JT9D-7 engine are presented. The goals of this test program were to: measure aerodynamic and inertia loads on the engine during flight, explore the effects of airplane gross weight and typical maneuvers on these flight loads, simultaneously measure the changes in engine running clearances and performance resulting from the maneuvers, make refinements of engine performance deterioration prediction models based on analytical results of the tests, and make recommendations to improve propulsion system performance retention. The test program included a typical production airplane acceptance test plus additional flights and maneuvers to encompass the range of flight loads in revenue service. The test results indicated that aerodynamic loads, primarily at take-off, were the major cause of rub-indicated that aerodynamic loads, primarily at take-off, were the major cause of rub-induced deterioration in the cold section of the engine differential thermal expansion between rotation and static parts and results performed on spray angle and combustion properties of sprays from flashing injectors. Author

Pratt and Whitney Aircraft Group, East Hartford, Conn.
B747/JT9D FLIGHT LOADS AND THEIR EFFECT ON ENGINE RUNNING CLEARANCES AND PERFORMANCE DETERIORATION; BCAC NAIL/P AND WA JT9D ENGINE DIAGNOSTICS PROGRAMS Final Report, 19 Feb. 1982 74 p refs
(Contract NAS3-20632)
(NASA-CR-165573; NAS 1.26:165573; PWA-5512-88) Avail: NTIS HC A04/MF A01 CSCL 21E

Flight loads on the 747 propulsion system and resulting JT9D blade to outer airsealed running clearances during representative acceptance flight and revenue flight sequences were measured. The resulting rub induced clearance changes, and engine performance changes were then analyzed to validate and refine the JT9D-7A short term performance deterioration model. Author

General Electric Co., Cincinnati, Ohio
ENGINE PERFORMANCE IMPROVEMENT; HIGH PRESSURE TURBINE ACTIVE CLEARANCE CONTROL Final Report, Jun. 1982 136 p refs
(Contract NAS3-20629)
(NASA-CR-165556; NAS 1.26:165556; RB2AEB198) Avail: NTIS HC A07/MF A01 CSCL 21E

An active clearance control system was developed which reduces fuel consumption and performance degradation. This system utilizes compressor discharge air during takeoff and fan
The stator used in this program as a one-sixth scale of a 762 mm (30 in.) diameter stator design with 50 vanes having a vane height of 17 mm (0.666 in.) and an aspect ratio of 1.77. A comprehensive overall test matrix was used to provide a complete engineering understanding of the effects of each variable over the full range of all the other variables. The range of each variable investigated was as follows: surface finish 0.1 micro (4 micro in.) to 2.4 micro (95 micro In.); boundary layer thickness 2 to 25 percent of channel height at each wall; fillet radius 0 mm (0 in.) to 1.0 mm (.040 in.) and turbulence 2 to 12 percent.

Author

N82-33391*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

STRUCTURAL TAILORING OF ENGINE BLADES (STAEBL) Interim Report
(NASA-CR-167948; NAS 1.26:167948; PWA-5774-21) Avail: NTIS HC A16/MF A01 CSCL 21E

A mathematical optimization procedure was developed for the structural tailoring of engine blades and was used to structurally tailor two engine fan blades constructed of composite materials without midspan shrouds. The first was a solid blade made from superhybrid composites, and the second was a hollow blade with

28
metal matrix composite liners. Three major computerized functions
were needed to complete the procedure: approximate analysis
with the established input variables, optimization of an objective
function, and refined analysis for design verification. S.L.

N82-33929# Teledyne Continental Motors, Mobile, Ala. Aircraft
Products Div.
EXHAUST EMISSIONS REDUCTION FOR INTERRMITTENT COM-
BUSTION AIRCRAFT ENGINES Final Report
Bernard J. Rezy, Kenneth J. Stuckas, J. Ronald Tucker, and Jay E.
Meyers May 1982 55 p reis
(Contract NAS3-19755)
(NASA-CR-167914; NAS 1.26:167914) Avail: NTIS
HC A04/MF A01 CSCL 21E
Three concepts which, to an aircraft piston engine, provide
reductions in exhaust emissions of hydrocarbons and carbon
monoxide while simultaneously improving fuel economy. The three
chosen concepts, (1) an improved fuel injection system, (2) an
improved cooling cylinder head, and (3) exhaust air injection, when
combined, show a synergistic relationship in achieving these goals.
In addition, the benefits of variable ignition timing were explored
and both dynamometer and flight testing of the final engine
configuration were accomplished. S.L.

N82-33939# General Electric Co., Cincinnati, Ohio. Aircraft
Engine Group.
The CF6 JET ENGINE PERFORMANCE IMPROVEMENT: LOW
PRESSURE TURBINE ACTIVE CLEARANCE CONTROL
B. D. Beck and W. A. Fasching Jun. 1982 159 p reis
(Contract NAS3-20629)
(NASA-CR-165557; NAS 1.26:165557; R82AE8462) Avail: NTIS
HC A08/MF A01 CSCL 21E
A low pressure turbine (LPT) active clearance control (ACC)
cooling system was developed to reduce the fuel consumption of
current CF6-50 turbofan engines for wide bodied commercial
aircraft. The program performance improvement goal of 0.3% delta
sfc was determined to be achievable with an improved impingement
cooling system. The technology enables the design of an optimiz-
ed manifold and piping system which is capable of a perform-
ance gain of 0.45% delta sfc. E.A.K.

N82-33943# Pratt and Whitney Aircraft Group, East Hartford,
Conn. Commercial Products Div.
ENERGY EFFICIENT ENGINE: TURBINE TRANSITION DUCT
MODEL TECHNOLOGY REPORT
K. Leach and R. Thurlin Aug. 1982 115 p reis
(Contract NAS3-20648)
HC A06/MF A01 CSCL 21E
The Low-Pressure Turbine Transition Duct Model Technology Program
was directed toward substantiating the aerodynamic
definition of a turbine transition duct for the Energy Efficient Engine.
This effort was successful in demonstrating an aerodynamically
viable compact duct geometry and the performance benefits
associated with a low camber low-pressure turbine inlet guide vane.
The transition duct design for the flight propulsion system was
tested and the pressure loss goal of 0.7 percent was exceeded.
Also, stru fairing pressure distributions, as well as wall pressure
coefficients, were in close agreement with analytical predictions.
Duct modifications for the integrated core/low spool were also
evaluated. The total pressure loss was 1.59 percent. Although the
increase in exit area in this design produced higher wall loadings,
reflecting a more aggressive aerodynamic design, pressure profiles
showed no evidence of flow separation. Overall, the results
acquired have provided a more complete design and diagnostic information
for the design of a turbine transition duct for both the flight
propulsion system and the integrated core/low spool. J.M.S.

A82-10457* # Effects of vane/blade ratio and spacing on fan
noise. R. A. Kantola (General Electric Co., Power Generation Group,
Lynn, MA) and P. R. Glese (General Electric Group, Cincinnati, OH).
American Institute of Aeronautics and
Astronautics, A80acoustics Conference, 7th, Palo Alto, CA, Oct.
The effects of vane/blade ratio and spacing on fan noise are
investigated to develop a fan noise prediction scheme which
is calibrated against experimental data. A 44 blade, 0.504 diameter fan
is used to demonstrate the production of fan noise data free from
excess noise caused by rotor turbulence interaction. Two stator
tors consisting of a cut-off set with 86 vanes, and a cut-on set of 48 vanes
are used, with a total range of spacing from 0.5 to 2.3 rotor chords.
The model includes viscous wake interaction noise and the potential
field interactions of both the rotor and stator. A free-field acoustic
environment is achieved by covering the walls, ceiling and floor with
0.7 m polyurethane foam wedges, providing less than + or - 1 dB
standing wave ratio at 200 Hz. Only a 3 dB drop in tone level occurs
as the spacing is increased from 0.5 to 2.3 rotor chords, and results
indicate that the rotor wakes impinging on the stator vanes are the
principal noise source for subsonic rotor speeds. D.L.G.

A82-11999* # Thermal expansion accommodation in a jet
engine frame. M. H. Schneider (General Electric Co., Cincinnati,
OH). American Society of Mechanical Engineers, Gas Turbine
Conference and Product Show, Houston, TX, Mar. 9-12, 1981)
Design advancements to enhance stress accommodation in gas
turbine engine frames are described. Consideration is given to
mechanical stiffness to maintain adequate turbine frame
thermal stresses in both ambient and transient modes. Noting that
thermal stresses occur due to differing temperatures at different parts
of the frame, the matching of the thermal expansion rates of different
materials is emphasized. Adequate stiffness is necessary to avoid
dynamic reactions leading to case cracking as a result of normal
imbalances of moving parts. Stress and deflection analysis of a total
frame concept using a three-dimensional finite element stress
analysis computer program, with modelling of all frame components,
is presented, and illustrations are provided. M.S.K.

A82-12120* # On the prediction of swirling flow fields
found in axisymmetric combustor geometries. D. L. Rhode, D. G. Lilley,
and D. K. McLaughlin (Oklahoma State University, Stillwater, OK).
In: Fluid mechanics of combustion systems: Proceedings of the
(A82-12101 02.34) New York, American Society of Mechanical
The paper reports research restricted to steady turbulence flow
in axisymmetric geometries under low speed and nonreacting
conditions. Numerical computations are performed for a basic
two-dimensional axisymmetric flow field in a conventional gas
turbine combustor. Calculations include a staircase
representation of the expansion flow, a conventional
k-epsilon turbulence model and realistic accommodation of swirl
effects. A preliminary evaluation of the accuracy of computed
flowfields is accomplished by comparisons with flow visualizations
using neutrally-buoyant helium-filled soap bubbles as tracer particles.
Comparisons of calculated results show good agreement, and it is
found that a problem in swirling flows is the accuracy with which the
sizes and shapes of the recirculation zones may be predicted, which
may be attributed to the quality of the turbulence model. D.L.G.

A82-16899# V/STOL propulsion control technology. H.
Brown (General Electric Co., Cincinnati, OH). American Institute of
Aeronautics and Astronautics and NASA Ames Research Center,
81-2634. 10 p. Contract No, NAS3-22057.
Results of a NASA sponsored study of V/STOL Propulsion
Control Analysis are presented. The study included propulsion
control requirements, design concepts and procedures, and control
designs for supersonic V/STOL. A variable cycle engine with a

ORIGINAL PAGE IS
OF POOR QUALITY
remote augmented lift system was used as a basis for establishing typical operating requirements and control concepts, and a nonlinear engine model was developed for control development as a precursor to real-time simulation capability. A simplified aircraft model was also used to investigate transition requirements, and a long-range technology plan was developed to define subsequent program requirements for achieving a real-time piloted simulation capability.

D.L.G.

A28-17788 * # A simple difference procedure for the vortex controlled diffuser. A. A. Bussalna and D. G. Lilley (Oklahoma State University, Stillwater, OK). American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, Paper 82-0109, 9 p. 21 refs. USAF-supported research; Grant No. NAG3-74.

A simple prediction procedure for sudden expansion incompressible flows is developed and applied to the vortex controlled diffuser. Transient Navier-Stokes equations of an incompressible fluid are solved by means of their associated difference equations in terms of the primitive pressure velocity variables. A computer code is used for the laminar flow simulation with free slip or no slip wall boundary conditions. In addition, predicted results confirm that effectiveness increases with increases in duct length and bleed flow rate.

D.L.G.


A new iterative solution technique for predicting the sound field radiated from a turbofan inlet in steady flight is presented. The sound field is divided into two regions: the sound field within and near the inlet which is computed using the finite element method and the radiation field beyond the inlet which is calculated using an integral solution technique. A continuous solution is obtained by matching the finite element and integral solutions at the interface between the two regions. The applicability of the iterative technique is demonstrated by comparison of experimental results with the theoretical results for several different inlet configurations with and without flow. These examples show that agreement between experiment and theory is obtained within five iterations.


An axial flow compressor has been tested with water droplet ingestion under a variety of conditions. The results illustrate the manner in which the compressor pressure ratio, efficiency and surge characteristics are affected. A model for estimating the performance of a compressor during water ingestion has been developed and the predictions obtained compare favorably with the test results. It is then shown that with respect to five droplet-associated nonlinearly-interacting processes (namely, droplet-blade interactions, blade performance changes, centrifugal action, heat and mass transfer processes and droplet break-up), the initial water content and centrifugal action play the most dominant role.

(Author)


This paper reports on work completed to develop an analytical method for predicting the transient non-linear response of a complete aircraft engine system due to the loss of a fan blade, and to validate the analysis by comparing the results against actual blade loss test data. The solution, which is based on the component element method, accounts for rotor-to-casing rubs, high damping and rapid deceleration rates associated with the blade loss event. A comparison of test results and predicted response show good agreement except for an initial overshoot spike not observed in test. The method is effective for analysis of large systems.

(K.L.)
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).

NB2-19221# National Aeronautics and Space Administration,
Lewis Research Center, Cleveland, Ohio.

THE AEROSPACE TECHNOLOGY LABORATORY (A
PERSPECTIVE, THEN AND NOW)
refs (NASA-TM-82754: E-1070) Avail: NTIS HC A02/MF A01
CSCL 14B

The physical changes that have taken place in aerospace
facilities since the Wright brothers' accomplishment 78 years
ago are highlighted. For illustrative purposes some of the technical
facilities and operations of the NASA Lewis Research Center
are described. These simulation facilities were designed to support
research and technology studies in aerospace propulsion. Author

NB2-32383# Pratt and Whitney Aircraft Group, East Hartford,
Conn. Energy Efficient Engine Component Development and
Integration Program.

ENERGY EFFICIENT ENGINE: HIGH PRESSURE TURBINE
UNCOOLED RIG TECHNOLOGY REPORT
W. B. Gardner Oct. 1979 242 p refs
(Contract NAS3-20646)
(NASA-CR-165149; NAS 1.26:165149; PWA-5594-92) Avail: NTIS
HC A11/MF A01 CSCL 14B

Results obtained from testing five performance builds (three
vane cascades and two rotating rigs of the Energy Efficient Engine
uncooled rig have established the uncooled aerodynamic efficiency
of the high-pressure turbine at 91.1 percent. This efficiency level
was attained by increasing the rim speed and annulus area (AN(2)),
and by increasing the turbine reaction level. The increase in
AN(2) resulted in a performance improvement of 1.15 percent. At
the design point pressure ratio, the increased reaction level rig
demonstrated an efficiency of 91.1 percent. The results of this
program have verified the aerodynamic design assumptions
established for the Energy Efficient Engine high-pressure turbine
component. Author
13 ASTRODYNAMICS
Includes powered and free-flight trajectories; and orbit and launching dynamics.

NB-26330* # National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.

MATERIAL AND PROCESSING NEEDS FOR SILICON SOLAR CELLS IN SPACE
Avail. NTIS HC A10/MF A01 CSCL 22A

The technical concerns of NASA in the area of space grade solar cells are summarized. Solar power needs are projected through 1987. The degradation of solar cell performance due to the effects of radiation on impurities and crystal defects and the improved performance of float zone silicon are illustrated. The reduction of oxygen and carbon in float zone silicon allows for much faster low temperature annealing of the defects. The effects of improved crystal purity on cell performance are summarized.


A system for the launching of lunar derived oxygen or raw materials into low lunar orbit or to L2 for transfer to low earth orbit is presented. The system described is a greatly simplified version of the conventional and sophisticated approach suggested by O'Neill using mass drivers with recirculating buckets. An electromagnetic accelerator is located on the lunar surface which launches 125 kg 'smart' containers of liquid oxygen or raw materials into a transfer orbit. Upon reaching apolune a kick motor is fired to circularize the orbit at 100 km altitude or L2. These containers are collected and their payloads transferred to a tanker OTV. The empty containers then have their kick motors refurbished and then are returned to the launcher site on the lunar surface for reuse. Initial launch capability is designed for about 500T of liquid oxygen delivered to low earth orbit per year with upgrading to higher levels, delivery of lunar soil for shielding, or raw materials for processing given the demand.


Since oxygen makes up 86% of the total mass of propellants which would normally have been brought up from the earth to LEO, considerable savings are available if this oxygen can be obtained from the moon for little Delta-V penalty. This paper presents a scenario in which 400 T/yr of LOX is delivered to LEO, with the ability for upgrading to 5000 T/yr. In this scenario, cylindrical tanks of liquid oxygen with a mass of 500 kg are launched from the lunar surface by a mass driver and rendezvous with a collection station in a 100-km lunar orbit. The oxygen is removed from each tank and placed into a tanker OTV which later will transfer from low lunar orbit to LEO with an aerobraking maneuver. Launch requirements for aerobraked chemical OTVs using earth oxygen are compared to those using lunar oxygen.

B.J.
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 (Alt).


A scale model of a satellite was tested in a large vacuum facility under electron bombardment and vacuum ultraviolet radiation to investigate the charging of dielectric materials on curved surfaces. The model was tested both stationary and rotating relative to the electron sources as well as grounded through one megohm and floating relative to the chamber. Surface potential measurements are presented and compared with the predictions of computer modelling of the stationary tests. Discharge activity observed during the stationary tests is discussed and signals from sensing devices located inside and outside of the model are presented.

(Author)


The feasibility of earth-to-space electromagnetic (railgun) launchers (ESRL) is considered, in order to determine their technical practicability and economic viability. The potential applications of the launcher include nuclear waste disposal into space, deep space probe launches, and atmospheric research. Examples of performance requirements of the ESRL system are a maximum acceleration of 10,000 g's for nuclear waste disposal in space (NWDS) missions and 2,500 g's for earth orbital missions, a 20 km/sec launch velocity for NWDS missions, and a launch azimuth of 90 degrees E. A brief configuration description is given, and test results indicate that for the 2020-2050 time period, as much as 3.0 MT per day of high-level nuclear waste could be launched. For earth orbital missions, a significant projectile mass was approximately 6.5 MT, and an integral distributed energy store could be launched. For earth orbital missions, the projectile requires a propulsion system, leaving an estimated payload mass of 650 kg. For the nuclear waste disposal in space mission, the high level waste mass was estimated at 250 kg. This preliminary assessment included technical, environmental, and economic analyses.

S. L.


NASA calculations have been performed simulating exposure of a spacecraft-like model to multiple electron guns. The results agree well with experiment. It is found that magnetic field effects are fairly small, but substantial differential charging can result from electron gun placement. Conditions for surface flashover are readily achieved.

(Author)


The design of a simulator system for emulating the characteristics of Shuttle/ Centaur avionic support equipment for launching the Solar Polar Mission and the Galileo probe are discussed. The simulators are being constructed on a modular basis for the Centaur control avionics, the Centaur Airborne Support Equipment avionics, the tanking skid ground support equipment, development mechanisms, the tanking skid ground support equipment, deployment mechanisms, the tanking onboard fluid functions, the star scanner guidance update avionics, the Orbiter command interface avionics, and the Orbiter power system. Each simulator portrays the actual working conditions, including signal delay times and harnessing. Block diagrams are provided of the interfaces and a flow diagram is presented of the software.

M. S. K.

N82-23945* # Battelle Columbus Labs., Ohio.
PRELIMINARY FEASIBILITY ASSESSMENT FOR EARTH-TO-SPACE ELECTROMAGNETIC (RAILGUN) LAUNCHERS
403 p refs
(Contract NAS3-22882)
(NASA-CR-167886, NAS 1.26:167886) Avail: NTIS
HC A18/MF A01 CSCL 148

An Earth to space electromagnetic (railgun) launcher (ESRL) for launching material into space was studied. Potential ESRL applications were identified and initially assessed to formulate preliminary system requirements. The potential applications included nuclear waste disposal in space, Earth orbital applications, deep space probe launchers, atmospheric research, and boost of chemical rockets. The ESRL system concept consisted of two separate railgun launcher tubes (one at 20 deg from the horizontal for Earth orbital missions, the other vertical for solar system escape disposal missions) powered by a common power plant. Each 2040 m launcher tube is surrounded by 10,200 homopolar generator/inductor units to transmit the power to the walls. Projectile masses are 6500 kg for Earth orbital missions and 2095 kg for nuclear waste disposal missions. For the Earth orbital missions, the projectile requires a propulsion system, leaving an estimated payload mass of 650 kg. For the nuclear waste disposal in space mission, the high level waste mass was estimated at 250 kg. This preliminary assessment included technical, environmental, and economic analyses.
15 LAUNCH VEHICLES AND SPACE VEHICLES

Includes boosters; manned orbital laboratories; reusable vehicles; and space stations.


Increasing demands for satellite communications channels have filled the C-band, have begun to fill the Ku-band, and have resulted in a developmental effort to utilize 2.5 GHz of the 30/20 GHz Ka band. Problems of rain attenuation in the Ku and Ka bands are explored, and solutions are indicated in the use of antenna gain coupled with ground terminal site diversity, and higher satellite power capabilities. Tradeoffs in satellite design are focused on the number of reflectors, increased f/d, gain and sidelobe performance, and total satellite capacity. The NASA 20/3C GHz program is described, including design features of two test systems to be launched in the 1980's to examine the functioning limits of two baseline systems.

D.H.K.

A82-27331*// Systematics General Corp., Sterling, Va.
COMMUNICATIONS SATELLITE SYSTEMS CAPACITY ANALYSIS Final Report
Larry Browne, Taylor Hines, and Brian Tunstall Jun. 1982
114 p refs.
(Contract NAS3-22888)
(NASA CR-167911) Avail: NTIS
HC A08/MF A01 CSCL 228

Analog and digital modulation techniques are compared with regard to efficient use of the geostationary orbit by communications satellites. Included is the definition of the baseline systems (both space and ground segments), determination of interference susceptibility, calculation of orbit spacing, and evaluation of relative costs. It is assumed that voice or TV is communicated at 14/11 GHz using either FM or QPSK modulation. Both the Fixed-Satellite Service and the Broadcasting-Satellite Service are considered. For most of the cases examined the digital approach requires a satellite spacing less than or equal to that required by the analog approach.

T.M.


An analysis has been made over a range of thruster, spacecraft and mission parameters to determine optimum electric propulsion requirements for LEO to GEO transfer missions. For this mission solar cell cover thicknesses of four to six mils each side appear to be an optimum compromise between mass and power loss due to radiation damage. The optimum range of thruster specific impulse for this mission is roughly from 1500 to 3000 seconds. Thrusters limited to much lower values of specific impulse and those requiring much higher specific impulse for good efficiency require substantially greater transfer times.

(Author)


The configurations, payload capabilities, and payload envelopes for Centaur in various applications are presented. The Centaur launch record is summarized and the Atlas/Centaur launch schedule is shown. Improvements in capability are reported on, and current and proposed vehicles are depicted. Dual Delta class spacecraft will be flown using a tandem adapter or large direct broadcast satellites in a single launch model. Shuttle/Centaur will permit spacecraft weights of up to 14,000 lb to be put into orbit, including payload lengths up to 40 ft. A new capability to transfer large deployed space systems from the Shuttle to high-altitude orbits at low thrusts will be available. Spacecraft lengths requiring the full, 60-foot cargo bay and weighing 20,000 lb could be placed in geosynchronous orbit with on-orbit rendezvous and assembly of the Centaur and spacecraft in low earth orbit.

C.D.
16 SPACE TRANSPORTATION

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

For related information see also 03 Air Transportation and Safety and 85 Urban Technology and Transportation.


General Dynamics/Convair is under NASA contract to integrate the Centaur upper stage into the space transportation system for future planetary missions. This requires that control of all safety critical functions be two-failure tolerant. The control system developed consists of five asynchronous computers, each contributing at their outputs to a 3-out-of-5 voting plane. Subsystem control is based on an end function redundancy management scheme. Analysis of multiple component failures and worst-case time-phase asynchrony among the computers is performed by a real-time computer simulation. The simulation emulates the hardware and subsystem interfaces, wire by wire, providing accessibility to any component for the insertion of preprogrammed failures. Observability is provided via a graphics system and diagnostic software. The simulation provides an engineering tool where the integrity of control system hardware and imbedded software can be demonstrated.

(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.

NB2.25280 National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
SATELLITE- AIDED LAND MOBILE COMMUNICATIONS
SYSTEM IMPLEMENTATION CONSIDERATIONS
(NASA-TM-B2861; E-1229; NAS 1.18:82861) Avail: NTIS
HC A02/MF AO1 CSCL 09F
It was proposed that a satellite-based land mobile radio
system could effectively extend the terrestrial cellular mobile
system into rural and remote areas. The market, technical and
economic feasibility for such a system is studied. Some of the
aspects of implementing an operational mobile-satellite system
are discussed. In particular, two key factors in implementation
are examined: (1) bandwidth requirements; and (2) frequency
sharing. Bandwidth requirements are derived based on the satellite
antenna requirements, modulation characteristics and numbers
of subscribers. Design trade-offs for the satellite system and
potential implementation scenarios are identified. Frequency
sharing is examined from a power flux density and modulation
viewpoint.

A82-27224* Open-loop nanosecond-synchronization for
wideband satellite communications. W. M. Holmes, Jr. (TRW Defense
and Space Systems Group, Space Systems Div., Redondo Beach,
CA). In: ITU/USA/80: Proceedings of the International Telecommu-
nications Conference, San Diego, CA, October 14-16, 1980. (A82-
27170 12-32) Research Triangle Park, NC, Instrument Society of
A synchronization technique for use with an onboard processing
satellite communication system is discussed. The satellite oscillator is
used both as the system time reference and as the frequency source
for all downlink carriers and data clocks. Downlink timing is
established at each system earth terminal through a combination of
carrier and data-clock tracking and a downlink timing epoch signal
consisting of one bit per TDM burst. Uplink timing is
established by an open-loop range prediction process using precision
ephemerides calculated and distributed by the central control
station. Overall timing accuracy of the uplink signal at the satellite
receiver of + or - 7 nanoseconds permits unambiguous identification
of each data bit position in a 128 Mbps TDMA burst. This is
accomplished by means of simple, inexpensive terminal hardware
using available crystal oscillators for time/frequency references and
digital synthesis techniques that may be implemented in digital LSI
chips.

A82-36925* Microwave intersatellite links for communications satel-
ites. G. R. Welti (COMSAT Laboratories, Clarksburg, MD). Institute of Electrical
and Electronics Engineers, International Conference on Communications,
Philadelphia, PA, June 14-17, 1982, Paper 5 p. 9 refs. Research sponsored by
the International Telecommunications Satellite Organization; Contract No. NAS3-
22905.
Applications and interface requirements for intersatellite links (ISLs) between
commercial communications satellites are reviewed, ranging from ISLS between
widely separated satellites to ISLS between clustered satellites. On-board pro-
cessing architectures for ISLs employing a variety of modulation schemes are
described. These schemes include FM remodulation and QPSK regeneration in
combination with switching and buffering. The various architectures are com-
pared in terms of complexity, required performance, antenna size, mass, and
power.
18 SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes spacecraft thermal and environmental control; and attitude control.

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

N82-1106* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TESTING OF A SPACECRAFT MODEL IN A COMBINED ENVIRONMENT SIMULATOR
A scale model of a satellite was tested in a large vacuum facility under electron bombardment and vacuum ultraviolet radiation to investigate the charging of dielectric materials on curved surfaces. The model was tested both stationary and rotating relative to the electron sources as well as grounded through one megohm and floating relative to the chamber. Surface potential measurements are presented and compared with the predictions of computer modelling of the stationary tests. Discharge activity observed during the stationary tests is discussed and signals from sensing devices located inside and outside of the model are presented.

M.G.

N82-1107* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VOLTAGE GRADIENTS IN SOLAR ARRAY CAVITIES AS POSSIBLE BREAKDOWN SITES IN SPACECRAFT-CHARGING-INDUCED DISCHarges
A possible explanation for environmentally-induced discharges on geostationary satellites exists in the electric fields formed in the cavities between solar cells - the small gaps formed by the cover slides, solar cells, metallic interconnects and insulating substrate. When exposed to a substorm environment, the cover slides become less negatively charged than the spacecraft ground. If the resultant electric field becomes large enough, then the interconnect could emit electrons (probably by field emission) which could be accelerated to space by the positive voltage on the cover slides. An experimental study was conducted using a small solar array segment in which the interconnect potential was controlled by a power supply while the cover slides were irradiated by monoenergetic electrons. It was found that discharges could be triggered when the interconnect potential became at least 500 volts negative with respect to the cover slides. Analytical modeling of satellites exposed to substorm environments indicates that such gradients are possible. Therefore, it appears that this trigger mechanism for discharges is possible.

T.M.

N82-14213* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACECRAFT CHARGING TECHNOLOGY, 1980
The third Spacecraft Charging Technology Conference proceedings contain 66 papers on the geosynchronous plasma environment, spacecraft modeling, charged particle environment interactions with spacecraft, spacecraft materials characterization, and satellite design and testing. The proceedings are a compilation of the state of the art of spacecraft charging and environmental interaction phenomena. For individual titles, see N82-14214 through N82-14275.

N82-14251* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SCATHA SPSS CHARGING RESPONSE: NASCAP PREDICTIONS COMPARED WITH DATA
Models for the satellite surface potential monitor (SSPM) units constructed in the NASCAP code and the results of comparing predictions to surface voltage and baseline current data are reported. Several peculiarities of the data are reported. Preliminary results from space simulations of a SCATHA model with environments representative of the day 87, 1979, eclipse injection event are presented, and their implications for predicting space response are discussed.

E.A.K.

N82-14269* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF NASCAP MODELLING RESULTS WITH LUMPED CIRCUIT ANALYSIS
Engineering design tools that can be used to predict the development of absolute and differential potentials by realistic spacecraft under geomagnetic substorm conditions are described. Two types of analyses are in use: (1) the NASCAP code, which computes quasistatic charging of geometrically complex objects with multiple surface materials in three dimensions; (2) lumped element equivalent circuit models that are used for analyses of particular spacecraft. The equivalent circuit models require very little computation time, however, they cannot account for effects such as the formation of potential barriers, that are inherently multidimensional. Steady state potentials of structure and insulation are compared with those resulting from the equivalent circuit model.

E.A.K.

N82-14267* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL MODELING OF SATELLITES IN GEOSYNCHRONOUS ENVIRONMENT
Experiences with surface charging of geosynchronous satellites are reviewed and mechanisms leading to discharges on satellite surfaces are considered. It was found that the large differential voltages between the surface and the substrate required to produce massive laboratory discharges do not occur on satellites in space. Analytical modeling predictions supported by dielectric charging data from P78-2, SCATHA (Spacecraft Charging at High Altitudes) flight results are discussed. Ungrounded insulator areas, buried charge layers (due to mid-energy charge particles), and positive differential voltages (where structure voltages are less negative than surrounding dielectric surface voltages) are considered as possible mechanisms producing satellite charge up.

J.D.H.

N82-14263* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USE OF CHARGING CONTROL GUIDELINES FOR GEO-SYNSCHRONOUS SATELLITE DESIGN STUDIES
N. John Stevens In its Spacecraft Charging Technol., 1980 Oct. 1980 p 789-801 refs (For primary document see N82-14123 05-18) Avail: NTIS HC A99/MF A01 CSCL 229
Several of the principle guidelines from the Spacecraft Charging Design Guidelines Handbook are presented with illustrative examples. Use of the geomagnetic substorm specification to qualify satellite designs, the evaluation of satellite designs by using analytical modeling techniques, the use of selected materials and coatings to minimize charging, the tying of all conducting elements to a common ground, and the use of electrical filtering to protect circuits from discharge induced upset are discussed. Discharge criteria and SCATHA data are excluded.

J.D.H.
The NASA Charging Analyzer Program (NASCAP) has been validated in a space environment. Data collected by the SCATHA (Spacecraft Charging at High Altitude) spacecraft has been used with NASCAP to simulate the charging response of the spacecraft ground conductor and dielectric surfaces with considerable success. Charging of the spacecraft ground observed in eclipse, during moderate and severe substorm environments, and in sunlight has been reproduced using the code. Close agreement between both the currents and potentials measured by the SSPM's, and the NASCAP simulated response, has been obtained for differential charging. It is concluded that NASCAP is able to predict spacecraft charging behavior in a space environment.

A92-18311* // Voltage gradients in solar array cavities as possible breakdown sites in spacecraft-charging-induced discharges.

A possible explanation for environmentally-induced discharges on geosynchronous satellites exists in the electric fields formed in the cavities between solar cells - the small gaps formed by the cover slides, solar cells, metallic interconnects and insulating surfaces. When exposed to a substorm environment, the cover slides become less negatively charged than the spacecraft ground. Hence, it is possible for metallic surfaces (usually silver mesh) to be at a negative potential in a cavity which has a 'positive' surface above it. If the resultant electric field becomes large enough, then the interconnect could emit electrons (probably by field emission) which could be accelerated to space by the positive voltage on the covers. An experimental study was conducted using a small solar array segment in which the interconnect potential was controlled by a power supply while the cover slider were irradiated by monoenergetic electrons. It was found that discharges could be triggered when the interconnect potential became at least 500 volts negative with respect to the cover slider. Analytical modeling of satellites exposed to substorm environments indicates that gradients are possible. Therefore, it appears that this trigger mechanism for discharges is possible. Details of the experiment and modeling study are presented.

(Author)
The secondary electron emission (SEE) characteristics of a variety of spacecraft materials were determined under UHV conditions using a commercial double pass CMA which permits sequential Auger electron spectroscopic analysis of the surface. The transparent conductive coating indium tin oxides (ITO) was examined on a potted and borosilicate glass and indium oxide on FED Teflon. The total SEE coefficient ranges from 2.5 to 2.6 on as-received surfaces and from 1.5 to 1.6 on Ar+ sputtered surfaces. A cylindrical sample holder permits measurement of the sputtered surfaces with 5 nm removed. A primary beam pulsed mode to reduce electron beam dosage was found quite important at the current densities necessary to do Auger studies.

M.D.K.

N82-14227# Pennsylvania State Univ., University Park.

OBIQUE-INCIDENCE SECONDARY EMISSION FROM CHARGED DIELECTRONS
James W. Robinson and Paul A. Budd In NASA, Lewis Research Center Spacecraft Charging Technol., 1980 Oct, 1981 p 198-210 refs (For primary document see N82-14213 05-18) (Grant NAG-3168)
Avail: NTIS HC A99/MF A01 CSCL 228
Experimental measurements and computer simulation of secondary electron emission coefficients for FEP-Teflon, for normal and oblique incidence in the presence of a normal electric field are reported. Knowledge of the electric field in the low-energy environment surrounding the spacecraft is an important consideration. A simulation using a conformal mapping, a Green's function, and a trajectory generator provides the necessary mathematical support for the measurements which have been made with normal fields of 1.5 and 2.7 kV/mm. When incidence is normal and normal field exceeds the critical energy, the coefficient is given by V(5.8) and for oblique incidence this expression may be divided by the cosine of the angle. The parameter V sub f is a function of normal field. Measurements for values of V sub f are presented.

M.D.K.

N82-14249# Systems Science and Software, La Jolla, Calif.

REPRESENTATION AND MATERIAL CHARGING RESPONSE OF GEOPLASMA ENVIRONMENTS
Avail: NTIS HC A99/MF A01 CSCL 228
Any process which may be modeled statistically for a simple plasma particle may be modeled by the particle in cell technique. The success of the calculation is then dependent on having a large enough number of particles that the statistical treatment is meaningful. Thus it is possible to include the effects of secondary electron emission, backscattering, charge sticking and possibly dielectric breakdown, photoemission, and spallation. The first plasma dielectric interaction included in the computer code for simulating plasma insulator interactions is secondary electron emission. A calculated current density vs. voltage curve is presented and compared to an experimental curve.

E.A.K.

N82-14272# Kansas Univ., Lawrence.

NUMERICAL SIMULATION OF PLASMA INSULATOR INTERACTIONS IN SPACE. PART 1: THE SELF CONSISTENT CALCULATION
Avail: NTIS HC A99/MF A01 CSCL 228
A computer program is being developed to simulate the interaction of a plasma with a conducting disk partially covered by an insulator. The computer runs consider only charge sticking to the substrate. Results indicate that the current density drawn by the dielectric increases approximately linearly with voltage for conductor voltages between 5 volts and 250 volts. Author

N82-14273# Kansas Univ., Lawrence.

NUMERICAL SIMULATION OF PLASMA INSULATOR INTERACTIONS IN SPACE. PART 2: DIELECTRIC EFFECTS
Avail: NTIS HC A99/MF A01 CSCL 228
A model of the satellite charging at high altitudes (SCATHA P78-2) satellite was used to simulate the charging response of SCATHA at geosynchronous orbit. The model includes a description of the geometry, currents to exposed surface materials, and electrical connections on the spacecraft. The charging response of the vehicle to that predicted by the NASCAP model for the Day 87, 1979 eclipse event, in which the spacecraft charged to several kilovolts negative during a magnetospheric substorm are compared. Double Maxwellian representations of the plasma environment reproduce the charging response observed experimentally.

E.A.K.

N82-14276# Systems Science and Software, San Diego, Calif.

CHARGING OF A LARGE OBJECT IN LOW POLAR EARTH ORBIT
D. E. Parks and I. Katz In NASA, Lewis Research Center Spacecraft Charging Technol., 1980 Oct, 1980 p 979-989 refs (Sponsored in part by AFGL) (For primary document see N82-14213 05-18) (Contract NAG-321762)
Avail: NTIS HC A99/MF A01 CSCL 228
The charging of a large sphere subject to the environment encountered by the shuttle orbiter as it passes through the auroral regions in its low polar Earth orbit was investigated. The environment consists of a low temperature dense plasma and relatively intense (200 nu A/sq m) field aligned flux of energetic electrons (approximately 5 to 10 keV). The potential on a sphere in eclipse is presented as a function of the ratio kappa of the charging rate produced by precipitating electrons to the discharging rate produced by ram ions. It was found that a 5 meter conducting sphere charges to potentials of order 1 kilovolt for kappa approximately 2, even though a 0.5 meter sphere charges to less than 100 volts. It is concluded that the natural charging environment can induce large potentials (approximately 1 kilovolt) on the shuttle orbiter.

A.R.H.

N82-16117# Martin Marietta Corp., Bethesda, Md.

Avail: NTIS HC A11/MF A01 CSCL 228
The cryogenic fluid management experiment (CFME), designed to characterize subcritical liquid hydrogen storage and expulsion in the low-q space environment, is discussed. The experiment utilizes a fine mesh screen fluid management device to accomplish
gas-free liquid expulsion and a thermodynamic vent system to intercept heat leak and control tank pressure. The experiment design evolved from a single flight prototype to provision for multimission (up to 7) capability. A detailed design of the CFME, a dynamic test article, and dedicated ground support equipment were generated. All materials and parts were identified, and components were selected and specifications prepared. Long lead times were generated, All materials and parts were identified, and experiment interfaces were defined. Phase 1 ground and flight safety reviews were conducted. Costs were estimated for fabrication and assembly of the CFME, which will become the storage and supply tank for a cryogenic fluid management facility to investigate fluid management in space.

R.J.F.


Particular attention is given to comparison of the actual response of the SCATHA (Spacecraft Charging At High Altitudes) P7B-2 satellite with theoretical (NASCAP) predictions. Extensive comparisons for a variety of environmental conditions confirm the validity of the NASCAP model. A summary of the capabilities and range of validity of NASCAP is presented, with extensive reference to previously published applications. It is shown that NASCAP is capable of providing quantitatively accurate results when the object is appropriately represented and fall within the range of conditions for which NASCAP was intended. Three dimensional electric field effects play an important role in determining the potential of dielectric surfaces and electrically insulated conducting surfaces, particularly in the presence of artificially imposed high voltages. A theory for such phenomena is presented and applied to the active control experiments carried out in SCATHA, as well as other space and laboratory experiments. Finally, some preliminary work toward modeling large spacecraft in polar Earth orbit is presented. An initial physical model is presented including charge emission. A simple code based upon the model is described along with code test results.

Author


The ion computer code is designed to calculate charge exchange ion densities, electric potentials, plasma temperatures, and current densities external to a neutralized ion engine in R-Z geometry. The present version assumes the beam ion current and density to be known and specified, and the neutralizing electrons to originate from a hot-wire ring surrounding the beam orifice. The plasma treatment being resistive, with an electron relaxation time comparable to the plasma frequency. Together with the thermal and electrical boundary conditions described below and other straightforward engine parameters, these assumptions suffice to determine the required quantities. The ion code, written in ASCII FORTRAN for UNIVAC 1100 series computers, is designed to be run interactively, although it can also be run in batch mode. The input is free-format, and the output is mainly graphical, using the machine-independent graphics developed for the NASCAP code. The executable routine calls the code's major subroutines in user-specified order, and the code allows great latitude for restart and parameter change.

Author


NASA has contracted with General Dynamics to design and develop an advanced Centaur liquid rocket propulsion system for the Galileo and Solar Polar Interplanetary missions in 1985-86. The control of the Centaur while it resides in the Shuttle cargo bay must meet the STS safety requirements to be dual failure tolerant and mission critical functions. The demonstration of the integrity of this control system in the event of multiple component failures and worst-case time-phase asynchronicity among the system's computers is performed by a real-time computer simulation. The simulation emulates the control hardware, subsystem interfaces, and imbedded software processes, via-bye-wire, to provide accessibility for fault isolation. Observability is provided via graphics and diagnostic software. Verification is the product of Monte Carlo simulation analysis. (Author)

Author


A computer program is being developed to simulate the interaction of a plasma with a conducting disk. Two configurations are examined: (1) the conductor is a quarter-circle of the center of a larger dielectric disk, and (2) the conductive disk is covered by a dielectric disk to the same size with a circular hole in the center of the dielectric, exposing a region of conductor. Results of the electrostatic plasma simulation are presented both with and without secondary electron emission from the dielectric, characteristic curves and voltage profiles are included.

Author


Electron emission experiments on Applied Technology Satellite 5 using a thermal electron emitter are reported and analyzed. Operations in eclipse charging environments showed that electron emission could partially discharge a negatively charged satellite. Typical operations resulted in kilovolt potentials being reduced by hundreds of volts for a few tens of seconds, followed by a gradual recharging over a period of minutes. Equilibrium currents were modeled with a one-dimensional current balance model. Currents on the order of 1 microampere were found, significantly below emitter capabilities. Application of a three-dimensional, time-dependent computer model showed that differential charging on the solar arrays was limiting the emitted current, preventing the complete discharge of the satellite, and allowing it to recharge in spite of the electron emitter.

Author


This paper considers the charging of the Space Shuttle Orbiter by energetic particles of environmental origin and from emission by accelerators. The results indicate that precipitating electrons quickly induce large voltages. High voltages may also occur when onboard accelerators inject energetic beams into the high altitude plasma. A significant conclusion from electron beam experiments is that the rockets charged to positive potentials much less than anticipated from the theory of probes in a quiescent plasma. Elementary theories predict the large negative potentials observed by firing energetic ions and predict severe differential charging of the Orbiter. (Author)
It is suggested that small energy discharges of low differential voltage that are associated with internal buried charge may be an important mechanism by which stored electrostatic energy is released from dielectrics on board orbiting spacecraft. The evidence from space given by Stevens (1980) is noted, and the laboratory experimental evidence of Frederickson is cited to demonstrate that discharges occur under circumstances with no external potential drop. Previous calculations indicating that significant internal electric fields can exist in dielectrics charged with multiple-kilovolt electron beams under conditions involving little or no external potential drop are reviewed. Attention is given to the internal discharge mechanism of Meulenberg (1976), and new calculations suggesting that the space environment is conducive to the formation of the conditions required by this mechanism are presented. Experimental procedures for checking the suggestions made are developed.


A theory is presented for the steady-state potential of insulated surfaces near exposed high voltages. The term 'insulated surfaces' is used to mean either dielectric surfaces or electrically isolated metallic surfaces. The potential is bounded below by the zero of the material's I-V curve assuming total suppression of secondary electrons, and above by assuming total extraction of secondaries. Within these bounds, the material's surface potential is determined consistently with the solution to Poisson's equation external to the vehicle. The theory is compared with rocket experiments and with SCATHA satellite data. Also, an explanation is suggested for the observed 'snapover' of solar cell coverslips from near plasma ground potential to near the potential of positively biased interconnects with increasing bias voltage.
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.

N82-20240*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GEOMETRY AND STARVATION EFFECTS IN HYDRODYNAMIC LUBRICATION

David E. Brewe and Bernard J. Hamrock 1982 16 p refs Proposed for presentation at the 59th Meeting of the Propulsion and Energies Panel Sym, on Problems in Bearings and Lubrication, Ottawa, Canada, 31 May - 3 Jun. 1982; sponsored by AGARD Prepared jointly with Army Aviation Research and Development Command, St. Louis (NASA-TM-82857; E-1147; NAS 1.15:82857; AVRADCOM-TR-82-C-17) Avail: NTIS HC AO2/MF A01 CSCL 20D

Numerical methods were used to determine the effects of lubricant starvation on the minimum film thickness under conditions of a hydrodynamic point contact. Starvation was effected by varying the fluid inlet level. The Reynolds boundary conditions were applied at the cavitation boundary and zero pressure was stipulated at the meniscus or inlet boundary. A minimum-film-thickness equation as a function of both the ratio of dimensionless load to dimensionless speed and inlet supply level was determined. By comparing the film generated under the starved inlet condition with the film generated from the fully flooded inlet, an expression for the film reduction factor was obtained. Based on this factor a starvation threshold was defined as well as a critically starved inlet. The changes in the film pressure buildup due to changing the available lubricant supply are presented in the form of three dimensional isometric plots and also in the form of contour plots.  

Author

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AN INSIGHT INTO AUXILIARY PROPULSION REQUIREMENTS OF LARGE SPACE SYSTEMS


Electric and chemical propulsion systems' requirements for Large Space Systems (LSS) launchable by a single Shuttle are considered. Sets of generic LSS classes (ranging in size from 30 m to 250 m) are described and the source of the propulsion system is described. The propulsion systems are designed for the specific mission and the spacecraft is sized for the propulsion system. The results are used to size the Auxiliary Propulsion System (thrust level, fuel requirements, power processor, etc).

T.M.

N82-27358*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE SPACE SYSTEMS/PROPULSION INTERACTIONS


Material illustrating the presentations on and the conclusions of workshop panels considering the missions, systems requirements and operations, and systems design and integration is presented. For individual titles, see N82-27359 through N82-27379.

ORIGINAL PAGE IS OF POOR QUALITY

N82-27371*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SYSTEMS INTEGRATION

James P. Pelouch, Jr. In its Large Space Systems/Propulsion Interactions Jun. 1982 p 123-126 (For primary document see N82-27358 18-20) Avail: NTIS HC A12/MF A01 CSCL 22B

The workings of systems integration, its accomplishments, the influences of its character and potential for further reduction in the silicon's carbon and oxygen content of the LSS, propulsion and its influences on the STS, propulsion and performance is discussed. The task of systems integration is to define, understand, and account for interactions between the major systems on a space mission. The safety and propulsion systems and their reliability are outlined. E.A.K.

N82-29354*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A NEW STRATEGY FOR EFFICIENT SOLAR ENERGY CONVERSION PARALLEL-PROCESSING WITH SURFACE PLASMONS


An advanced concept for direct conversion of sunlight electricity, which aims at high efficiency by tailoring the conversion process to separate energy bands within the broad solar spectrum is introduced. The objective is to obtain a high level of spectrum-splitting without sequential losses or unique materials for each frequency band. In this concept, sunlight excites a spectrum of surface plasma waves which are processed in parallel on the same metal film. The surface plasmons transport energy to an array of metal-barrier-semiconductor diodes, where energy is extracted by inelastic tunneling. Diodes are tuned to different frequency bands by selecting the operating voltage and geometry, but all diodes share the same materials.  

Author

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EFFECTS OF PROCESSING AND DOPANT ON RADIATION DAMAGE REMOVAL IN SILICON SOLAR CELLS


Gallium and boron doped silicon solar cells, processed by ion-implantation followed by either laser or furnace anneal were irradiated by 1 MeV electrons and their post-irradiation recovery by thermal annealing determined. During the post-irradiation anneal, gallium-doped cells prepared by both processes recovered more rapidly and exhibited none of the severe reverse annealing observed for similarly processed 0.1 cm boron doped cells. Ion-implanted furnace annealed 0.1 cm boron doped cells exhibited the lowest post-irradiation annealing temperatures (200 C) after irradiation to 5 X 10^13 e^-/cm^2. The drastically lowered recovery temperature is attributed to the reduced oxygen and carbon content of the 0.1 cm silicon cells. Analysis based on defect properties and annealing kinetics indicates that further reduction in annealing temperature should be attainable with further reduction in the silicon's carbon and/or divacancy content after irradiation.  

Author

A description is presented of the results of a preliminary design study of a regenerative fuel cell energy storage system for application to future low-earth orbit space missions. The high energy density of the storage system is based on state-of-the-art alkaline electrolyte technology and incorporates dedicated fuel cell and electrolysis cell modules. In addition to providing energy storage, the system can provide hydrogen and oxygen for attitude control of the satellite and for life support. During the daylight portion of the orbit, the electrolysis module uses power provided by the solar array to generate H2 and O2 from the product water produced by the fuel cell module. The fuel cell module supplies electrical power during the dark period of the orbit.

G.R.


It is pointed out that spacecraft utilization projections for the 1980s and beyond show a trend toward extended lifetimes and larger electric power systems. The need for improved power management and energy transfer arising in connection with this trend has resulted in the conduction of a Solar Array Switching Power Management study. A description is presented of initial development work performed in the study, taking into account the characteristics for three mission classes. Attention is given to the manner LEO platform (250-kW average load), the unmanned GEO platform (50-kW average load), and an ion propulsion orbit transfer vehicle (50- to 250-kW load).

G.R.


Gallium Arsenide solar cells now equal or surpass the ubiquitous silicon solar cells in efficiency, radiation resistance, annealability, and in the capability for producing usable power output at elevated temperatures. NASA has developed a research and development program to capitalize on these advantages. In this paper we review the current state and future prospects for R&D in this promising solar cell material, and indicate the progress being made toward development of GaAs cells suitable for a variety of space missions. Results are presented from studies which demonstrate conclusively that GaAs cells can provide a net mission cost and weight savings for certain important mission classes.


The standard integrated circuit technology has been developed to design and fabricate new innovative planar multijunction solar cell chips for concentrated sunlight applications. This 1 cm x 1 cm cell consisted of several voltage generating areas connected in series. The internal voltages are 3.6 V and short-circuit currents of 90 mA were obtained at 80 AM1 sun. A dramatic increase in both short-circuit current and open circuit voltage with increased light levels was observed.


The subject interface measurements are described for the Ion Auxiliary Propulsion Office's P80-1 mission thruster, which is being used to study the space environment interaction of a medium-size ion thruster. The thruster and the diagnostic devices and the effects to be measured include: 1) quartz crystal microbalances to detect nonvolatile deposition due to thruster operation; 2) warm and cold solar cell monitors for nonvolatile and volatile (mercury) deposition; 3) neutral and ion collectors to characterize the low energy plasma ions; and 4) a probe to measure the spacecraft potential and thruster-generated electron currents to biased spacecraft surfaces. The diagnostics will also assess space environmental interactions of the spacecraft and thrusters. The diagnostic data will characterize thruster interfaces and provide data useful for future applications.


An analytical procedure for predicting thrust chamber life is developed. The hot-gas-wall ligaments separating the coolant and combustion gas are subjected to pressure loading and severe thermal cycling. The resulting stresses interact during plastic straining causing incremental bulging of the ligaments during each firing cycle. This mechanism of plastic ratcheting is analyzed and a method using a yield surface for combined bending and membrane loading developed for determining the incremental permanent deformation and progressive thinning near the center of the ligaments. Fatigue and tensile instability are analyzed as possible failure modes. Results of the simplified analyses compare favorably with available experimental data and field experience with metal-semiconductor field effect (Oxidy Freo High Conductivity) copper. They are also in reasonably good agreement with experimental data for NARloy Z, a copper-zirconium-silver alloy developed by the Rocketdyne Division of Rockwell International.


A model is presented that explains the flat-spot power loss phenomenon observed in silicon solar cells operating under deep space (low temperature, low intensity) conditions. Evidence is presented suggesting that the effect is due to localized metallurgical interactions between the silicon substrate and the contact metallization. These reactions are shown to be localized in regions in which the PN junction is destroyed and replaced with a metal-semiconductor-like interface. Results for the PN junction is destroyed and replaced with a metal-semiconductor-like interface. Results for the PN junction are presented along with a method of preventing the effect through the suppression of vacancy formation at the free surface of the contact metallization. Preliminary data indicating the effectiveness of a TiN diffusion barrier in preventing the effect are also given.


Proceeds made by NASA toward implementation of equipment for the conversion, management, and distribution of voltage power in space applications are reviewed. Work has been carried forward on components such as bipolar transistors, deep impurity semiconductors, conductors, dielectrics, magnetic devices, and rotary power transfer. Specific programs for the high voltage systems have included research on lightweight, low-cost conductors featuring graphite fibers containing electron donor materials for wires and cables with reduced mass and the conductivity of copper. Attention has also been given to the development of high-temperature, high-strength, high-conductivity materials for advanced space power systems. The use of gallium arsenide and other high performance materials has been investigated. Work has been carried forward on graphite fibers with reduced mass and high electrical conductivity. A semiconductor has been fabricated with a voltage of 1200 V at 100 A, with a gain of 10 and 0.5 microsecond rise time. A 25 kW transformer has also been built which performs at 20 kHz with an efficiency of 99.2%.

M.S.K.
LOW-THRUST LAP SENSITIVITY STUDY Final Report
L Schoeneman 12 Apr. 1982 285 p refs
(Contract NAS3-22665)
(NASA-CR-166521; NAS 1.26:166521) Avail NTIS
HC A12/MF A01 CSCL 21H

A comparison of the cooling requirements and attainable specific impulse performance of engines in the 445 to 4448N thrust class utilizing LOX/JP-1, LOX/Hydrogen and LOX/Methane propellants is presented. The unique design requirements for the regenerative cooling of low-thrust engines operating at high pressures (up to 6894 kPa) were explored analytically by comparing single cooling with both fuel and oxidizer, and dual cooling with both the fuel and the oxidizer. The effects of coolant channel geometry, channel length, and contraction ratio on the ability to provide proper cooling were evaluated, as was the resulting specific impulse. The results show that larger contraction ratios and smaller channels are highly desirable for certain propellant combinations.

LOW-THRUST CHEMICAL PROPULSION SYSTEM PROPELLANT EXPULSION AND THERMAL CONDITIONING STUDY EXECUTIVE SUMMARY
F. Merino, I. Wakabayashi, R. L. Pleasant, and M. Hill Apr. 1982 42 p refs
(Contract NAS3-22650)
(NASA-CR-165602; NAS 1.26:165602) Avail NTIS
HC A08/MF A01 CSCL 21C

The multiple discharge chamber of an electrostatic ion thruster is discussed. No reductions in discharge losses were obtained, despite repeated demonstration of anode potentials more positive than the bulk of the discharge plasma. The potential associated with biased anode operation was reduced as the magnetic integral above the biased anodes was increased. The hollow cathode is discussed. The experimental configuration of the Hall current thruster had a uniform field throughout the ion generation and acceleration regions. To obtain reliable ion generation, it was necessary to reduce the magnetic field strength, to the point where excessive electron backflow was required to establish ion acceleration. The theoretical study of ion acceleration with closed electron drift paths resulted in two classes of solutions. One class has the continuous potential variation in the acceleration region that is normally associated with a Hall current accelerator. The other class has an almost discontinuous potential step near the anode and of the acceleration region. This step increases a significant fraction of the total acceleration potential difference.

LOW-THRUST CHEMICAL PROPULSION SYSTEM PROPELLANT EXPULSION AND THERMAL CONDITIONING STUDY
F. Merino, I. Wakabayashi, R. L. Pleasant, and M. Hill Apr. 1982 218 p refs
(Contract NAS3-22650)
(NASA-CR-165604; GDC-NAS-82-001; NAS 1.26:165602) Avail NTIS
HC A08/MF A01 CSCL 21H

Preferred techniques for providing abort pressurization and engine feed system net positive suction pressure (NPSP) for low thrust chemical propulsion systems (LTPS) were determined. A representative LTPS vehicle configuration is presented. Analysis tasks include: propellant heating analysis; pressurant requirements for abort propellant dump; and comparative analysis of pressurization techniques and thermal subcoolers.

LOW-THRUST CHEMICAL PROPULSION SYSTEM PROPELLANT EXPULSION AND THERMAL CONDITIONING STUDY
F. Merino, I. Wakabayashi, R. L. Pleasant, and M. Hill Apr. 1982 218 p refs
(Contract NAS3-22650)
(NASA-CR-167841; GDC-NAS-82-002; NAS 1.26:167841) Avail NTIS
HC A10/MF A01 CSCL 21H

Thermal issues for satisfying engine net positive suction pressure (NPSP) requirements, and propellant expulsion systems for achieving propellant dump during a return-to-launch site (RTLS) abort were studied for LH2/LO2 and LCH4/LO2 upper stage propellant combinations. A state-of-the-art thermal conditioning system employing helium injection beneath the liquid surface shows the lowest weight penalty for LO2 and LCH4. A technology system incorporating a thermal subcooler (heat exchanger) for engine NPSP results in the lowest weight penalty for the LH2 tank. A preliminary design of two state-of-the-art and two new technology systems indicates a weight penalty difference too small to warrant development of a LH2 thermal subcooler. Analysis results showed that the LH2/LO2 propellant expulsion system is optimized for maximum dump line diameter, whereas the LCH4/LO2 system is optimized for minimum dump line diameter (LCH4) and maximum dump line diameter (LO2). The primary uncertainty is the accurate determination of two-phase flow rates through the dump system; experimentation is not recommended because this uncertainty is not considered significant.

(Grant NAG3-76)
(NASA-CR-167888; NAS 1.26:167888) Avail NTIS
HC A05/MF A01 CSCL 21C

Characteristics of several advanced electric propulsion systems are evaluated and compared. The propulsion systems studied are mass driver, rail gun, MPD thruster, hydrogen free radical thruster and mercury electron bombardment ion engine. These are characterized by specific impulse, overall efficiency, input power, average thrust, power to average thrust ratio and average thrust to dry weight ratio. Several important physical characteristics, such as dry system mass, mass accelerability, length, bore size and current pulse requirement are also evaluated in appropriate cases. Only the ion engine can operate at a specific impulse beyond 2000 sec. Rail gun, MPD thruster and free radical thruster are currently characterized by low efficiencies. Mass drivers have the best performance characteristics in terms of overall efficiency, power to average thrust ratio and average thrust to dry weight ratio. But, they can only operate at low specific impulses due to large power requirements and are extremely long due to limitations of driving current. Mercury ion engines have the next best performance characteristics while operating at higher specific impulses. It is concluded that, overall, ion engines have somewhat better characteristics as compared to the other electric propulsion systems.

(Grant NAG3-76)
(NASA-CR-167888; NAS 1.26:167888) Avail NTIS
HC A05/MF A01 CSCL 21C

A number of energy momentum anomalies are described that result from use of Abraham-Lorentz electromagnetic theory. These anomalies have their origin in the motion of charged bodies or current carrying conductors relative to the observer. The anomalies can be avoided by using the nonflow approach, based on internal energy of the electromagnetic field. The anomalies can also be avoided by using the flow approach, if all contributions to flow work are included. The general objective of this research is a fundamental physical understanding of electric and magnetic fields which, in turn, might promote the development of new concepts in electric space propulsion. The approach taken is to investigate quantum representations of these fields.
Tradeoffs between electric propulsion system mass ratio and transfer time from LEO to GEO were conducted parametrically for various thruster efficiency, specific impulse, and other propulsion parameters. A computer model was developed for performing orbit transfer calculations which included the effects of aerodynamic drag, radiation degradation, and occultation. The tradeoff results showed that thruster technology areas (or integrated propulsion should be directed towards improving primary thruster efficiency in the range from 1500 to 2500 seconds, and be continued towards reducing specific mass. Comparison of auxiliary propulsion systems showed large total propellant mass savings with integrated electric auxiliary propulsion. Stationkeeping is the most demanding on orbit propulsion requirement. At area densities above 0.5 sq m/kg, East-West stationkeeping requirements from solar pressure exceed North-South stationkeeping requirements from gravitational forces. A solar array pointing strategy was developed to minimize the effects of atmospheric drag at low altitude, enabling electric propulsion to initiate orbit transfer at Shuttle’s maximum cargo carrying altitude. Gravity gradient torques are used during ascent to sustain the spacecraft roll motion required for optimum solar array illumination. A near optimum cover glass thickness of 6 miles was established for LEO to GEO transfer.

Author


173 p refs [Contract NAS3-22661] (NASA-167889-Vol-2; NAS 1.20-167889-Vol-2; TRW-37255-6002-UT-Vol-2) Avail: NTIS HC A05/MF A01 CSCL 21C

The calculation approach is described for parametric analyses of candidate electric propulsion systems employed in LEO to GEO missions. Occultation relations, atmospheric density effects, and natural radiation effects are presented. A solar cell cover glass tradeoff is performed to determine optimal cover glass thickness. Solar array and spacecraft pointing strategies are described for low altitude flight and for optimum array illumination during ascent. Mass ratio tradeoffs versus transfer time provide direction for thruster technology improvements. Integrated electric propulsion analysis is performed for orbit boosting, inclination change, attitude control, stationkeeping, repositioning, and disposal functions as well as power sharing with payloads on orbit. Comparison with chemical auxiliary propulsion is made to quantify the advantages of integrated propulsion in terms of weight savings and concomitant launch cost savings.

Author

STUDY OF ELECTRICAL AND CHEMICAL PROPULSION SYSTEMS FOR AUXILIARY PROPULSION OF LARGE SPACE SYSTEMS. VOLUME 1: EXECUTIVE SUMMARY


The objective was to determine the direction auxiliary propulsion research and development should take to best meet upcoming needs. The approach used was to define the important electrical and chemical propulsion characteristics in terms of the demands that will be imposed by future spacecraft. Comparisons of these desired characteristics and capabilities with those presently available was then used to identify deficiencies. T.M.

Author


A82-11762

Attention is given to recent work at COMSAT Laboratories on improving silicon solar cell efficiencies and open-circuit voltages for both high (more than 1000 ohm-cm) and low (less than 1 ohm-cm) resistivities. It is noted that open-circuit voltages above 650 mV have been obtained for 0.1 ohm-cm cells and that air mass zero efficiencies of 12.5% have been measured from 4-mil 1,250 ohm-cm.

C.R.


The LeRC/Hughes 30-cm mercury ion thruster has been developed to a state of maturity such that it has become meaningful to formulate models for describing the performance characteristics of the major subassemblies. The thruster hollow cathode and the ion optics subassemblies have been investigated with this objective and conceptual, semiquantitative models have been formulated for relating lifetime and performance capabilities to design and operating parameters. This paper summarizes the investigations, discusses the factors considered for inclusion in the models, and describes the status of the models.

Author


As a consequence of endurance and structural tests performed on 900-series engineering model thrusters (EMT), several modifications in design were found to be necessary for achieving test goals. The modified thruster is known as the J-series EMT. The most important of these design modifications affect the accelerator grid, gimbal mount, cathode polepiece, and wiring harness. The paper discusses the design modifications incorporated, the condition(s) they corrected, and the characteristics of the modified thruster.

Author


The current status of Mass Driver Two, a linear synchronous motor for accelerating payloads or reaction mass, is discussed. Mass Driver Two combines all the essential elements of an operational mass driver with the exception of bucket recirculation and payload handling. These essential elements include: magnetic flight, vacuum environment, superconducting bucket coils, high acceleration (micrometric) capability, optical position sensing and electronic triggering, power circuitry similar to that of a flight article, and regenerative braking. Mass Driver Two is operated on a single shot basis. V.L.


Configurations of a typical mass driver reaction engine (MDRE) are presented and its use for delivery of payloads to geosynchronous orbit (GEO) from low earth orbit (LEO) is discussed. Basic rocket equations are developed for LEO to GEO round-trip missions using a
single exhaust velocity. It is shown that exhaust velocities in the 5-10 km/sec range (specific impulse of 500-1000 sec) are well suited for mass drivers, minimizing the overall cost of missions. Payload delivery rate fractions show that there is little to be gained by stretching out LEO to GEO transfer times from 90 to 180 days. It therefore pays to use the shorter trip time, approximately doubling the amount of delivered payload during any fixed time of use of the MDRE.

V.L.


The present inventory of developed bipropellant engines suitable for the orbit transfer of large space structures is based on the use of storable propellants (nitrogen tetroxide/monomethyl hydrazine). A range of engine sizes from 22N (5 lbf) to over 26,690N (6000 lbf) is available. These engines are capable of delivering specific impulse values from 2795 to 3089 N-s/kg (285 to 315 lbf-sec/lbm). A comparison is made between the attainable specific impulse of these demonstrated engines and future low-thrust engine designs which can utilize LOX/RP-1, LOX-methane, and LOX/hydrogen propellants. The requirements for cooling these small engines for multi-hour burns as well as the merits of operating at nonoptimum performance mixture ratios to improve cooling margins and reduce tank volumes are addressed in this paper. (Author)


Analytical studies to identify and then design a high performance scalable ion thruster operating with either argon or xenon for use in large space systems are presented. The magnetoelectrostatic containment concept is selected for its efficient ion generation capabilities. The iterative nature of the bounding magnetic fields allows the designer to scale both the diameter and length, so that the thruster can be adapted to spacecraft growth over time. Three different thruster assemblies (conical, hexagonal and hemispherical) are evaluated for a 12 cm diameter thruster and performance mapping of the various thruster configurations shows that conical discharge chambers produce the most efficient discharge operation, achieving argon efficiencies of 60-97% at 240-280 eV/ion. Preliminary testing of the large 30 cm thruster, using argon propellant, indicates a 35% improvement over the 12 cm thruster in mass utilization efficiency. Since initial performance is found to be better than projected, a larger 50 cm thruster is already in the development stage. N.B.
23 CHEMISTRY AND MATERIALS

(GENERAL)
Includes biochemistry and organic chemistry.

THERMODYNAMICS AND KINETICS OF THE SULFATION OF POROUS CALCIUM SILICATE
The sulfation of plasma sprayed calcium silicate in flowing SO2/air mixtures at 900 and 1000 C was investigated thermogravimetrically. Reaction products were analyzed using electron microprobe and X-ray diffraction analysis techniques, and results were compared with thermodynamic predictions. The percentage, by volume, of SO2 in air was varied between 0.036 and 10 percent. At 10 percent SO2 the weight gain curve displays a concave downward shoulder early in the sulfation process. An analytical model was developed which treats the initial process as one which decays exponentially with increasing time and the subsequent process as one which decays exponentially with increasing weight gain. At lower SO2 levels the initial rate is controlled by the reactant flow rate. At 1100 C and 0.036 percent SO2 there is no reaction, in agreement with thermodynamic predictions.

PERFORMANCE OF PTFE-LINED COMPOSITE JOURNAL BEARINGS
(NASA-TM-82779: E-1110) Avail: NTIS HC AO2/MF AO1 CSCL 131
Plain cylindrical journal bearings consisting of aramid fiber reinforced epoxy outer shells and glass fiber reinforced PTFE lubricating liners were evaluated. All materials in these bearings are electrically nonconductive; thus eliminating the problem of galvanic corrosion sometimes encountered with metal bearings installed in dissimilar metal mountings. Friction and wear characteristics were determined for loads, temperatures, and oscillating conditions that are typical of current airframe bearing applications. Friction and wear characteristics were found to be compatible with most airframe bearing requirements from -23 C to 121 C. Contamination with MIL H-5606 hydraulic fluid increased wear of the PTFE liners at 121 C, but did not affect the structural integrity of the aramid/epoxy composite. Author

INEXPENSIVE CROSS-LINKED POLYMERIC SEPARATORS
Polyvinyl alcohol (PVA), cross-linked chemically with aldehyde reagents, produces membranes which demonstrate oxidation resistance, dimensional stability, low ionic resistivity (less than 0.8 Ohms sq cm), low zincate diffusivity (less than 1 x 10 to the -7th mols/sq cm per min), and low zinc dendrite penetration rate (greater than 350 min) which make them suitable for use as alkaline battery separators. They are intrinsically low in cost, and environmental health and safety problems associated with commercial production appear minimal. Preparation, property measurements, and cell test results in Ni/Zn and Ag/Zn cells are described and discussed.

QUANTITATIVE SEPARATION OF TETRALIN HYDROPEROXIDE AND ITS DECOMPOSITION PRODUCTS
A method for the separation and analysis of tetrallin hydroperoxide and its decomposition products by high pressure liquid chromatography has been developed. Elution with a single, mixed solvent from a microbore column was employed. Constant response factors (internal standard method) over large concentration ranges and reproducible retention parameters are reported.

ORIGINAL PAGE IS OF POOR QUALITY
24 COMPOSITE MATERIALS
Includes laminates.

N82-11117# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

NOVEL IMPROVED PMR POLYMIDES

A series of N-phenylnadimide (PN) modified PMR polyimide composites reinforced with graphite fibers was investigated. The improved flow matrix resins consist of N-phenylnadimide (PN), monomethyl ester of 5-norbornene-2, 3-dicarboxylic acid (NE), dimethyl ester of 3,3', 4,4'-benzophenonetetracarboxylic acids (BTE), and 4,4' methylenedianiline (MDA). Five modified PMR resin systems were formulated by the addition of 4 to 20 mole percent N-phenylnadimide to the standard PMR-15 composition. These formulations and the control PMR resin were evaluated for rheological characteristics. The initial thermal and mechanical properties of the PN modified PMR and the control PMR/Cellon 6000 composites were determined. The results show that the addition of N-phenylnadimide to PMR-15 significantly improved the resin flow characteristics without sacrificing the composites properties. Concentrations of 4 and 9 mole percent PN appear to improve the thermoxidative stability of PMR composites.

A.R.H.

N82-14287# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

DURABILITY/LIFE OF FIBER COMPOSITES IN HYDROTHERMOMECHANICAL ENVIRONMENTS

Statistical analysis and multiple regression were used to determine and quantify the significant hydrothermomechanical variables which influence the tensile durability/life (cycle loading, fatigue) of boron-fiber/epoxy-matrix (B/E) and high-modulus-fiber/epoxy-matrix (HMS/E) composites. The use of the multiple regression analysis reduced the variables from fifteen, assumed initially, to six or less with a probability of greater than 0.999. The reduced variables were used to derive predictive models for compression an intralaminar shear durability/life of B/E and HMS/E composites assuming isoparametric fatigue behavior. The predictive models were subsequently generalized to predict the durability/life of graphite-fiber-reinforced generalized model is of simple form, predicts conservative values compared with measured data and should be adequate for use in preliminary designs.

B.W.

N82-16181# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

PREDICTION OF COMPOSITE HYGRAL BEHAVIOR MADE SIMPLE

A convenient procedure is described to determine the hygral behavior (moisture expansion coefficients and moisture stresses) of angleplied fiber composites using a pocket calculator. The procedure consists of equations and appropriate graphs for various (+ or - theta) ply combinations. The procedure predicted the stiffness and moisture expansion coefficients as functions of (+ or - theta) in order to simplify and expedite the use of the equations. The procedure is applicable to all types of balanced, symmetric fiber composites including unidirectional and interply hybrids. The versatility and generality of the procedure is illustrated using several step-by-step numerical examples.

Author

N82-21265# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

STRENGTH ADVANTAGES OF CHEMICALLY POLISHED BORON FIBERS BEFORE AND AFTER REACTION WITH ALUMINUM

In order to determine their strength potential, the fracture properties of different types of commercial boron fibers were measured before and after application of secondary strengthening treatments. The principal treatments employed were a slight chemical polish, which removed low strength surface flaws, and a heat treatment in oxygen, which contracted the fibers and thereby compressed intrinsic bulk flaws. Those fiber types most significantly strengthened were 200 to 400 micrometers (8 to 16 mil) diameter boron on tungsten fibers produced in a single chemical vapor deposition reactor. The slight polish increased average tensile strengths from 3.4 to 4.4 CN/m2 (600 to 640 ksi) and reduced coefficients of variation from about 15 to 3 percent. The oxygen heat treatment plus slight polish further improved average strengths to 5.6 CN/m2 (800 ksi) with coefficients near 3 percent. To ascertain whether these excellent properties could be retained after fabrication of B/Al composites, as produced and polished 203 micrometers (8 mil) fibers were thoroughly coated with aluminum, heat treated at 8/Al fabricating temperatures, and then tested in tension and flexure at room temperature. The pre-polished fibers were observed to retain their superior strengths to higher temperatures than the as-produced fibers even though both were subjected to the same detrimental reaction with aluminum.

Author

N82-21269# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

TUNGSTEN FIBER REINFORCED SUPERALLOY COMPOSITE HIGH TEMPERATURE COMPONENT DESIGN CONSIDERATIONS

Tungsten fiber reinforced superalloy composites (TFRS) are intended for use in high temperature turbine components. Current turbine component design methodology is based on applying the experience, sometimes semiempirical, gained from over 30 years of superalloy component design. Current composite component design capability is generally limited to the methodology for low temperature resin matrix composites. Often the tendency is to treat TFRS as just another superalloy or low temperature composite. However, TFRS behavior is significantly different than that of superalloys, and the high environment adds consideration not common in low temperature composite component design. The methodology used for preliminary design of TFRS components are described. Considerations unique to TFRS are emphasized.

Author

N82-21260# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

THERMAL DEGRADATION OF THE TENSILE PROPERTIES OF UNDIRECTIONALLY REINFORCED FP-A1203/EZ 33 MAGNESIUM COMPOSITES

The effects of isothermal and cyclic exposure on the room temperature axial and transverse tensile strength and dynamic flexural modulus of 35 volume percent and 55 volume percent FP-A1203/EZ 33 magnesium composites were studied. The composite specimens were continuously heated in a sand bath maintained at 350 C for up to 150 hours or thermally cycled between 50 and 250 C or 50 and 350 C for up to 3000 cycles. Each thermal cycle lasted for a total of six minutes with a hold time of two minutes at the maximum temperature. Results indicate...
to significant loss in the room temperature axial tensile strength and dynamic flexural modulus of composites thermally cycled between 50 and 350 °C, or of composites thermally heated to 350 °C for up to 150 hours from the strength and modulus data for the untreated, as fabricated composites. In contrast, thermal cycling between 50 and 350 °C caused considerable loss in both room temperature strength and modulus. Fractographic analysis and measurement of composite transverse strength and matrix hardness of thermally cycled and isothermally heated composites indicated matrix softening and fiber/matrix debonding due to void growth at the interface and crack arrest as likely causes of the strength and modulus loss behavior. S.L.

**REFERENCES**


The strength degradation of unidirectional fiber composites is investigated using a modified Calcein test method with thick and thin test specimens. The test data obtained are interpreted using the stress/strain curves from back-to-back strain gages, examination by scanning electron microscope, and predictive equations for distinct failure modes including fiber compression failure, Euler buckling, delamination, and flexure. The longitudinal compressive fracture is induced by a combination of delamination, flexure, and fiber tier breaks. No distinct fracture surface characteristics can be associated with unique failure modes. An equation is described which can be used to extract the longitudinal compression strength knowing the longitudinal tensile and flexural strengths of the same composite system. M.G.

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**ORIGINAL PAGE IS OF POOR QUALITY**
A gripping system has been developed for long-term, elevated temperature testing of composite materials. A gripping system can be used for long-term, elevated temperature testing of composite materials. Determinations from several coupons taken from different regions of a laminate are not accurate. At present fiber volume fractions are not directly measured but rather are calculated from the weight fraction and densities of the composite and fiber. Image analysis techniques can and should be applied to determine fiber volume fraction. However, several factors have to be considered in this connection. It is necessary to make many measurements of the local fiber area fractions, and the preparation of representative planar cross sections parallel to the fiber axis may be difficult.

G.R.


The basic chemistry, cure processes, properties, and applications of high temperature resins known as polyimides are surveyed. Condensation aromatic polyimides are prepared by reacting aromatic diamines with aromatic dianhydrides, aromatic tetracarboxylic acids, or with dialkyl esters of aromatic tetracarboxylic acids, depending on the intended end use. The first is for coatings or films while the latter are more suitable for polyimide matrix resins. Prepreg solutions are made by dissolving reactants in an apropos reactive solvent, and advances in the addition of a diamine on the double bond and radical polymerization of the double bond are noted to have yielded a final cure product with void-free characteristics. Attention is given to properties of the Skybond, Pyralin, and N-109B polyimide prepreg materials and characteristics of aging in the NP-150 polyimides. Finally, features of the NASA-developed PMR polyimides are reviewed.

M.S.K.


A gripping system has been developed for long-term, elevated temperature testing of composite materials at 15/Celanon 6000/ composites at elevated temperatures. The method involves compression of grit-blasted laminate between grit-blasted metal to give a non-slip interface for load transfer. Tensile testing at both 316 C and room temperature indicated that deformation was elastic to fracture and that the relationship in tensile properties for the uniaxial laminate is the same as that for several panels in addition, the tensile properties for uniaxial PMR 15/Celanon 6000/ are identical at 316 C and room temperature. For nominally 50% volume percent fiber, the elastic modulus is 119.6 GPa, the fracture stress is 1700 MPa, and the strain to fracture is about 1.15 percent. In addition, data are presented which indicate that the gripping system can be used for long-term, elevated temperature testing of composite materials.


PMR polyimide resin was prepared from 4,4'-methyleneedianiline, the dimethyl ester of 3,3',4,4'-biphenyltetraacrylsilicyclic acid and the monomethyl ester of 5-norbornene-2,3-dicarboxylic acid (NE). The NE group serves as a chain terminator and crosslinking site. PMR/Celanon 6000 composites were fabricated from resins having varying NE concentrations using two molding processes, and the laminates characterized in forced torsion. Glass transition temperatures (Tg) of the NE group containing systems were observed in the crosslinked resins, as compared with the literature value of 284 C reported for the uncrosslinked system. Tg did not decrease with decreasing NE concentrations over the range from 2.0 to 1.25 moles. Stiochiometry, within the range studied, showed little influence on shear properties; however, a 25% variation in matrix shear modulus with processing was observed. The G(12) values determined in forced torsion were in excellent agreement with those reported from tensile tests of +0-45 deg laminates. A branching and possible secondary crosslink mechanism is proposed based on dynamic mechanical behavior and infrared spectra of the composites.

M.S.K.


It is pointed out that the fiber volume fraction is probably the most important parameter influencing the properties of fibrinous composite materials. The present investigation is concerned with questions regarding the accurate determination of this parameter. It is found that an estimate of the fiber volume fraction based on determinations from several coupons taken from different regions of a laminate is not accurate. At present fiber volume fractions are not directly measured but rather are calculated from the weight fraction and densities of the composite and fiber. Image analysis techniques can and should be applied to determine fiber volume fraction. However, several factors have to be considered in this connection. It is necessary to make many measurements of the local fiber area fractions, and the preparation of representative planar cross sections parallel to the fiber axis may be difficult.

G.R.

A82-25336 • National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


A summary of research investigations on manufacturing methods, fabrication methods, and testing of high temperature composites for use in gas turbine engines is presented. Ceramic/ceramic, ceramic/ceramic/metal, and metal/metal composites are considered. Directional solidification of superalloys and eutectic matrix metal selection, and the preparation of test specimens are discussed.

J.D.

A82-31149 • National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


The Lewis Research Center is conducting a series of programs intended to identify, understand, and develop the application of composite materials to structural components for turbojet engines. A significant part of that effort is directed to establishing resistance, defect growth, and strain rate characteristics of composite materials over the wide range of environmental and load conditions found in commercial turbojet engine operations. Both analytical and experimental efforts are involved.

Author


Sensitivity analysis results are presented to assess the effects of a multitude of important parameters on fiber composite design and structural response. These results were obtained by using optimum design procedures in conjunction with sensitivity analyses. Sensitivity analyses were performed to assess the effects on composite optimum design and structural response of parameters such fiber transverse and shear properties, in situ matrix elastic and strength properties, correlation coefficients used in composite micromechanics and in combined strength predictions, processing variables, and perturbations of loading conditions. The results show that matrix properties, fiber volume ratio and small perturbations of the loading conditions have significant effects on certain composite structural responses. The remaining parameters have negligible effect.

(Author)

A82-12130 • Composites Horizons, Pomona, Calif.


Under certain conditions of combined fire and impact, graphite fibers are released to the atmosphere by graphite fiber composites. The retention of graphite fibers in these situations is investigated. Hybrid combinations of graphite tape and cloth, glass cloth and resin additives are studied with resin systems. Polyimide resins form the most resistant composites and resins based on simple
nvolac epoxies the least resistant of those tested. Great improvement in the containment of the stress was obtained in using graphite/glass hybrids, and nearly complete prevention of individual fiber release is made possible by the use of resin additives.

S.L.


ANALYSIS OF CRACK PROPAGATION AS AN ENERGY ABSORPTION MECHANISM IN METAL MATRIX COMPOSITES Interim Report, Sep. 1979 - Dec. 1980 Donald F. Adams and Daniel F. Murphy Feb. 1981 159 p refs (Grant NsG-3217)


The crack initiation and crack propagation capability was extended to the previously developed generalized plane strain, finite element micromechanics analysis. Also, an axisymmetric analysis was developed, which contains all of the general features of the plane analysis, including elasplastic material behavior, temperature-dependent material properties, and crack propagation. These analyses were used to generate various example problems demonstrating the inelastic response of, and crack initiation and propagation in, a boron/aluminum composite. B.W.

N82-15123*# Purdue Univ., Lafayette, Ind. Composite Materials Lab.

INDENTATION LAW FOR COMPOSITE LAMINATES S. H. Yang 31 Jul. 1981 47 p refs (Grant NsG-3185)

(NASA-CR-165460; CML-81-1) Avail: NTIS HC A03/MF A01 C5CL 11D

Static indentation tests are described for glass/epoxy and graphite/epoxy composite laminates with steel balls as the indenter. Beam specimens clamped at various spans were used for the tests. Loading, unloading, and reloading data were obtained and fitted into power laws. Results show that: (1) contact behavior is not appreciably affected by the span; (2) loading and reloading curves seem to follow the 1.5 power law; and (3) unloading curves are described quite well by a 2.5 power law. In addition, values were determined for the critical indentation, alpha sub cr which can be used to predict permanent indentations in unloading. Since alpha sub cr only depends on composite material properties, only the loading and unloading curve are needed to establish the complete loading-unloading-reloading behavior.

Author

N82-16176*# TRW, Inc., Cleveland, Ohio.


(Contract NAS3-20360)

(NASA-CR-165294; ER-7891-F) Avail: NTIS HC A03/MF A01 C5CL 11D

The fabrication of boron/aluminum fan blades for the F-404 Supersonic Cruise Research prototype engine by rapid air bonding of fully dense monolaptes is described, and the fan blades evaluated. The blade configuration is representative of a low-aspect ratio advanced design blade with super sonic capability. Dowel pull tests of this geometry, which substituted boron/ aluminum for titanium, suggested that excessive shear stresses were present in the root. A re-designed blade, incorporating a titanium tang and root, was fabricated by hot isostatic pressing. Blades appeared well bonded but the airfoil contained sizable areas of deformation and identification from the alumina grain used as a pressure transmitting medium. The use of hot isostatic pressing with a formed steel encapsulator should eliminate this problem.

J.D.H.


MICROMECHANICAL PREDICTIONS OF CRACK PROPAGATION AND FRACTURE ENERGY IN A SINGLE FIBER BORON/ALUMINUM MODEL COMPOSITE Donald F. Adams and Jayant M. Mahishi Feb. 1982 65 p refs

(Grant NsG-3217)

(NASA-CR-165650; UWME-DR-201-101-1) Avail: NTIS HC A04/MF A01 C5CL 11D

The axisymmetric finite element model and associated computer program developed for the analysis of crack propagation in a composite consisting of a single broken fiber in an annular sheath of matrix material was extended to include a constant displacement boundary condition during an increment of crack propagation. The constant displacement condition permits the growth of a stable crack, as opposed to the catastrophic failure in an earlier version. The finite element model was refined to respond more accurately to the high stresses and steep stress gradients near the broken fiber end. The accuracy and effectiveness of the conventional constant strain axisymmetric element for crack problems was established by solving the classical problem of a penny-shaped crack in a thick cylindrical rod under axial tension. The stress intensity factors predicted by the present finite element model are compared with existing continuum results.

S.L.


(Contract NAS3-20405)

(NASA-CR-165213; NAS 1.26:165213) Avail: NTIS HC A04/MF A01 C5CL 11D

Date for evaluating the effects of moisture and temperature on the integrity of fiber composite components was gathered. In particular, the static and cyclic performance of three composite laminates containing flaws was investigated at room temperature and at 422 K (350 F) in wet and dry conditions.

R.J.F.

N82-29363*# Hughes Aircraft Co., Torrance, Calif. Electron Dynamics Div.


(Contract NAS3-22505)

(NASA-CR-167809; NAS 1.26:167809; W-09170) Avail: NTIS HC A06/MF A01 C5CL 11D

Pyrolytic graphite promises to have significant advantages as a material for multistage depressed collector electrodes. Among these advantages are lighter weight, improved mechanical stiffness under shock and vibration, reduced secondary electron backstreaming for higher efficiency, and reduced outgassing at higher operating temperatures. The essential properties of pyrolytic graphite and the necessary design criteria are discussed. This includes the study of suitable electrode geometries and methods of attachment to other metal and ceramic collector component consistent with typical electrical, thermal, and mechanical requirements.

Author

N82-31448*# Douglas Aircraft Co., Inc., Long Beach, Calif.


(Contract NAS3-21763)

(NASA-CR-165448; NAS 1.26:165448) Avail: NTIS HC A07/MF A01 C5CL 11D

A reduced drag fairing for the afterbody enclosing the thrust reverser actuator on the DC-9 has been developed with Kevlar-49/ PMR-15 advanced composite material. The improved fairing reduces airplane drag 1% compared to the production baseline. Use of composites reduces weight 40% compared to an equivalent metal fairing. The Kevlar-49/PMR-15 advanced composite is an organic matrix material system that can be used at temperatures up to 500 F.

Author

A82-13403* # Fatigue of Ni-Al-Mo aligned eutectics at elevated temperatures, J. M. Tartaglia (Climax Molybdenum Company of Michigan, Ann Arbor, MI) and N. S. Stoloff (Rensselaer Polytechnic Institute, Troy, NY). Metallurgical Transactions A - Physical Metal-
The elevated-temperature mechanical behavior of two aligned eutectics (Ni-8.1 wt % Al-26.4 wt % Mo and Ni-6.3 wt % Al-31.2 wt % Mo) has been investigated utilizing monotonic and cyclic testing in vacuum. Tensile yield strength and fatigue resistance increased from 25 to 725 C, but then we were reduced at 825 C. The fatigue lives of specimens tested at 725 C decreased sharply with decreasing frequency. A shift from surface to internal crack initiation was observed upon increasing the test temperature from 725 to 825 C. Stage II crack propagation was observed at both temperatures, in contrast to stage I cracking at 25 C. The test results are compared to those for other nickel and cobalt-base aligned eutectics to show that the frequency effect on fatigue life is not limited to the Ni-Al-Mo system.

A82-31339


Mechanical tests were conducted on B/Al composites and, for comparison, FP-Al2O3/Al composites in the as-fabricated condition and following high-temperature isothermal exposure or thermal cycling. In B/Al (1100), isothermal exposure at 773 K for 125 hr reduced toughness, measured by the work of fracture, from 78 to 10 kJ/sq m, and a similar reduction was observed after equivalent thermal cycling. In B/Al (6061), the same thermal exposure reduced toughness from 44.5 to 8 kJ/sq m, but the effect of thermal cycling was less detrimental. In FP-Al2O3/Al, the work of fracture was insensitive to either type of treatment. Experimental results are interpreted in terms of matrix softening, interface properties, and fiber notch sensitivity.

V.L.

A82-46220


Aluminum metal matrix composites with a low cost fiber, e.g. SiC, provide for an attractive combination of high elastic modulus and longitudinal strengths coupled with a low density. SiC (volume fraction 0.65)-aluminum (6061) systems have been studied in order to optimize fiber composite strength and processing parameters. A comparison of two SiC/aluminum composites produced by AVCO and DWA is provided. Fiber properties are shown to alter composite tensile properties and fracture morphology. The room temperature tensile strengths appear to be insensitive to thermal exposures at 500 C up to 150 h. The elastic modulus of the composites also appears to be stable up to 400 C, however, variations in the loss modulus are apparent. The fracture morphology reflects the quality of the interfacial bond, fiber strengths and fiber processing.

(Author)
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.


The NASA Redox energy storage system is under active technology development. The hardware undergoing laboratory testing is either 310 sq. cm. or 929 sq. cm. (0.33 sq. ft. or 1.0 sq. ft. per cell active area with up to 40 individual cells connected to make up a modular cell stack. This size of hardware allows rather accurate projections to be made of the shunt power/pump power tradeoffs. The modeling studies that were completed on the system concept are reviewed along with the approach of mapping the performance of Redox cells over a wide range of flow rates and depths of discharge of the Redox solutions. Methods are outlined for estimating the pumping and shunt current losses for any type of cell and stack combination. These methods are applicable to a variety of pumping options that are present with Redox systems. The results show that a fully developed Redox system has acceptable parasitic losses when using a fixed flow rate adequate to meet the worst conditions of current density and depth of discharge. These losses are reduced by about 65 percent if variable flow schedules are used. The exact value of the overall parasitics will depend on the specific system requirements of current density, voltage limits, charge, discharge time, etc.


A method of making a membrane comprised of a hydrochloric acid-insoluble sheet of a mixture of a rubber and a powdered ion transport material is disclosed. The sheet can be present as a coating upon a flexible and porous substrate. These membranes can be used in oxidation-reduction electrical accumulator cells wherein the reduction of one member of a couple is accomplished by the oxidation of the other member of the couple on the other side of the cell and this must be accomplished by a change in chloride ion concentration in both sides. The method comprises preparing a mixture of fine rubber particles, a solvent for the rubber and a powdered ion transport material. The mixture is formed into a sheet and dried to produce a microporous sheet. The ion transport material includes particles ranging from about 0.01 to 10 microns in size and comprises from 20 to 50 volume percent of the microporous sheet.

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

N82-32277* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. CROSS-LINKED POLYVINYL ALCOHOL FILMS AS ALKALINE BATTERY SEPARATORS Dean W. Sheibley, Michelle A. Manzo, and Olga D. Gonzalez


Cross-linking methods were investigated to determine their effect on the performance of polyvinyl alcohol (PVA) films as alkaline battery separators. The following types of cross-linked PVA films are discussed: (1) PVA-dialdehyde blends post-treated with an acid or ac acid peroxide solution (two-step method) and (2) PVA-dialdehyde blends cross-linked during film formation (drying) by using a reagent with both aldehyde and acid functionality (one-step method). Laboratory samples of each cross-linked type of film were prepared and evaluated in standard separator screening tests. The pilot-plant batches of films were prepared and compared to measure differences due to the cross-linking method. The pilot-plant materials were then tested in nickel oxide - zinc cells to compare the two methods with respect to performance characteristics and cycle life. Cell test results are compared with those from tests with Celgard. Author


A laminated structural device that has the ability to change shape, position and resonant frequency without using discrete motive components is described. The laminate may be a combination of layers of an electrically conductive matrix material. A power source selectively places various levels of charge on the electrically conductive filaments imbedded in the respective layers to produce various configurations in a predetermined manner. The layers may be electrically conductive, having imbedded piezoelectrically active filaments. A combination of layers of electrically conductive matrix material may be laminated to layers of piezoelectric active material.


The characteristics inherent in Redox flow systems permit considerable latitude in designing systems for specific storage applications. The first of these characteristics is the absence of plating/deplating reactions with their attendant morphology changes at the electrodes. This permits a given Redox system to be operated over a wide range of depths of discharge and charge/discharge rates. The second characteristic is the separation of power generating components (stacks) from the energy storage components (tanks). This results in cost effective system design, ease of system growth via modularization, and freedom from sizing constraints so that the whole spectrum of applications, from utilities down to single residence can be considered. The final characteristic is the commonality of the reactant fluids which assures that all cells at all times are receiving reactants at the same state of charge. Since no cell can be out of balance with respect to any other cell, it is possible for some cells to be charged while others are discharging, in effect creating a DC to DC transformer. It is also possible for various groups of cells to be connected to separate loads, thus supplying a range of output voltages. Also, trim cells can be used to maintain constant bus voltage as the load is changed or as the depth of discharge increases. The commonality of reactant fluids also permits any corrective measures such as rebalancing to occur at the system level instead of at the single cell level.

54 ORIGINAL PAGE IS OF POOR QUALITY
The Cr(III) complexes in the NASA Redox Energy Storage System were isolated and identified as Cr(H2O)6(+3) and Cr(H2O)5Cl(+2) by ion-exchange chromatography and visible spectrophotometry. The cell reactions during charge-discharge cycles were followed by means of visible spectrophotometry. The spectral bands were resolved into component peaks and concentrations calculated using Beer’s Law. During the charge mode Cr(H2O)5Cl(+2) is reduced to Cr(H2O)5Cl(++) and during the discharge mode Cr(H2O)5Cl(+) is oxidized back to Cr(H2O)5Cl(+2). Both electrode reactions occur via a chloride-bridge inner-sphere reaction pathway. Hysteresis effects can be explained by the slow attainment of equilibrium between Cr(H2O)6(+3) and Cr(H2O)5Cl(+2).

Author


Experimental results are reported on the behavior of a rechargeable Na cell incorporating a Cr0.5V0.5S2 cathode. The cell operates at 120 °C and uses as electrolyte a 1M solution of NaI in 1,2-bis(methoxy-ethoxy)ethane (triglyme). The mechanism of discharge of Cr0.6V0.5S2 involves Na intercalation. It is found that the maximum rechargeable capacity of the Cr0.6V0.5S2 cathode is 0.7 eflow/mol. With an average cell voltage of 1.9 V, the theoretical specific energy of the cathode is 273 Whr/kg.

V.L.


The combustion performance of a rich lean combustor (developed for liquid fuel) for combustion of simulated coal gases ranging in heating value from 167 to 244 Btu/scf were assessed. The 244 Btu/scf gas is typical of the product gas from an oxygen blown gasifier, while the 167 Btu/scf gas is similar to that from an air blown gasifier. Although meeting NOx goals for the 167 Btu/scf gas, NOx performance of the rich lean combustor did not meet program goals with the 244 Btu/scf gas because of high thermal NOx, similar to expected from conventional lean burning combustors. The NOx emissions are a valuable guide to adequate fuel air mixing in the rich stage resulting from the design of the large central fuel nozzle delivering 71% of the total gas flow. NOx generation from NH3 was significant at ammonia concentrations significantly less than 0.5%. These levels occur depending on fuel gas cleanup system design. However, NOx yield from ammonia injected into the fuel gas decreased rapidly with increasing ammonia level, and is projected to be less than 10% at NH3 levels of 0.5% or higher.

S.L.


Characteristics of the premixed flame in uniform straining flow are investigated by the technique of activation-energy asymptotics. An inverse method is used, which avoids some of the restrictions of previous analyses. It is shown that this method recovers known results for adiabatic flames. New results for flames with heat loss are obtained, and it is shown that, in the presence of finite heat loss, straining can extinguish flames. A stability analysis shows that straining can suppress the cellular instability of flames with Lewis number less than unity. Strain can produce instability of flames with Lewis number greater than unity. A comparison shows a good agreement between theoretical deductions and experimental observations of Ishizuka, Miyakawa & Law (1981). (Author)


The combustion performance of a rich lean combustor (ROL) combustor was evaluated when operated on low and mid heating value gaseous fuels. Two synthesized fuels were prepared having lower heating values of 10.2 M.J/m. (274 Btu/scf) and 6.6 MJ/m (176 Btu/scf). These fuels were configured to be representative of actual fuels, being composed primarily of nitrogen, hydrogen, carbon monoxide, and carbon dioxide. A liquid fuel assist fuel nozzle was modified to inject both the gaseous fuels. The ROL combustor liner was not changed from the configuration used when the liquid fuels were tested. Both gaseous fuels were tested over a range of power levels from 50 percent load to maximum rated power of the DDN Model 570-K Industrial gas turbine engine. Exhaust emissions were recorded for four power levels at several rich zone equivalence ratios to determine NOx sensitivity to the rich zone operating point. For the mid Btu heating value gas, NOx emissions were all below 20 ppmc and smoke was below a 10 smoke number. For the mid heating value gas, NOx emissions were in the 50 to 70 ppmc range with the smoke below a 10 smoke number. (Author)

The secondary effects in turbulent combustion instabilities leading to flashback are investigated, including those due to buoyancy and contraction at the combustor outlet. Experiments were conducted in an oblong, rectangular cross-section combustion tunnel, where the effects of a bluff-body flames holder were generated by a rear-facing step behind a streamlined inlet nozzle. The experiments in which it was located at the top. Irrespective of the flow obstructions introduced downstream, the critical equivalence ratio for flashback was consistently lower with the step at the bottom, indicating that buoyancy was enhancing the growth of the recirculation zone that pushed the flame upstream and caused flashback. The contraction at the exit of the combustion chamber had a promoting influence on the process of vortex pairing, re-enforcing the influence of the trailing vortices over that of the recirculation vortex system, and thereby curbing the tendency to flashback. Provided that the flow velocity was low, however, the characteristic features of combustion instabilities leading to flashback in the absence of contraction could still be established in its presence.


A program has been carried out to develop a catalytic reactor capable of operation in environments representative of those anticipated for advanced automotive gas turbine engines. A reactor consisting of a graded cell honeycomb support with a combination of noble metal and metal oxide catalyst coatings was built and successfully operated for 1000 hr. At an air preheat temperature of 740 K and a propane/air ratio of 0.02 by mass, the adiabatic flame temperature was held at about 1700 K. The graded cell monolithic reaction measured 5 cm in diameter by 10.2 cm in length and was operated at a reference velocity of 14.0 m/s at 1 atm. Measured NOX levels remained below 5 ppm, while unburned hydrocarbon concentrations registered far more than the maximum in ppm levels being nominally below 20 ppm.


Fuel and lubricant deposits on solid surfaces, though often of similar visual appearance, differ in composition, depending on the nature of the deposit formers and the circumstances of deposition. To help establish these relations an Infrared Emission Fourier Polarization Microspectrophotometer was constructed to record infrared spectra from the deposits on their original support. By focusing on small aggregates with a reflecting microscope objective and by discriminating against the randomly polarized blackbody radiation with a rotating polarizing filter phase-locked to an amplifier, excellent Fourier emission spectra of polarized bands could be obtained. In many instances, the microscope objective was adequate without the polarizer. The analysis was calibrated against a very thin film of polyethylene terephthalate attached to a highly reflective aluminum mirror on the same position. (Author)


Premixed, turbulent flames are important in connection with investigations of fundamental, turbulent-acting-flow processes and the study of practical combustion devices, such as spark ignition engines and premixed, prevaporized gas turbine combustors which burn premixed reactants. The considered investigation is concerned with the application of laser induced Rayleigh scattering to measure the gas density in premixed, methane-air flames. A description is provided of the results of density and velocity measurements in an optically, premixed methane-air flame stabilized in grid turbulence of low Reynolds number. It is found that where applicable, Rayleigh scattering can be used to good advantage to measure molecular number densities. Mean and rms density results show that the mean flame thickness with axial distance but that the maximum in rms does not change appreciably.


Problems related to combustion generated polution are explore, taking into account the mechanisms of NO formation from nitrogen compounds in hydrogen flames studied by laser fluorescence, the structure and similarity of nitric oxide production in turbulent diffusion flames, the effect of steam addition on NO formation, and the formation of NO2 by laminar flames. Other topics considered are concerned with propellant combustion, fluidized bed combustion, the combustion of droplets and sprays, premixed flame studies, fire studies, and flame stabilization. Attention is also given to coal flammability, chemical kinetics, turbulent combustion, soot, coal combustion, the modeling of combustion processes, combustion diagnostics, detonations and explosions, ignition, internal combustion engines, combustion studies, and furnaces.


Results of measurements of time-averaged chemiluminescence emissions from CH, OH, and CO2 and of Na tracer emissions along lateral lines-of-sight through a cylindrical premixed swirl-stabilized combustor are reported. Assuming axial symmetry and small optical depth, raw data are inverted to obtain local emission levels from these species as a function of radius. The chemiluminescence emissions are interpreted as signatures of chemical reaction and used in determining the regions of reactions and heat release in the combustor. The data are compared with composition and velocity data obtained in the combustor for identical operating conditions. The results demonstrate that reaction occurs in a relatively narrow, turbulent flame-like combustion zone which begins upstream of the time-averaged location of the swirl-induced recirculation zone and propagates round and laterally away from the recirculation zone into the unburned gas.


The local extinction of Bunsen flame tip and edges of hydrocarbon/air premixtures has been experimen tally investigated using a variety of burners. Results show that, while for both rich propane/air and butane/air mixtures tip opening occurs at a constant fuel equivalence ratio of 1.44 and is therefore independent of the intensity, uniformity, and configuration of the approach flow, for rich methane/air flames burning is intensified at the tip and therefore opening is not possible. These results substantiate the concept and dominance of the diffusional stratification mechanism in causing extinction, and clarify the theoretical predictions on the possible opening of two-dimensional flame wedges. (Author)


Experimental results of exit plane NO/NO(x) emissions from atmospheric monodisperse fuel spray combustion are presented. Six different hydrocarbon fuels were studied: isopropanol, n-propanol, n-octane, iso-octane, n-heptane and methanol. The results indicate an optimum droplet size for minimizing NO/NO(x) production for all of the test fuels. At the optimum droplet diameter, reductions in NO/NO(x) relative to the NO(x) occurred at droplet diameters of 55 and 48 microns respectively, as compared to a 50-micron droplet size for isopropanol. The occurrence of the minimum NO(x) point at different droplet diameters for the different fuels appears to be governed by the extent of prevaporization of the fuel in the spray, and is consistent with theoretical calculations based on each fuel's physical properties. Estimates are also given for the behavior of heavy fuels and of polydisperse fuel sprays in shifting the minimum NO(x) point compared to a monodisperse situation. (Author)


The extinction limits of lean propane/air mixtures in the stagnation-point flow of a flat surface were mapped as functions of the surface temperature and the mixture concentration, velocity, and temperature. The maximum flame temperatures and the flame locations were also measured. The results show that the extinction limits are extremely insensitive to the nature of the surface, which can be heated to 1000 °C. On the other hand preheating the gas mixture increases the flame temperature by an almost equal amount and therefore significantly extends the extinction limits. It is also found that at extinction the maximum flame temperatures and the flame locations, which when scaled with the velocity gradient, assume almost constant values independent of the other system variables investigated. (Author)


Flame configurations, flame-front cellular instability, and extinction of propane/air mixtures in the stagnation-point flow are experimentally studied for their dependence on downstream heat loss, preferential diffusion, and flame stretch. Boundaries for lean- and rich-limit extinction, stabilization of corrugated flames, and local extinction caused by sharp curvatures are mapped for varying propane concentrations and freestream velocities. Flame location and temperature at extinction are determined as functions of stagnation surface temperature, extent of preheating, propane concentration, and freestream velocity. Results substantiate the theoretical predictions of the different extinction modes for lean and rich flames in the absence of downstream heat loss, and yield useful insight on the extinction characteristics when finite downstream heat loss does exist. It is further shown that flame-front instability occurs only for rich mixtures in accordance with preferential diffusion considerations, and that flame stretch has a stabilizing effect such that flame-front instability is completely inhibited before the onset of extinction. (Author)


(Previously announced in STAR as N81-15029)


A description is presented of the results of a research program directed at an improved understanding of condensate deposition rate phenomena in combustion systems. The conducted experiments make use of real-time optical laser reflectance-interference-polarization techniques in flame environments. The obtained new data and the results of previous gravimetric experiments are employed as a basis for the development of a comprehensive convective diffusion deposition theory, taking into account the assumption of a multicomponent vapor or multisize class particles 'source-free' boundary layer. The theory makes it possible to predict self-consistent salt/ash/soot deposition rate predictions over a wide variety of environmental conditions.

G.R.
26 METALLIC MATERIALS

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

N82-10195$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

CREEP SHEAR BEHAVIOR OF THE OXIDE DISPERSION STRENGTHENED SUPERALLOY MA 6000E

The shear rupture life of the oxide dispersing strengthened (ODS) superalloy MA 6000E was determined at 650 and 760 °C. The rupture life at 650 °C was 550,000 hours, and at 760 °C was 250,000 hours. The rupture life is about 5% higher than the rupture life of conventional cast superalloy B-1900+Hf.

Author

N82-11182$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TRENDS IN HIGH TEMPERATURE GAS TURBINE MATERIALS

High performance - high technology materials are among the technologies that are required to allow the fruition of such improvements. Materials trends in hot section components are reviewed, and materials for future use are identified. For combustors, vanes, and disc a, common trend of using multiple material construction to permit advances in technology is identified.

N82-11183$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UNIVERSAL BONDING ENERGY RELATIONS IN METALLIC ADHESION

Scaling relations which map metallic adhesive binding energy onto a single universal binding energy curve are discussed in relation to adhesion, friction, and wear in metals. The scaling involved normalizing the energy to the maximum binding energy and normalizing distances by a suitable combination of Thomas-Fermi screening lengths. The universal curve was found to be accurately represented by $E^* (A^*) = -(1+\beta A^*) \exp (-A^*)$ where $E^*$ is the normalized binding energy, $A^*$ is the normalized separation, and $\beta$ is the normalization constant. Calculated cohesive energies of potassium, barium, copper, molybdenum, and samarium were also found to scale by similar relations, suggesting that the universal relation may be more general than for the simple free electron metals.

N82-11184$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FAILURE ANALYSIS OF A TOOL STEEL TORQUE SHAFT

A low design load drive shaft used to deliver power from an experimental exhaust heat recovery system to the crankshaft of an experimental diesel truck engine failed during highway testing. An independent testing laboratory analyzed the failure by routine metallography and attributed the failure to fatigue induced by a banded microstructure. Visual examination by NASA of the failed shaft plus the knowledge of the torsional load that it carried pointed to a 100 percent ductile failure with no evidence of fatigue. Scanning electron microscopy confirmed this. Torsional test specimens were produced from pieces of the failed shaft and torsional overload testing produced identical failures to that which had occurred in the truck engine. This pointed to a failure caused by a high overload and although the microstructure was defective it was not the cause of the failure.

A.R.H.

N82-12216$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELEVATED TEMPERATURE FATIGUE TESTING OF METALS
Marvin H. Hirschberg in AGARD Fatigue Test Methodology Oct. 1981 18 p refs (For primary document see N82-13274 04-31) Avail: NTIS HC A12/MF A01

PROGRESS IN PROTECTIVE COATINGS FOR AIRCRAFT GAS TURBINES: A REVIEW OF NASA SPONSORED RESEARCH

Problems associated with protective coatings for advanced aircraft gas turbines are reviewed. Metallic coatings for preventing titanium fires in compressors are identified. Coatings for turbine section are also considered. Ductile aluminum coatings for protecting internal turbine-blades cooling passage surface are also identified. Composite modified external overlay McCIAIY coatings deposited by low-pressure plasma spraying are found to be better in surface protection capability than vapor deposited MCCIAIY coatings. Thermal barrier coating (TBC) studies are presented. The design of a turbine airfoil is integrated with a TBC, and computer-aided manufacturing technology is applied.

S.L.

N82-13281$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELEVATED TEMPERATURE FATIGUE TESTING OF METALS
Marvin H. Hirschberg in AGARD Fatigue Test Methodology Oct. 1981 18 p refs (For primary document see N82-13274 04-31) Avail: NTIS HC A12/MF A01

N82-17335$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

REVIEW OF NASA PROGRESS IN THERMAL BARRIER COATINGS FOR STATIONARY GAS TURBINES

Ceramic thermal barrier coatings for industrial/utility gas turbines were investigated. In burner rig tests of a zirconia yttria/nickel chromium aluminum yttrium ZrO2-12w/Y2O3/ NiCrAlY coating system on air cooled superalloy specimens, ceramic coating life (spallation) was found to be sensitive to Na and V concentration in the fuel. The locations of coating spallation correspond to areas where combustion products were predicted to condense. Three new thermal barrier coating systems were tested. These are based on calcium silicate, ZrO2-8w/Y2O3, and a MgO-NiCrAlY cermet. The spall resistance can be increased by reducing the ceramic layer thickness from 0.038 to 0.013 cm and by the use of an oxidation/corrosion resistant bond coat.

S.L.
EFFECT OF ALUMINUM PHOSPHATE ADDITIONS ON FRICTION AND WEAR OF METALLIC GLASSES

Thomas P. Jacobson and Stanley H. Young

Mar. 1982 18 p refs

NASA-TP-1985; NAS 1.60:1985; E-638) Avail: NTIS

Friction and wear experiments were conducted with elemental iron exposed to various corrosive media including two acids, base, and a salt. Studies involved various concentrations of nitric and sulfuric acids, sodium hydroxide, and sodium chloride. Load and reciprocating sliding speed were kept constant. With the base NaOH an increase in normality beyond 0.01 N resulted in a decrease in both friction and wear. X-ray photoelectron spectroscopy (XPS) analysis of the surface showed a decreasing concentration of ferric oxide (Fe2O3) on the iron surface with increasing NaOH concentration. With nitric acid (HNO3) friction decreased in solutions to 0.05 N, beyond which no further change in friction was observed. The concentration of Fe2O3 on the surface continued to increase with increasing normality. XPS analysis revealed the presence of sulfates in addition of Fe2O3 on surfaces exposed to sulfuric acid and iron chlorides but no sodium on surfaces exposed to NaCl.

Author

EB2-21298
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECT OF ALUMINUM PHOSPHATE ADDITIONS ON COMPOSITION OF THREE-COMPONENT PLASMA-SPRAYED SOLID LUBRICANT

Thomas P. Jacobson and Stanley H. Young

Mar. 1982 18 p refs

NASA-TP-1990; E-713; NAS 1.60:1990) Avail: NTIS

Three concentrations of AlPO4 were added to the mixtures: 1.25, 2.5, and 6.25 percent by weight. Analysis showed that 1.25 wt% AlPO4 yielded a CaF2 deficiency, 2.6 wt% kept the powder mixture during the plasma-spraying procedure, and 6.25 percent as 35NiCr-35Ag-3OCaF2. To minimize segregation of nonmetals, the lubricating coating, NASA LUBE PS106, specified by weight 5 x 10 to the 17th power ions/sq cm was used. Small reductions within the wear scar of an implanted rider after 20 microns of a small area of the laser treated sample varied from 35 to 75 W/sq mm, while the scanning speed was about 80 cm per minute. In cyclic oxidation tests, the specimens were heated in a burner rig for 8 minutes and for 3 minutes. It is indicated that the laser treated specimens had the same life as the untreated ones. However, in corrosion tests, the specimens were heated in a burner rig for 8 minutes and for 3 minutes. It is indicated that the laser treated specimens had the same life as the untreated ones. However, in corrosion tests, in which the burner rig flame contained 100 PPM sodium, fuel equivalent, the laser treated samples exhibit nearly a fourfold life improvement over that of the reference samples varied. In both tests, the lives of the samples inversely with the thickness of the laser melted layer of zirconia.

E.A.K.

EB2-21300
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
FRICITION WEAR AND AUGER ANALYSIS OF IRON IMPLANTED WITH 1.5-MeV NITROGEN IONS

John Ferrante and William R. Jones, Jr.

Mar. 1982 14 p refs


The effect of implantation of 1.5-MeV nitrogen ions on the friction and wear properties of iron was studied in a pin-on disk apparatus. An implantation dose of 5 x 10 to the 17th power ions/sq cm was used. Small reductions in initial and steady-state wear rates were observed for nitrogen-implanted iron riders as compared with unimplanted controls. Auger electron spectroscopy revealed a subsurface Gaussian nitrogen distribution with a maximum concentration of 15 at. % at a depth of 8 x 10 to the -7th m. A similar analysis within the wear scar of an implanted rider after 20 microns of wear yielded only background nitrogen concentration, thus giving no evidence for diffusion of nitrogen beyond the implanted range.

Author

EB2-21301
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
FRICITION AND SURFACE CHEMISTRY OF SOME FERROUS-BASE METALLIC GLASSES

Kazuhisa Miyoshi and Donald H. Buckley

Mar. 1982 18 p refs


Friction and wear experiments were conducted with elemental iron exposed to various corrosive media including two acids, base, and a salt. Studies involved various concentrations of nitric and sulfuric acids, sodium hydroxide, and sodium chloride. Load and reciprocating sliding speed were kept constant. With the base NaOH an increase in normality beyond 0.01 N resulted in a decrease in both friction and wear. X-ray photoelectron spectroscopy (XPS) analysis of the surface showed a decreasing concentration of ferric oxide (Fe2O3) on the iron surface with increasing NaOH concentration. With nitric acid (HNO3) friction decreased in solutions to 0.05 N, beyond which no further change in friction was observed. The concentration of Fe2O3 on the surface continued to increase with increasing normality. XPS analysis revealed the presence of sulfates in addition of Fe2O3 on surfaces exposed to sulfuric acid and iron chlorides but no sodium on surfaces exposed to NaCl.

Author

EB2-22346
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF LASER GLAZED ZrO2 TBCs IN CYCLIC OXIDATION AND CORROSION BURNER TEST RIGS

I. Zaplatynsky

Apr. 1982: sponsored by American Vacuum Society

NASA-TM-82830; E-1195; NAS 1.15:82830) Avail: NTIS

The performance of laser glazed zirconia thermal barrier coatings (TBCs) was evaluated in cyclic oxidation and cyclic corrosion tests. Plasma sprayed zirconia coatings of two thicknesses were partially melted with a CO2 laser. The power density of the focused laser beam was varied from 35 to 75 W/sq mm, while the scanning speed was about 80 cm per minute. In cyclic oxidation tests, the specimens were heated in a burner rig for 8 minutes and for 3 minutes. It is indicated that the laser treated specimens had the same life as the untreated ones. However, in corrosion tests, the specimens were heated in a burner rig for 8 minutes and for 3 minutes. It is indicated that the laser treated specimens had the same life as the untreated ones. However, in corrosion tests, in which the burner rig flame contained 100 PPM sodium, fuel equivalent, the laser treated samples exhibit nearly a fourfold life improvement over that of the reference samples varied. In both tests, the lives of the samples inversely with the thickness of the laser melted layer of zirconia.

E.A.K.

EB2-22347
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
METHOD AND APPARATUS FOR COATING SUBSTRATES USING LASERS Patent Application


A method for coating substrates using lasers is described. Metal substrates, preferably of titanium and titanium alloys, are coated by alloying or forming TiN on a substrate surface. In the process a laser beam strikes the surface of a moving substrate in the presence of purified nitrogen gas. A small area of the substrate surface is quickly heated, without melting, and reacts with the nitrogen to form a solid solution. This process of alloying or forming TiN, which occurs by diffusion of nitrogen into the titanium, is reviewed.

Author
EFFECT OF OXIDE FILMS ON HYDROGEN PERMEABILITY

The effect of oxide films developed in situ from CO/CO₂ mixtures on hydrogen permeability in refractory materials was investigated. The permeability of cubic, tetragonal, and monoclinic phases of zirconium oxide and its partially stabilized form was measured, and the effects of sputtering and implantation with nitrogen ions were studied. M.G.

IMPROVED THERMAL BARRIER COATING SYSTEM Patent Application

A high temperature oxidation resistant thermal barrier coating system for nickel-, cobalt-, or iron-base alloy substrates is described. An inner metal bond coating contacts the substrate, and a thermal barrier coating covers the bond coating. NiCrAlY, and CoCrAlY alloy are satisfactory as bond coating compositions, which are 6-18% chromium, 6-18% aluminum, and 0.05 to 1.5% yttrium or 0.05 to 3.0% ytterbium. The coatings containing yttrium are preferred over those containing zirconium. An outer thermal barrier coating of partially stabilized zirconium oxide (zirconia) which is between 6% and 8% by weight, of yttrium oxide (yttria) covers the bond coating. Partial stabilization provides a material with superior durability. Partially stabilized zirconia consists of mixtures of cubic, tetragonal, and monoclinic phases. NASA

PROCEDURE FOR DETERMINING THE HYDROGEN PERMEABILITY OF REFRACTORY MATERIALS Patent Application

The procedure for determining the hydrogen permeability of refractory materials was developed. The effects of oxide films and sputtering on hydrogen permeability were studied. The permeability of cubic, tetragonal, and monoclinic phases of zirconium oxide and its partially stabilized form was measured, and the effects of sputtering and implantation with nitrogen ions were studied. M.G.

EFFECT OF OXIDE FILMS ON HYDROGEN PERMEABILITY OF METALS WITH THEIR FRICTION PROPERTIES

The relation between the frictional behavior and the hydrogen permeability of metals was investigated. The hydrogen permeability decreased rapidly with increasing temperature and increased with increasing pressure. The segregation of contaminants may be responsible for the friction behavior. Author

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through a nozzle resulting in a small partial pressure of about 0.5% to 2.5% during the first two minutes of deposition. The flow of nitrogen is then stopped, and the sputtering ambient is reduced to pure argon through a nozzle without interrupting the sputtering process. When nitrogen is deliberately introduced during the crucial interface formation, some of the titanium at the interface reacts to form titanium nitride while the metal of the substrate also forms the nitride. These two nitrides atomically mixed together in the interfacial region act to more strongly bind the growing apparatus in a vacuum chamber. Nitrogen was readily contained, exhibiting no measurable loss by sputtering process, reduced to pure argon through a nozzle without interrupting the 0.5% to 2.5% during the first two minutes of deposition. The flow of nitrogen is then stopped, and the sputtering ambient is reduced to pure argon through a nozzle without interrupting the sputtering process.

A thin sputtered film is discussed which exhibits improved adherence to a substrate and has improved friction and wear characteristics. Each substrate is placed directly below a titanium carbide target of a commercial radiofrequency diode apparatus in a vacuum chamber. Nitrogen is bled into the system through a nozzle resulting in a small partial pressure of about 0.5% to 2.5% during the first two minutes of deposition. The flow of nitrogen is then stopped, and the sputtering ambient is reduced to pure argon through a nozzle without interrupting the sputtering process.

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The effect of sterilization gamma irradiation on the friction and wear properties of ultra-high molecular weight polyethylene (UHMWPE) sliding against stainless steel 316L in dry air at 23°C is investigated. The results are used in the development of artificial joints which are to surgically replace diseased human joints. A pin-on-disk sliding friction apparatus is used, a constant sliding speed of 0.061 m/s is maintained, a normal load of 1 kgf is applied with dead weight, and the irradiation dose levels are (1) 0.5 Mrad. Wear and friction data and conditions for each of the ten tests are summarized, and include: (1) wear volume as a function of the sliding distance, (2) incremental rate, and (3) coefficient of friction as a function of the sliding distance. It is shown that the friction and wear properties of UHMWPE are not significantly changed by the irradiation doses of 2.5 and 5.0 Mrad, (2) the irradiation increases the amount of insoluble gel as well as the amount of linear molecular weight material, and (3) after run-in the wear rate is either steady or gradually decreases as a function of the sliding distance.

K.S.


The thermal fatigue resistance of several oxide dispersion strengthened (ODS) alloys has been evaluated through cyclic exposure in fluidized beds. The ODS nickel-base alloy MA 754 and ODS iron-base alloy MA 965 as well as four experimental ODS Ni-16Cr-4.5Al base alloys with and without Ta additions were examined. Both bare and coated alloys were subjected to up to 6000 cycles where each cycle consisted of a 3 minute immersion in a fluidized bed at 1100°C followed by a 3 minute immersion in a bed at 650°C. Testing revealed that the thermal fatigue resistance of the ODS nickel-base alloys was excellent and about equal to that of directionally solidified superalloys. However, the thermal fatigue resistance of MA 965 was found to be poor. Metallographic examination of tested specimens revealed that, in general, the post-test microstructures can be rationalized on the basis of previous diffusion, mechanical property, and oxidation studies. (Author)


Several oxide dispersion strengthened (ODS) alloys have been tested for cyclic, long-term, high gas-velocity oxidation to 1100°C and hot corrosion at 900°C. Both nominally Ni-16Cr-4.5AI and Fe-20Cr-4.5AI ODS alloys were subjected to up to about 2500 cycles, where each cycle consisted of 1 hr in a hot, Mach 0.3, combusted gas stream followed by a 3-min quench in an ambient temperature, Mach 0.3 air blast. For comparison to existing technology, a coated superalloy was simultaneously tested. The ODS iron alloy exhibited nearly superior behavior, surviving 3000 oxidation and 2300 hot corrosion cycles essentially unscathed. While the ODS nickel alloys exhibited adequate oxidation resistance, the long-term hot corrosion resistance could be marginal, since the best life for such alloys under these conditions was only about 1100 cycles. However, the hot corrosion resistance of the ODS Ni-base alloys is excellent in comparison to that of traditional superalloys.


Crystallographic and elastic moduli data are presented which document the degree of texture in several oxide dispersion-strengthened (ODS) nickel-base alloys. The existence of strong crystallographic textures in such multicrystalline alloys is considered important, since the small angle grain boundaries may be partially responsible for creep threshold stresses. Gleiter (1979) has shown that ideal, low energy boundaries will act as vacancy sources only when the applied stress is larger than a threshold stress, while large angle grain boundaries will emit vacancies at all stress levels. The continued operation of a net vacancy in an ODS alloy must be avoided, since it will lead to a localized disruption of the microstructure.


The requirement of large, recrystallized, highly elongated grains is of primary importance to the development of suitable high temperature resistant oxide dispersion strengthened-superalloys. In the present study the recrystallization behavior of MA 6000E, a recently developed Y203 strengthened superalloy produced by mechanical alloying, was examined using transmission and replica microscopy. Gradient and isothermal annealing treatments were applied to extruded and hot rolled products. It was found that conversion from a very fine (0.2 micron) grain structure to a coarse (approximately 10 mm) grain structure is controlled by that the dissolution of the gamma prime phase, while grain shape was controlled primarily by the thermal gradient. The fine uniform oxide dispersion seemed to have only a secondary influence in determining the grain shape as columnar grains could be grown transverse to the working direction by appropriate application of the thermal gradient. (Author)


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Nickel was substituted for Co to produce 0.5 and the standard 10% versions of MAR-247, a cast nickel-base superalloy. The microstructures of the alloys were examined in cross section, face and edge, and stress-rupture tested conditions using a variety of metallographic techniques and differential thermal analysis. As cobalt concentration was reduced from 10 to 0 wt %, the gamma-prime weight fraction decreased from 59 to 41%, W and Ti concentrations in the gamma-prime phase increased from 5 to 8 and 2 to 3 at.%, respectively; the mean gamma-prime particle size increased from 0.6 to 0.8 micron; Cr and Al concentrations in the gamma matrix decreased from 17 to 13 and 12 at.%, respectively; and the weight fraction of carbides increased by approximately 1%. V.L.

Thermal fatigue and oxidation data were obtained on TAZ-8A and M22 alloys and variations. Double-edge wedge tests were performed on 36 specimens, representing 18 distinct variations (including the 0 wt %, CoNiCrAlY + aluminide systems) of TAZ-8A and M22 alloys. Each alloy variation consisted of a baseline plasma spray coating (12%Al-NiCoCrAlY), three aluminide coatings including the baseline aluminide (701), two NiCoCrAlY (6%Al) + aluminide systems and four NiCoCrAlY + aluminide coatings were evaluated. The two-step coating processes were investigated since it offered the advantage of tailoring the composition as well as properly coating surfaces of an integral or segmented nozzle. Cyclic burner rig thermal fatigue and oxidation/corrosion tests were used to evaluate the candidate coating systems. The plasma sprayed 12%Al-NiCoCrAlY was rated the best coating in thermal fatigue resistance and outperformed all coatings by a factor between 1.4 to 2.5 in cycles to crack initiation. However, this coating is not applicable to integral or segmented nozzles due to the line of sight limitation of the plasma spray process. The 9%Al-NiCoCrAlY + Mod. 701 aluminide (32 w/o Al) was rated the best coating in oxidation/corrosion resistance and was rated the second best in thermal fatigue resistance.

The plasma sprayed coatings, both duplex and graded types, were primarily zirconia-based, although a calcium silicate was also evaluated. Both atmospheric burner rig tests and high pressure tests (135 psig) showed that several present-day thermal barrier coatings to combustion gases found in electric utility turbines was assessed. The plasma sprayed coatings, both duplex and graded types, were primarily zirconia-based, although a calcium silicate was also evaluated. Both atmospheric burner rig tests and high pressure tests (135 psig) showed that several present-day thermal barrier coatings have a high potential for service in gas turbines burning the relatively clean GT No. 2 fuel. However, coating improvements are needed for use in turbines burning lower grade fuel such as residual oil. The duplex ZrO2.8Y2O3/NiCrAlY coating was ranked highest and selected for near-term field testing, with Ca2SiO4/NiCrAlY ranked second. Graded coatings show potential for corrosive and erosion operating conditions and were not further developed. The coating degradation mechanisms for each coating system subjected to the various environmental conditions are also described.

DEVELOPMENT OF MATERIALS AND PROCESS TECHNOLOGY FOR DUAL ALLOY DISKS Final Report

Techniques for the preparation of dual alloy disks were developed and evaluated. Four material combinations were evaluated in the form of HIP consolidated and heat treated cylindrical and plate shapes in terms of elevated temperature tensile, stress rupture and low cycle fatigue properties. The process evaluation indicated that the psi HIP AF-115 rim/low density powder Rene 95 hub combination offered the best overall range of mechanical properties for double disk applications. The feasibility of this dual alloy concept for the production of more complex components was demonstrated by the scale up fabrication of a prototype CFM-56 disk made from this AF-115/F111/95 combination. The hub alloy ultimate tensile strength was approximately 92 percent of the program goal of 1520 MPa (220 ksi) at 480 C (900 F) and the rim alloy stress rupture goal of 300 hours at 675 C (1250 F)/925 MPa (134 ksi) was exceeded by 200 hours. The low cycle fatigue properties were


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There was an absence of rupture notch sensitivity in both alloys. The joint tensile properties were approximately 85 percent of the weaker of the two materials (Rene 95) and the stress rupture properties were equivalent to those of the weaker of the two materials (Rene 95).

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**N92-19360**
Pratt and Whitney Aircraft, East Hartford, Conn.

**TAILORED PLASMA SPRAYED MCCAlY COATINGS FOR AIRCRAFT GAS TURBINE APPLICATIONS**

(NA33-21792) 
(PW-A-5642-21) Avail: NTIS

**HC A07/MF A01 CSCL 11F**

Eighteen plasma sprayed coating systems, nine based on the NiCoCrAlY chemistry and nine based on the CoCrAlY composition, were evaluated to identify coating systems which provide equivalent or superior life to that shown by the electron beam physical vapor deposited NiCoCrAlY and CoCrAlY coatings respectively. NiCoCrAlY type coatings were examined on a single crystal alloy and the CoCrAlY based coatings were optimized on the B1900+ Hf alloy. Cyclic burner rig oxidation and hot corrosion and tensile ductility tests were used to evaluate the various coating candidates. For the single crystal alloy, a low pressure chamber plasma sprayed NiCoCrAlY + Si coating exhibited a 2x oxidation life improvement at 1394 K (2050 F) over the vapor deposited CoCrAlY material. This showed equivalent tensile ductility. A silicon modified low pressure chamber plasma sprayed CoCrAlY coating was found to be more durable than the baseline vapor deposited CoCrAlY coating on the B1900+ Hf alloy.

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**N92-26436**
Cincinnati Univ., Ohio. Dept. of Materials Science and Metallurgical Engineering.

**HIGH TEMPERATURE LOW CYCLE FATIGUE MECHANISMS FOR NICKEL BASE AND A COPPER BASE ALLOY**


**HC A08/MF A01 CSCL 11F**

Damage mechanisms were studied in Rene 95 and NARloy Z, using optical, scanning and transmission microscopy. In the microstructure of Rene 95, crack initiation was mainly associated with cracking of surface MC carbides, except for hold time tests at higher strain rates where initiation was associated with a grain boundary mechanism. A mixed mode of propagation with a faceted fracture morphology was typical for all alloy types and tensile test variables. The dependence of life on maximum tensile stress can be demonstrated by the data falling onto three lines corresponding to the three tensile hold times, in the life against maximum tensile stress plot. In NARloy Z, crack initiation was always at the grain boundaries. The mode of crack propagation depended on the cycle character. The life decreased with decreasing strain rate and with tensile hold times. In terms of damage mode, different life prediction laws may be applicable to different cycle characters.

A.R.H.

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**N92-26439**

**HOT ISOSTATICALLY PRESSED MANUFACTURE OF HIGH STRENGTH MERL 76 DISK AND SEAL SHAPES**


**HC A07/MF A01 CSCL 11F**

The feasibility of using MERL 76, an advanced high strength direct hot isostatic pressed powder metallurgy superalloy, as a full scale component in a high technology, long life, commercial gas turbine engine were demonstrated. The component was a JTBD first stage turbine disk. The JTBD alloy disk temperature capability was increased by at least 22 C and the weight of JTBD high pressure turbine rotating components was reduced by at least 35 pounds by replacement of forged Superalloy components with hot isostatic pressed (HIP) MERL 76 components. The process control plan and acceptance criteria for manufacture of MERL 76 HIP consolidated components were generated. Disk components were manufactured for spin/burst rig test, experimenta...
The effect of cobalt on the basic mechanical properties and microstructure of wrought nickel-base superalloys has been investigated experimentally by systematically replacing cobalt by nickel in Udemit 700 (17 wt% Co) commonly used in gas turbine (jet engine) applications. It is shown that the room temperature tensile yield strength and tensile strength only slightly decrease in fine-grained (disk) alloys and are basically unaffected in coarse-grained (blinding) alloys as cobalt is removed. Creep and stress rupture resistances at 760 °C are found to be unaffected by cobalt level and decrease sharply only when the cobalt level is reduced below 8 vol% in the disk alloys. The effect of cobalt is explained in terms of gamma prime strengthening kinetics.

V.L.


Aluminide intermetallics, because of their strength, microstructural stability, and oxidation resistance at elevated temperatures, represent potential structural materials for use in advanced energy conversion systems. This inherent potential of the intermetallics can currently not be realized in connection with the general brittleness of the materials under ambient conditions. It is pointed out, however, that brittleness is not an inherent characteristic. Single crystals are ductile and polycrystals may be, too, if their grains are fine enough. The present investigation is concerned with an approach for reducing material brittleness, taking into account thermomechanically induced grain refinement in NAI, a B2 aluminide which melts at 1638 °C and which retains complete order to its melting point. Attention is given to the kinetics of recrystallization and grain growth of warm-worked, nickel-rich material.

G.R.
27 NONMETALLIC MATERIALS

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

N82-11210*  National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. CASTABLE HIGH TEMPERATURE FRAC'TORY MATERIALS

Patent Application
Isidor Zapiatynsky, inventor (to NASA) Filed 13 Oct. 1981


The fabrication of chemically inert ceramic bodies that are both high refractory and porous is disclosed. A paste is formed by mixing alumina grain having a uniform particle size with colloidal silica that is stabilized with ammonia. This paste is then cast without forming a compact and dried without pressing. After sintering, the cast body was sufficiently green strength to be handled, and it is transfered to a furnace for drying. A green body is prepared in accordance with the invention does not undergo shrinkage during either curing or prolonged subsequent heating.

N82-11211# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. FABRICATION AND WEAR TEST OF A CONTINUOUS FIBER/PARTICULATE COMPOSITE TOTAL SURFACE HIP REPLACEMENT

Paper

Continuous fiber woven E-glass composite femoral shells having the same elastic properties as bone were fabricated. The shells were then encrusted with filled epoxy wear resistant composite. The cement was cured using ambient temperatures. The friction and wear results, but sliding speed was found to have an identical magnitude as the unencrusted shell. The same study was repeated using carbon fiber reinforced composite. The results were identical to the E-glass composite.-Author

N82-14359* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ULTRASONIC VELOCITY FOR ESTIMATING DENSITY OF STRUCTURAL CERAMICS


The feasibility of using ultrasonic velocity as a measure of bulk density of sintered alpha silicon carbide was investigated. The material studied was either in the as-sintered condition or hot isostatically pressed in the temperature range from 1860 to 2050 C. Densities varied from approximately 2.8 to 3.2 g cu cm. Results show that the bulk nominal density of structural grade silicon carbide articles can be estimated from ultrasonic velocity measurements to within 1 percent using 20 MHz longitudinal waves and a commercially available ultrasonic time intervalometer. The ultrasonic velocity measurement technique shows promise for screening out material with unacceptably low density levels.

N82-15187# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. NITRIDATION OF SILICON M.S. Thesis Case Western Reserve Univ.


Silicon powders with three levels of impurities, principally Fe, were nitrided in He or H2. Non-densifying mechanisms of material transport were dominant in all cases. High purity Si showed coarsening in He while particle growth was suppressed in H2. Lower purity powder coarsened in both He and H2. The same three Si powders and Si /111/ single crystal wafers were nitrided in both N2 and N2/H2 atmospheres. Hydrogen increased the degree of nitridation of all three powders and the alpha/beta ratio of the lower purity powder. Some Si3N4 whiskers and open channels through the surface nitride layer were observed in the presence of Fe, the nitridation-enhancing effects of Fe. Thermodynamic calculations showed that when SiO2 is present on the Si, addition of H2 to the nitriding atmosphere decreases the amount of SiO2 and increases the partial pressure of Si-containing volatile species, the Ls., Ns, and SIO. Large amounts of NH3 and SiH4 were also predicted to form.-Author

N82-15189* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. GEOMETRICAL ASPECTS OF THE TRIBOLOGICAL PROPERTIES OF GRAPHITE FIBER REINFORCED POLYIMIDE COMPOSITES


A Latin square experimental test design was used to evaluate the effect of temperature, load and sliding speed on the tribological properties of graphite fiber reinforced polyimide (GFRP) composite specimens. Hemispherically tipped composite riders were slid against 440 C HT stainless steel disks. Composites were made to previous studies in which hemispherically tipped 440 C HT stainless steel riders were slid against GFRP composite disks and to studies in which GFRP was used as a liner in plain spherical bearings. The results indicate that sliding surface geometry is especially important, in that different geometries can give completely different friction and wear results. Load, temperature, and sliding distance were found to influence the friction and wear results but sliding speed was found to have little effect. Experiments on GFRP riders with 10 weight percent additions of graphite fluoride showed that this addition has no effect on friction and wear.-Author

N82-15190* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ELUCIDATION OF WEAR MECHANISMS BY FERROGRAPHIC ANALYSIS


The use of ferrographic analysis in conjunction with light and scanning electron microscopy is described for the elucidation of wear mechanisms taking place in operating equipment. Examples of adhesive wear, abrasive wear, corrosive wear, rolling element fatigue, lubricant breakdown, and other wear modes are illustrated. In addition the use of magnetic solutions to precipitate nonmagnetic debris from aqueous and nonaqueous fluids is described.-Author

N82-16239* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. TRIBOLOGICAL CHARACTERISTICS OF A COMPOSITE TOTAL SURFACE HIP REPLACEMENT Final Report


Continuous fiber, woven E-glass composite femoral shells having the same elastic properties as bone were fabricated. The
shells were then encrusted with filled epoxy wear resistant coatings and run dry against ultrahigh molecular weight polyethylene acetabular cups were comparable to those of a vitallium ball articulation with an ultrahigh molecular weight polyethylene acetabular cup.

**N82-19373**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**TRIBOLOGICAL PROPERTIES AT 25°C OF SEVEN POLYIMIDE FILMS BONDED TO 440°C HC-TEMPERATURE STAINLESS STEEL**

Robert L. Fusaro Feb. 1982 23 p refs (NASA-TP-1944; E-758) Avail: NTIS HC A02/MF A01 CSQL 07C

The tribological properties of seven polyimide films applied to 440°C high temperature stainless steel substrates were studied at 25°C with a pin-on-disk type of friction and wear apparatus. The polyimides fell into two groups according to friction and wear properties. Group I polyimides had slightly lower friction but much higher wear than group II polyimides. The wear mechanism was predominantly adhesion, but the wear particles were larger for group I polyimides. For most of the polyimides the transfer films consisted of clumps of compacted wear particles. One polyimide composition produced a very thin transfer film that sheared plastically in the contact area.

**N82-19374**
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**SURFACE CHEMISTRY AND WEAR BEHAVIOR OF SINGLE-CRYSTAL SILICON CARBIDE SLIDING AGAINST IRON AT TEMPERATURES TO 1500°C IN VACUUM**

Kazuhisa Miyoshi and Donald H. Buckley Feb. 1982 14 p refs (NASA-TP-1947; E-654) Avail: NTIS HC A02/MF A01 CSQL 07C

X-ray photoelectron and Auger electron spectroscopy analyses and morphological studies of wear and metal transfer were conducted with a single-crystal silicon carbide 0001 surface in contact with iron at various temperatures to 1500°C in a vacuum of 10^-8 mbar. The results indicate that below 800°C, carbide-carbon and silicon are primarily seen on the silicon carbide surface. Above 800°C the graphite increased rapidly with increase in temperature. The outermost surficial layer, which consists mostly of graphite and little silicon at temperatures above 1200°C is about 2 nm thick. A thicker layer, which consists of a mixture of graphite, carbide, and silicon is approximately 10 nm thick. Furthermore, the surface sliding temperature is to 800°C, the more the metal transfer produced. Above 800°C, there was a transfer of rough discontinuous, and thin iron debris instead of smooth, continuous and thin iron film which was observed to transfer below 800°C. Two kinds of fracture pits were observed on the silicon carbide surface: (1) a pit with a spherical asperity; and (2) multangular shaped pits.
THERMAL AND OXIDATIVE DEGRADATION STUDIES OF FORMULATED C-ETHERS BY GEL-PERMEATION CHROMATOGRAPHY


Gel-permeation chromatography was used to analyze C-ether lubricant formulations from high-temperature bearing tests and from micro-oxidation tests. Three mu-styragel columns (one 500 and two 100 A) and a tetrahydrofuran mobile phase were found to adequately separate the C-ether degradation products. The micro-oxidation tests yielded degradation results qualitatively similar to those observed from the bearing tests. Micro-oxidation tests conducted in air yielded more degradation than did tests in nitrogen. No great differences were observed between the thermal-oxidative stabilities of the two C-ether formulations or between the catalytic degradation activities of silver and M-50 steel. C-ether formulation I did yield more degradation than did formulation II in 111- and 29-hour bearing tests, respectively.

Author

EFFECTS OF ENVIRONMENT ON MICROHARDNESS OF MAGNESIUM Oxide

Hiroyuki Ishigaki (Osaka Univ.) and Donald H. Buckley Apr. 1982 11 p refs (NASA-TP-20007; E-916; NAS 1.60:2002) Avail: NTIS HC AO2/MF AO1 CSCL O1B

Micro-Vickers hardness measurements of magnesium oxide single crystals were conducted in various environments. These environments included air, nitrogen gas, water, mineral oil, with or without various additives, and aqueous solutions with various pH values. Indentations were made on the (100) plane with the diagonals of the indentation in the (100) direction. The results indicate that a sulfur containing additive in mineral oil increased hardness, a chlorine containing additive in mineral oil decreased hardness, and aqueous solutions of hydrogen chloride decreased hardness. Other environments were found to have little effect on hardness. Mechanically polished surfaces showed larger indentation creep than did as-cleaved surfaces.

Author

TRIBOLOGICAL PROPERTIES OF SINTERED POLYCRYSTALLINE AND SINGLE CRYSTAL SILICON CARBIDE


Fiber reinforced PMR ply-ylmides are finding increased acceptance as high performance structural materials for high performance applications. Prepreg materials based on this novel class of highly processable, high temperature resistant polysulfides are commercially available and the PMR concept is used by other investigators. The current status of first and second generation PMR polyimides were reviewed. Emphasis is given to the chemistry, processing and applications of the first generation material known as PMR-15.

T.M.

METHOD OF PROTECTING A SURFACE WITH A SILICON-SLURRY/ALUMINIDE COATING Patent


A technique for fabricating textured surfaces on polymers without altering their surface chemistry is described. A surface of a fluorocarbon polymer is exposed to a beam of ions to texture it. The polymer which is to be surface-roughened is then cast over the textured surface of the fluorocarbon polymer. After curing, the cast polymer is peeled off the textured fluorocarbon polymer, and the peeled off surface has negative replica of the textured surface. The microsopic surface texture provides large surface areas for adhesive bonding. In cardiovascular prosthesis applications the surfaces are relied on for the development of a thin adherent well nourished thrombus.

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

THERMAL OXIDATIVE DEGRADATION REACTIONS OF LINEAR PERFLUOROALKY LETHERS


Thermal and thermal oxidative stability studies were performed on linear perfluoro alkyl ether fluids. The effect on degradation by metal catalysts and degradation inhibitors were reported. The linear perfluoro alkeylthers are inherently unstable at 316 C in an oxidizing atmosphere. The metal catalysts greatly increased the rate of degradation in oxidizing atmospheres. In the presence of these catalysts in an oxidizing atmosphere, the degradation inhibitors were highly effective in arresting degradation at 288 C. However, the inhibitors had only limited effectiveness at 316 C. The metals promote degradation by chain scission. Based on elemental analysis and oxygen consumption data, the linear perfluoro alkeylther fluids have a structural arrangement based on difluoroformyl and tetrafluoroethylene units, with the former predominating.

S.L.

TEXTURING POLYMER SURFACES BY TRANSFER CASTING Patent


A technique for fabricating textured surfaces on polymers without altering their surface chemistry is described. A surface of a fluorocarbon polymer is exposed to a beam of ions to texture it. The polymer which is to be surface-roughened is then cast over the textured surface of the fluorocarbon polymer. After curing, the cast polymer is peeled off the textured fluorocarbon polymer, and the peeled off surface has negative replica of the textured surface. The microscopic surface texture provides large surface areas for adhesive bonding. In cardiovascular prosthesis applications the surfaces are relied on for the development of a thin adherent well nourished thrombus.

Official Gazette of the U.S. Patent and Trademark Office
A review of the various lubrication regimes, with particular emphasis on boundary lubrication, is presented. The types of wear debris and extent of surface damage are illustrated for each regime. The role of boundary surface films along with their modes of formation and important physical properties are discussed. In addition, the effects of various operating parameters on friction and wear in the boundary lubrication regime are considered.

Author


A low cost coating for protecting metallic base system substrates from atmospheric corrosion, high gas velocity oxidation, thermal fatigue and hot corrosion is described. The coating is particularly useful for protecting vanes and blades in aircraft and land based gas turbine engines. A lacquer slurry comprising cellulose nitrate containing high purity silicon powder is sprayed onto the superalloy substrates. The silicon layer is then aluminized to complete the coating. The Si-Al coating is less costly to produce than advanced aluminides and protects the substrate from oxidation and thermal fatigue for a much longer period of time than the conventional aluminide coatings. While more expensive Pt-Al coatings may last longer they provide equal protection on certain substrates, the Si-Al coating exceeded the performance of both types of 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.

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

N82-29459* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
TRIBOLOGICAL EVALUATION OF COMPOSITE MATERIALS MADE FROM A PARTIALLY FLUORINATED POLYIMIDE
Robert L. Fusaro Apr. 1982 40 p ref
(NASA-TM-82832; E-1199; NAS 1.15:82832) Avail: NTIS
HC A03/MF A01 CSCL 11G

Preliminary tribological studies on a new polyimide formulated from the diamine 2,2-bis[4-(4-aminophenoxyl)phenyl] hexafluoropane (4-BDAF) indicates polyimides made from this diamine have excellent potential for high temperature applications. Two different polyimides were formulated from the diamine, and five different composites were formulated using one of the polyimides. Composites were made using 10 weight percent (w/o) graphite fluoride powder, 20 w/o PTFE powder, 30 w/o silver powder, or 50 w/o carbon fibers, both graphitic and nongraphitic types. The powder additions did not improve the tribological properties as much as the carbon fibers, and the graphitic fibers produced better results than did the nongraphitic fibers. Results also indicated that improved high temperature stability and tribological properties may be obtained with a polyimide made from the dianhydride pyromellitic acid (PMDA) rather than the dianhydride benzophenonetetraacrylic acid (BTDA).

Author

N82-30401* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
DEPOSITION OF REACTIVELY ION BEAM SPUTTERED SILICON NITRIDE COATINGS
A. Grill (Ben Gurion Univ. of the Negev) Aug. 1982 11 p refs
(NASA-TM-82942; E-1310; NAS 1.15:82942) Avail: NTIS
HC A02/MF A01 CSCL 11D

An ion beam source was used to deposit silicon nitride films by reactively sputtering a silicon target with beams of Ar and N2 mixtures. The nitrogen fraction in the sputtering gas was approximately 0.2. The absorbance was 0.7, the absorption coefficient was 67,000 cm to the -1 and the transmittance was 0.1

Author

N82-29465* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
FULLY PLASMA-SPRAYED COMPLIANT BACKED CERAMIC TURBINE SEAL Patent

A seal having a high temperature abradable lining material encircling the tips of turbine blades in turbomachinery is discussed. The minimum operating clearances between the blade tips and the lining of a high pressure turbine are maintained. A low temperature easily decomposable material, such as a polymer, in powder form is blended with a high temperature oxidation 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.

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

N82-29458* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
BOUNDARY LUBRICATION: REVISITED
(NASA-TM-82856; E-1181; NAS 1.15:82856) Avail: NTIS
HC A03/MF A01 CSCL 11G

Indenting experiments were conducted with the silicon nitride (0001) surface in contact with a spherical diamond indenter in air. Sliding friction experiments were also conducted with silicon carbide in contact with iron and iron-based binary alloys at room temperature and 800 C. Fracture pits with a spherical particle and spherical wear debris were observed as a result of indenting and sliding. Spherical debris may be produced by a mechanism that involves a spherical-shaped fracture along the circular or spherical stress trajectories under the inelastic deformation zone.

Author
SURFACE TEXTURING OF FLUOROPOLYMERS Patent

A novel method is disclosed for improving surface texture for adhesive bonding, metal bonding, substrate plating, decal substrate preparation, and biomedical implant applications. The surface to be bonded is dusted in a controlled fashion to produce a dispersed layer of fine mesh particles which serve as masks. The surface texture is produced by impinging gas ions on the masked surface. The textured surface takes the form of pillars or cones. The bonding material, such as a liquid epoxy, flows between the pillars which results in a bond having increased strength. For bonding metals a thin film of metal is vapor or sputter deposited onto the textured surface. Electroplating or electroless plating is then used to increase the metal thickness in the desired amount.

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

OVERLAY METALLIC-CERMET ALLOY COATING SYSTEMS Patent Application

A substrate, such as a turbine blade, vanes, or the like, which is subjected to high temperature use is coated with a base coating of an oxide dispersed, metallic alloy (cermet). A top coating of an oxidation, hot corrosion, erosion resistant alloy of nickel, cobalt, or iron is then deposited on the base coating. A heat treatment is used to improve the bonding. The base coating serves as an inhibitor to interdiffusion between the protective 10 top coating and the substrate. Otherwise, the protective top coating would rapidly interact detrimentally with the substrate and degrade by spalling of the protective oxides formed on the outer surface at elevated temperatures.

Applications of the bonded material are in the field of aerospace propulsion where the substrate may be nonmetallic or metallic and the bond strength is that of a metallic bond. The bond strength is the same whether the substrate is coated with a metal bond coating or a ceramic bond coating. The bond strength is improved when the bond strength of the thermal barrier coating is used over the metallic bond coating. The bond strength can be varied widely by adjusting the heating rate, the coating thickness, and the type of bond coating.

The use of the present invention has been found to be effective in increasing the bond strength. The present invention can be applied to any substrate material which is subject to high temperature use.


Ball-on-disc sliding friction experiments were carried out at 17 m/min (100 rev/min) to investigate the effect of oxygen concentration varying from 20% (air) to 0.001% (nitrogen) on the boundary-lubricating characteristics of an unformulated C ether in the temperature range 20-300 C. Results were then compared with those obtained for a five-ring polyphenylether in air and in nitrogen. The C ether yielded lower wear and lower friction coefficients than a five-ring polyphenylether in both air and nitrogen over most of the temperature range. Friction polymer was observed around the wear scars of most test specimens, with much greater quantities of friction polymer produced in a low-oxygen environment. Thus, with respect to friction polymer production, the C ether behaved very much like the polyphenylether.

A82-23021 * Dynamics of solid dispersions in oil during the lubrication of point contacts. II - Polyethylene alcohol. C. Cusano (Illinois, University, Urbana, IL) and H. E. Sloney (NASA, Lewis Research Center, Cleveland, OH). (American Society of Lubrication Engineers, Annual Meeting, 36th, Pittsburgh, PA, May 11-14, 1981.) ASLE Transactions, vol. 25, Apr. 1982, p. 190-197. 18 refs. (Previously announced in STAR as N81-20275)

V.L.


The effects of the heating rate during sintering/fining on the final density, microstructure, and strength of Si3N4-6 wt.% Y2O3 and beta-prime sialon, sintered for four hours at 1750 C, are examined. In Si3N4-6 wt% Y2O3 increasing the heating rate from 7 C/min to 25 C/min to 90 C/min results in a corresponding decrease in the final density from 9.01 g/cu cm to 2.52 g/cu cm to 2.76 g/cu cm. In the beta-prime sialon composition all three heating rates produce an equivalent final density of 3.13 g/cu cm. All heating rates in both compositions produce nonhomogeneous microstructures. The room-temperature strength of Si3N4-6 wt% Y2O3 increases from 372 to 510 MPa with increased density, while the corresponding strengths for the beta-prime sialon at equivalent densities are 445 to 445 MPa.

N.B.


In view of the support offered by previous work for the suggestion that Fe may affect alpha-Si3N4 formation and microstructural development, a two-part study was conducted to differentiate the effects of H2 and Fe in, first, the nitridation of pure and of Fe-containing powder in N2 and N2-4% H2, and then the nitridation of (1 1 1) Si single crystal wafers with and without Fe powder on the surface. The degree of nitridation is most strongly affected by H2 at 1200 C, but by Fe at 1375 C, where Fe-containing samples in either atmosphere were almost completely nitrided. While neither H2 nor Fe alone changed the ratio of alpha-Si3N4 to beta-Si3N4, the combination of H2 and Fe increased it at both temperatures.

O.C.

N82-17367* TRW Defense and Space Systems Group, Redondo Beach, Calif.

IMPROVED TACK PMR

One reactive diluent and several high boiling solvents were investigated for providing long shell life tack and drape to PMR polyimide prepreg materials. The most promising approach was to introduce dimethoxy ethyl ether (diglyme) to the normal methanol solvent. Compression and autoclave molding cycles were developed for the improved tack prepreg which provided up to 15% higher thermomechanical properties than conventional PMR-15 composites. Near the conclusion of this investigation, it was discovered that diglyme constituted a potential hazard because its auto ignition temperature is 464 K. Consequently, it was recommended that diglyme should not be used as a tackifier for PMR prepregs.

Author


Experimental data are presented on viscosity, elastic shear modulus, and limiting shear stress of 12 liquid lubricants. It is shown that transition histories do affect the limiting shear stress of the materials in the form of isothermal compression resulting in a lower density and lower limiting stress than isobaric cooling. The measured limiting shear strength data show almost no effect with slide-to-roll ratios of 0.1 or more. In pressure viscosity measurements of the polymer solutions, it is found that for some temperatures, the pressure viscosity coefficient of the blend is slightly less than that of the base, which results in the crossing of the viscosity-pressure isotherms at high pressures.

D.L.G.
Characteristic parameters of several advanced electric propulsion systems are highly transient in nature. (Author)

The room-temperature strength distributions of a sintered and a hot-pressed SIC were examined as-machined, after oxidation at 1370 C, and after oxidation under load at 1370 C. The strengths were observed to be dependent both on the duration of oxidation and the magnitude of the applied load. Processes resulting in both strengthening and weakening behavior were observed to occur, at times simultaneously within the same strength distribution. This dynamic situation indicates that the strength-controlling flaw populations are highly transient in nature. (Author)


Contact stress analysis was conducted for ceramic-metal and ceramic-ceramic interfaces using a finite element model. Ceramics investigated included NC-132 hot-pressed silicon nitride, NC-350 reaction-bonded silicon nitride, hexagonal SiC, and RBN-104 reaction-bonded silicon nitride. The results are shown to be well correlated with closed-form solution both for normal and normal-tangential loading. The latter load condition is found to be especially critical for ceramic materials due to the presence of a high tensile stress at the trailing edge of the ceramic surface contact zone. It is shown that during sliding contact or biaxial loading, the magnitude of this tensile stress increases with the coefficient of friction. V.L.


Net shape techniques have been used in the production of rotating and static vehicular engine high-performance components composed of sintered Alpha-SiC (SASC). Injection-molded rotors have been cold spin tested, as well as a slip-cast combustor assembly hot rig. SASC pistons and cylinder liners have also been constructed for an opposed piston, two-cycle diesel test rig while test results are presented. An uncoked, minimum-friction internal combustion engine with multi-fuel capability due to its elevated combustion temperatures appears to be achievable in the near term by means of SASC technology. The flexural strength of SASC at 1500 C is 446 MPa, identical to that at room temperature, and excellent strength retention has been demonstrated after 3500 hours of cyclic exposure. O.C.


Characteristic parameters of several advanced electric propulsion systems are evaluated and compared. The propulsion systems studied are mass driver, rail gun, argon MPD thruster, hydrogen free radical thruster and mercury electron bombardment ion engine. Overall, ion engines have somewhat better characteristics as compared to the other electric propulsion systems. (Author)


Transformation of structural ceramics from the laboratory to production requires development of near net shape fabrication techniques which minimize finish grinding. One potential technique for producing large quantities of complex-shaped parts at a low cost, and microstructure of sintered silicon nitride fabricated by injection molding is discussed and compared to data generated from isostatically dry-pressed material. Binder selection methodology, compounding of ceramic and binder components, injection molding techniques, and problems in binder removal are discussed. Strength, oxidation resistance, and microstructure of sintered silicon nitride fabricated by injection molding is discussed and compared to data generated from isostatically dry-pressed material. (Author)


Characteristic parameters of several advanced electric propulsion systems are evaluated and compared. The propulsion systems studied are mass driver, rail gun, argon MPD thruster, hydrogen free radical thruster and mercury electron bombardment ion engine. Overall, ion engines have somewhat better characteristics as compared to the other electric propulsion systems. (Author)
28 PROPPELLANTS AND FUELS

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

For related information see also 07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, and 44 Energy Production and Conversion.

N82-21415* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
RESONANCE TUBE HAZARDS IN OXYGEN SYSTEMS
Ph.D. Thesis - Toledo Univ., 1975
(NASA-TM-82801: E-1140; NAS 1.15:82801) Avail: NTIS HC A02/MF A01 CSCL 21D

An experimental and analytical program was carried out to determine whether fluid dynamic oscillations could create a hazard in gaseous oxygen flow systems. The particular fluid dynamic oscillation studied was that of atmospheric pressure oscillations because it was excited in a tee-shaped configuration characteristic of configurations found in many industrial high pressure gas flow systems. The study found that oscillations could be caused by the oscillations were direct heating and ignition of the piping system by the gas, the greatly augmented heating that could occur if inert contaminants were present, and the ignition of metallic contaminants. Asbestos was used as the inert contaminant; titanium, aluminum, magnesium and steel were chosen as ignitable metallic contaminants. The oscillations in the tee-shaped configuration were compared to oscillations driven by choked convergent nozzles and were found to differ markedly. Temperature generated at the end or base of the resonance tube exceeded 1089 K for both gaseous oxygen and nitrogen and reached 1645 K when asbestos was added. Aluminum in both powder and fiber form was readily ignited within the resonance tube when the supply pressures were less than 8270 kPa whereas at higher supply pressures the mixture exploded with enough violence to destroy the apparatus in less than 10 sec. In addition to aluminum, magnesium, and titanium, samples of 400 series stainless steels were also ignited within the resonance tube. The ignition occurred within a few seconds after the oxygen flow began. Author

ORIGINAL PAGE IS OF POOR QUALITY

N82-24334* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EXPERIMENTS ON FUEL HEATING FOR COMMERCIAL AIRCRAFT
(NASA-TM-82878; E-1254; NAS 1.15:82878) Avail: NTIS HC A02/MF A01 CSCL 21D

An experimental jet fuel with a -33°C freezing point was chilled in a wing tank simulator with superheated fuel heating to improve low temperature flowability. Heating consisted of circulating a portion of the fuel to an external heat exchanger and returning the heated fuel to the tank. Flowability was determined by the mass percent of unpumpable fuel (holdup) left in the simulator as the resonance tube at the conclusion of testing. The study demonstrated that fuel heating is feasible and improves flowability as compared to that of baseline, unheated tests. Delayed heating with ignition when the fuel reaches a prescribed low temperature limit, showed promise of being more efficient than continuous heating. Regardless of the mode or rate of heating, complete flowability (zero holdup) could not be restored by fuel heating. The severe, extreme-day environment imposed by the test caused a very small amount of subfreezing fuel to be retained near the tank surfaces even at high rates of heating. Correlations of flowability established for unheated fuel tests also could not be applied to test results if based on boundary-layer temperature or a solid index (subfreezing point) characteristic of the fuel. Author

N82-27519* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECT OF SOME NITROGEN COMPOUNDS THERMAL STABILITY OF JET A
Albert C. Antoncic Jun. 1982 20 p refs
(NASA-TM-82908: NAS 1.15:82908) Avail: NTIS HC A02/MF A01 CSCL 21D

The effect of known concentrations of some nitrogen containing compounds on the thermal stability of a conventional fuel, namely, Jet A was investigated. The concentration range from 0.01 to 0.1 wt% nitrogen was examined. Solutions were made containing, individually, pyrrole, indole, quinoline, pyridine, and 4 ethylpyridine at 0.01, 0.03, 0.06, and 0.1 wt% nitrogen concentrations in Jet A. The measurements were all made by using a standard ASTM test for evaluating fuel thermal oxidation behavior, namely, ASTM D3241, 'thermal oxidation stability of turbine fuels (JFTOT procedure). Measurements were made at two temperature settings, and "breakpoint temperatures" were determined. The results show that the pyrrole and indole solutions have breakpoint temperatures substantially lower than those of the Jet A used. S.L.
would not preclude the use of antimisting kerosene in a jet high pressure facility and in attitude relight/cold ignition facility, testing, and assessed the performance of the combustor in a antimisting kerosene fuel in laboratory acrd bench component with using antimisting kerosene and to determine the extent of Performance of the fuel pump and control system was evalu-

The analyses, designs, fabrication, and cold-flow acceptance testing of LOX/RP-1 preburner components required for a high-pressure staged-combustion rocket engine are discussed. Separate designs of injectors, combustion chambers, turbine simulators, and hot-gas mixing devices are provided for fuel-rich and oxidizer-rich operation. The fuel-rich design addresses the problem of non-equilibrium LOX/RP-1 combustion. The oil wedge ment and use of a pseudo-kinetic combustion model for predicting operating efficiency, physical properties of the combustion products, and the potential of generating solid carbon, are presented. The oxygen-rich design addresses the design criteria for the prevention of metal ignition. This is accomplished by the selection of materials and the generation of well-mixed gases. The combining of unique propellant injector element designs with secondary oxygen rich design addresses the design criteria for the prevention of non-equilibrium LOX/RP-1 combustion. The development of high-pressure staged-combustion rocket engine are discussed. The analyses, designs, fabrication, and cold-flow acceptance testing of LOX/RP-1 preburner components required for a high-pressure staged-combustion rocket engine are discussed. Separate designs of injectors, combustion chambers, turbine simulators, and hot-gas mixing devices are provided for fuel-rich and oxidizer-rich operation. The fuel-rich design addresses the problem of non-equilibrium LOX/RP-1 combustion. The oil wedge ment and use of a pseudo-kinetic combustion model for predicting operating efficiency, physical properties of the combustion products, and the potential of generating solid carbon, are presented. The oxygen-rich design addresses the design criteria for the prevention of metal ignition. This is accomplished by the selection of materials and the generation of well-mixed gases. The combining of unique propellant injector element designs with secondary oxygen rich design addresses the design criteria for the prevention of non-equilibrium LOX/RP-1 combustion.

**An Assessment of the Use of Antimisting Fuel in Turbofan Engines**

Final Report

Seaborn, Calif.

1980


(NASA CR-165258; AD-A104673; PWA-5697-29; FAAA-CT-81-58) Avail: NTIS HC A04/MF A01 CSSL 21/4

An evaluation was made on the effects of using antimisting kerosene (AMK) on the performance of the components from the fuel system and the combustor of a current in-service JTBD aircraft engine. The objectives were to identify problems associated with using antimisting kerosene and to determine the extent of degradation required to allow the engine components to achieve satisfactory operation. The program consisted of a literature survey and a test program, which evaluated the antimisting kerosene fuel in laboratory and bench component testing, and assessed the performance of the combustor in a high pressure facility and in an attitude reheat/cold ignition facility. Performance of the fuel pump and control system was evaluated in an open-loop simulation. Thus far, the results do not preclude the use of antimisting kerosene in a jet engine application.

**Barriers to the Utilization of Synthetic Fuels for Transportation**

Final Report

Washington, D. C.

1980


(NASA Order C7-5707-D; Contract DE-RAO/8-1-00080) Avail: NTIS HC A04/MF A01 CSSL 21D

The primary types of engines for transportation uses are reviewed and the specifications for conventional fuels are compared with specifications for synthetic fuels. Synfuel processes nearing the commercialization phase are reviewed. The barriers to using synfuels can be classified into four groups: technical, such as the uncertainty that an aircraft engine design can satisfy the desired performance criteria; environmental, as the risk that the engine emissions cannot meet the applicable environmental standards; economic, including the cost of using a synfuel relative to conventional transportation fuels; and market, involving market penetration by offering new engines, establishing new distribution systems and/or changing user expectations.

T. M.

**External Fuel Vaporization Study**

Final Report

East Hartford, Conn.

1981


(NASA CR-165513; UTRC-81-91532-15) HC A05/MF A01 CSSL 21D

The feasibility of external fuel vaporization in advanced aircraft gas turbine engines is addressed. Experiments were run to determine key fuel properties including boiling points, dew points, critical temperature, critical pressure, heat transfer coefficients, deposit formation rates, and deposit removal in a flowing system. Of particular concern were the heat transfer rate in the heat exchanger and the performance of the orifice used in the throttling process. Three fuels were utilized in the experiments including Jet-A, Experimental refueling broad specification fuel, and a premium No. 2 diesel fuel. Engine conditions representing the NASA Energy Efficient Engine at sea level takeoff cruise, and idle were simulated in the vaporization system and it was found that single phase flow was maintained in the heat exchanger and downstream of the throttle. Deposits encountered in the heat exchanger represented a thermal resistance as high as 0.0013 sq m K/Watt and a deposit formation rate as high as 800 micro-gc/sq cm hr. These values are equivalent to a buildup of 0.068 cm of thickness in 36 hours resulting in a more severe fouling condition than originally anticipated. It was found that the deposits can be removed by cleaning with air at a temperature of 720 K for 10 minutes.

R. J. F.

**Oxidation and Formations of Deposit Precursors in Hydrocarbon Fuels**

Final Report

Menlo Park, Calif.

1982


(NASA CR-22510; NASA CR-165254; PYU-2115) Avail: NTIS HC A03/MF A01 CSSL 21D

A practical fuel, home heating oil no. 2 (Fuel C), and the pure hydrocarbon, n-dodecane, were subjected to mild oxidation at 130 C and the resulting oxygenated reaction products, deposit precursors, were analyzed using field ionization mass spectrometry. Results for fuel C indicated that, as oxidation was initially extended, certain oxygenated reaction products of increasing molecular weights in the form of monomers, dimers, and trimers were produced. Further oxidation time increase resulted in further increase in monomers but a marked decrease in dimers and trimers. This suggests that these larger molecular weight products have proceeded to form deposits and separated from the fuel mixture. Results for a dodecane indicated that yields for dimers and trimers were very low. Dimers were produced as a result of interaction between oxygenated products with each other rather than with another fuel molecule. This occurred even though fuel molecule concentration was 50 times, or more greater than that for these oxygenated reaction products.
TESTING OF FUEL/OXIDIZER-RICH, HIGH-PRESSURE PREBURNERS
Final Report
B. R. Lawver May 1982 253 p refs (Contract NAS3-22647)
(NASA-CR-165609; NAS 1.28;165609) Avail: NTIS
H.C. A12/MF A01 CSCL 21D

Results of an evaluation of high pressure combustion of fuel rich and oxidizer rich LOX/RP-1 propellants using 4,0 inch diameter prototype preburner injectors and chambers are presented. Testing covered a pressure range from 9.8 to 17.5 M/N/square meters (1329 to 2540 psi). Fuel rich mixture ratios ranged from 0.238 to 0.367; oxidizer rich mixture ratios ranged from 27.2 to 47.5. Performance, gas temperature uniformity, and stability data for two fuel rich and two oxidizer rich preburner injectors are presented for a conventional like-on-like (LOJ) design and a platelet design Injector. Kinetically limited combustion is shown by the excellent agreement of measured fuel rich gas composition and C performance data with kinetic model predictions. The oxidizer rich test results support previous equilibrium combustion predictions.

SOLAR TURBINES International, San Diego, Calif.
LOW NOX HEAVY FUEL COMBUSTOR CONCEPT PROGRAM
D. J. White and Alan J. Kubasco May 1982 50 p refs (Contract DENS-14145)
(NASA-CR-167876; NASA A126;167876) DOE/NASA/1045-2;
SR82-R-4994-08) Avail: NTIS
HC A03/MF A01 CSCL 21D

Three simulated coal gas fuels based on hydrogen and carbon monoxide were tested during an experimental evaluation with a rich lean combustor: these were a simulated Winkler gas, Lurgi gas and Blue Water gas. All three were simulated by mixing together the necessary pure component species, to levels typical of fuel gases produced from coal. The Lurgi gas was also evaluated with ammonia addition. Fuel burning in a rich lean mode was emphasized. Only the Blue Water gas, however, could be operated in such fashion. This showed that the expected NOx signature form could be obtained, although the absolute values of NOx were above the 75 ppm goals for most operating conditions. Lean combustion produced very low NOx well below 75 ppm with the Winkler and Lurgi gases. In addition, these low levels were not significantly impacted by changes in operating conditions.

S. L.

Lockheed-California Co., Burbank
ADDITIONAL EXPERIMENTS ON FLOWABILITY IMPROVEMENTS OF AVIATION FUELS AT LOW TEMPERATURES,
VOLUME 2 Final Report
Francis J. Stockemoer and Ronald L. Deane Aug. 1982 56 p refs
(Contract NAS3-21977)
(NASA-CR-167912; NASA A126;167912) Avail: NTIS
HC A04/MF A01 CSCL 21D

An investigation was performed to study flow improver additives and scale-model fuel heating systems for use with aviation hydrocarbon fuel at low temperatures. Tests were performed in a facility that simulated the heat transfer and temperature profiles anticipated in wing fuel tanks during flight of long-range commercial aircraft. The results are presented of experiments conducted in a test tank simulating a section of an outer wing integral fuel tank approximately full-scale in height, chilled through heat exchange panels bonded to the upper and lower horizontal surfaces. A separate system heated lubricating oil externally by a controllable electric heater, to transfer heat to fuel pumped from the test tank through an oil-to-fuel heat exchanger, and to recirculate the heated fuel back to the test tank.

B. W.
flexure strength, while those with 10% open porosity of magnitudes much smaller than one micron as well as those with 2-4% interconnected open porosity of about one micron did not decrease in strength after 900°C exposure. It was determined that preoxidation treatment at 1350°C prevents the 20-30% strength degradation due to internal oxidation, and evidence is presented which suggests that surface pit formation in some RBSN may result from contamination by the furnace environment rather than any intrinsic material properties.


It is shown that scanning laser acoustic microscopy (SLAM) is able to detect such fracture-controlling flaws in dense silicon carbide materials as surface voids, whose diameter-by-depth size is a minimum of 75 by 17 microns in reaction-bonded SiC and 68 by 25 microns in alpha-SiC. Surface conditions such as pitting, which have been found to limit the discernibility of drilled holes, become important when pit and drilled hole sizes become comparable.


The hydrocarbon fuels RP-1, commercial-grade propane, JP-7 and chemically pure propane were subjected to tests in a high pressure fuel coking apparatus in order to evaluate their thermal decomposition limits and carbon deposition rates in heated copper tubes. A fuel thermal stability parametric evaluation was conducted at 136-340 atmospheres, bulk fuel velocities of 6-30 m/sec, and tube wall temperatures of 422-811 K, and the effect of inside wall material on deposit formation was evaluated in tests using nickel-plated tubes. Results show RP-1 deposit formation at wall temperatures between 600 and 800 K, with peak deposit formation near 700 K. Substitution of deoxygenated JP-7 for RP-1 showed no improvement, and the carbon deposition rates for propane fuels were found to be higher than either of the kerosene fuels. Nickel plating of the tube walls significantly reduced RP-1 carbon deposition rates.


The fuel properties used in the design of a flash vaporization system for aircraft gas turbine engines were evaluated in experiments using a flowing system to determine critical temperature and pressure, boiling points, dew points, heat transfer coefficients, deposit formation rates, and deposit removal. Three fuels were included in the experiments: Jet-A, an experimental reference broad specification fuel, and a premium No. 2 diesel fuel. Engine conditions representing a NASA Energy Efficient Engine at sea-level take-off, cruise, and idle were simulated in the vaporization system and it was found that single phase flow was maintained in the heat exchanger and downstream of the throttle. Deposits encountered in the heat exchanger represented a thermal resistance as high as 1300 sq M K/watt and a deposit formation rate over 1000 gC/sq cm hr.

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

N82-13281*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
ELEVATED TEMPERATURE FATIGUE TESTING OF METALS
Marvin H. Hirschgberg In AGARD Fatigue Test Methodology
Oct. 1981 18 p refs (For primary document see N82-13274
(c6)
04-31)
Avail: NTIS HC A12/MF A01
Material characterization and evaluation conducted for the purpose of calculating fatigue crack initiation lives of components operating at elevated temperatures are discussed. The major technology areas needed to perform a life prediction of an aircraft engine hot section component and the steps required for life prediction are outlined. These include: the determination of the operating environment, the calculation of the thermal and mechanical loading of the component, the cyclic stress strain and creep behavior of the material required for structural analyses, the structural analysis to determine the local stress strain temperature time response of the material at the critical location in the component, and from a knowledge of the fatigue, creep, and failure resistance of the material, a prediction of the life of the component.
E.A.K.

N82-20339*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
IDENTIFICATION OF MULTIVARIABLE HIGH PERFORMANCE TURBOFAN ENGINE DYNAMICS FROM CLOSED LOOP DATA
The multivariable instrumental variable/approximate maximum likelihood (IV/AML) method or recursive time-series analysis is used to identify the multivariable (four inputs-three outputs) dynamics of the Pratt and Whitney F100 engine. A detailed nonlinear engine simulation is used to determine linear engine model structures and parameters at an operating point using open loop data. Also, the IV/AML method is used in a direct identification mode to identify models from actual closed loop engine test data. Models identified from simulated and test data are compared to determine a final model structure and parameterization that can predict engine response for a wide class of inputs. The ability of the IV/AML algorithm to identify useful dynamic models from engine test data is assessed. Author

N82-22386*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
ULTRASONIC SCANNING SYSTEM FOR IMAGING FLAW GROWTH IN COMPOSITES
A system for measuring and visually representing damage in composite specimens while they are being loaded was demonstrated. It uses a hobbyist grade microcomputer system to control data taking and image processing. The system scans operator selected regions of the specimen while it is under load in a tensile test machine and measures internal damage by the attenuation of a 2.5 MHz ultrasonic beam pass through the specimen. The microcomputer dynamically controls the position of ultrasonic transducers mounted on a two axis motor driven carriage. As many as 65,536 samples can be taken and filed on a floppy disk system in less than four minutes. S.L.

Lange and Singleton (1978) have observed pressure pulses above a turbomolecular pump. They reported that the mean pulse frequency increased with
the temperature of the pump cooling water and that the evolved gas was mainly hydrogen. The present investigation takes into account tests conducted with a similar pumping system. The pumping system was equipped with additional pressure-monitoring equipment in order to study these pulsations in more detail. It was found that at least two distinct types of pressure pulsations may be present in a turbomolecular-pumped ultrahigh vacuum system. The random hydrogen pulses are easily eliminated for period of days by changing the cooling water temperature. The cyclic pulses consisting mainly of water vapor are not likely to be a problem in normal experiments.

G.R.
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.

N82-51585# Case Western Reserve Univ., Cleveland, Ohio. Inst. of Technology
COAXIAL PRIME FOCUS FEEDS FOR PARABOLOIDAL REFLECTORS
(Contract NAS3-22342)
(NASA-CA-167934; NAS 1.26:167934) Avail: NTIS HC A07/MF A01 CSCL 20N
A TE11 - TM11 dual mode coaxial feed for use in prime focus paraboloidal antenna systems is investigated. The scattering matrix parameters of the internal bifurcation junction was determined by the residue calculus technique. The scattering parameters and radiation fields of the aperture were found from the Weinstein solution. The optimum modeling ratio for minimum cross-polarization was determined along with the corresponding optimum feed dimensions. A peak cross-polarization level of -58 dB is predicted. The frequency characteristics were also investigated and a bandwidth of 5% is predicted over which the cross-polarization remains below -30 dB, the input VSWR is below 1.15, and the phase error is less than 10 deg. Theoretical radiation patterns and efficiency curves for a paraboloidal reflector illuminated by this feed were computed. The predicted sidelobe level is below -30 dB and aperture efficiencies greater than 70% are possible. Experimental results are also presented that substantiate the theoretical results. In addition, experimental results for a "short-cup" coaxial feed are given. The report includes extensive design data for the dual-mode feed along with performance curves showing cross-polarization as a function of feed parameters. The feed is useful for low-cost ground based receiving antennas for use in direct television satellite broadcasting service. Author

N82-13302# Arinc Research Corp., Annapolis, Md.
THE 30/20 GHz COMMUNICATIONS SATELLITE TRUNKING NETWORK STUDY
(Contract NAS3-22496)
(NASA-CA-165407) Avail: NTIS HC A04/MF A01 CSCL 178
Alternative transmission media for a CONJOS wide trunking network in the years 1990 and 2000 are examined. The alternative technologies compared fiberoptic, conventional C-band and Ku-band satellites, and 30/20 GHz satellites. Three levels of implementation were considered - a 10-city network, a 20-city network, and a 40-city network. The cities selected were the major metropolitan areas with the greatest communications demand. All intercity volume, data, and video traffic carried more than 40 miles was included in the analysis. In the optimized network, traffic transmitted less than 50 miles was found to be better served by fiber optic cable in 1980. By the year 2000, the crossover point would be down to 200 miles, assuming availability of 30/20 GHz satellites. Author

N82-17420# Future Systems, Inc., Gaithersburg, Md.
CROSS-IMPACT STUDY OF FOREIGN SATELLITE COMMUNICATIONS ON NASA'S 30/20 GHZ PROGRAM
Aug. 1980 244 p refs
(Contract NAS3-21500)
(NASA-CA-165184; F81-251) Avail: NTIS HC A11/MF A01 CSCL 178
A comprehensive traffic demand forecast and a scenario for the transition process from current satellite systems to more advanced systems of the 1980's are presented. Systems configurations with and without the use of 30/20 GHz are described and these two alternatives are compared. It is concluded that: (1) the use of 30/20 GHz will result in increased satellite capacity, which will be needed to satisfy demand; (2) the use of 30/20 GHz will decrease the transmission cost, especially for broadband communications; (3) in some areas, particularly Europe and Japan but also the U.S., 30/20 GHz is the only available frequency band for customer premise Earth stations because of the dense terrestrial microwave networks; and (4) the development of 30/20 GHz technology will improve U.S. markets for equipment and satellites in many world regions. Author

N82-20362# Hughes Aircraft Co., El Segundo, Calif. Space and Communications Group.
(Contract NAS3-22340)
(NASA-CA-165409 Vol-1; NAS 1.26:165409 Vol-1; SCG-810339R) Avail: NTIS HC A06/MF A01 CSCL 17
Summary information on the final communication system design, communication payload, space vehicle, and development plan for the 30/20 GHz flight experiment will be installed on the LEASAT spacecraft which will be placed into orbit from the space shuttle cargo bay. The communication concept has two parts: a truck service and a customer premise service (CPS). The trucking system serves four spot beams which are interconnected in a satellite switched time division multiple access mode by an IF switch matrix. The CPS covers two large areas of the eastern United States with a pair of scanning beams. M.G.

N82-20363# Hughes Aircraft Co., El Segundo, Calif. Space and Communications Group.
(Contract NAS3-22340)
(NASA-CA-165409 Vol-2; NAS 1.26:165409 Vol-2; SCG-810339R) Avail: NTIS HC A02/MF A01 CSCL 178
A detailed technical description of the 30/20 GHz flight experiment system is presented. The overall communication system is described with performance analyses, communication operations, and experiment plans. Hardware descriptions of the payload are given with the tradeoff studies that led to the final design. The spacecraft bus which carries the payload is discussed and its interface with the launch vehicle system is described. Finally, the hardwares and the operations of the terrestrial segment are presented. R.J.F.

N82-20364# Hughes Aircraft Co., El Segundo, Calif. Space and Communications Group.
(Contract NAS3-22340)
(NASA-CA-165409 Vol-3; NAS 1.26:165409 Vol-3; SCG-810339R) Avail: NTIS HC A32/MF A01 CSCL 178
An approach to the requirements document to be used to procure the system by NASA is presented. The basic approach is similar to the requirements document used in the commercial communications satellite. Enough detail requirements are given to define the system without tight constraints. R.J.F.

N82-20365# Hughes Aircraft Co., El Segundo, Calif. Space and Communications Group.
The development plan for the 30/20 GHz flight experiment system is presented. A master program schedule with detailed development plans for all subsystems is planned with careful attention given to how technology items to ensure a minimal risk. The work breakdown structure shows the organization of the program along with detailed task definitions. The R&D costs based on the development plan are also given.

R.J.F.

A NEW ANTENNA CONCEPT FOR SATELLITE COMMUNICATIONS

G. Skahill and D. Ciccolella Jun. 1982 111 p refs (Contract NAS8-232887)

A novel antenna configuration of two reflecting surfaces and a phased array is examined for application to satellite communications and shown to be superior in every respect to earlier designs for service to the continental United States from synchronous orbit. The vignetted effects that affect other reflector optical systems is eliminated by use of a reflecting field element. The remaining aberrations, predominantly coma, are isolated in the time delay distribution at the surface of the array and can be compensated by ordinary array techniques. The optics exhibits infinite bandwidth and the frequency range is limited only by the design of the array.

Author

The relationship between approaches to planning satellite communication services and spectrum-orbit utilization is considered, with emphasis on the fixed-satellite and the broadcasting-satellite services. It is noted that there are several possible approaches to planning space services, differing principally in the rigidity with which technical parameters are prescribed, in the time for which a plan remains in force, and in the flexibility provided for implementation. With some planning approaches, spectrum-orbit utilization is fixed at the time the plan is made. Others provide for greater flexibility by making it possible to postpone some decisions on technical parameters. In addition, the two political questions of what is equitable access and how it can be guaranteed in practice play an important role.


Serial minimum-shift keyed (MSK) modulation, a technique for generating and detecting MSK using series filtering, is ideally suited for high data rate applications provided the required conversion and matched filters can be closely approximated. Low-pass implementations of these filters as parallel inphase- and quadrature-mixer structures are characterized in this paper in terms of signal-to-noise ratio (SNR) degradation from ideal and envelope deviation. Several hardware implementations utilizing microwave devices or lumped elements are presented. Optimization of parameter values results in realizations whose SNR degradation is less than 0.5 dB at error probabilities of .000001.


A large available margin must be provided for satellite communications systems operating near 20 GHz, which occasionally experience fades due to rain attenuation. It is proposed that this margin may be achieved in high-capacity FDM systems by digitally adjusting a large margin to those links which are experiencing deep fades, while maintaining a small fade margin on all others. Single-beam SCPC operation and multi-beam, satellite-switched FDMA systems are described, and the optimization of the dynamic FDMA links in a severely fading environment is investigated. A solution is derived which takes into account: (1) transponder intermodulation distortion, (2) cochannel and cross-polarization antenna interference, and (3) rain fade characteristics. The sample system configuration presented shows that such systems reach availability levels approaching 0.9999 at Ka-Band. O.C.
33 ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability; components, e.g., tunnel diodes and transistors; microcircuitization; and integrated circuitry.

For related information see also 69 Computer Operations and Hardware and 90 Solid-State Physics.

N82-15311# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
PROCEEDINGS OF THE CONFERENCE ON HIGH-TEMPERATURE ELECTRONICS
(NASA-TI-84039; DB81-02605; CONF-810318) Avail: NTIS HC A07/MF A01 CSCL 09C

The development of electronic devices for use in high temperature environments is addressed. The instrumental needs of planetary exploration, fossil and nuclear power reactors, turbine engine monitoring, and well logging are defined. Emphasis is placed on the fabrication and performance of materials and semiconductor devices, circuits and systems and packaging. For individual titles, see N82-15312 through N82-15337.

N82-15319# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
HIGH TEMPERATURE ELECTRONIC REQUIREMENTS IN AEROPHOPULSION SYSTEMS

The needs for high temperature electronic and electro-optic devices as they would be used on aircraft engines in either research and development applications, or operational applications are discussed. The conclusion reached is that the temperature at which the devices must be able to function is in the neighborhood of 500 to 600 °C either for R&D or for operational applications. In R&D applications the devices must function in this temperature range when in the engine but only for a moderate period of time. On an operational engine, the reliability requirements dictate that the device be able to be burned-in at temperatures significantly higher than those at which they will function on the engine. The major point made is that semiconductor technology must be pushed well beyond at which silicon will be able to function.

M.G.

N82-23397# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
THREE-DIMENSIONAL RELATIVISTIC FIELD-ELECTRON INTERACTION IN A MULTICAVITY HIGH-POWER KLYSTRON. PART 2: WORKING EQUATIONS

A high power multicavity klystron amplifier was designed and a computation package containing all equations and procedures needed is presented. The rigorously derived three dimensional relativistic axysymmetric equations of motion are used to compute the bunched current and the induced RF gap voltage for all interaction cavities except the input and second cavities, where the linear space charge wave theory data are employed in order to reduce the computation time. Both distance step and time step integration methods are used to compute Fourier coefficients of both the beam current and induced current.

S.L.

N82-24415# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MULTISTAGE DEPRESSED COLLECTOR FOR DUAL MODE OPERATION Patent

A depressed collector which captures the spent electrons of a microwave transmitting tube at high efficiency in both high and low power modes of operation is described. The collector comprises entrance and end electrodes, the end electrode having a spike extending toward entrance electrode. Intermediate electrodes and the entrance electrode each have a central aperture and, together, these electrodes capture most high power mode spent electrons. The apertures of the electrodes increase in size in a downstream direction. To capture low power mode spent electrons a low power mode electrode is positioned between the last intermediate electrode and the end electrode. This electrode has a central aperture preferably smaller but no larger than that of the last intermediate electrode. An auxiliary low power mode electrode may be added having a central aperture larger than that of the low power mode electrode. All of the electrodes are at voltages provided by a voltage divider connected between a potential.

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

N82-24431# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
FIRST RESULTS OF MATERIAL CHARGING IN THE SPACE ENVIRONMENT Interim Report

A satellite experiment, designed to measure potential charging of typical thermal control materials at near geosynchronous

ORIGINAL PAGE IS OF POOR QUALITY
A coupled cavity traveling wave tube with a velocity taper, which affords beam wave resynchronization and thereby enhances described. The 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 internal cavity dimensions. The required changes in cavity dimensions can be accomplished by gradually increasing the cavity radius decreasing the gap length from cavity to cavity. The velocity reduction is carried out without an increase in circuit resistive losses and the upper and lower cut off frequencies are reduced in approximately the same manner.

E.A.K.

NB2-30474# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMPONENT TECHNOLOGY FOR SPACE POWER SYSTEMS


NASA-TM-82938; E-1322; NASA 1.15:82928) Avail: NTIS HC A02/MF A01 CSCL 09C

The Lewis/OAST program for the development of Component Technology for Space Power Systems is described. The program is divided into five generic areas: semiconductor devices (transistors, thyristors, and diodes); conductors (materials and transmission lines); dielectrics; magnetic devices; and thermal control devices. Examples of progress in each of the five areas is discussed. Bipolar power transistors up to 1000 V at 100 A with a gain of 10 and a 0.5 μsec rise and fall time are presented. A new class of semiconductor devices with a possibility of switching 1000 000 V is described. Several 100 kW rotary power transformer designs and a 25 kW, 20 kHz transformer weighing 3.2 kg have been developed. Progress on the creation of diamond-like films for thermal devices and intercalated carbon fibers with the strength of steel and the conductivity of copper at one third the mass of copper is presented. Author

NB2-33695# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SUMMARY OF ELECTRIC VEHICLE dc MOTOR-CONTROLLER TESTS Final Report


The differences in the performance of dc motors are evaluated when operating with chopper type controllers, and when operating on direct current. The interactions between the motor and the controller which cause these differences are investigated. Motor-controlled tests provided some of the data the quantified motor efficiency variations for both ripple free and chopper modes of operation.

S.L.

NB2-24432# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SIMPLIFIED dc TO dc CONVERTER Patent Application

Robert P. Gruber, inventor (to NASA) Filed 14 Apr. 1982 17 p

(NASA-Case-LEW-13489-1; US-Patent-Appi-SN-386181B) Avail: NTIS HC A02/MF A01 CSCL 09A

A dc to dc converter is disclosed which has a minimum number of components, outputs voltage regulation, and output current limiting without any circuits converting the output to any other circuits of the converter. The converter is comprised of a transformer having a primary winding through which current is directed in alternate directions by metal oxide semiconductor transistors connected between the primary winding and a dc source or battery. A secondary winding of the transformer is connected to a rectifying and filter circuit to provide unidirectional output current. Both windings of the transformer are carried on the respective outer legs of an E-core with the center leg of the core proving a leakage reactance. This leakage reactance has the same effect as placing an inductor in series with the rectifiers in output circuit.

NASA

NB2-25441# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMPUTER MODELING OF MULTIPLE-CHANNEL INPUT SIGNALS AND INTERMODULATIONS CAUSED BY NONLINEAR TRAVELING WAVE TUBE AMPLIFIERS

N. Stankiewicz May 1982 26 p

(NASA-TP-1999; E-722; NASA 1.60:1999) Avail: NTIS HC A03/MF A01 CSCL 09A

The multiple channel input signal to a soft limiter amplifier as a traveling wave tube is represented as a finite, linear sum of Gaussian functions in the frequency domain. Linear regression is used to fit the channel shapes to a least squares residual error. Distortions in output signal, namely intermodulation products, are produced by the nonlinear gain characteristic of the amplifier and constitute the principal noise analyzed in this study. The signal to noise ratios are calculated for various input powers from saturation to 10 dB below saturation for two specific distributions of channels. A criterion for the truncation of the series leads to ambiguous results in the signal to noise ratios.

Author

NB2-28568# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COUPLED CAVITY TRAVELING WAVE TUBES WITH VELOCITY TAPERING Patent


A coupled cavity traveling wave tube with a velocity taper, which affords beam wave resynchronization and thereby enhances described. The 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 internal cavity dimensions. The required changes in cavity dimensions can be accomplished by gradually increasing the cavity radius decreasing the gap length from cavity to cavity. The velocity reduction is carried out without an increase in circuit resistive losses and the upper and lower cut off frequencies are reduced in approximately the same manner.

E.A.K.
A82-20746# Hard permanent magnet development trends and their application to A.C. machines, H. F. Mildrum (NASA, Lewis Research Center, Cleveland, OH), Institute of Electrical and Electronics Engineers, Annual Meeting, Philadelphia, PA, Oct. 5-9, 1981, Paper 8 p. 27 refs. Research supported by the U.S. Department of Energy; Contract No. DEN3-188.
The physical and magnetic properties of Mn-Al-C, Fe-Cr-Co, and RE-TM (rare earth-transition metal intermetallics) in polymeric and soft metal bonded or sintered form are considered for ac circuit machine usage. The mr nanofabrication processes for the magnetic materials are reviewed, and the mechanical and electrical properties of the magnetic materials are compared, with consideration given to the reference Alnico magnet. The Mn-Al-C magnets have the same magnetic properties and costs as Alnico units, operate well at low temperatures, but have poor high temperature performance. Fe-Cr-Co magnets also have comparable cost to Alnico magnets, and operate at high or low temperature, but are brittle, expensive, and contain Co. RE-Co magnets possess a high energy density, operate well in a wide temperature range, and are expensive. Recommendation for exploring the rare-earth alternatives are offered. M.S.K.

A 30-channel remotely located multiplexer and amplifier module is developed for the measurement of wind tunnel models, which substantially reduces the amount of wiring necessary and thus provides higher accuracy. The module provides for a wide variety of transducer voltage outputs to be multiplexed and amplified within the module, and all signals are able to exit the module on two wires. The module is self-calibrating, and when coupled with the electronically scanned pressure instrumentation widely used in wind tunnels, it allows the modular wind tunnel models to be fabricated and checked before installation into the wind tunnel. N.B.

These basic switching regulators; buck, boost, and buck/boost, employing a multiloop standardized control module (SCM) were characterized by a common small signal block diagram. Employing the unified model, regulator performance such as stability, audiosusceptibility, output impedance, and step load transient are analyzed and key performance indexes are expressed in simple analytical forms. More importantly, the performance characteristics of all three regulators are shown to enjoy common properties due to the unique SCM control scheme which nullifies the positive zero and provides adaptive compensation to the moving poles of the buck and boost converter. This allows a unified design procedure to be devised for selecting the key SCM control parameters for an arbitrarily given power stage configuration and parameter values, such that all regulator performance specifications can be met and optimized concurrently in a single design attempt. (Author)

Avail: NTIS H9 A02/MF A01 CSCL 09C
The current and voltage waveshapes associated with the power transistor and the power diode in an example current-or-voltage step-up (boost) converter are analyzed to help isolate the problems and possible tradeoffs involved in the design of high voltage high power converters operating at switching frequencies in the range of 100 KHz. Although the fast switching speeds of currently available power diodes and transistors permit converter operation at high switching frequencies, the resulting time rates of changes of current coupled with parasitic inductances in series with the semiconductor switches, produce large repetitive voltage transients across the semiconductor switches, potentially far in excess of the device voltage ratings. The need is established for semiconductor switch protection circuitry to control the peak voltages appearing across the semiconductor switches, as well as to provide the wave shaping action required for a given semiconductor device. The possible tradeoffs, as well as the factors affecting the tradeoffs that must be considered in order to maximize the efficiency of the converters are enumerated. A.R.H.

Avail: NTIS HC A08/MF A01 CSCL 09C
Three types of solid state power controllers (SSPCs) for high voltage, high power DC system applications were developed. The first type utilizes a SCR power switch. The second type employs an electromechanical power switch with solid state commutation, and the third type utilizes a transistor power switch. Significant accomplishments include high operating efficiencies, fault clearing, high temperature performance and vacuum operation. E.A.K.

Avail: NTIS HC A15/MF A01 CSCL 09C
Computer aided design and analysis techniques were applied to power processing equipment. Topics covered include: (1) discrete time domain analysis of switching regulators for performance analysis; (2) design optimization of power converters using augmented Lagrangian penalty function technique; (3) investigation of current-injected-multiphase controlled switching regulators; and (4) application of optimization for Navy VSTOL engine power system. The generation of switch models and the development and application of computer aided design techniques to solve the different mathematical models are discussed. Recommendations are made for future work that would enhance the application of the computer aided design techniques for power processing systems. A.R.H.

Avail: NTIS HC A07/MF A01 CSCL 09C
The feasibility of developing a high temperature capacitor for 1100 F operation which is as small and light as conventional capacitors for normal operating temperatures is discussed. Pyrolytic boron nitride (PBN) was selected for the dielectric, The PBN capacitors were made by slicing and lapping material from thick blocks and then sputtering thin film electrodes. These capacitors had breakdown strengths of 7,000 v/mm and a dissipation factor of less than 0.001 at 1100 F. Additional processing improvements were made after testing a multi-layer or stacked PBN capacitor for 1,000 hours at 1100 F. Sputter etching the
Toward developing an aeronautics ULF waveform, a study was conducted to determine the impact of different UlFs on the surface of the specimen. Measurements, which have advanced the state of the art in high-voltage transistors for use in resonant circuit applications, were discussed. Techniques, improvements such as controlling the electric field at the surface and preserving lifetimes in the collector region, which have advanced the state of the art in high-voltage transistors, are described. These improvements can be applied directly to the development of 1200 volt, 200 ampere transistors.

M.D.K.

**N82-15069**
**HIGH VOLTAGE POWER TRANSistor DEVELOPMENT**
(Contract NAS8-23226)
NASA-CR-165547, Rept 81-955-HTRAN-R5)
Avail: NTIS HC A04/MF A01 CSCL 09A

Design considerations, fabrication procedures, and methods of evaluation for high-voltage power-transistor development are discussed. Techniques that control the electric field at the surface and preserving lifetimes in the collector region, which have advanced the state of the art in high-voltage transistors, are presented. Design improvements such as controlling the electric field at the surface and preserving lifetimes in the collector region, which have advanced the state of the art in high-voltage transistors, are discussed. These improvements can be applied directly to the development of 1200 volt, 200 ampere transistors.

M.D.K.

**N82-18506**
Pennsylvania State Univ., University Park, Dept. of Electrical Engineering.
**SECONDARY ELECTRON EMISSION FROM A CHARGED DIELECTRIC IN THE PRESENCE OF NORMAL AND OBLIQUE ELECTRIC FIELDS**
M.S. Thesis
Babram Javidi Feb. 1982 110 p refs
(Contract NAS8-23166)
NASA-CR-168558, Avail: NTIS HC A06/MF A01 CSCL 09C

The secondary electron emission coefficient was obtained for a FEP-Teflon dielectric charged with monoenergetic electrons normally incident upon the surface of the specimen. Measurements of the secondary electron emission coefficient were done for normal and oblique incidence with different primary beam energies; in the presence of normal and oblique electric fields. A collimated probing beam was directed to different points on the surface of the specimen and the released or accumulated charge was monitored using an electrometer. The measured data for different probing beam energies, different impact points and different angles of incidence points were plotted vs. impact energy and impact point. Data analyzed by computer simulations to find the potential distribution on the surface of the specimen and the electric field around it, is presented and discussed.

M.D.K.

**N82-18509**
Pennsylvania State Univ., University Park, Dept. of Electrical Engineering.
**MAPPING OF ELECTRICAL POTENTIAL DISTRIBUTIONS WITH CHARGED PARTICLE BEAMS**
James W. Robinson Feb. 1982 61 p refs
(Grant NoG-3168)
NASA-CR-165556, Avail: NTIS HC A04/MF A01 CSCL 09C

Methods for measuring electrostatic potentials on and near dielectric surfaces charged to several kilovolts were studied. Secondary emission from charged dielectric surfaces is measured. Candidates for potential measurement include the induced charge, from which potential is calculated; the trajectory endpoints of either high or low energy particles traversing the region near the surface; trajectory impact on the surface; and creating ions at points of interest near the surface. Some of the methods require computer simulations and iterative calculations if potential maps are to be generated. Several approaches are described and compared. A method using a half-cylinder as a test chamber and low-energy probing beams is adapted for the measurement of secondary emission.

N.W.

**N82-22439**
Duke Univ, Durham, N. C. Dept. of Electrical Engineering.
**ANALYSIS OF TRANSISTOR AND SNUBBER TURN-OFF DYNAMICS IN HIGH-FREQUENCY HIGH-VOLTAGE HIGH-Power CONVERTERS**
Paul M. Wilson, Thomas G. Wilson, and Harry A. Owen, Jr. 1982 0 p refs
(Grant NoG-3157)
NASA-CR-168760, NAS 1.26:163870, Avail: NTIS HC A02/MF A01 CSCL 09C

To dc to converters which operate reliably and efficiently at switching frequencies high enough to effect substantial reductions in the size and weight of converter energy storage elements are studied. A two winding current or voltage stepup (buck-boost) dc-to-dc converter power stage submodular designed to operate in the 5-25 kW range, with an input voltage range of 110 to 180 V dc, and an output voltage of 250 V dc is emphasized. In order to assess the limitations of present day component and circuit technologies, a design goal switching frequency of 1 MHz was maintained. The converter design requirements represent a unique combination of high frequency, high voltage, and high power operation. The turn off dynamics of the primary circuit power switching transistor and its associated turn off snubber circuitry are investigated.

S.L.

**N82-23935**
**PRELIMINARY DESIGN DEVELOPMENT OF 100 KW ROTARY POWER TRANSFER DEVICE**
(Contract NAS8-22266)
NASA-CR-165431, NAS 1.26:165431, GE-81SDS4215, Avail: NTIS HC A08/MF A01 CSCL 09C

Contactless power transfer devices for transferring electrical power across a rotating spacecraft interface were studied. A power level of 100 kW was of primary interest and the study was limited to alternating current devices. Rotary transformers and rotary capacitors together with the required dc to ac power conditioning electronics were examined. Microwave devices were addressed. The transformer with resonant circuit power conditioning was selected as the most feasible approach. The rotary capactor would be larger while microwave devices would be less efficient. A design analysis was made of a 100 kW, 20 kHz power transfer device consisting of a rotating transformer, power conditioning electronics, drive mechanism and heat rejection system. The size, weight and efficiency of the device were determined. The characteristics of a baseline slip ring were presented. Aspects of testing the 100 kW power transfer device were examined. The power transfer device is a feasible concept which can be implemented using presently available technologies.

Author

**N82-24424**
Department of Energy, Washington, D. C.
**DEVELOPMENT OF A DUAL-FIELD HETEROPOlar POWER CONVERTER**
David B. Eisenhaure, Bruce Johnson, Tim E. Blaisdips, and Emery StGeorge Aug. 1981 68 p refs
(Contract NAS8-20817; DE-A01-77CS-1044)

The design and testing of a 400 watt, dual phase, dual rotor, field modulated inductor alternator is described. The system is designed for use as a flywheel to ac utility line or flywheel to dc bus (electric vehicle) power converter. The machine is unique in that it uses dual rotors and separately controlled fields to produce output current and voltage which are in phase with each other. Having the voltage and current in phase allows the power electronics to be made of simple low cost components. Based on analytical predictions and experimental results, development of a complete 22 kilowatt (30 Hp) power conversion system is recommended. This system would include power electronics and controls and would replace the inductor alternator with an improved electromagnetic conversion system.

Author
The proposed approach for control of the peaking of the output discussed, and a circuit is presented for recovering trapped snubber suppression of its secondary emission ('bootstrap' charging). The reliability improvement is projected by the use of remote high

The problems caused by the interaction between the input filter, output filter, and the control loop are discussed. The input filter design is made more complicated because of the need to avoid performance degradation and also stay within the weight and loss limitations. Conventional input filter design techniques are then discused. The concept of pole-zero cancellation is reviewed; this concept is the basis for an approach to control the peaking of the output impedance of the input filter and thus mitigate some of the problems caused by the input filter. The proposed approach for controlling the output impedance of the input filter is to use a feedforward loop working in conjunction with a feedback loop, thus forming a total state control scheme. The design of the feedforward loop for a buck regulator is described. A possible implementation of the feedforward loop design is suggested.

Both straight and chopped dc motor performance data for a General Electric SB4438A1 dc shunt motor with a General Electric EV-1 controller is presented in tabular and graphical formats. Effects of motor temperature and operating voltage are also shown. The maximum motor efficiency is approximately 85% at low operating temperatures in the straight dc mode. Chopper efficiency can be assumed to be 95% under all operating conditions. For equal speeds, the motor operated in the chopped mode develops slightly more torque and draws more current than it does in the straight mode.

The maximum motor efficiency is approximately 85% at low operating temperatures in the straight dc mode. Chopper efficiency can be assumed to be 95% under all operating conditions. For equal speeds, the motor operated in the chopped mode develops slightly more torque and draws more current than it does in the straight mode.

J.D.


The paper examines the charging of a checkerboard array of two materials, only one of which tends to acquire a negative potential due to the suppression of its secondary emission ('bootstrap' charging). The NASCAP predictions for the equilibrium potential difference between the two materials are compared to results based on an analytical model.


Anisotropic Mn-Al-C (Ni) magnets are potent substitutes for Alnico 5 and 8. The limited machinability of the alloy and the fact that it is cobalt-free makes it particularly interesting. The low Curie point and the costly warm extrusion process needed for grain orientation are drawbacks. The objective of this study was a detailed magnetic characterization of the material for possible use in electric machinery. The principal sub-tests of the study were the largest extruded bars presently available, of 31 mm diameter. Easy and hard axis magnetization curves and second-quadrant recoil loop fields were measured at various temperatures ranging from -50 C to +150 C. Property variations over the cross section of a bar were also studied.


Future high capacity satellite communication systems require signal processing on board satellites. The on-board signal processor includes switching of RF signals between multiple antennas to provide interconnection between the uplink and downlink beams. This paper describes the development of a dynamic switch matrix for a TDMA satellite switching system to be used in the next generation communications satellites. In this paper, a dynamic switch matrix,
which includes the microwave switch matrix, the distribution control unit and the timing source, will be described. Several different microwave switch matrix architectures and switching devices were evaluated and compared. A unique coupler crossbar switch matrix architecture with dual-gate field effect transistor as switching element was developed. Experimental results of both microwave switch matrix (MSM) and distribution control unit (DCU) are presented. These test results verify the MSM with coupler crossbar architecture and dual-gate FET as switching element will meet the future SS-TDMA system requirements. Finally, the reliability of the dynamic switch matrix is addressed. The analysis shows reliability of 0.9981 for 7 year space operation can be achieved for the designed dynamic switch matrix.


Fluid Mechanics and Heat Transfer

Includes boundary layers; hydrodynamics; fluidics; mass transfer; and ablation cooling.

For related information see also 02 Aerodynamics and 77 Thermodynamics and Statistical Physics.

N82-11397*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

LEWIS RESEARCH CENTER’S COAL-FIRED, PRESSURIZED, FLUIDIZED-BED REACTOR TEST FACILITY

(NASA-TM-81816: E-621) Avail: NTIS HC A03/MF A01 CSCL 20D

A 200-kilowatt-thermal, pressurized, fluidized-bed (PFB) reactor, research test facility was designed, constructed, and operated as part of a NASA-funded project to assess and evaluate the effect of PFB hot-gas effluent on aircraft turbine engine turbogenerators. Some of the techniques and component’s developed for this PFB system are described. One of the more important items was the development of a two-in-one, gas-solids separator that removed 95% of the solids in 1600 S to 1900 F gases. Another was a coal and sorbent feed and mixing system for injecting the fuel into the pressurized combustion chamber. Also important were the controls and data-acquisition systems that enabled one person to operate the entire facility. The solid, liquid, and gas sub-systems all had problems that were solved over the 2-year operating time of the facility, which culminated in a 400-hour, hot-gas, turbine test.

A.R.H.

N82-11398*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

HIGH THERMAL POWER DENSITY HEAT TRANSFER Patent
Application

James F. Morris, inventor (to NASA) Filed 30 Oct, 1980 10 p

Heat from a high temperature heat pipe is transferred through a vacuum or a gap filled with electrically nonconducting gas to a cooler heat pipe. The heat pipe is used to cool the nuclear reactor while the heat pipe is connected thermally and electrically to a thermionic converter. If the reactor requires greater thermal power density, geometries are used with larger heat pipe areas for transmitting and receiving energy than the area for conducting the heat to the thermionic converter. In this way the heat pipe capability for increasing thermal power densities compensates for the comparatively low thermal power densities through the electrically non-conducting gap between the two heat pipes.

NASA

N82-17452*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

EFFECTS OF ARC CURRENT ON THE LIFE IN BURNER RIG THERMAL CYCLING OF PLASMA SPRAYED ZrSUB2-YSUB2OYSUB3


An analysis of thermal cycle life data for four sets of eight thermal barrier coated specimens representing arc currents (plasma gun power) of 925, 1200, 1500, or 1875 amps, sprayed with the ZrO2-BY203/NiCrAlY plasma spray coated Rene 41 rods were thermal cycled to 1040 C in a Mach 0.3-Jet A/air burner flame. The experimental results indicate the existence of a minimum or threshold power level which coating life expectancy is less than 500 cycles. Above the threshold power level, coating life expectancy more than doubles and increases with arc current.

T.M.

N82-19494*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

HYDRODYNAMIC AND AERODYNAMIC BREAKUP OF LIQUID SHEETS

(NASA-TM-82806: E-1138) Avail: NTIS HC A02/MF A01 CSCL 20D

The effect of hydrodynamic, aerodynamic and liquid surface forces on the mean drop diameter of water sprays that are produced by the breakup of nonswirling and swirling water sheets in quiescent air and in airflows similar to those encountered in gas turbine combustors is investigated. The mean drop diameter is used to characterize fuel sprays and it is a very important factor in determining the performance and exhaust emissions of gas turbine combustors.

S.L.

N82-20467*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

FLOW THROUGH ALIGNED SEQUENTIAL ORIFICE TYPE INLETS


Choked flow rate and pressure profile data were taken and studied for configurations consisting of four axially aligned, sequential orifice inlets of 0.5 length diameter ratio with separation distances of 0.66 and 32 diameters. A flow coefficient - reduced chord pressure temperature plot represents the flow rate data for the two cases. At a separation distance of 32 diameters the pressure profiles dropped sharply at the entrance and partially recovered within each orifice - the exception being at low temperatures, where fluid jetting through the last orifice occurred. At a separation distance of 0.66 diameter fluid jetting was prevalent at the lower inlet temperatures. These results are in qualitative agreement with data for four axially aligned, sequential Borda inlets and for tubes with single sharp edge orifice or Borda inlets to L/D’s of 105 and with a water flow visualization study.

S.L.

N82-22452*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

GENERATION OF INSTABILITY WAVES AT A LEADING EDGE

Marvin E. Goldstein 1982 12 p refs Proposed for presentation...
A thermal barrier coating is applied to solid film cooled hardware. Also, thermal barrier coating systems are used to provide corrosion resistance and thermal protection on base metal surfaces. An inert gas, such as argon, is discharged through the apertures during the application of the thermal barrier coating system by plasma spraying. This flow of inert gas reduces both blocking of the holes and base metal oxidation during the coating operation. NASA

**N82-26811**### National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**DEPOSITION FORMATION IN HYDROCARBON ROCKETS FUELS WITH AN EVALUATION OF A PROPANE HEAT TRANSFER CORRELATION**


A high pressure fuel coking testing apparatus was designed and developed and was evaluated to study decomposition limits and carbon decomposition rates in heated copper tubes for hydrocarbon fuels. A commercial propane (90% grade) and chemically pure (CP) propane were tested. Heat transfer to supercritical propane was evaluated at 136 atm, bulk fluid velocities of 6 to 20 m/s, and tube wall temperatures in the range of 422 to 611 K. A forced convection heat transfer correlation developed in a previous test verified a prediction of most of the experimental data within a + ur - 30% range, with good agreement, for the CP propane data. No significant differences were apparent in the predictions derived from the correlation when the carbon resistance was increased with the film resistance. A post-test scanning electron microprobe analysis indicated occurrences of migration and interdiffusion of copper into the carbon deposit.

**N82-28574**### National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**THE DRYOUT REGION IN FRICTIONALLY HEATED SLIDING CONTACTS**


Some conditions under which boiling and two-phase flow can occur in or near a wet sliding contact are determined and illustrated. The experimental apparatus consisted of a tool pressed against an instrumented slider plate and motion picture sequences were taken at 4000 frames/sec. The temperature and photographic data demonstrated surface conditions of boiling, drying trapped gas evolution (solutions), and volatility of fluid mixture components. The theoretical modeling and analysis are in reasonable agreement with experimental data.

**N82-30498**### National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FLOW VISUALIZATION STUDY OF THE HORSESHOE VORTEX IN A TURBINE STATOR CASCADE**

Raymond E. Gaugier and Louis M. Russell Jun, 1982 33 p refs (NASA-TP-1884; E-815; NAS 1.60.1884) Avail: NTIS HC A03/MF A01 CSCL 20D

Flow visualization techniques were used to show the behavior of the horseshoe vortex in a large scale turbine stator cascade. Oil drops on the end wall surface flowed in response to local shear stresses, indicating the limiting flow streamlines at the surface. Smoke injected into the flow and photographed showed time averaged flow behavior. Neutrally buoyant helium filled soap bubbles followed the flow and photographed as streaks, indicating the paths followed by individual fluid particles. Preliminary attempts to control the vortex were made by injecting air through control jets drilled in the end wall near the vane leading edge. Seventeen different hole locations were tested, one at a time, and the effect of the control jets on the path followed by smoke in the boundary layer was recorded photographically.

**ORIGINAL PAGE IS OF POOR QUALITY**
TURBULENT SOLUTION OF THE NAVIER-STOKES EQUATIONS FOR UNIFORM SHEAR FLOW
To study the nonlinear physics of uniform turbulent shear flow, the unaveraged Navier-Stokes equations are solved numerically. This extends our previous work in which mean gradients were absent. For initial conditions, modified three-dimensional-cosine velocity fluctuations are used. The boundary conditions are modified periodic conditions on a stationary three-dimensional numerical grid. A uniform mean shear is superimposed on the initial and boundary conditions. The three components of the mean-square velocity fluctuations are initially equal for the conditions chosen. As in the case of no shear the initially nonrandom flow develops into an apparently random turbulence at higher Reynolds number. Thus, randomness or turbulence can apparently arise as a consequence of the structure of the Navier-Stokes equations. Except for an initial period of adjustment, all fluctuating components grow with time. The initial equality of the three intensity components is destroyed by the shear, the transverse components becoming smaller than the longitudinal one, in agreement with experiment. Also, the shear creates a small-scale structure in the turbulence. The nonlinear solutions are compared with linearized ones.

Choked flow rate and pressure profile data were taken and studied for two axially aligned sequential configurations consisting of: (1) Four Borda type inlets of 1.9 1/D with two separation distances of 0.8 and 30 diameters. (2) Four orifice type inlets of 0.5 1/D with two separation distances of 0.66 and 32 diameters. A flow-coefficient reduced-temperature plot can be used to represent the flow rate data for each geometry. At the larger separation distances, the pressure profiles dropped sharply at the entrance and partially recovered within each of the Borda and orifice inlet configurations; the exception being the last inlet where at low entrance temperatures, fluid jetting could occur. For the smaller spacings fluid jetting was prevalent throughout each of the inlet configurations at lower inlet temperatures. These results are in qualitative agreement with data of tubes with single Borda or sharp-edge orifice type inlets to 105 1/D and water flow visualization studies.

A82-16570 * # Toward the use of similarity theory in two-phase choked flows. R. C. Hendricks, R. J. Simoenu (NASA, Lewis Research Center, Cleveland, OH), and J. V. Sengers (Maryland, University, College Park, MD). In: Scaling in two-phase flows; Proceedings of the Winter Annual Meeting, Chicago, IL, November 18-21, 1980. Meeting sponsored by the American Society of Mechanical Engineers, New York, American Society of Mechanical Engineers (Heat Transfer Symposia Series. HTD Volume 14), 1980, p.45-53, 13 refs.
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.

A solution to the rapid-distortion theory for small-scale turbulence in flow round an axisymmetric obstacle is derived. General formulae for velocity covariances and Eulerian time scales are obtained and are evaluated for the particular case of flow round a sphere. The large-scale limit for this flow is also discussed.

Heat transfer characteristics are analyzed for a cooled two-dimensional porous medium having a curved boundary. A general analytical procedure is given in combination with a numerical conformal mapping method used to transform the porous region into an upper half plane. To illustrate this method, results are evaluated for a cosine shaped boundary subjected to uniform external heating. The results show that grid-generated turbulence and the extent that internal heat conduction causes the heated surface to have a more uniform temperature.

A method is developed to determine the shape of steady state solidification interfaces formed when liquid above its freezing point circulates over a cold surface. The solidification interface, which is at uniform temperature, will form in a shape such that the non-uniform energy convected to it is locally balanced by conduction into the solid. The interface shape is of interest relative to the crystal structure formed during solidification; regulating the crystal structure has application in casting naturally strengthened metallic composites. The results also apply to phase-change energy storage devices, where the solidified configuration and overall heat transfer are provided. The analysis uses a conformal mapping technique to relate the desired interface coordinates to the components of the temperature gradient at the interface. These components are unknown because the interface shape is unknown. A Cauchy integral formulation provides a second reference involving the components, and a simultaneous solution yields the interface shape.
show that the decay exponent m depends on the ratio of the initial length scales of velocity and temperature, although when this ratio is greater than 2.5 such dependence is negligible. The theory shows that m is not truly constant, but within the range covered by the experiments it is nearly so. The agreement between theory and experiment lends credence to the idea that the decay of fluctuations is controlled largely by turbulent relative dispersion. (Author)


The flowfields of gas turbine combustion chambers were investigated. Six flowfield configurations with sidewall angles alpha = 90 and 45 deg, and swivl vane angles phi = 0, 45 and 70 deg, are characterized. Photography of neutrally-buoyant helium-filled soap bubble tufts, and injected smoke helps to characterize the time-mean streamlines, recirculation zones, and regions of highly turbulent flow. Five-hole pitot probe pressure measurements allow the determination of time-mean velocities u, v and w. An advanced computer code equipped with a standard two-equation k-e turbulence model was used to predict the pressure and corresponding flow situations and to compare results with the experimental data. J.D.H.


Measurements were made of the heat transfer rate through turbulent and transitional boundary layers on an isothermal, convexly curved wall and downstream flat plate. The effect of convex curvature on the fully turbulent boundary layer was a reduction of the local Stanton numbers 20% to 50% below those predicted for a flat wall under the same circumstances. The recovery of the heat transfer rates on the downstream flat wall was extremely slow. After 60 cm of recovery length, the Stanton number was still typically 15% to 20% below the flat wall predicted value. Various effects important in the modeling of curved flows were studied separately. These are: the effect of initial boundary layer thickness, the effect of freestream velocity, the effect of freestream acceleration, the effect of unheated starting length, and the effect of the maturity of the boundary layer. An existing curvature prediction model was tested against this broad heat transfer data base to determine where it could appropriately be used for heat transfer predictions.


Measurements and computations are being applied to an axisymmetric swirling flow, emerging from swirl vanes at angle phi, entering a large chamber test section via a sudden expansion of various side-wall angles alpha. New features are: the turbulence measurements are being performed on swirling as well as nonswirling flow; and all measurements and computations are also being performed on a confined jet flowfield with realistic downstream blockage. Recent activity falls into three categories: (1) Time-mean flowfield characterization by five-hole pitot probe measurements and by flow visualization; (2) Turbulence measurements by a variety of single- and multi-wire hot-wire probe techniques; and (3) Flowfield computations using the computer code developed during the previous year's research program. (Author)


Downstream mixing of coaxial jets discharging in an expanded duct was studied to obtain data for the evaluation and improvement of turbulent transport models currently used in a variety of computational procedures throughout the propulsion community for combuster flow modeling. Flow visualization studies showed four major shear regions occurring: a wake region immediately downstream of the inner jet inlet duct; a shear region farther downstream between the inner and annular jets; a recirculation zone; and a reattachment zone. A combination of turbulent momentum transport rate and two velocity component data were obtained simultaneously. Five hole pitot probe pressure measurements were made to determine the turbulence level. Axial, radial and azimuthal velocities and turbulent momentum transport rate measurements in the r-z and r-theta planes were used to determine the mean value, second central moment (or rms fluctuation from mean), skewness and kurtosis for each data set probability density function (p.d.f.). A combination of turbulent mass transport rate, concentration and velocity data was obtained system. Velocity and mass transport in all three directions as well as concentration distributions were used to obtain the mean, second central moments, skewness and kurtosis for each p.d.f. These LV/LIF measurements also exposed the existence of a large region of countergradient turbulent axial mass transport in the region where the annular jet fluid was accelerating the inner jet fluid. S.L.
process was dominated by circulations (secondary flows) of a length scale on the order the lobe dimensions which were associated with strong radial velocities observed near the lobe exit plane. The "benchmark" model mixer experiment conducted for code assessment purposes is discussed. N.W.

N82-29349# United Technologies Research Center, East Hartford, Conn.
(NASA-CR-3483; NAS 1.26;3483) Avail: NTIS HC A05/ MF A01 CSCL 20D

A general program was conducted to develop and assess a computational method for predicting the flow properties in a turbofan forced mixed duct. The detail assessment of the resulting computer code is presented. It was found that the code provided excellent predictions of the kinematics of the mixing process throughout the entire length of the mixer nozzle. The thermal mixing process between the hot and cold flows was found to be well represented in the low speed portion of the flowfield.

N82-29460# United Technologies Research Center, East Hartford, Conn.
(NASA-CR-3494; NAS 1.26;3494; RB1-912929) Avail: NTIS HC A07/ MF A01 CSCL 20D

A finite difference method is developed for making detailed predictions of three dimensional subsonic/turbulent flow in turbofan lobe mixers. The governing equations are solved by a forward-marching solution procedure which corrects an inviscid potential flow solution for viscous and thermal effects, secondary flows, total pressure distortion and losses, internal flow blockage and pressure drop. Test calculations for a turbulent coaxial jet flow verify that the turbulence model performed satisfactorily for this relatively simple flow. Lobe mixer flows are presented for two geometries typical of current mixer design. These calculations included both hot and cold flow conditions, and both matched and mismatched Mach number and total pressure in the fan and turbine streams.

N82-294452# Southwest Research Inst., San Antonio, Tex.
STUDY OF VAPOR FLOW INTO A CAPILLARY ACQUISITION DEVICE Final Report Franklin T. Dodge and Edgar B. Bowles Apr. 1982 24 p refs (Contract NAS3-22664)
(NASA-CR-167883; NAS 1.26;167883; SuRI02-6369) Avail: NTIS HC A04/ AF A01 CSCL 20D

An analytical model was developed that prescribes the conditions for vapor flow through the window screen of a start basket. Several original submodels were developed as part of this model. The submodels interrelate such phenomena as the effect of internal evaporation of the liquid, the bubble point change of a screen in the presence of wicking, and the effect on wicking of a difference between the static pressure of the liquid and the surrounding vapor. Most of these interrelations were verified by a series of separate tests, which were also used to determine certain empirical constants in the models. The equations of the model were solved numerically for typical start basket designs, and a simplified start basket was constructed to verify the predictions, using both volatile and nonvolatile test liquids. The test results verified the trends predicted by the model.

S.L.

N82-27698# Pennsylvania State Univ., University Park. Turbomachinery Lab.
THREE DIMENSIONAL FLOW FIELD INSIDE COMPRESSOR BLADE, INCLUDING BLADE BOUNDARY LAYERS Semiautual Progress Report J. M. Gaimes, M. Pongere, and B. Lakkhistoire Jun. 1982 78 p refs (Grant NsG-3260)
(NASA-CR-169120; NAS 1.26;169120; PSU/Turbo-82-A) Avail: NTIS HC A03/ MF A01 CSCL 20D

The Reynolds stress equation, pressure strain correlation, and dissipative terms and diffusion are discussed in relation to turbulence modelling using the Reynolds stress model. Algebraic modeling of Reynolds stresses and calculation of the boundary layer over an axial cylinder are examined with regards to the kinetic energy model for turbulence modelling. The numerical analysis of blade and hub wall boundary layers, and an experimental study of rotor blade boundary layer in an axial flow compressor rotor are discussed. The Patankar-Spalding numerical method for two dimensional boundary layers is included. A.R.H.

N82-21639# Connecticut Univ., Storrs, Dept. of Mechanical Engineering.
TURBINE ENDWALL SINGLE CYLINDER PROGRAM Semianual Status Report, 1 Jan. - 1 Jul. 1982 Lee S. Langston 1 Jul. 1982 50 p refs (Grant NSG-3238)
(NASA-CR-169278; NAS 1.26;169278) Avail: NTIS HC A03/ MF A01 CSCL 20D

Detailed measurement of the flow field in front of a large-scale single cylinder, mounted in a wind tunnel is discussed. A better understanding of the three dimensional separation occurring in front of the cylinder on the endwall, and of the vortex system that is formed is sought. A data base with which to check analytical and numerical computer models of three dimensional flows is also anticipated. Author

N82-31639# City Coll. Research Foundation, New York. Turbomachinery Lab.
EXPERIMENTAL STUDY OF TURBULENCE IN BLADE END WALL CORNER REGION R. Rai Aug. 1982 110 p refs (Grant NAG3-122)
(NASA-CR-169283; NAS 1.26;169283; RF-05438) Avail: NTIS HC A06/ MF A01 CSCL 20D

Corner flows and wall pressure fluctuations, design and fabrication of the test model, preliminary results on boundary layer, flow visualization, turbulence intensity and spectra measurements are presented. The design considerations and fabrication report on the newly built wind tunnel to be used for subsequent continuation of the research effort is also presented. S.L.

N82-31641# Cornell Univ., Ithaca, N. Y. Energy Program.
EXHAUST GAS MEASUREMENTS IN A PROPANE FUELED SWIRL STABILIZED COMBUSTOR M. S. Aanad Aug. 1982 177 p refs (Grant NAG3-1019)
(NASA-CR-169293; NAS 1.26;169293; E-82-A) Avail: NTIS HC A09/ MF A01 CSCL 20D

Exhaust gas temperature, velocity, and composition are measured and combustor efficiencies are calculated in a lean premixed swirl stabilized laboratory combustor. The radial profiles of the data between the co- and the counter swirl cases show significant differences. Co-swirl cases show evidence of poor turbulent mixing across the combustor in comparison to the counter-swirl cases. NO sub x levels are low in the combustor but substantial amounts of CO are present. Combustion efficiencies are low and surprisingly constant with varying outer swirl in contradiction to previous results under a slightly different inner swirl condition. This difference in the efficiency trends is expected.

S.L.
to be a result of the high sensitivity of the combustor to changes in the inner swirl. Combustor operation is found to be the same for propane and methane fuels. A mechanism is proposed to explain the combustor operation and a few important characteristics determining combustor efficiency are identified.

J.D.

N82-31642*Cornell Univ., Ithaca, N. Y.
FLOW PROCESS IN COMBUSTORS
F. C. Gouldin Jun. 1982 16 p refs
(Grant NsG-3019)
(NASA-CR-169298; NAS 1.26:169294) Avail: NTIS
HC A02/AF A01 CSCL 20D
Fluid mechanical effects on combustion processes in steady flow combustors, especially gas turbine combustors were investigated. Flow features of most interest were vorticity, especially swirl, and turbulence. Theoretical analyses, numerical calculations, and experiments were performed. The theoretical and numerical work focused on noncombusting flows, while the experimental work consisted of both reacting and nonreacting flow studies. An experimental data set, e.g., velocity, temperature and composition, was developed for a swirl flow combustor for use by combustion modelers for development and validation work.

J.D.

N82-31643* Oklahoma State Univ., Stillwater, School of Mechanical and Aerospace Engineering
David G. Lilley 31 Jul. 1982 252 p refs
(Grant NAG3-74)
(NASA-CR-169295; NAS 1.26:169295; SASR-4) Avail: NTIS
HC A12/AF A01 CSCL 20D
Experimental and theoretical research undertaken on 2-D axisymmetric geometries under low speed, nonreacting, turbulent, swirling flow conditions is reported. The flow enters the test section and proceeds into a larger chamber (the expansion ratio D/d = 2) via a sudden or gradual expansion (sidewall angle alpha = 90 and 45 degrees). Inlet swirl vanes are adjustable to a variety of vane angles with values of phi = 0, 38, 45, 60 and 70 degrees being emphasized.

Author

A82-10961* A heat exchanger computational procedure for temperature-dependent fouling. L. M. Chiapetta and E. J. Szetela

A novel heat exchanger computational procedure is described which provides a means of rapidly calculating the distributions of fluid flow, wall temperatures, deposit formation, and pressure loss at various points in a heat exchanger. The procedure is unique in that it is capable of treating wide variations in heat exchanger geometry without recourse to restrictive assumptions concerning heat exchanger type (e.g., co-flow, counterflow, cross flow devices, etc.). The analysis has been used extensively to predict the performance of counterflow heat exchangers in which one fluid behaves as a perfect gas (e.g., air) while the other fluid is assumed to be a dilatant fluid. The model has been extended to include the effects on heat exchanger performance of time varying inflow conditions. Heat exchanger performance degradation due to deposit formation with time can be simulated, making this procedure useful in predicting the effects of temperature-dependent fouling.

(Author)


Six flowfield configurations are investigated with sidewall angles of 90 and 45 deg, and swirl vane angles of 0, 45, and 70 deg. It is found that central recirculation zones occur for the swirling flow cases investigated, which extend from the inlet to x/D = 1.7, where x is the axial polar coordinate, and D is the test section diameter. Five-hole pitot probe pressure measurements are used to determine time-mean velocities, and corresponding flow situations are predicted and compared to results of experimental data. Excellent agreement is found for the nonswirling flow, although poor agreement is found for swirling flow cases, especially near the inlet. The discrepancy is attributed to the lack of realism in the turbulence model, and to inadequate specification of time-mean velocity and turbulence energy distributions at the inlet.

A82-17880* Atomization and combustion properties of flashing injectors. A. S. P. Solomon, S. D. Ruppe (Pennsylvania State University, University Park), Westinghouse Research Laboratories, Monroeville, PA, L-D. Chen, and G. M. Faeth (Pennsylvania State University, University Park).
to flow in a combustion tunnel where the flame is stabilized by a back-facing step. Solutions for both nonreacting and reacting flow fields were obtained which satisfactorily describe the essential features of turbulent combustion in a lean propane-air mixture that were observed in the laboratory by means of high speed Schlieren photography. (Author)


The problem of free and natural convection with combined driving forces is considered in general and all possible configurations are identified. Dimensionless parameters are discussed in order to help categorize the various problems, and existing work is critically evaluated. Four distinct cases are considered for conventional convection and for the situation when the body force and the density gradient are parallel but opposite. Considerable emphasis is given to unstable convection in horizontal layers. C.D.


The integral representation method was used to obtain numerical solutions of the compressible, unsteady, two-dimensional Navier-Stokes equations for subsonic flows. The equations were written with the vorticity, the density, and the enthalpy as independent variables. The method was tested by solving the following problems: the flow over a flat plate, around a circular cylinder, and around a Joukowski airfoil. The last two problems involved massive flow separation. The approach offers the capability of confining the domain of computations to the region where two quantities, the vorticity and the difference in dilatation between the real flow and the potential flow, are non-negligible. (Author)


The considered investigation is concerned with the development of an efficient computational method for obtaining a physical understanding of an internal turbulent field. The employed approach makes use of a two-equation model for the turbulence to obtain the numerical solution of a two-dimensional confined turbulent flow. The mean flow governing equations are considered along with the governing equation of the mean temperature and concentrations, and the boundary conditions. The numerical procedure for solving the turbulent flow is discussed, taking into account an approximation to the nonlinear terms, and the inner and outer coupling. Attention is given to a stability convergence analysis, the stability characteristics, and computational examples. G.R.


A numerical technique is presented for the analysis of turbulent flow associated with combustion. The technique uses Chorin's random vortex model (rvm), an algorithm capable of tracing the action of elementary turbulent eddies and their cumulative effects without imposing any restriction upon their motion. In the past, the rvm has been used with success to treat nonreacting turbulent flows, revealing in particular the mechanism of large-scale structures, the so-called coherent structures. Introduced here is a flame propagation algorithm, also developed by Chorin, in conjunction with volume sources modelling the mechanical effects of the exothermic process of combustion. As an illustration of its use, the technique is applied...

The six-orientation hot-wire technique is applied to nonreacting axisymmetric flowfields, obtaining measurements of time-mean and rms volatges at six different orientations, thus providing enough information to determine the time-mean velocities, turbulence intensities, and shear stresses. At each location in the flow, there are six different values of each of the above quantities that can be obtained using six sets of measurements of three adjacent orientations. Flowfield surveys of both sidewall and nonswirling confined jets are used to calculate estimates of the mean velocity components and the normal and shear turbulent stresses, and comparisons with independent data are made. A sensitivity analysis of the data reduction technique demonstrates that the largest uncertainties are to be expected in the turbulent shear force estimates.


Liquid undergoing nonlinear Marangoni instability in a circular cylinder is examined, with attention given to roll-cell development and interaction. Surface deformations are neglected and the side walls are considered as adiabatic and impermeable, allowing the liquid to freely slip. The nonlinear convective states are calculated and their stability is defined. The behavior and amplitude of cells forming in the liquid, heated from below, is modeled in order to derive all the transport properties. A new small parameter is formulated which is related to the critical Marangoni number of the infinite matrix expressing the eigenvalue expansion of the problem. The observed roll cell amplitudes and transport properties are shown to be available from simple eigenvalues, with double eigenvalues, indicating the existence of two roll-states as predicted by linear theory, nonlinear theory calculates transitions from one steady convective state to another.


It is shown that flames which spread vertically down thermally thin fuels at the same Damköhler number, and therefore have the same dimensionless spread rate, show the same dimensionless temperature fields irrespective of differences in physical size. The Frey and Tien (1976) effects of pressure on flame size are due to the effects of pressure on the character of the induced buoyant flow.


This paper describes a computer code for calculating the flow dynamics of constant density flow in the second stage trumpet shaped nozzle section of a two stage MHD swim combustor for application to a disk generator. The primitive pressure-velocity variable, finite-difference computer code has been developed to allow the computation of inert nonreacting turbulent swirling flows in an axisymmetric MHD model swirl combustor. The method and program involve a staggered grid system for axial and radial velocities, and a line relaxation technique for efficient solution of the equations. Turbulence simulation is by way of a two-equation Kappa-epsilon model. The code produces as output the flowfield map of the nondimensional stream function, axial, and swirl velocity. Good agreement was obtained between the theoretical predictions and the qualitative experimental results. The best seed injector location for uniform seed distribution at combustor exit is with injector located centrally on the combustor axis at entrance to the second stage combustor.


Self-adaptive solution algorithms are developed for nonlinear heat conduction problems encountered in analyzing materials for use in high temperature or cryogenic conditions. The nonlinear effects are noted to occur due to convection and radiation effects, as well as temperature-dependent properties of the material.

M.S.K.

C-D
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.

N82-14494*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN EXPERIMENTAL INVESTIGATION INTO THE FEASIBILITY OF A THERMOELECTRIC HEAT FLUX GAGE

An experiment was conducted to determine the feasibility of using a commercially available thermoelectric device as a heat flux gage. In certain research applications, the thermoelectric heat flux gage can provide a relatively simple means to model a warm fluid--cold wall. The experiment showed that heat flux through the gage could be correlated within two percent to the applied thermoelectric current through the device and the hot and cold side temperature with a simple algebraic equation.

Author

N82-19521*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH-SPEED LASER ANEMOMETER SYSTEM FOR INTRAROTOR FLOW MAPPING IN TURBOMACHINERY

A fringe-type laser anemometer with innovative features is described. The innovative features include: (1) rapid, efficient data acquisition processes, (2) detailed graphic display of data being accumulated, and (3) input laser-beam positioning that allows greater optical access to the intrarotor region. Results are presented that demonstrate the anemometer's capability in flow mapping within a transonic axial-flow compressor rotor.

M.D.K.

N82-22481*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRINGE LOCALIZATION REQUIREMENTS FOR THREE-DIMENSIONAL FLOW VISUALIZATION OF SHOCK WAVES IN DIFFUSE-ILLUMINATION DOUBLE-PULSE HOLOGRAPHIC INTERFEROMETRY

A theory of fringe localization in rapid-double-exposure, diffuse-illumination holographic interferometry was developed. The theory was then applied to compare holographic measurements with laser anemometer measurements of shock locations in a transonic axial-flow compressor rotor. The computed fringe localization error was found to agree well with the measured localization error. It is shown how the view orientation and the curvature and positional variation of the strength of a shock wave are used to determine the localization error and to minimize it. In particular, it is suggested that the view direction not deviate from tangency at the shock surface by more than 30 degrees.

Author

N82-23515*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
Pockels-effect cell for gas-flow simulation

A Pockels effect cell using a 75 cu cm DKP crystal was developed and used as a gas flow simulator. Index of refraction gradients were produced in the cell by the fringing fields of parallel plate electrodes. Calibration curves for the device were obtained for index of refraction gradients in excess of 0.0025 m/S L.

N82-28605*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LASER ANEMOMETER USING A FABRY-PEROT INTERFEROMETER FOR MEASURING MEAN VELOCITY AND TURBULENCE INTENSITY ALONG THE OPTICAL AXIS IN TURBOMACHINERY


A technique for measuring a small optical axis velocity component in a flow with a large transverse velocity component is presented. Experimental results are given for a subsonic free jet operating in a laboratory environment, and for a 0.508 meter diameter turbine stator cascade. Satisfactory operation of the instrument was demonstrated in the stator cascade facility with an ambient acoustic noise level during operation of about 105 dB. In addition, the turbulence intensity measured with the interferometer was consistent with previous measurements taken with a fringe type laser anemometer.

T.M.

N82-31863*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEVELOPMENT AND UTILIZATION OF A LASER VELOCIMETER SYSTEM FOR A LARGE TRANSONIC WIND TUNNEL

The need for measurements of the velocity flow field about spinning propeller nacelle configurations at Mach numbers to 0.8 was met by a specially developed laser velocimeter system. This system, which uses an argon ion laser and 4 beam, 2 color optics, was required to operate in the hostile environment associated with the operation of a large transonic wind tunnel. To overcome the conditions present in locating the sensitive optics in close proximity to the wind tunnel, an isolation system was developed. The system protects the velocimeter from the high vibrations, elevated temperatures, destructive acoustic pressures and low atmospheric pressures attendant with the operation of a large transonic wind tunnel. The system was utilized to map the flow field in front of, behind and in between the rotating blades of an advanced swept blade propeller model at a Mach number of 0.8. The data collected by the system will be used to correlate and verify computer analyses of propeller nacelle flow fields and propeller performance.

R.J.F.

N82-31664*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A DIGITAL OPTICAL TORQUEMETER FOR HIGH ROTATIONAL SPEED APPLICATIONS

A digital optical torque meter system designed for applications at high rotational speeds was fabricated and tested for zero stability at speeds up to 20,000 rpm. Data obtained in a spin rig and with simulated inputs demonstrate that the system is capable of measuring torque bar twist to within 0.03 degrees at speeds of 30,000 rpm. The optical system uses fiber optic bundles to transmit light to the torque bar and to silicon avalanche detectors. The system is microcomputer based and provides measurements of
average torque and torque as a function of angular shaft position. The torquemeter requires no bearings or other contact between the rotating torque bar and the nonrotating optics, and tolerates movement of the torque bar as large as 1 mm relative to the optics.

R.J.F.

N82-32662*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXTENDING THE FREQUENCY OF RESPONSE OF LIGHTLY DAMPED SECOND ORDER SYSTEMS: APPLICATION TO THE DRAG FORCE ANEMOMETER

Gustavo C. Fralick Aug. 1982 26 p refs

(NASA-TM-82297; E-1176; NAS 1.15:82927) Avail: NTIS HC A03/MF A01 CSCL 14B

It is shown that a conventional electronic frequency compensator does not provide adequate compensation near the resonant frequency of a lightly damped second order system, such as the drag force anemometer. The reason for this is discussed, and a simple circuit modification is presented which overcomes the difficulty. The improvement is shown in theoretical frequency response curves as well as in the experimental results from two typical drag force anemometers.

Author

N82-32670*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NEW VERSIONS OF OLD FLOW VISUALIZATION SYSTEMS

Walton L. Howes In NASA. Langley Research Center Flow Visualization and Laser Velocimetry for Wind Tunnels Sep. 1982 p 59-64 (For primary document see N82-32663 23-35) Avail: NTIS HC A16/MF A01 CSCL 14B

A small, modified Mach-Zehnder interferometer placed in series with a much larger schlieren optical system spanning the test section is examined. In one arm of the interferometer, light from the schlieren is focused through a pinhole and recollimating lens to produce a reference beam which interferes with the remaining object beam from the other arm. The object and reference beams are separated only over a small interval following the test section, and differential vibrations are greatly reduced. Color schlieren has technical, as well as aesthetic, advantages over black-and-white schlieren. Since each color is associated with a specific amount of refraction, quantitative evaluation of certain refractive-index fields becomes possible using very simple equations derived from ray trace theory. Rainbow schlieren of an acetylene flame, and the evaluated refractive index distribution are shown. Root-mean-square refractive index fluctuations in homogeneous, isotropic turbulence were determined using the rainbow schlieren. Since these fluctuations determine the root-mean-square refraction, which is indicated by the overall color of the image.

E.A.K.

N82-32672*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROPELLER FLOW VISUALIZATION TECHNIQUES


Propeller flow visualization techniques were tested. The actual operating blade shape as it determines the actual propeller performance and noise was established. The ability to photographically determine the advanced propeller blade tip deflections, local flow field conditions, and gain insight into aeroelastic instability is demonstrated. The analytical prediction methods which are being developed can be compared with experimental data. These comparisons contribute to the verification of these improved methods and give improved capability for designing future advanced propellers with enhanced performance and noise characteristics.

E.A.K.

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FLOW VISUALIZATION OF SHOCK-BOUNDARY LAYER INTERACTION


Two and three-dimensional shock-boundary layer interaction data were obtained from supersonic wind tunnel tests. These interactions are studied both with and without boundary layer bleed. The data verify computational fluid dynamic codes. Surface static pressure, pitot pressure, flow angularity, and bleed rates, are studied by flow visualization techniques. Surface oil flow using fluorescent dye and laser sheet using water droplets as the scattering material are used for flow visualization.

E.A.K.

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STATUS OF LASER ANEMOMETRY IN TURBOMACHINERY RESEARCH AT THE LEWIS RESEARCH CENTER

Richard G. Seasholtz In NASA. Langley Research Center Flow Visualization and Laser Velocimetry for Wind Tunnels Sep. 1982 p 227-234 refs (For primary document see N82-32663 23-35) Avail: NTIS HC A16/MF A01 CSCL 14B

Laser anemometer systems were developed for a full-annular turbine stator cascade facility and for a compressor rotor facility, both in ambient temperature axial flow facilities with a 20-inch tip diameter. The optical configurations of the two anemometers are similar single-component fringe-type backscatter systems with a probe volume diameter of 125 microns and length of about 2 mm. Laser anemometer measurements are compared with numerical solutions for a transonic axial flow compressor rotor and a turbine stator cascade.

M.G.

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DEVELOPMENT OF A LASER VELOCIMETER FOR A LARGE TRANSONIC WIND TUNNEL


On a 8 x 6 Foot Supersonic Wind Tunnel a laser velocimeter was utilized in the testing of advanced high speed turbopropellers. The system, using a 15-W argon-ion laser, a 3-beam 2-axis transmitting-receiving optics package, a zoom lens with 1- to 4-m focal lengths, and a 0.4-m corner mirror was initially assembled and tested in the checkout room. During the time the system was deployed in the checkout area, experience was acquired in the alignment and operation of the system and the data acquisition system and software were developed. By using air jet simulate tunnel air flow, the system worked quite well. However, problems with beam alignment arose because of reduced atmospheric pressure. Mounting the laser into a vessel maintained at atmospheric pressure with defectors mounted to the external walls improved operation for about 2 hours before misalignment recurred. The system was remounted to the positioning platform in an enclosure that provides both thermal and acoustic isolation.

R.J.F.

N82-32689*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SEEDING CONSIDERATIONS FOR AN LV SYSTEM IN A LARGE TRANSONIC WIND TUNNEL

When it was decided to use a laser velocimeter to measure the properties of propellers, seeding was a great concern since large particles fall to flow and small ones are too small to be seen. Many methods were tried and weeded out by using a Malvern particle sizer. The most promising ones were tested in the tunnel and the laser velocimeter (LV) measurements compared to theoretical values of velocity as the particle approached a blunt nose body along a stagnation streamline. Data obtained from the LV system were compared with the one dimensional particle lag calculation. This figure showed the theoretical velocity over the blunt nose and a velocity profile for 5 um particles. This indicated the particles were approximately 5 um. The seeding method is shown. The seed was atomized by 2 seeders run with all 12 available atomizer jets on. The atomizer seed traveled from these two seeders through four 1 inch tubes 20 feet long to the plenum chamber where this cluster of tubes injected the seed into the air stream. The tubes were located 60 feet from the model and could be moved only by shutting the tunnel down. Future seeding plans are shown.

R.J.F.

A82-32690 # National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

LV MEASUREMENTS WITH AN ADVANCED TURBOPROP
Harvey E. Neumann and J. S. Serafini In NASA. Langley Research Center Flow Visualization and Laser Velocimetry for Wind Tunnels Sep. 1982 p 255-256 (For primary document see N82-32663 23-35)

Avail. NTIS HC A16/MF A01 CSCL 14B

Non-intrusive measurements of velocity about a spinner-propeller-nacelle configuration were made at a Mach number of 0.8. A laser velocimeter (LV) specifically developed for these measurements was used to determine the flow field of the advanced swept S/3-3 propeller. The data will be used to study the flow and to verify computer prediction codes. The usefulness of the LV data in detecting flow anomalies and to substantiate the data quality was demonstrated. Some typical results are given. Mach number profiles at the entrance of the propeller are compared with theoretical predictions. The LV data is in excellent agreement with the axisymmetric, compressible, inviscid theory (without blades) ahead of the propeller except near the hub. The data indicate blade blockage near the spinner. Blade to blade variations in axial velocity for four radial positions at the propeller exist are also given. The large apparent wake near the hub is associated with the hub chocking. The blade to blade variation of axial velocity ahead of a shock within the blade passage is given.

R.J.F.

A82-30300 # Three sensor hot wire/film technique for three dimensional mean and turbulence flow field measurement. B. Lakshminarayana (Pennsylvania State University, University Park, PA). TSI Quarterly, vol. 8, Jan-Mar. 1982, p. 3-13, 49 refs. Grant No. NGL-39-009-007; No. NSG-3012; No. NSG-3032.

Methods of measuring the three dimensional flow field using a three-sensor, hot-wire probe is described in this paper, with emphasis on the techniques developed by the author's group at The Pennsylvania State University. The hot wire equations, data processing procedure, calibration techniques, and a discussion of various errors in the measurement are included. Some typical data acquired by this probe is also included. (Author)


Digital imaging techniques are utilized as a measure of surface displacement components in laser speckle metrology. An image scanner which is interfaced to a computer records and stores in memory the laser speckle pattern of an object in a reference and deformed configuration. Subsets of the deformed images are numerically correlated with the references as a measure of surface displacement. Discrete values are determined around a closed contour for plane problems which then become input to a boundary integral equation method in order to calculate surface traction in the contour. Stresses are then calculated within this boundary. The solution procedure is illustrated by a numerical example of a case of uniform tension. (Author)


A complete data analysis system utilizing laser speckle interferometer and Experimental Integral Equation Method (EBIE) is described. A host computer provides the optical data analysis and serves as an input device to a POP11/VAX computer for numerical analysis. The basic theory of pointwise filtering and digital correlation is described as experimental data input to the BIE method. (Author)


A miniature drag-force anemometer is described which is capable of measuring unsteady as well as steady-state velocity head and flow direction. It consists of a cantilevered beam with strain gages located at the base of the beam as the force measuring element. The dynamics of the beam are like those of a lightly damped second-order system with a natural frequency as high as 40 kilohertz depending on beam geometry and material. The anemometer can be used to measure and control wind tunnel velocities. (Author)

A82-22470 # Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

THIN FILM TEMPERATURE SENSORS, PHASE 3

NASA-CR-165476; NAS 1.26-165476; PWA-5708-28) Avail. NTIS HC A05/MF A01 CSCL 14B

A thin film thermocouple system installation for engine test evaluation was designed, and an engine test plan was prepared. Film adherence, outgassing, accuracy, and drift characteristics were improved. Film thickness was increased to 14 microns, and drift was reduced to less than 0.02 percent of Fahrenheit temperature per hour on actual turbine blades at 1255 K. S.L.

97
A one-dimensional resonant-particle model of a free electron laser (FEL) is used to calculate laser gain and conversion efficiency of electron energy to photon energy. The optical beam profile for a resonant optical cavity is included in the model as an axial variation of laser intensity. The electron beam profile is matched to the optical beam profile and modeled as an axial variation of current density. Effective energy spread due to beam emittance is included. Accelerators appropriate for a space-based FEL oscillator are reviewed. Constraints on the concentric optical resonator and on systems required for space operation are described. An example is given of a space-based FEL that would produce 1.7 MW of average output power at 0.5 micron wavelength with over 50% conversion efficiency of electrical energy to laser energy. It would utilize a 10 m-long amplifier centered in a 200 m-long optical cavity. A 3-amp, 65 meV electrostatic accelerator would provide the electron beam and recover the beam after it passes through the amplifier. Three to five shuttle flights would be needed to place the laser in orbit.

A.R.H.
37 MECHANICAL ENGINEERING

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

N82-12442* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

MODIFIED FACE SEAL FOR POSITIVE FILM STIFFNESS Patent

The film stiffness of a face seal is improved without increasing the sealing and clear space area by using an apparatus which includes 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 primary seal ring in the form of a nose piece. The stiffness of rotor support bearings: thus seals can play an important part in supporting and stabilizing rotor systems. This work done to determine forces generated in ring seals is reviewed. Working formulas are presented for seal stiffness and damping, and geometries to maximize stiffness are discussed. An example is described where a change in seal design stabilized a previously unstable rotor.

Author

N82-1643* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


Results are presented for the use of surface analytical tools including field ion microscopy, Auger emission spectroscopy analysis (AES), cylindrical mirror Auger analysis and X-ray photoelectron spectroscopy (XPS). Data from the field ion microscope reveal adhesive transfer (wear) at the atomic level with the formation of surface compounds found in the bulk, and AES reveals that this transfer will occur even in the presence of surface oxides. Both AES and XPS reveal that in abrasive wear with silicon carbide and diamond contacting the transition metals, the surface and the abrasive undergo a chemical or structural change which effects wear. With silicon carbide, silicon volatilizes leaving behind a pseudo-graphitic surface and the surface of diamond is observed to graphitize. B.W.

N82-16411* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


Seals can exert large forces on rotors. As an example, in a turbopump ring seal film stiffness as high as 90 MN/m (600,000 lb/in) have been measured. This stiffness is comparable to the stiffness of rotor support bearings: thus seals can play an important part in supporting and stabilizing rotor systems. This work done to determine forces generated in ring seals is reviewed. Working formulas are presented for seal stiffness and damping, and geometries to maximize stiffness are discussed. An example is described where a change in seal design stabilized a previously unstable rotor.

Author

N82-16412* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


The effects of artificially produced dents and grooves on the elastohydrodynamic (EHD) film thickness profile in a sliding point contact were investigated by means of optical interferometry. The defects, formed on the surface of a highly polished ball, were held stationary at various locations within and in the vicinity of the contact region while the disk was rotating. It is shown that the defects, having a geometry similar to what can be expected in practice, can dramatically change the film thickness which exists when no defects are present in or near the contact. This change in film thickness is mainly a function of the position of the defects in the inlet region, the geometry of the defects, the orientation of the defects in the case of grooves, and the depth of the defect relative to the central film thickness.

Author

N82-16413* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


Lubricants, usually Newtonian fluids, are assumed to experience laminar flow. The basic equations used to describe the flow are the Navier-Stokes equation of motion. The study of hydrodynamic lubrication is, from a mathematical standpoint, the application of a reduced form of these Navier-Stokes equations in association with the continuity equation. The Reynolds equation can also be derived from first principles, provided of course that the same basic assumptions are adopted in each case. Both methods are used in deriving the Reynolds equation, and the assumptions inherent in reducing the Navier-Stokes equations are specified. Because the Reynolds equation contains viscosity and density terms and these properties depend on temperature and pressure, it is often necessary to couple the Reynolds with energy equation. The lubricant properties and the energy equation are presented. Film thickness, a parameter of the Reynolds equation, is a function of the elastic behavior of the bearing surface. The governing elasticity equation is therefore presented.

A.R.H.

N82-19540* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

COMPOSITE SEAL FOR TURBOMACHINERY Patent
Robert C. Bill and Lawrence P. Ludwig, Inventors (to NASA) Issued 20 Oct. 1981 5 p Filed 20 Nov. 1979 Division of
A gas path seal suitable for use with a turbine engine or compressor is provided. A shroud wearable or shrouded by the abrasion of the rotor blades of the turbine or compressor shrouds the rotor blades. A compliant backing surrounds the shroud. The backing is a yieldingly deformable porous material covered with a thin ductile layer. A mounting fixture surrounds the flesh temperature model. The effects of surface roughness on force roughness on surface roughness parameters, surface patterns, and temperature parameters were theoretically verified. The reported work is a summary of NASA contributions to high performance engine and transmission bearing analysis to high performance engine and transmission bearing analysis.

Author:

A numerical solution of an elastohydrodynamically lubricated (EHL) line contact between two long, rough-surface cylinders that considers the frictional heating of asperities was obtained. Pressure distribution, temperature distribution, film thickness, and EHL load for given speeds, lubricant properties, material properties of surfaces, and surface roughness parameters were theoretically solved by simultaneous solution of the elasticity equation and the Reynolds equation for two partially rough surfaces. The pressure due toasperity contact was calculated by assuming a Gaussian distribution of surface irregularities. The elastic deformation used for film thickness computation was found from the two kinds of pressure by finite strain analysis. The temperature rise in the contact zone was calculated by using the Blok-Jaeger flash temperature model. The effects of surface roughness on EHL load for various slide-to-roll ratios, surface roughness parameters, surface patterns, and temperature parameters were studied. It was found that the maximum temperature rise in most cases occurred in the inlet zone, and that the minimum film thickness decreased and the maximum temperature increased as the surface roughness was increased.

Author:

A gas path seal suitable for use with a turbine engine or compressor is provided. A shroud wearable or shrouded by the abrasion of the rotor blades of the turbine or compressor shrouds the rotor blades. A compliant backing surrounds the shroud. The backing is a yieldingly deformable porous material covered with a thin ductile layer. A mounting fixture surrounds the flesh temperature model. The effects of surface roughness on surface roughness parameters, surface patterns, and temperature parameters were theoretically verified. The reported work is a summary of NASA contributions to high performance engine and transmission bearing analysis to high performance engine and transmission bearing analysis.

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Author:
viscosity. There were relatively large decreases, and viscosity generally fell in the 5 to 7 centistokes range. The lubricants had no significant effect on the vibration signature of the transmission. A.R.H.

FULLY PLASMA-SPRAYED COMPLIANT BACKED CERAMIC TURBINE SEAL Patent Application
A seal with a high temperature abrasadable lining material which encloses the tips of turbine blades in turbomachinery was designed. The seal is directed to maintaining the minimum operating clearances between the blade tips and the lining of a high pressure turbine. A low temperature easily decomposable material in powder form is blended with a high temperature oxidation resistant metal powder. The two materials are simultaneously deposited on a substrate formed by the turbine casing. Alternatively, 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 the porous structure which gives a cushion effect. No brazing is required by only plasma spraying for depositing both the powders of the metal and polymer material as well as the ceramic powder. NASA

MULTIROLLER TRACTION DRIVE SPEED REDUCER: EVALUATION FOR AUTOMOTIVE GAS TURBINE ENGINE
Tests were conducted on a nominal 14:1 fixed-ratio Nasvytis multiroller traction drive retrofitted as the speed reducer in an automotive gas turbine engine. Power turbine speeds of 45,000 rpm and a drive output power of 102 kW (137 hp) were reached. The drive operated under both variable roller loading (proportional to torque) and fixed roller loading (automatic loading mechanism locked). The drive operated smoothly and efficiently as the engine speed reducer. Engine specific fuel consumption with the traction speed reducer was comparable to that with the original helical gearbox.

TOOTH PROFILE ANALYSIS OF CIRCULAR-CUT, SPIRAL-BEVEL GEARS
Ronald L. Huston (Cincinnati Univ.), Yael Lin (Technion - Israel Inst. of Technology), and John J. Coy 1982 20 p refs Presented at the Design Engr. Tech. Conf., Washington, D.C., 12-15 Sep. 1982; sponsored by ASME Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio (NASA-TP-82845; E-1029; NAS 1.15:82845; AVRADCOM-TR-82-C-05) Avail: NTIS HC A02/MF A01 CSCL 131
An analysis of tooth profile changes in the transverse plane of circular-cut, spiral-bevel crown gears is presented. The analysis assumes a straight-line profile in the mid-transverse plane. The profile variation along the centerline is determined by using expressions for the variation of the spiral angle along the tooth centerline, together with the profile description at the mid-transverse plane. It is shown that the tooth surface is a hyperboloid and that significant variations in the pressure angle are possible.
AVRADCOM-TR-82-C-8) Avail: NTIS HC A02/MF A01 CSCL

Spur gear stress analysis results are presented for a variety of loading conditions, support conditions, fillet radii, and rim thickness. These results are obtained using the SAP IV finite-element code. The maximum stresses, occurring at the root surface, substantially increase with decreasing rim thickness for partially supported rims (that is, with loose-fitting hubs). For fully supported rims (that is, with tight-fitting hubs), the root surface stresses slightly decrease with decreasing rim thickness. The fillet radius is found to have a significant effect upon the maximum stresses at the root surface. These stresses increase with increasing fillet radius. The fillet radius has little effect upon the internal root section stresses.

Author

N82-30562# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRECISION OF SPIRAL-BEVEL GEARS

The kinematic errors in spiral bevel gear trains caused by the generation of nonconjugate surfaces, by axial displacements of the gears during assembly, and by eccentricity of the assembled gears were determined. One mathematical model corresponds to the motion of the contact ellipse across the tooth surface, (geometry I) and the other along the tooth surface (geometry II). The following results were obtained: (1) kinematic errors induced by errors of manufacture may be minimized by applying special machine settings, the original error may be induced by order of magnitude, the procedure is most effective for geometry 2 gears, (2) when trying to adjust the bearing contact pattern between the gear teeth for geometry I gears, it is more desirable to shim the gear axially; for geometry II gears, shim the opinion axially; (3) the kinematic accuracy of spiral bevel drives are most sensitive to eccentricities of the gear and less sensitive to eccentricities of the pinion. The precision of mounting accuracy and manufacture are most crucial for the gear, and less so for the pinion.

E.A.K.

N82-31691# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INFLUENCE OF CORROSIVE SOLUTIONS ON MICROHAIRNESS AND CHEMISTRY OF MAGNESIUM OXIDE /001/ SURFACES
Hiroyuki Ishigaki (Osaka Univ.), Kazuhiro Miyoshi, and Donald H. Buckley Aug. 1982 11 p refs (NASA-TP-2040; E-1035; NAS 1.60:2040) Avail: NTIS HC A02/MF A01 CSCL 20K

X-ray photoelectron spectroscopy analyses and hardness experiments were conducted on cleaved magnesium oxide /001/ surfaces. The magnesium oxide bulk crystals were cleaved to specimen size along the /001/ surface, and indentations were made on the cleaved surface in corrosive solutions containing HCl, NaOH, or HNO3 and in water without exposing the specimen to any other environment. The results indicated that chloride (such as MgCl2) and sodium films are formed on the magnesium oxide surface as a result of interactions between an HCl-containing solution and a cleaved magnesium oxide surface. The chloride films soften the magnesium oxide surface. In this case microhardness is strongly influenced by the pH value of the solution. The lower the pH, the lower the microhardness. Sodium films, which are formed on the magnesium oxide surface exposed to an NaOH containing solution, do not soften the magnesium oxide surface.

Author

N82-32734# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE INFLUENCE OF SURFACE DENTS AND GROOVES ON TRACTION IN SLIDING EHD POINT CONTACTS

(NTA-TM-82943; E-1345; NAS 1.15:32943) Avail: NTIS HC A02/MF A01 CSCL 20K

Changes in traction, caused by dents and grooves on a highly polished ball, are investigated as these defects approach and go through sliding elastohydrodynamic point contacts. The contacts are formed with the ball loading against a transparent disk. The ball and thus the topographical features are held stationary at various locations in the vicinity and within the contact while the disk is rotating. These topographical features can cause substantial changes in the traction when compared to traction obtained with smooth surfaces.

S.L.

N82-32735# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PLASTIC DEFORMATION AND WEAR PROCESS AT A SURFACE DURING UNLUBRICATED SLIDING
Takashi Yamamoto (Tokyo Univ. of Agriculture and Technology, Japan) and Donald H. Buckley 1982 36 p refs Proposed for presentation at the Joint Lubrication Conf., Washington, D.C., 4-6 Oct. 1982; sponsored by AMSE and the Am. Soc. of Lubrication Eng.

(NTA-TM-82820; E-1169; NAS 1.15:82820) Avail: NTIS HC A03/MF A01 CSCL 20K

The plastic deformation and wear of a 304 stainless steel surface sliding against an aluminum oxide rider with a spherical surface (the radius of curvature: 1.3 cm) were observed by using scanning electron and optical microscopes. Experiments were conducted in a vacuum of one million Pa and in an environment of fifty thousandth Pa of chlorine gas at 25 C. The load was 500 grams and the sliding velocity was 0.1 centimeter per second. The deformed surface layer which accumulates and develops successively is left behind the rider, and step shaped protuberances are developed even after single pass sliding under both environmental conditions. A fully developed surface layer is gradually torn off leaving a characteristic pattern. The mechanism for tearing away of the surface layer from the contact area and sliding track contour is explained assuming the simplified process of material removal based on the adhesion theory for the wear of materials.

S.L.

N82-32736# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF SHOT PEENING ON SURFACE FATIGUE LIFE OF CARBURIZED AND HARDENED AISI 9310 SPUR GEARS

ORIGINAL PAGE IS OF POOR QUALITY
bear fingure tests in contaminated and noncontaminated oil filters having absolute removal ratings of 3, 50, 49, and 105 microns, with lubricant and sample temperatures maintained at 327 K. Ultra clean lubrication was found to produce bearing fatigue lives that were approximately twice that obtained in previous tests with contaminated oil using 3 micron absolute filtration. It was also observed that the centrifugal oil filter has the same effectiveness as a 30 micron absolute filter in preventing surface damage.


An investigation was conducted to examine the adhesion and friction of single-crystal diamond in contact with various transition metals and the nature of metal transfer to and sliding friction experiments were conducted with diamond in sliding contact with the metals yttrium, titanium, zirconium, vanadium, iron, cobalt, nickel, tungsten, platinum, rhodium and rhodium. All experiments were conducted with loads of 0.05 to 0.3 N, at a sliding velocity of 0.003 m per minute, in a vacuum of 10 to the -8th Pa, at room temperature, and on the (111) plane of diamond with sliding in a 110 line type direction. The results of the investigation indicate that the coefficient of friction for diamond in contact with various metals is related to the relative chemical activity of the metals in high vacuum. The more active the metal, the higher the coefficient of friction. All the metals examined transferred to the surface of diamond in sliding.

A82-19335 * Optimal tooth numbers for compact standard spur gear sets. M. Suave (Akron University, Akron, OH), J. Coy (U.S. Army, Propulsion Laboratory, Cleveland, OH), and D. P. Couverson (NASA, Lewis Research Center, Cleveland, OH), American Society of Mechanical Engineers, Design Engineering Technical Conference, Hartford, CT, Sept. 20-23, 1981, Paper 81-DET-115. 9 p. 23 refs. Members, $2.00; nonmembers, $4.00.

The design of a standard gear mesh is treated with the objective of minimizing the gear life for a given ratio, pinion torque, and allowable tooth strength. Scorr, pitting fatigue, bending fatigue, and the kinematic limits of contact ratio and interference are considered. A design space is defined in terms of the number of teeth of the pinion and the diametral pitch. This space is then combined with the objective function of minimum center distance to obtain an optimal design region. This region defines the number of pinion teeth for the most compact design. The number is a function of the gear ratio only. A design example illustrating this procedure is also given.

A82-30022 * Effect of tangential traction and roughness on crack initiation/propagation during rolling contact. N. Soda (Tokyo University, Tokyo, Japan) and T. Yamamoto (NASA, Lewis Research Center, Cleveland, OH; Tokyo University of Agriculture and Technology, Tokyo, Japan). (American Society of Lubrication Engineers, Annual Meeting, 30th, Pittsburgh, PA, May 11-14, 1981) ASLE Transactions, vol. 26, Apr., 1982, p. 198-205; Discussion, p. 205; Authors’ Closure, p. 205, 206, 17 refs. (Previously announced in STAF as NB-11306)


Designers of small gas turbine engines prefer a close-coupled compressor to turbine shafting arrangement, which in some designs necessitates the use of a small reverse-flow annular combustor. A design methodology for obtaining the maximum performance potential of these combustors is necessary. This paper describes an approach to optimize the design process and gain insight into primary zone performance through interactive theoretical analyses and experimental tests. Three candidate combustor designs are described which address the performance limiting problem areas associated with small annular combustors. Design methodology centers around understanding and controlling primary zone performance, surface distress and weight loss were compared to previous
AERODYNAMICS AND THE INTERACTION OF THE DISTRIBUTED FUEL WITH INTERNAL AIRFLOW PATTERNS. COMPLETE THREE-DIMENSIONAL FLOW FIELD ANALYTICAL PERFORMANCE PREDICTION PROCEDURES ARE PRESENTED AND RESULTS COMPARED WITH PERFORMANCE AND EMISSION MEASUREMENTS DESCRIBED BY PROBES INSERTED AT THE EXIT OF THE PRIMARY ZONE. THE EFFECTIVE USE OF ANALYTICAL PERFORMANCE PREDICTION METHODS IN THE DESIGN PROCESS IS DEMONSTRATED. (Author)

A82-35062° # COR: DEVELOPMENT FOR AUTOMOTIVE GAS TURBINES. P. T. Ross, J. R. Williams (General Motors Corp., Detroit Diesel Allison Div., Indianapolis, IN), and D. H. Anderson (NASA, Lewis Research Center, Cleveland, OH). AIAA Paper 82-1208. 2 p. 9 refs. Research supported by the U.S. Department of Energy; Contract No. DEN3-166.

The development of a combustor system for the AGT 100 automotive gas turbine engine is described. A maximum turbine inlet temperature of 1288°C reached during the regenerative cycle, and air up to 1024°C is supplied to the turbine engine. A maximum turbine inlet temperature of 1288°C at a different variable geometry position, the CO was 30 times below program limits. Complete three-dimensional flow field analytical performance predictions are made for future introduction into the main program for calculating the gear tooth bending stresses under dynamic loads.


The method of component mode synthesis is developed to determine the forced response of nonlinear, multishell, rotor-bearing systems. The formulation allows for simulation of system response due to blade loss, distributed unbalance, base shock, maneuver loads, and specified fixed frame forces. The motion of each rotating component of the system is described by superposing constraint modes associated with boundary coordinates and constrained precessional modes associated with internal coordinates. The precessional modes are truncated for each component and the reduced component equations are assembled with the nonlinear supports and interconnections to form a set of nonlinear system equations of reduced order. These equations are then numerically integrated to obtain the system response. A computer program, which is presently restricted to single shaft systems, has been written and results are presented for transient system response associated with blade loss dynamics with squeeze film dampers, and with interference rubs. (Author)


N82-10401° # CLEVELAND STATE UNIV., OHIO. DEPT. OF MECHANICAL ENGINEERING.


A new digitized approach was developed for the static and dynamic load analysis of spur gear. An iterative procedure was used to calculate directly the variable-variable gear mesh stiffness as a function of transmitted load, gear tooth profile errors, gear tooth deflections and gear hub torsional deformation, and position of contacting profile points. The developed approach can be used to analyze the loads, Hertz stresses, and PV for the normal and high contrast ratio gearing, presently the modeling is limited to the condition that for a given gear all teeth have identical spacing and profiles (with or without surface imperfections). Certain types of simulated sinusoidal profile errors and pitting can cause interruptions of the gear mesh stiffness function and, thus, increase the dynamic loads in spur gearing. In addition, a finite element stress and mesh subprogram was developed for future introduction into the main program for calculating the gear tooth bending stresses under dynamic loads. (Author)

N82-11465° # Rocketdyne, Canoga Park, Calif.

ADVANCED SUPERPOSITION METHODS FOR HIGH SPEED TURBPUMP VIBRATION ANALYSIS Interim Report C. E. Nelson and A. D. Campany 19 May 1981 66 p. 19 refs. (Contract NAS3-22930) (NASA-CR-165379; R/D81-149) Avail: NTIS HC A05/MF A01 CSCL 13 (A) The small, high pressure Mark 48 liquid hydrogen turbopump was analyzed and dynamically tested to determine the cause of high speed vibration at an operating speed of 92,400 rpm. This approach the design point operating speed of 96,000 rpm. The initial dynamic analysis in the design stage and subsequent further analysis of the rotor only dynamic models failed to predict the vibration characteristics found during testing. An advanced procedure for dynamics analysis was used in this investigation. The procedure involves developing accurate dynamic models of the rotor assembly and casing assembly by a finite element analysis. The dynamically instrumented assemblies are independently tested to verify the analytical models. The verified models are then combined with modal superposition techniques to develop a completed turbopump model where dynamic characteristics are determined. The results of the dynamic testing and analysis obtained are presented and methods of moving the high speed vibration characteristics to speeds above the operating range are recommended. Recommendations for use of these advanced dynamic analysis procedures during initial design phases are given.

N82-11468° # Mechanical Technology, Inc., Latham, N.Y.


Methods of determining the contact surface temperature in reciprocating seals are investigated. Direct infrared measurement of surface temperatures of a rod exiting a loaded casing or simulated seal are compared with surface thermocouple measurements. Significant cooling of the surface requires several milliseconds so that exit temperatures may be considered representative of internal contact temperatures.

N82-11467° # Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

JTBD HIGH PRESSURE COMPRESSOR PERFORMANCE IMPROVEMENT Progress Report. Sep. 1978 - Apr. 1981 W. O. Gaffin 11 Nov. 1981 47 p. refs. (Contract NAS3-20630) (NASA-CR-165531; PWA-5651-162) Avail: NTIS HC A03/MF A01 CSCL 13 (A) An improved performance high pressure compressor with potential application to all models of the JTBD engine was designed. The concept consisted of a single, integrally bladed, annular, blisk turbomachinery wheel, without the danger of damaging the blades during transients and maneuvers. The improved compressor demonstrated thrust specific fuel consumption and exhaust gas temperature improvements of 1.0 percent and at least 10 C over the takeoff and climb power ranges at sea level static conditions, compared to a bll-of-material high pressure compressor. Surge margin also improved 4 percentage points over the high power operating range. A thrust specific fuel consumption improvement of 0.7 percent at typical cruise conditions was calculated based on the sea level test results.

B.W.
A small, high-pressure, LOX turbopump was designed, fabricated and tested. The pump is a single-stage centrifugal type with power to the pump supplied by a single-stage partial-admission axial-impulse turbine. Design conditions included an operating speed of 7330 rpm, pump discharge pressure of 2977 N/cm² (4318 psia), and a pump flow rate of 16.4 Kg/s (38.2 lb/s). The turbopump contains a self-compensating axial thrust balance piston to eliminate axial thrust loads on the bearings during steady-state operation. Testing of the turbopump was achieved using a gaseous hydrogen high-pressure flow to drive the turbine, which generally is propelled by LOX/LH2 combustion products, at 1041K (1874 R) inlet temperature and at a design pressure ratio of 1.424. Test data obtained with the turbopump are presented which include head-flow-efficiency performance, suction performance, balance piston performance and LOX seal performance. Mechanical performance of the turbopump is also discussed. Author

CHELSEA TRACTION CVT FOR ELECTRIC VEHICLES Final Report
(Contract DE-AC02-78CS00249) NASA-CR-163253; DOE/NASA/2749-81-1) Avail: NTIS HC A19/MF A01 CSCL 131
Development of a gas turbine powertrain with a 30% fuel economy improvement over a comparable S1 reciprocating engine, operation within 0.41 HC, 3.4 CO, and 0.40 NOx grams per mile emissions levels, and ability to use a variety of alternate fuels is summarized. The powertrain concept consists of a single-shaft engine with a ceramic inner shell for containment of hot gasses and support of twin regenerators. It uses a fixed-geometry, lean, premixed, pre vaporized combustor, and a ceramic radial turbine rotor supported by an oil-lubricated journal bearing. The engine is coupled to the vehicle through a wide range continuously variable transmission, which utilizes gearing and a variable ratio metal compression bell. A response assist flywheel is used to achieve acceptable levels of engine response. The package offers a 100 lb weight advantage in a Chrysler K Car front-wheel-drive installation. Initial layout studies, preliminary transient thermal analysis, ceramic inner housing structural analysis, and detailed performance analysis were carried out for the basic engine. S.L.

AEROSPACE CHEMICAL PROPULSION SYSTEM ENGINEERING TEST FACILITY (ETF) 200 MW POWER PLANT Final Report
The results of traction tests performed on two fluids are presented. These tests covered a pressure range of 1.0 to 2.5 GPa, an inlet temperature range of 30°C to 70°C, a speed range of 10 to 80 m/s, aspect ratios of 5 to 5 and spin from 0 to 2.1 percent. The test results are presented in the form of two dimensionless parameters, the initial traction slope and the maximum traction peak. With the use of a suitable rheological fluid model the actual traction curves measured can now be reconstructed from the two fluid parameters. More importantly, the knowledge of these parameters together with the fluid rheological model, allow the prediction of traction under conditions of spin, slip and any combination thereof. Comparison between theoretically predicted traction under these conditions and those measured in actual traction tests shows that this method gives good results. Author

The small passenger car transmission test was initiated to supply electric vehicle manufacturers with technical information regarding the performance of commercially available transmissions. This information would enable EV manufacturers to design a more energy efficient vehicle. With this information the manufacturers would be able to estimate vehicle driving range as well as speed and torque requirements for specific road load performance characteristics. This report covers the testing of a Chevrolet Malibu 200C automatic transmission with lockup. The transmission was tested in accordance with 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 90 percent range both for drive performance test and coast performance tests. The torque, speed and efficiency curves map the complete performance characteristics for the Chevrolet Malibu 200C automatic transmission with lockup. Author
The thermomechanical performance characteristics of high speed lubricated double row spherical roller bearings are presented. The analysis includes predictions of the performance of the SPHERBEAN computer program with the aid of these analytical tools: the Hertzian contact problem for conjugate tooth surfaces can be solved. These results are useful in determining compressive load capacity and surface fatigue life of spiral bevel gears. A general theory of kinematical errors exerted by manufacturing and assembly errors is developed. This theory is used to determine the analytical relationship between gear misalignments and kinematical errors. This is important to the study of noise and vibration in geared systems.

The geometry of spiral bevel gears and their rational design are studied. The nonconjugate tooth surfaces of spiral bevel gears are, in theory, replaced (or approximated) by conjugated tooth surfaces. These surfaces can be generated by two conical surfaces, and by a conical surface and a revolution. Although these conjugated tooth surfaces are similar to the actual ones, the determination of their principal curvatures and directions is still a co-ordinated problem. Therefore, a new approach, to the solution of these is proposed. Direct relationships between the principal curvatures and directions of the tool surface and those of the generated gear surface are obtained. With the aid of these analytical tools, the Hertzian contact problem for conjugate tooth surfaces can be solved. These results are useful in determining compressive load capacity and surface fatigue life of spiral bevel gears. A general theory of kinematical errors exerted by manufacturing and assembly errors is developed. This theory is used to determine the analytical relationship between gear misalignments and kinematical errors. This is important to the study of noise and vibration in geared systems.

Maximum efficiencies in the mid-ninety percent range both for drive performance and coast performance tests. The torque, speed, and efficiency curves are presented which provide the complete performance characteristics for the Mercury Lynx automatic transmission.

Thermal shock tolerance, thermal gradient, thermal cycle, erosion, abradability, and durability characteristics of the plasma sprayed system were improved by refinement and optimization of the plasma spray process and the metal substrate design. The acceptability of the final seal system for engine testing was demonstrated by an extensive rig test program which included thermal shock tolerance, thermal gradient, thermal cycle, erosion, and abradability tests. An interim seal design was also subjected to 2600 endurance test cycles in a JT9D-7 engine.
Aircraft Corp.), A. Mueller (Cessna Aircraft Corp.), and J. Hembrey (Cessna Aircraft Corp.) 29 Jan. 1982 149 p refs (Contract NAS5-21285) NASA-CR-165398; NAS 1.28; 165398; CWWR-81.021) Avail: NTIS HC A04/MF A01 CSCL 131 Spur gear stress analysis results are presented for a variety of loading conditions, support conditions, root radii, and rim thicknesses. These results are obtained using the SAP-IV finite element code. The maximum stresses, occurring at the root surface, substantially increase with decreasing rim thickness for partially supported rims (that is, with loose fitting hubs). For fully supported rims (that is, with tight fitting hubs), the root surface stresses slightly decrease with decreasing rim thickness. The fillet radius has a significant effect upon the maximum stresses at the root surface. These stresses increase with decreasing fillet radius. Finally, the fillet radius has little effect upon the internal root section stresses. S.L.

The AGT101 technology - An automotive alternative. R. A. Rackley and K. A. Davis (Garrett Turbine Engine Co., Phoenix, AZ). Int: Inter society Energy Conversion Engineering Conference, 16th, Atlanta, GA, August 9-14, 1081, Proceedings. Volume 2. (A82-11701 02-44) New York, American Society of Mechanical Engineers, 1981, p. 1403-1407. Contract No. DEN3-167. The Advanced Gas Turbine Powertrain System Development Project is oriented at providing the United States automotive industry the technology base necessary to produce gas turbine powertrains for automotive applications that will have: (1) reduced fuel consumption, (2) the ability to use a variety of fuels, (3) low emissions, and (4) competitive cost/performance. The AGT101 powertrain being developed consists of a regeneratively cooled single-shaft gas turbine engine rated at 74.6 kW (100 hp) coupled to a split-differential gearbox and a Ford automatic overdrive transmission. Performance predictions for the AGT101 powertrain represent a 59-percent improvement on baseline estimates over a 1985 conventionally-powered automobile for the combined federal driving cycle. (Author)

A82-18407 Alignment of fluid molecules in an EHD contact. J. L. Lauer, L. E. Keller, F. H. Choi, and V. W. King (Rensselaer Polytechnic Institute, Troy, NY), American Society of Lubrication Engineers and American Society of Mechanical Engineers, Lubrication Conference, New Orleans, LA, Oct. 5-7, 1981, ASLE Prog-lnt-SCS-01, B p. 7 refs. Members, $4.00; nonmembers, $4.00. Grants No. AF-AFOSR-78-3473; No. NSG-3160. Dichroic infrared emission spectra have been obtained from an operating elastohydrodynamic contact under conditions showing unequivocally that the molecules of the fluid are aligned under shear flow in the bulk of the fluid and that the extent of the alignment is increased by the presence of an additive in a small concentration. This work applied particularly to polyphenyl ether and to 1,1,2-trichloroethane as the additive, but similar results have been obtained with polyethylene terephthalate and the same additive. The observation of two separate glass transitions for the polyethylene terephthalate solution is an indication of the occurrence of a phase separation in the Hertzian inlet zone. A model has been developed to explain the effect of these phenomena and their relation to traction. (Author)

A82-18426 Measurement of oil film thickness for application to elastomeric Stirling engine rod seals. A. I. Krauter (Carrier Corp., Research Div., Syracuse, NY). American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, New Orleans, LA, Oct. 5-7, 1981, ASME Paper 81-Lub-10, 5 p. 11 refs. Members, $2.00; nonmembers, $4.00. Contract No. DEN3-22. The rod seal in the Stirling engine has the function of separating high pressure gas from low or ambient pressure oil. An experimental apparatus was designed to measure the oil film thickness distribution for an elastomeric seal in a reciprocating application. Test results were conducted on commercial elastomeric seals having a 76 mm rod and a 3.8 mm axial width. Test conditions included 70 and 80 seal diameters, a sliding velocity of 0.8 m/sec, and a zero pressure gradient across the seal. An acrylic cylinder and a typical synthetic base automotive lubricant were used. The experimental results showed that the effect of seal hardness on the oil film thickness is considerable. A comparison between analytical and experimental oil film profiles for an elastomeric seal during relatively high speed reciprocating motion showed an overall qualitative agreement. J.F.

A82-18431 Regimes of traction in concentrated contact lubrication. S. Bair and W. O. Winer (Georgia Institute of Technology, Atlanta, GA). American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, New Orleans, LA, Oct. 5-7, 1981, ASME Paper 81-Lub-16, 5 p. 11 refs. Members, $2.00; nonmembers, $4.00. Grant No. NSG-3166. Experimental evidence is presented for the existence of three regimes of traction in concentrated contacts. Data are obtained in a rolling contact simulator by varying the lubricant, temperature, rolling speed, load and surface roughness at a fixed slide-to-roll ratio. At lower thicknesses the mixed regime is encountered, and traction is increased due to asperity interaction, while at higher film thicknesses, the lubricant pressure is distributed over a greater area than the Hertzian region, resulting in a lower average pressure and reduced traction. D.L.G.

A82-18449 Single pass rub phenomena - Analysis and experiment. F. E. Kennedy (Dartmouth College, Hanover, NH), American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, New Orleans, LA, Oct. 5-7, 1981, ASME Paper 81-Lub-55, 7 p. 10 refs. Members, $2.00; nonmembers, $4.00. Grant No. NG-3253. An experimental and analytical investigation is presented of contact phenomena for the case of a fully-dense copper gas path seal segment which is rubbed by a single steel blade tip at room temperature. The experiments were executed on a pendulum-type test device, with forces, rub energy, surface temperature and residual deformation being determined for each single-pass rub test. Thermal and mechanical factors influencing single-pass rub surface temperatures were modeled analytically. It is found that large plastic strains occurred on near the contact surface of the copper rub
A82-19334 * # Surface geometry of circular cut spiral bevel gears. R. L. Huston (Cincinnati, University, Cincinnati, OH) and J. J. Coy (U.S. Army, Automotive Laboratory, Cleveland, OH). American Society of Mechanical Engineers, Design Engineering Technical Conference, Hartford, CT, Sept. 20-23, 1981, Paper 81-DET-114, 6 p., 7 refs. Members, $2.00; nonmembers, $4.00. Grant No. NGS-3188.

An analysis of the surface geometry of spiral bevel gears formed by a circular cutter is presented. The emphasis is upon determining the tooth surface principal radii of curvature of crown (flat) gears. Specific results are presented for Involute, straight, and hypobolic cutter profiles. It is shown that the geometry of circular cut spiral bevel gears is somewhat simpler than a theoretical logarithmic spiral bevel gear. (Author)


Anaerobic polymers are useful as solventless leak sealants with good vacuum properties at moderate temperatures. Locite 290 can seal leaks in a range generally encountered in carefully constructed ultrahigh vacuum and high vacuum systems. It was found that small leaks are sealed best under vacuum, whereas large leaks should be sealed at atmospheric pressure. The high-temperature behavior of Locite 290 is limited by its fast cure, which prevents deep penetration into small leaks; cracking eventually occurs at the entrance to the leak. Repeated thermal cycling to about 300 C is possible, however, provided viscosity, curing time, and leak size are properly matched to the operation of the seal. This may require special formulations for high-temperature vacuum applications. J.F.


Graphite is one of the most commonly known lubricants. Its effectiveness in a range between room temperature (RT) and 840 C is reportedly improved by adding cadmium oxide. CdO-graphite powder in a gas carrier has been used in numerous applications that rely on dry lubrication. A coating of this composition was developed and successfully tested in foil air bearings for long periods up to a temperature of 427 C and at a normal connecting load (during starting and stopping) of 14 kPa based on bearing projected area. The addition of ultra-fine silver to the CdO-graphite has improved the coating endurance. At 427 C, the CdO-graphite-Ag coating performed better than CdO-graphite without silver, both for extended periods at 14 kPa loading and for limited periods at 35 kPa. At 88 C, the coating was tested for an extended period up to 28 kPa and has also successfully completed high-speed shock tests to an acceleration level of 100g. (Author)


A development program is described whose goal is the accumulation of the technology base needed by the U.S. automobile industry for the production of automotive gas turbine powertrains. Such gas turbine designs must exhibit reduced fuel consumption, a multi-fuel capability, and low exhaust emissions. The AGT101 powertrain described is a 74.6 kW regenerative single-shaft gas turbine, operating at a maximum inlet temperature of 1644 K and coupled to a split differential gearbox and automatic overdrive transmission. The engine is single stage centrifugal compressor and single stage radial inflow turbine are mounted on a common shaft, and will operate at a maximum rotor speed of 100,000 rpm. All high temperature components, including the turbine rotor, are ceramic. O.C.


Second-year efforts within a three-year study to develop and extend finite element (FE) methodology to efficiently handle the transient/steady state response of rotor-bearing-stator structure associated with gas turbine engines are outlined. The two main areas aim at (1) implementing the squeeze film damper and establishment of a general purpose program for evaluation; and (2) determination of the numerical characteristics of the FE-generated rotor-bearing-stator simulation scheme. The governing FE field equations are set out and the solution methodology is presented. The choice of ADINA as the general-purpose method is described. G.C.
FE code is explained, and the numerical operational characteristics of the direct integration approach of FE-generated rotor-bearing-stator simulations is determined, including benchmarks, comparison of explicit vs. implicit methodologies of direct integration, and demonstration problems.


An acceptable and feasible ceramic turbine wheel design has been achieved, and the relevant temperature, stress, and success probability analyses are discussed. The design is described, the materials selection presented, and the engine cycle conditions analysis parameters shown. Measured MOR four-point strengths are indicated for room and elevated temperatures, and engine conditions are analyzed for various cycle states, materials, power inputs, turbine inlet temperatures, and speeds. An advanced gas turbine ceramic turbine rotor thermal and stress model is developed, and cumulative probability of survival is shown for first and third-year properties of SIC and Si3N4 rotors under different operating conditions, computed for both blade and hub regions. Temperature and stress distributions for steady-state and worst-case shutdown transients are depicted.


A description is presented of the development and use of a preprocessor to create a NASTRAN finite element model of a complex spur, helical, or spiral bevel gear quickly, inexpensively, and accurately. The preprocessor creates a ready to run NASTRAN input deck including the executive, case control, and bulk data sections. It generates nodes and solid elements to model spur, helical, or spiral bevel gear teeth with integral shafting. Either a complete gear shafting model or a symmetric model is created. The fundamental building block of the gear model is the base layer. The base layer is the mesh configuration of one layer of one tooth segment which is then duplicated, translated, and rotated to create the completed model of the gear. Once the base layer is created, the construction of the finite element model is straightforward.

G.R.
38 QUALITY ASSURANCE AND RELIABILITY
Includes product sampling procedures and techniques; and quality control.

N82-18612# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METAL HONEYCOMB TO POROUS WIREFORM SUBSTRATE DIFFUSION BOND EVALUATION
(NASA-TM-82793; E-959) Avail: NTIS HC A02/MF A01 CSCL 14D
Two nondestructive techniques were used to evaluate diffusion bond quality between a metal foil honeycomb and porous wireform substrate. The two techniques, crenographics and acoustic-ultrasonics, are complementary in revealing variations of bond integrity and quality in shroud segments from an experimental aircraft turbine engine.

S. L.

N82-19550# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIENCE WITH MODIFIED AEROSPACE RELIABILITY AND QUALITY ASSURANCE METHOD FOR WIND TURBINES
(NASA-TM-82803; DOE/NASA/20320-38; E-1142) Avail: NTIS HC A02/MF A01 CSCL 14D
The SRQA approach assures that the machine is not hazardous to the public or operating personnel, can operate unattended on a utility grid, demonstrates reliability creation, and helps establish the quality assurance and maintainability requirements for future wind turbine projects. The approach consisted of modified failure modes and effects analysis (FMEA) during the design phase, minimal hardware inspection during parts fabrication, and three simple documents to control activities during machine construction and operation. Five years experience shows that this low cost approach works well enough that it should be considered by others for similar projects.

T. M.

N82-20561# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INTERRELATION OF MATERIAL MICROSTRUCTURE, ULTRASONIC FACTORS, AND FRACTURE TOUGHNESS OF TWO PHASE TITANIUM ALLOY
(NASA-TM-82810; E-1151; NAS 1.15:82810) Avail: NTIS HC A02/MF A01 CSCL 14D
The pivotal role of an alpha-beta phase microstructure in governing fracture toughness in a titanium alloy, Ti-6Al-4V, is demonstrated. The interrelation of microstructure and fracture toughness is demonstrated using ultrasonic measurement techniques originally developed for nondestructive evaluation and material property characterization. It is shown that the findings determined from ultrasonic measurements agree with conclusions based on metallurgical, metallographic, and fractographic observations concerning the importance of alpha-beta morphology in controlling fracture toughness in two phase titanium alloys.

Author

N82-18813# Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering.
ULTRASONIC INPUT-OUTPUT FOR TRANSMITTING AND RECEIVING LONGITUDINAL TRANSDUCERS COUPLED TO SAME FACE OF ISO TROPIC ELASTIC PLATE Final Report
James H. Williams, Jr., Hira Karagule, and Samson S. Lee Washington, D.C. NASA Feb. 1982 29 p refs (Grant NSG-3110)

(Author)
CHAPTER 39: STRUCTURAL MECHANICS

Includes structural element design and weight analysis; fatigue; and thermal stress.


N82-11491*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
INTEGRATED ANALYSIS OF ENGINE
(NASA-TM-82713; E-986) Avail: NTIS HC A02/MF A01 CSCL
20K

The need for light, durable, fuel efficient, cost effective aircraft requires the development of engine structures which are flexible, made from advanced materials (including composites), resist higher temperatures, maintain tight clearances and have lower maintenance costs. The formal quantification of any several of these requires integrated computer programs (multi-level and/or interdisciplinary analysis programs interconnected) for engine structural analysis/design. Several integrated analysis computer programs are under development at Lewis Research Center. These programs include: (1) COBSTRAN-Composite Blade Structural Analysis, (2) CODSTRAN-Composite Durability Structural Analysis, (3) CISTRAN-Composite Impact Structural Analysis, (4) STAEBL-Structural Tailoring of Engine Blades, and (5) ESMOSS-Engine Structures Modeling Software System. These other related programs, developed under Lewis sponsorship, are described.

The major technology areas needed to perform a life prediction of an aircraft turbine engine hot section component are discussed and the steps required for life prediction are outlined. These include the determination of the operating environment, the calculation of the thermal and mechanical loading of the component, the cyclic stress-strain and creep behavior of the material required for structural analysis, and the structural analysis to determine the local stress-strain-temperature response of the material at the critical location in the components. From a knowledge of the fatigue, creep, and failure resistance of the material, a prediction of the life of the component is made. Material characterization and evaluation conducted for the purpose of calculating fatigue crack initiation lives of components operating at elevated temperatures are emphasized.

N82-16419*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
ELEVATED TEMPERATURE FATIGUE TESTING OF METALS
(NASA-TM-82745; E-1058) Avail: NTIS HC A02/MF A01 CSCL 20K

A set of aeroelastic equations describing the motion of an arbitrarily mistuned cascade with flexible, pretwisted, nonuniform blades is developed using an extended Hamilton's principle. The derivation of the equations has its basis in the geometric nonlinear theory of elasticity in which the elongations and shears are negligible compared to unity. A general expression for shortening of a blade is derived and is explicitly used in the formulation. The blade aerodynamic loading in the subsonic and supersonic regime is obtained from two dimensional, unsteady, cascade theories. The aerodynamic, inertial and structural coupling between the bending (in two planes) and torsional motions of the blade is included. The equations are used to investigate the aeroelastic stability and to quantify the effect of frequency mistuning on flutter in turbomachines. Results indicate that a moderate amount of intentional mistuning has enough potential to alleviate flutter problems in unshrouded, high aspect ratio turbomachines. S.L.

N82-20565*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
ELASTIC-PLASTIC FINITE-ELEMENT ANALYSES OF THERMALLY CYCLED SINGLE-EDGE WEDGE SPECIMENS
Albert Kaufman Mar. 1982 27 p refs
(NASA-TP-19828; E-657; NAS 1.80;1982) Avail: NTIS HC A02/MF A01 CSCL 20K

Elastic-plastic stress-strain analyses were performed for single-edge wedge alloys subjected to thermal cycling in fluidized beds at 316 and 1088 C. Four cases involving different nickel-base alloys (IN 100, Mar M-200, NASA TAZ-B, and Rene 80) were analyzed by using the MARC nonlinear, finite element computer program. Elastic solutions from MARC showed good agreement with previously reported solutions obtained by using the NASTRAN and ISOP3DQ computer programs. Equivalent total strain ranges at the critical locations calculated by elastic analyses agreed within 3 percent with those calculated from elastic-plastic analyses. The elastic analyses always resulted in compressive mean stresses at the critical locations. However, elastic-plastic analyses showed tensile mean stresses for two of the four alloys and an increase in the compressive mean stress for the high-strength plastic strain case. M.G.

N82-21804*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
COUPLED BENDING-BENDING-TORSION FLUTTER OF A MISTUNED CASCADE WITH NONUNIFORM BLADES
Kyoungsoo Rao V. Koza (Tet.Edu Unk) and Robert E. Kielb 1982
(NASA-TM-82813; E-1156; NAS 1.15;82813) Avail: NTIS HC A02/MF A01 CSCL 20K

The blade aerodynamic loading in the subsonic and supersonic flow regimes is obtained from two dimensional, unsteady, cascade theories. The aerodynamic, inertial and structural coupling between the bending (in two planes) and torsional motions of the blade is included. The equations are used to investigate the aeroelastic stability and to quantify the effect of frequency mistuning on flutter in turbomachines. Results indicate that a moderate amount of intentional mistuning has enough potential to alleviate flutter problems in unshrouded, high aspect ratio turbomachines. S.L.

N82-24601*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
NONLINEAR STRUCTURAL AND LIFE ANALYSES OF A COMBUSTOR LINER
(NASA-TM-82846; E-1216; NAS 1.15;82846) Avail: NTIS HC A02/MF A01 CSCL 20K

Three dimensional, nonlinear finite element structural analyses were performed for a simulated combustor liner specimen to assess the capability of nonlinear analyses using classical inelastic material models to represent the thermoplastic creep response of the one half scale component. Results indicate continued cyclic hardening and ratcheting while experimental data suggested a stable stress strain response after only a few loading cycles. The computed stress strain history at the critical location was put into two life prediction methods, strainrange partitioning and a Pratt and Whitney combustor life prediction method to evaluate the ability to predict cyclic crack initiation. It is found that the life prediction analyses over predicted the observed cyclic crack initiation life. E.A.K.
N82-24502*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVALUATION OF INELASTIC CONSTITUTIVE MODELS FOR NONLINEAR STRUCTURAL ANALYSIS


HC A02/MA A01 CSCL 20K

The influence of inelastic material models on computed stress-strain states, and therefore predicted lives, was studied for thermomechanically loaded structures. Nonlinear structural analyses were performed on a fatigue specimen which had been subjected to thermally cycling in fluidized beds and on a mechanically load cycled backside notch specimen. Four incremental plasticity creep models (isotropic, kinematic, combined isotropic kinematic, combined plus transient creep) were exercised using the MARC program. Of the plasticity models, kinematic hardening gave results most consistent with experimental observations. Life predictions using the computed strain histories at the critical location with a strain-range partitioning approach considerably overpredicted the crack initiation life of the thermal fatigue specimen.

S.L.

N82-26701*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BIRD IMPACT ANALYSIS PACKAGE FOR TURBINE ENGINE FAN BLADES


HC A02/MA A01 CSCL 20K

For abstract see A62-30182

N82-31707*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE DISPLACEMENTS AND STABILITY ANALYSIS OF NONLINEAR PROPELLER STRUCTURES


HC A02/MA A01 CSCL 20K

The use of linear rigid formats in COSMIC NASTRAN without DMAP procedures for the analysis of nonlinear propeller structures is described. Approaches for updating geometry and applying follower forces for incremental loading are demonstrated. Comparisons are made with COSMIC NASTRAN rigid formats and other independent finite element programs. Specifically, the comparisons include results from the four approaches for updating the geometry using RIGID FORMAT 1, RIGID FORMATS 4 and 13, MARC and MSC/NASTRAN. It is shown that the 'user friendly' updating approaches (without DMAPS) can be used to predict the large displacements and instability of those nonlinear structures. These user friendly approaches can be easily implemented by the user and predict conservative results.

Author

N82-31708*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TENSILE BUCKLING OF ADVANCED TURBOPROPS


HC A02/MA A01 CSCL 20K

Theoretical studies were conducted to determine analytically the tensile buckling of advanced propeller blades (turbo props) in centrifugal fields, as well as the effects of tensile buckling on other types of structural behavior, such as resonant frequencies and flutter. Theoretical studies were also conducted to establish the advantages of using high performance composite turbo props as compared to titanium. Results show that the vibration frequencies are not affected appreciably prior to 80 percent of the tensile speed. Some frequencies approach zero as the tensile buckling speed is approached. Composites provide a substantial advantage over titanium on a buckling speed to weight basis. Vibration modes change as the rotor speed is increased and substantial geometric coupling is present.

R.J.F.

N82-33744*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NONLINEAR CONSTITUTIVE THEORY FOR TURBINE ENGINE STRUCTURAL ANALYSIS


Avail: NTIS HC A19/MF A01 CSCL 20K

A number of viscoplastic constitutive theories and a conventional constitutive theory are evaluated and compared in their ability to predict nonlinear stress-strain behavior in gas turbine engine components at elevated temperatures. Specific application of these theories is directed towards the structural analysis of combustor liners undergoing transient, cyclic, thermomechanical load histories. The combustor liner material considered in this study is Hastelloy X. The material constants for each of the theories (as a function of temperature) are obtained from existing, published experimental data. The viscoplastic theories and a conventional theory are incorporated into a general purpose, nonlinear, finite element computer program. Several numerical examples of combustor liner structural analysis using these theories are given to demonstrate their capabilities. Based on the numerical stress-strain results, the theories are evaluated and compared. Author


Stress-strain curves are obtained for a variety of glass fiber and carbon fiber reinforced plastics in dynamic tension, over the stress-strain range of 0.00067-2070/see. The test method is of the one-bar block-to-bar type, using a rotating disk or a pendulum as the loading apparatus and yielding accurate stress-strain curves up to the breaking strain. In the case of glass fiber reinforced plastic, the tensile strength, strain to peak impact stress, total strain and total absorbed energy all increase significantly as the strain rate increases. By contrast, carbon fiber reinforced plastics show lower rates of increase with strain rate. It is recommended that hybrid composites incorporating the high strength and rigidity of carbon fiber reinforced plastic with the high impact absorption of glass fiber reinforced plastics be developed for use in structures subjected to impact loading.

O.C.


The suggestion is made that the standard compact specimen (with opening displacement measured at the crack mouth) may be entirely suitable for J-integral determinations if a very simple conversion factor is used. Experimental determination of J and J-values requires the measurement of displacements at the points of load application. For the compact specimen this is a difficult task. On the basis of studies reported by Newman (1979) and Fisher and Buzzard (1980), it is suggested that for any J-based test the standard compact specimen can be expected a very good approximation to the load point displacement (within 3.4 percent) can be obtained by measuring the crack mouth displacement and multiplying by 0.773.

G.R.

N82-14531# Arizona Univ., Tucson, Dept. of Aerospace and Mechanical Engineering.

THE APPLICATION OF PROBABILISTIC DESIGN THEORY TO HIGH TEMPERATURE LOW CYCLE FATIGUE

112 ORIGINAL PAGE IS OF POOR QUALITY
Metal fatigue under stress and thermal cycling is a principal mode of failure in gas turbine engine hot section components such as turbine blades, nozzles, and combustor liners. Designing for fatigue is subject to considerable uncertainty, e.g., scatter in cycles to failure, available fatigue test data and operating environment data, uncertainties in the models used to predict stresses, etc. Methods of analyzing fatigue test data for probabilistic design purposes are summarized. The general strain life as well as homo- and hetero-scedastic models are considered. Modern probabilistic design theory is reviewed and examples are presented with appropriate application to reliability analysis of gas turbine engine components.

A.R.H.


The state of stress beneath traction drive type of contacts were analyzed. Computing stresses and stress reversals on various planes for points beneath the surface were examined. The effect of tangential and axial friction under gross slip conditions is evaluated with the models. Evaluations were performed on an RC (rolling contact) tester configuration and it is indicated that the classical fatigue stresses are not altered by friction forces typical of lubricated contact. Higher values of friction can result in surface shear reversal that exceeds the stresses at the depth of maximum shear reversal under rolling contact. E.A.K.


Finite element papers published in the open literature on the static bending and free vibration of layered, anisotropic, and composite plates and shells are reviewed. A literature review of large-deflection and large-amplitude free oscillations of layered composite plates and shells is also presented. Non-finite element literature is cited for continuity of the discussion. J.D.H.

N82-20564# Case Western Reserve Univ., Cleveland, Ohio. FATIGUE LIFE PREDICTION IN BENDING FROM AXIAL FATIGUE INFORMATION S. S. Manson and U. Muralidharan. Feb. 1982 38 p refs (Grant NAG3-39) (NASA-CR-165563; NAS 1.26:165563) Avail: NTIS HC A03/MF A01 CSCL 20K

Bending fatigue in the low cyclic life range differs from axial fatigue due to the plastic flow which alters the linear stress-strain relation normally used to determine the nominal stresses. An approach is presented to take into account the plastic flow in calculating nominal bending stress (S sub b bending) based on true surface stress. These functions are derived in closed form for rectangular and circular cross sections. The nominal bending stress and the axial fatigue stress is plotted as a function of life (N sub S) and these curves are shown for several materials of engineering interest. S.L.


Two path independent integral parameters which show some degree of promise as fracture criteria are the C^* and delta T sub c integrals. The mathematical aspects of these parameters are reviewed. This is accomplished by deriving generalized vector forms of the parameters using conservation laws which are valid for arbitrary, three dimensional, cracked bodies with crack surface tractions (or applied displacements), body forces, inertial effects and large deformations. Two practical conclusions are that delta T sub c is a valid crack tip parameter during nonsteady as well as steady state creep and that delta T sub c has an energy rate interpretation whereas C^* does not. An efficient, small displacement, infinitesimal strain, displacement based finite element model is developed for general elastic/plastic material behavior. For the numerical studies, this model is specialized to two dimensional plane stress and plane strain and to power law creep constitutive relations.

S.L.


Longitudinal specimens of Waspaloy containing either coarse grains with small gamma or fine grains with large gamma were tested in air at a frequency of 0.33 Hz or 0.50 Hz. The coarse grained structures exhibited planar slip on (111) planes and precipitate shearing at all temperatures. Cracks initiated by a Stage 1 mechanism and propagated by a striation forming mechanism. At 700 C and 800 C, cleavage and intergranular cracking were observed. Testing at 500 C, 700 C, and 800 C caused precipitation of grain boundary carbides. At 700 C, carbides precipitated on slip bands. The fine grained structures exhibited planar slip on (111) planes. Dislocations looped the large gamma precipitates. This structure led to stress saturation and propagation was observed. Increasing temperatures resulted in increased specimen oxidation for both heat treatments. Slip band and grain boundary oxidation were observed. At 800 C, oxidized grain boundaries were cracked by intersecting slip bands which resulted in intergranular failure. The fine specimens had crack initiation later in the fatigue life, but with more rapid propagation crack propagation. A.R.H.


Specimens tested for the AGARD strain range partitioning program were investigated. Rene 80 and IN 100 were tested in air and in vacuum: at 871 C, 925 C, and 1000 C; and in the coated and uncoated condition. The specimens exhibited a multiplicity of high-temperature low-cycle fatigue damage. Observations of the various forms of damage were consistent with material and testing conditions and were generally in agreement with previous studies. In every case observations support a contention that failure occurs at a particular combination of crack length and maximum stress. A failure criterion which is applicable in the regime of testing studied is presented. The predictive capabilities of this criterion is straightforward.

Author


Thermal boundary-layer stresses (near free edges) and...
Theoretical and Applied Mechanics.

ANALYSIS OF CRACKS EMANATING FROM A CIRCULAR HOLE IN UNIDIRECTIONAL FIBER REINFORCED COMPOSITES, PART 2 Final Report
(NASA-CR-165434; NAS 1.26:165434) Avail: NTIS
HC A03/MF A01 CSLC 20K

An analytical method is developed for cracks emanating from a circular hole in an off-axis unidirectional fiber-reinforced composite. The method which is formulated by using conservation laws of elasticity and fundamental relationships in anisotropic fracture mechanics, provides a convenient and accurate means to examine the complicated crack behavior, when used in conjunction with a suitable numerical scheme such as the finite element method. The formulation is eventually reduced to a system of linear algebraic equations of mixed-order singular kernels. The fracture parameters, describing crack-tip deformation and fracture in the composite, are obtained explicitly. Effects of material anisotropy and crack/hole geometry are examined also. Of particular interest are the energy release rates associated with crack extension; their values are evaluated for various cases. Results show that mixed-mode stress intensity factors and energy release rates associated with the cracks emanating from a hole change very appreciably with fiber orientation in the composite. K sub 1 and G increase monotonically with increasing theta; but K sub 2 reaches its maximum at theta = 45 deg. and then decreases gradually as theta increases further. Author

INTERLAMINAR CRACK GROWTH IN FIBER REINFORCED COMPOSITES DURING FATIGUE, PART 3 Final Report
(NASA-CR-165434; NAS 1.26:165434) Avail: NTIS
HC A03/MF A01 CCLC 20K

Interlaminar crack growth behavior in fiber-reinforced composites subjected to fatigue loading was investigated experimentally and theoretically. In the experimental phase, inter-laminar crack propagation rates and mechanisms were determined for the cases of various geometries, laminate parameters and cyclic stress levels. A singular hybrid-stress finite element method was used in conjunction with the experimental results to examine the local crack-tip behavior and to characterize the crack propagation during fatigue. Results elucidate the basic nature of the cyclic delamination damage, and relate the interlaminar crack growth rate to the range of mixed-mode crack-tip stress intensity factors. The results show that growth rates are directly related to the range of the mixed-mode cyclic stress intensity factors by a power law relationship. Author

EDGE DELAMINATION IN ANGLE-PLY COMPOSITE LAMINATES, PART 5 Final Report
(NASA-CR-165439; NAS 1.26:165439) Avail: NTIS
HC A03/MF A01 CCLC 20K

A theoretical method was developed for describing the edge delamination stress intensity characteristics in angle-ply composite laminates. The method is based on the theory of anisotropic elasticity. The edge delamination problem is formulated using Lekhnitskii's complex-variable stress potentials and eigenfunction expansion method. The method predicts exact orders of the three-dimensional stress singularity in a delamination crack tip region. With the aid of boundary collocation, the method predicts the complete stress and displacement fields in a finite-dimensional, delaminated composite. Fracture mechanics parameters such as the mixed-mode stress intensity factors and associated energy release rates for edge delamination can be calculated explicitly. Solutions are obtained for edge delaminated (theta-theta theta-theta) angle-ply composites under uniform axial extension. Effects of delamination lengths, fiber orientations, lamination and geometric variables are studied. Author

BOUNDARY-LAYER EFFECTS IN COMPOSITE LAMINATES: FREE-EDGE STRESS SINGULARITIES, PART 6 Final Report
S. S. Wang and I. Choi Apr. 1981 38 p refs 6 Vol. (Grant NSG-3044)
(NASA-CR-165440; NAS 1.26:165440) Avail: NTIS
HC A03/MF A01 CCLC 20K

A rigorous mathematical model was obtained for the boundary-layer free-edge stress singularity in angle-ply and crossplied fiber composite laminates. The solution was obtained using a method consisting of complex-variable stress function potentials and eigenfunction expansions. The required order of the boundary-layer stress singularity is determined by solving the transcendental characteristic equation obtained from the homogeneous solution of the partial differential equations. Numerical results obtained show that the boundary-layer stress singularity depends only upon material elastic constants and fiber orientations of the adjacent plies. For angleplied and crossplied laminates the order of the singularity is weak in general. Author

CREEP CRACK-GROWTH: A NEW PATH-INDEPENDENT INTEGRAL (T SUB 2) AND COMPUTATIONAL STUDIES
Ph.D. Thesis Final Report
R. B. Stonessifer and S. N. Atluri Jul. 1982 112 p refs
(Grant NAG3-58)
(NASA-CR-167897; NAS 1.26:167897) Avail: NTIS
HC A06/MF A01 CCLC 20K

The development of valid creep fracture criteria is considered. Two path-independent integral parameters which show degree of promise are the T^2 and (Delta T) Sub 2 integrals. The mathematical aspects of these parameters are reviewed by deriving generalized vector forms of the parameters using conservation laws which are valid for arbitrary, three dimensional, cracked
bodies with crack surface tractions (or applied displacements), body forces, inertial effects, and large deformations. Two principal conclusions are that (Delta) T= E has an energy rate interpretation whereas C does not. The development and application of fracture criteria often involves the solution of boundary/singular value problems associated with deformation and stresses. The finite element method is used for this purpose. An efficient, small displacement, infinitesimal strain, displacement based finite element model is specialized to two dimensional plane stress and plane strain and to power law creep constitutive relations. A mesh shifting/remeshing procedure is used for simulating crack growth. The models are implemented with the quarter-point node technique and also with specially developed, conforming, crack-tip singularity elements which provide for the crack to the power law strain singularity associated with the HRR crack-tip field. Comparisons are made with a variety of analysis solutions and alternate numerical solutions for a number of problems.

J.D.

A PRELIMINARY STUDY OF CRACK INITIATION AND GROWTH AT STRESS CONCENTRATION SITES

D. S. Dawickey, J. P. Gallagher, G. A. Hartman, and A. M. Rajendra
Sep. 1982 30 p refs

(Available: NTIS HC A03/MF A01 CSCL 20K)
Crack initiation and propagation models for notches are examined. The Dowling crack initiation model and the E1 Haddad et al. crack propagation model were chosen for additional study. Existing data was used to make a preliminary evaluation of the crack propagation model. The results indicate that for the crack sizes in the test, the elastic parameter K gave good correlation for the crack growth rate data. Additional testing, directed specifically toward the problem of small cracks initiating and propagating from notches is necessary to make a full evaluation of these initiation and propagation models.

A cantilevered, shallow shell of circular cylindrical curvature and rectangular planform exhibits free vibration behavior which differs considerably from that of a cantilevered beam or of a flat plate. Some numerical results can be found for the problem in the previously published literature, mainly obtained by using various finite element methods. The first attempt at a definitive study of the problem, presenting accurate non-dimensional frequency parameters for wide ranges of aspect ratio, shallowness ratio and thickness ratio. The analysis is based upon shallow shell theory. Numerical results obtained by using the Ritz method, with algebraic polynomial trial functions for the displacements. Convergence is investigated, with attention being given both to the number of terms taken for each co-ordinate direction and for each of the three components of displacement. Accuracy of the results is also established by comparison with finite element results for shallow shells and with other accurate flat plate solutions. (Author)

Vibration analysis of turbomachinery blades has traditionally been carried out by means of beam theory. In recent years two-dimensional methods of blade vibration analysis have been developed, most of which utilize finite elements and tend to require considerable computation time. More recently a two-dimensional method of blade analysis has evolved which does not require finite elements and is based upon shell equations. The present investigation has the primary objective to demonstrate the accuracy and limitations of blade vibration analyses which utilize one-dimensional, beam theories. It is found that beam theory is generally inadequate to determine the free vibration frequencies and mode shapes of moderate to low aspect ratio turbomachinery blades. The shallow shell theory, by contrast, is capable of representing all the vibration modes accurately. However, the one-dimensional beam theory has an important advantage over the two-dimensional shell theory for blades and vibration modes. It uses fewer degrees of freedom, thus requiring less computer time.

Applications of a vector quantity, path-independent integral which has an energy interpretation to the characterization of crack-tip fields in the range from fast to slow crack propagation are examined. The crack tip characterization parameter is defined in terms of a conservation integral for an area around the crack tip in a two-dimensional cracked body. The actual physical interpretation of the parameter is shown to be the difference in crack lengths displayed by two identical bodies which have equal load histories. A steady-state value is obtained for the parameter for cases of steady-state creep and is shown to be related to the standard path-independent integral for macroscopic self-similar crack growth under mode I conditions. A finite element model is developed for viscoplastic material models, using an initial strain approach with steps in a size employed in tangent stiffness methods.

The paper considers the pre and post buckling behavior of general structures exposed to high temperature fields for long durations wherein creep effects become significant. The solution to this problem is made possible through the use of closed upper bounding constraint surfaces which enable the development of a new time stepping algorithm. This permits the stable and efficient solution of structural problems which exhibit indefinite tangent properties. Due to the manner of constraining/bounding successive iterates, the algorithm developed herein is largely non-adaptive, inherently stable, sufficiently flexible to handle geometric material and boundary induced nonlinearity, and can be incorporated into either finite element or difference simulations. To illustrate the capability of the procedure, as well as, the physics of creep induced pre and post buckling behavior, the results of several numerical experiments are included. (Author)
Moving singularity creep crack growth analysis with the \( \Delta T/c \) and \( (\Delta T)^{c} \) integrals. R. B. Stonesifer and S. N. Atluri (Georgia Institute of Technology, Atlanta, GA). *Engineering Fracture Mechanics*, vol. 16, no. 6, 1982, p. 769-782. 11 refs. Grant No. NAG3-98.

The physical meaning of \( \Delta T/c \) and its applicability to creep crack growth are reviewed. Numerical evaluation of \( \Delta T/c \) and \( (\Delta T)^{c} \) is discussed with results being given for compact specimen and strip geometries. A moving crack-tip singularity, creep crack growth simulation procedure is described and demonstrated. The results of several crack growth simulation analyses indicate that creep crack growth in 304 stainless steel occurs under essentially steady-state conditions. Based on this result, a simple methodology for predicting creep crack growth behavior is summarized.

(Author)

On ultrasonic factors and fracture toughness. L. S. Fu (Ohio State University, Columbus, OH). *Symposium on Nondestructive Evaluation*, 13th, San Antonio, TX, April 21-23, 1981, Proceedings. (A82-42851 21-38)

Recent experimental and theoretical studies on ultrasonics have shown that the scattering of elastic waves by material defects yields data which characterize crack properties, such as size and orientation, and also the mechanical properties of the given material. The present study, elastodynamic fields due to the presence of a pair of inhomogeneities in a material of plate geometry are investigated by the method of equivalent inclusions. The stress amplitude change of the plates during the passage of plane time-harmonic waves is found, and the relation between fracture toughness and ultrasonic factors is determined. The approach used does not assume the existence of a sharp crack in the material.

O.C.


Lee (1989) has proposed a theory based on the decomposition of the total deformation gradient to an elastic and plastic part, and from it has concluded that the additive decomposition of the strain rates holds only approximately. Lubarda and Lee (1981) have declared that Lee's 'exact finite-deformation kinematics shows the almost universal assumption that the total velocity strain or rate of deformation is the sum of elastic and plastic rates to be in error'. Hence questions are raised regarding the validity of essentially all finite deformation elastoplasticity theories. The present investigation is concerned with these questions. It is shown that the additive decomposition of the strain rates follows from all common finite elastoplasticity concepts. Lee's theory is examined, and it is shown that this theory also leads to an additive strain rate decomposition, and therefore, his conclusion stems from misinterpretation. It is found that the elastic and the plastic strain rates considered by Lee do not correspond to the same configuration. They are, therefore, not compatible measures.

G.R.


A study on the elastic behavior of Interface cracks in adhesively bonded lap-shear joints is presented. The problem is investigated by using a recently developed method of analysis based on conservation laws in elasticity for nonhomogeneous solids and fundamental relationships in fracture mechanics of dissimilar materials. The formulation leads to a pair of linear algebraic equations in mixed-mode stress intensity factors. Singular crack-tip stress intensity solutions are obtained directly by information extracted from the far field. Stress intensity factors and associated energy release rates are obtained for various cases of interest. Fundamental nature of the Interfacial flaw behavior in lap-shear adhesive joints is examined in detail.

(Author)


The fundamental nature of the boundary-layer effect in fiber-reinforced composite laminates is formulated in terms of the theory of anisotropic elasticity. The basic structure of the boundary-layer field solution is obtained by using Lekhnitski's stress potentials (1963). The boundary-layer stress field is found to be singular at composite laminate edges, and the exact order or strength of the boundary layer stress singularity is determined using an eigenfunction expansion method. A complete solution to the boundary-layer problem is then derived, and the convergence and accuracy of the solution are analyzed, comparing results with existing approximate numerical solutions. The solution method is demonstrated for a symmetric graphite-epoxy composite.

V.L.
43 EARTH RESOURCES

Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry; and aerial photography. For instrumentation see 35 Instrumentation and Photography.

N82-14562*I National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

RELIABLE AERIAL THERMOGRAPHY FOR ENERGY CONSERVATION Final Report
Original contains color illustrations (Contract DE-MA01-78CS-02070) (NASA-TM-81766; DOE/NASA/20270-1; E-828) Avail: NTIS HC A03/MF A01 CSCL 08B

A method for energy conservation, the aerial thermography survey, is discussed. It locates sources of energy losses and wasteful energy management practices. An operational map is presented for clear sky conditions. The map outlines the key environmental conditions conducive to obtaining reliable aerial thermography. The map is developed from defined visual and heat loss discrimination criteria which are quantized based on flat roof heat transfer calculations. E.A.K.

N82-18664*I National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

GROUND-TRUTH OBSERVATIONS OF ICE-COVERED NORTH SLOPE LAKES IMAGED BY RADAR

Field observations support the interpretation that differences in the strength of radar returns from the ice covers of lakes on the North Slope of Alaska can be used to determine where the lake is frozen completely to the bottom. An ice/frozen soil interface is indicated by a weak return and an ice/water interface by a strong return. The immediate value of this result is that SLAR (side-looking airborne radar) imagery can now be used to prepare maps of large areas of the North Slope showing where the lakes are shallower or deeper than 1.7m (the approximate draft of the lake ice at the time of the SLAR flights). The bathymetry of these shallow lakes is largely unknown and is not obvious from their sizes or outlines. Such information could be very useful, for example in finding suitable year-round water supplies.

Author (GRA)

N82-24525*I National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

LANDSAT REMOTE SENSING: OBSERVATIONS OF AN APPALACHIAN MOUNTAINTOP SURFACE COAL MINING AND RECLAMATION OPERATION
Oct. 1979 7 p ref Original contains color imagery. Original photography may be purchased from the EROS Data Center, Sioux Falls, S.D. 57198 Original contains color illustrations (E82-10247; NASA-TM-84194; NAS 1.15:84194) Avail: NTIS HC A02/MF A01 CSCL 08I

The potential benefits of using LANDSAT remote sensing data by state agencies as an aide in monitoring surface coal mining operations are reviewed. A mountaintop surface mine in eastern Kentucky was surveyed over a 5 year period using satellite multispectral scanner data that were classified by computer analyses. The analyses were guided by aerial photography and by ground surveys of the surface mines procured in 1976. The application of the LANDSAT data indicates that: (1) computer classification of the various landcover categories provides information for monitoring the progress of surface mining and reclamation operations; (2) successive yearly changes in barren and revegetated areas can be qualitatively assessed for surface mines of 100 acres or more of disturbed area; (3) barren areas consisting of limestone and shale mixtures may be recognized, and revegetated areas in various stages of growth may be identified against the hilly forest background. E.A.K.
44 ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells and batteries; global sources of energy; fossil fuels; geophysical conversion; hydroelectric power; and wind power.

For related information see also 07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 85 Urban Technology and Transportation.

N82-10503# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

EFFECT OF POSITIVE PULSE CHARGE WAVEFORMS ON THE ENERGY EFFICIENCY OF LEAD-ACID TRACTION CELLS Final Report

John J. Smithwick Sep, 1981 11 p refs (Contract DE-AIO1-77CS-51044)

(NASA-TM-82708: E-991; DOE/NASA/B1044-22) Avail: NTIS HC A02/MF A01 CSCL 10A

The effects of four different charge methods on the energy conversion efficiency of 300 ampere hour lead acid traction cells were investigated. Three of the methods were positive pulse charge waveforms; the fourth, a constant current method, was used as a baseline of comparison. The positive pulse charge waveforms were: 120 Hz full wave rectified sinusoidal; 120 Hz silicon controlled rectified; and 1 kHz square wave. The constant current charged was set at the time average pulse current of each pulse waveform, which was 150 amps. The energy efficiency does not include charger losses. The lead acid traction cells were charged to 70 percent of rated ampere hour capacity in each case. The results of charging the cells using the three different pulse charge waveforms indicate there was no significant difference in energy conversion efficiency when compared to constant current charging at the time average pulse current value.

Author

N82-10504# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SOLAR CELL DEVELOPMENT FOR THE POWER EXTENSION PACKAGE


The PEP is a 32 kilowatt flexible substrate, retrievable, solar array system for use on the Space Shuttle. Solar cell costs will be reduced by increasing cell area and simplifying cell and glass fabrication processes and specifications. The cost goal is to produce cells below $30 per watt. Two and ten ohm-cm silicon cells were investigated. In phase I of the cell development program a few thousand candidate cells will be produced and evaluated for utility and quality. In phase II a large number of cells will be fabricated to verify production readiness and cell yields and costs. This schedule is compatible with PEP initial operational capability in 1984. Approximately 140,000 large area cells will be fabricated for two PEP arrays. The test of the cell development and testing, including a radiation damage test and side-by-side comparison of candidate cell types with pre- and post-irradiation airplane calibration of outer space short-circuit current, is reported.

T.M.

N82-15504# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

CATALYTIC COMBUSTION OF RESIDUAL FUELS


(NASA-TM-82731: E-1040) Avail: NTIS HC A02/MF A01 CSCL 21B

A noble metal catalytic reactor was tested using two grades of petroleum derived residual fuels at specified inlet air temperatures, pressures, and reference velocities. Combustion efficiencies greater than 99.5 percent were obtained. Steady state operation of the catalytic reactor required inlet air temperatures of at least 800 K. At lower inlet air temperatures, upstream burning in the premixing zone occurred which was probably caused by fuel deposition and accumulation on the premixing zone walls. Increasing the inlet air temperature prevented this occurrence. Both residual fuels contained about 0.5 percent nitrogen by weight. NOx sub x emissions ranged from 50 to 110 ppm by volume at 15 percent excess O2. Conversion of fuel-bound nitrogen to N2 sub x ranged from 25 to 50 percent. M.D.K.

N82-13608# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

GAS-TURBINE CRITICAL RESEARCH AND ADVANCED TECHNOLOGY SUPPORT PROJECT Annual Report

John S. Clark, Philip E. Hodge, Carl E. Lowell, David N. Anderson, and Donald F. Schultz Mar, 1981 80 p refs (Contract DE-AIO1-77ET-10350)

(NASA-TM-82179: E-737) Avail: NTIS HC A03/MF A01 CSCL 10B

A technology database for utility gas turbine systems capable of burning coal derived fuels was developed. The following areas are investigated: combustion; materials; and system studies. A two stage test rig is designed to study the conversion of fuel-bound nitrogen to NOx. The feasibility of using heavy fuels in catalytic combustors is evaluated. A statistically designed series of hot corrosion burner rig tests was conducted to measure the corrosion rates of typical gaseous alloys with several fuel contaminants. Fuel additives and several advanced thermal barrier coatings are tested. Thermal barrier coatings used in conjunction with low critical alloys and those used in a combined cycle system in which the stack temperature was maintained above the acid corrosion temperature are also studied. E.A.K.
2MKiLOWATT WIND TURBINE Final Report


The rotor blade configuration, fabrication methods, analyses, operating experience, design modifications, and cost are described. Each 60-ft (-18.3-m-) long aluminum blade used current aircraft fixed wing and rotary wing design and fabrication technologies. Structural damage, repairs, and modifications that occurred during 6500 hours of operation are summarized.

T.M.

N82-14677*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NEW FEATURES AND APPLICATIONS OF PRESTO, A COMPUTER CODE FOR THE PERFORMANCE OF REGENERATIVE, SUPERHEATED STEAM TURBINE CYCLES


The code was designed to analyze performance at valves-wide-open design flow. The code can model conventional steam cycles as well as cycles that include such special features as process steam extraction and feedwater heating by external heat sources. Convenience features and extensions to the special features were incorporated into the PRESTO code. The features are described, and detailed examples illustrating the use of both the original and the special features are given.

T.M.

N82-14681*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SUMMARY AND EVALUATION OF THE CONCEPTUAL DESIGN STUDY OF A POTENTIAL EARLY COMMERCIAL MHD POWER PLANT (CSPEC) Final Report


The conceptual design study of a potential early commercial MHD power plant (CSPEC) is described and the results are summarized. Each of two contractors did a conceptual design of an approximately 1000 MWe open-cycle MHD/steam plant with oxygen enriched combustion air preheated to an intermediate temperature in a metallic heat exchanger. The contractors were close in their overall plant efficiency estimates but differed in their capital cost and life cycle cost estimates. The contractors' conclusions included that its MHD plant design compared favorably in cost of electricity with conventional coal-fired steam plants. The other contractor is making such a comparison as part of a follow-on study. Each contractor did a preliminary investigation of part-load performance and plant availability. The results of NASA studies investigating the effect of plant size and oxidizer preheat temperature on the performance of CSPEC-type MHD plants are also described. The efficiency of a 1000 MWe plant is about three points higher than that of a 200 MWe plant. Preheating to 1600 F gives an efficiency about one and one-half points higher than preheating to 800 F for all plant sizes. For each plant size and preheat temperature there is an optimum oxidizer size and MHD generator length that gives the highest plant efficiency.

B.W.

N82-16495*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


The program is directed toward development of the technology for safe, reliable, environmentally acceptable large wind turbines that have the potential to generate a significant amount of electricity at costs competitive with conventional electric generator systems. In addition, these large wind turbines must be fully compatible with electric utility operations and interface requirements. Advances are made by gaining a better understanding of the system design drivers, improvements in the analytical design tools, verification of design methods with operating field data, and the incorporation of new technology and innovative designs. An overview of the program activities is presented and includes results from the first and second generation field machines (Mod-OA, -1, and -2), the design phase of the third generation wind turbine (Mod-5) and the advanced technology projects. Also included is the status of the Department of Interior WTS-4 machine.

T.M.

N82-16691*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL STUDY OF AN INTEGRAL CATALYTIC COMBUSTOR: HEAT EXCHANGER FOR STIRLING ENGINES


(Contract DE-AI01-77CS-51100)

The feasibility of using catalytic combustion with heat removal for the Stirling engine to reduce exhaust emissions and also improve heat transfer to the working fluid was studied using spaced parallel plates. An internally air-cooled heat exchanger was placed between two noble metal catalytic plates. A preheated fuel-air mixture passed between the plates and reacted on the surface of the catalyzed plates. Heat was removed from the catalytic surface by radiation and convection to the air-cooled heat exchangers and control temperature and minimize thermal nitrogen oxide emissions. Test conditions were inlet combustion air temperatures from 850 to 900 K, inlet velocities of about 10 m/s, equivalence ratios from 0.5 to 0.9, and pressures from 1.3x10 to the 6th power to 2.0x10 to the 5th power Pa. Propane fuel was used for all testing. Combustion efficiencies greater than 99.5 percent were measured. Nitrogen oxide emissions ranged from 1.7 to 3.3 g NO2/kg fuel. The results demonstrate the feasibility of the concept and indicate that further investigation of the concept is warranted.

A.R.H.
with both simple gas turbine and combined cycles for small, clean-fuel-fired utility power generation and industrial cogeneration applications. For large powerplants with integrated coal gasifiers, the economic advantages appear to be marginal. T.M.

N82-19870* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**PHOSPHORIC ACID FUEL CELL TECHNOLOGY STATUS**


A review of the current phosphoric acid fuel cell system technology development efforts is presented for multimegawatt systems for electric utility applications and for multikilowatt systems for on-site integrated energy system applications. Improving fuel cell performance, reducing cost, and increasing durability are the technology drivers at this time. Electrodes, matrices, intercell cooling, bipolar/separator plates, electrolyte management, and fuel selection are discussed. B.W.

N82-19871* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**MECHANISM AND MODELS FOR ZINC METAL MORPHOLOGY IN ALKALINE MEDIA**


Based on experimental observations, a mechanism is presented to explain existence of the different morphologies of electrodeposited zinc in alkaline solution. The high current density dendrites appear to due to more rapid growth on the nonbasal crystallographic planes than on the basal plane. The low current density moss apparently results from dissolution from the nonbasal planes at low cathodic voltages. Electrochemical models were sought which would produce such a phenomenon. The fundamental plating mechanism alone accounts only for different rates on different planes, not for zinc dissolution from a plane in the cathodic region. Fourteen models were explored; two models were in accord with the proposed mechanism. One involves rapid disproportionation of the zinc +1 species on the nonbasal planes. The other involves a redox reaction (corrosion) between the zinc-zincate and hydrogen-water systems. S.L.

N82-19872* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**PERFORMANCE AND OPERATIONAL ECONOMICS ESTIMATES FOR A COAL GASIFICATION COMBINED-CYCLE COGENERATION POWERPLANT**


A performance and operational economics analysis is presented for an integrated-gasifier, combined-cycle IGCC system to meet the steam and baseeload electrical requirements. The effect of time variations in steam and electrical requirements is included. The amount and timing of electricity purchases from sales to the electric utility are determined. The resulting expenses for purchased electricity and revenues from electricity sales are estimated by using an assumed utility rate structure model. Cogeneration results for a range of potential IGCC cogeneration system sizes are compared with the fuel consumption and costs of natural gas and electricity to meet requirements without cogeneration. The results indicate that an IGCC cogeneration system could save about 10 percent of the total fuel energy presently required to supply steam and electrical requirements without cogeneration. Also for the assumed future fuel and electricity prices, an annual operating cost savings of 21 percent to 26 percent could be achieved with such a cogeneration system. An analysis of the effects of electricity price, fuel price, and system availability indicates that the IGCC cogeneration system has a good potential for economical operation over a wide range in these assumptions. R.J.F.

N82-19873* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


The first two years of operation of a stand alone photovoltaic (PV) power system for the village of Tangaye, Upper Volta in West Africa are described. The purpose of the experiment was to demonstrate that PV systems could provide reliable power for multiple use applications in remote areas where local technical expertise is limited. The 1.8 kW (peak) power system supplies 120-V (d.c.) electrical power to operate a grain mill, a water pump, and mill building lights for the village. The system was initially sized to pump a part of the village water requirements from an existing improved well, and to meet a portion of the current requirements. The data, observations, experiences, and conclusions developed during the first two years of operation are discussed. Reports of the tests of the mills used in the project are included. B.W.

N82-20688* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**PERFORMANCE MAPPING STUDIES IN REDOX FLOW CELLS**


Pumping power requirements in any flow battery system constitute a direct parasitic energy loss. It is therefore useful to determine the practical lower limit for resistant flow rates. Through the use of a theoretical framework based on electrochemical first principles, two different experimental flow mapping techniques were developed to evaluate and compare electrodes as a function of flow rate. For the carbon felt electrode presently used in NASA-Lewis Redox cells, a flow rate 1.5 times greater than the stoichiometric rate seems to be the required minimum. Author

N82-21710* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


The microprocessor system and program used to control the operation of the 200-kW Mod-DA wind turbines is described. The system is programmed to begin startup and shutdown sequences automatically and to control and monitor, the rotor speed and power output are controlled with integral and proportional control of the blade pitch angle. Included in the report are a description of the hardware and a discussion of the software programming technique. A listing of the PL/M software program is given. Author

N82-21712* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


Automobile gas turbine engine regenerator performance was studied in a regenerator test facility that provided a satisfactory simulation of the actual engine operation with independent control of airflow and gas flow. Velocity and temperature distributions were measured immediately downstream...
of both the core high-pressure-side outlet and the core low-
pressure-side outlet. For the original engine housing, the
regenerator temperature effectiveness was 1 to 2 percent higher
than the design value, and the heat transfer effectiveness was
2 to 4 percent lower than the design value over the range of
test conditions simulating 50 to 100 percent of gas generator
speed. Recalculating the design values to account for seal leakage
decreased the design heat transfer effectiveness to values
consistent with those measured herein. A baffle installed in the
engine housing high-pressure-side inlet provided more uniform
velocities out of the regenerator and improved the effectiveness.
A housing designed to provide more uniform axial flow to the regenerator was also tested. Although temperature
uniformity was improved, the effectiveness values were not
improved. Neither did 50-percent flow, blockage (90 degree
segment) applied to the high-pressure-side inlet change the
effectiveness significantly.

Author

N82-21714# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

METHOD FOR REDUCING IMPULSIVE NOISE GENERATED
BY WIND TURBINE ROTORS
Larry A. Vitera. 1982 7 p refs Presented at the Intern.
Conf on Noise Control Eng., San Francisco, 17-19 May 1982
(Contract No. A103767E/0320)
(NASA-TM-82794; E-1128; DOE/NASA/20320-36 NAS
15 B82794) Avail: NTIS HC A02/MF A01 CSCL 10B

Large wind turbines can generate both broad band and
impulsive noises. These noises can be controlled by proper choice
of rotor design parameters such as rotor location with respect
to the supporting tower, tower geometry and tip speed. A method
was developed to calculate the impulsive noise generated when
the wind turbine blade experiences air forces that are periodic
functions of the rotational frequency. This phenomenon can occur
when the blades operate in the wake of the support tower and the
nonuniform velocity field near the ground due to wind shear.
Results from this method were compared with measured sound
spectra taken at locations of one to two rotor diameters from
the DGE/NASA Mod-1 wind turbine. The calculated spectra
were generally in good agreement with the measured data in both the amplitude
of the predominant harmonics and the roll of rate with frequency.
Measured sound pressure levels far from the Mod-1 (15 rotor
diameters), however, were higher than predicted. Simultaneous
measurements in the near and far field indicated that the
propagation effects could enhance the sound levels by more
than 10 dB above that expected by spherical dispersion. These
propagation effects are believed to be due to terrain and
atmospheric characteristics of the Mod-1 site.

Author

N82-22649# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

EFFECT OF ROTOR CONFIGURATION ON GUYED TOWER
AND FOUNDATION DESIGNS AND ESTIMATED COSTS
FOR INTERMEDIATE SITE HORIZONTAL AXIS WIND
TURBINES
G. R. Frederick (Toledo Univ.), J. J. Wineniller, and J. M. Savino
Mar. 1982 39 p refs
(NASA-TM-82084; DOE/NASA/20320-39; NAS 1,582084)
Avail: NTIS HC A02/MF A01 CSCL 10B

Three designs of a guyed cylindrical tower and its foundation
for an intermediate size horizontal axis wind turbine generator
are discussed. The primary difference in the three designs is the
configuration of the rotor. Two configurations are two-blade rotors
with teetering hubs - one with full span pitchable blades, the
other with fixed pitch blades. The third configuration is a
three-bladed rotor with a rigid hub and fixed pitch blades. In all
calculations the diameter of the rotor is 38 meters and the
axis of rotation is 30.4 meters above grade, and the power
output is 2000 kW and 400 kW. For each configuration the
design is based upon for the most severe loading condition either
operating wind or hurricane conditions. The diameter of the tower
is selected to be 1.5 meters (since it was determined that this
would provide sufficient space for access ladders within the tower)
with guy rods attached at 10.7 meters above ground. Completing
a design requires selecting the required thicknesses of the various
cylindrical segments, the number and diameter of the guy rods,
the number and size of soil anchors, and the size of the central
foundation. The lower natural frequencies of vibration are
determined for each design to ensure that operation near
resonance does not occur. Finally, a cost estimate is prepared
for each design. A preliminary design and cost estimate of a
cantilever tower (light and not guyed) and its foundation
is also presented for each of the three configurations.

Author
WIND-DRIVEN TURBINE GENERATORS

N82-23678*
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

EVALUATION OF LIGHTNING ACCOMMODATION SYSTEMS FOR WIND-DRIVEN TURBINE GENERATORS Final Report

Wind-driven turbine generators are being evaluated as an alternative source of electric energy. Areas of favorable location for the wind-driven turbines (high wind density) coincide with areas of high incidence of thunderstorm activity. These locations, coupled with the 30-m or larger diameter rotor blades, make the wind-driven turbine blades probable terminations for lightning strikes. Several candidate systems of lightning accommodation for composite-structural-material blades were designed and their effectiveness evaluated by submitting the systems to simulated lightning strikes. The test data were analyzed and system design were reviewed on the basis of the analysis. T.M.

N82-23684*
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

WIND TURBINE DYNAMICS

Recent progress in the analysis and prediction of the dynamic behavior of wind turbine generators is discussed. The following areas were addressed: (1) the adequacy of state of the art analysis tools for designing the next generation of wind power systems; (2) the use of state of the art analysis tools designers; and (3) verifications of theory which might be lacking or inadequate. Summary of these informative discussions as well as the questions and answers which followed each paper are documented in the proceedings. For individual titles, see N82-23685 through N82-22733.

N82-23698*
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

APPLICATIONS OF THE DOE/NASA WIND TURBINE ENGINEERING INFORMATION SYSTEM
Harold E. Neustadter and David A. Spera In Its Wind Turbine Dyn. May 1981 p 113-120 refs (For primary document see N82-23684 14-44) Avail: NTIS HC A18/MF A01 CSC SL 10B

A statistical analysis of data obtained from the Technology and Engineering Information Systems was made. The systems analyzed consist of the following elements: (1) sensors which measure critical parameters (e.g., wind speed and direction, output power, blade loads and component vibrations); (2) remote multiplexing units (RMUs) on each wind turbine which frequency-modulate, multiplex and transmit sensor outputs; (3) on-site instrumentation to record, process and display the sensor output; and (4) statistical analysis of data. Two examples of the capabilities of these systems are presented. The first illustrates the standardized format for application of statistical analysis to each directly measured parameter. The second shows the use of a model to estimate the variability of the rotor thrust loading, which is a derived parameter.

N82-23699*
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

CALCULATION OF GUARANTEED MEAN POWER FROM WIND TURBINE GENERATORS
David A. Spera In Its Wind Turbine Dyn. May 1981 p 139-150 refs (For primary document see N82-23684 14-44) Avail: NTIS HC A18/MF A01 CSC SL 10B

A method for calculating the 'guaranteed mean' power output of a wind turbine generator is proposed. The term 'mean power' refers to the average power generated at specified wind speeds during short-term tests. Correlation of anemometers, the method of bins for analyzing non-steady data, the PROP Code for predicting turbine power, and statistical analysis of deviations in test data from theory are discussed. Guaranteed mean power density for the Clayton Mod-OA system was found to be 9 watts per square meter less than theoretical power density at all power levels with a confidence level of 0.999. This amounts to 4 percent of rated power.

N82-23707*
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

WIND FLUTTER ANALYSIS OF A HORIZONTAL-Axis WIND TURBINE WITH A TWO-BLADED TEETERING ROTOR
David C. Janetzke and Krishna R. V. Kaza (Toledo Univ.) In NASA, Lewis Research Center Wind Turbine Dyn. May 1981 p 201-210 refs (For primary document see N82-23684 14-44) Avail: NTIS HC A18/MF A01 CSC SL 10B

Whirl flutter and the effect of pitch-flap coupling on teetering motion of a wind turbine were investigated. The equations of motion are derived for an idealized five-degree-of-freedom mathematical model of a horizontal-axis wind turbine with a two-bladed teetering rotor. The model accounts for the out-of-plane bending motion of each blade, the teetering motion of the rotor, and both the pitching and yawing motions of the rotor support. Results show that the design is free from whirl flutter. Selected results are presented indicating the effect of variations in rotor support damping, rotor support stiffness, and pitch-flap coupling on pitching, yawing, teetering, and blade bending motions.

N82-23710*
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COMPARISON OF UPWIND AND DOWNWIND ROTOR OPERATION OF THE DOE/NASA 100-KW MOD-0 WIND TURBINE
John C. Glasgow, Sean R. Miller, and Robert D. Corrigan In Its Wind Turbine Dyn. May 1981 p 225-234 refs (For primary document see N82-23684 14-44) Avail: NTIS HC A18/MF A01 CSC SL 10B

Tests were conducted on a 38m diameter horizontal axis wind turbine, which had first a rotor downwind of the supporting truss tower and then upwind of the tower. Aside from the placement of the rotor and the direction of rotation of the drive train, the wind turbine was identical for both tests. Three aspects of the test results are compared: rotor blade bending loads, rotor teeter response, and nacelle yaw moments. As a result of these tests, it is shown that while mean flatwise bending moments were unaffected by the placement of the rotor, cyclic flatwise bending tended to increase with wind speed for the downwind rotor while remaining somewhat uniform with wind speed for the upwind rotor, reflecting the effects of increased wind disturbance for downwind rotor. Rotor teeter response was not significantly affected by the rotor location relative to the tower, but appears to reflect reduced teeter stability near rated wind speed for both configurations. Teeter stability appears to return above rated wind speed, however. Nacelle yaw moments are higher for the upwind rotor but do not indicate significant design problems for either configuration.

N82-23711*
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

A REVIEW OF RESONANCE RESPONSE IN LARGE HORIZONTAL-AXIS WIND TURBINES
Timothy L. Sullivan In Its Wind Turbine Dyn. May 1981 p 237-244 refs (For primary document see N82-23684 14-44) Avail: NTIS HC A18/MF A01 CSC SL 10B

Field operation of the Mod-0 and Mod-1 wind turbines is described. Operational experience shows that 1 per rev excitation exists in the drive train, high aerodynamic damping prevents resonance response of the blade flatwise modes, and teetering hub substantially reduces the chordwise blade response to odd harmonic excitation. These results can be used by designer to guide to system frequency placement. In addition it is found that present analytical techniques can accurately predict wind turbine natural frequencies.

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N82-23730* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE NASA-LeRC WIND TURBINE SOUND PREDICTION CODE
Larry A. Vitterna In its Wind Turbine Dyn. May 1981 p 411-418 refs (For primary document see N82-23884 14-44) Avail: NTIS HC A18/MF A01 CSCL 10B
Since regular operation of the DOE/NASA MOD-1 wind turbine began in October 1979 about 10 nearby households have complained of noise from the machine. Development of the NASA-LeRC with turbine sound prediction code began in May 1980 as part of an effort to understand and reduce the noise generated by MOD-1. Tone sound levels predicted with this code are in generally good agreement with measured data taken in the vicinity MOD-1 wind turbine (less than 2 rotor diameters). Comparison in the far field indicates that propagation effects due to terrain and atmospheric conditions may be amplifying the actual sound levels by about 6 dB. Parametric analysis using the code has shown that the predominant contributions to MOD-1 rotor noise are: (1) the velocity deficit in the wake of the support tower; (2) the high rotor speed; and (3) off column operation. Author

N82-24647* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN OF 35-KILOWATT BIPOLAR NICKEL-HYDROGEN BATTERY FOR LOW EARTH ORBIT APPLICATION
The needs of multidisk storage for low Earth orbit applications are featured. The modular concept, with projected energy densities of 20-24 W-hr/lb and 700-900 W-hr/ft3, has significant improvements over state of the art capabilities. Other design features are: active cooling, a new scheme for H2-O2 recombination, and pore size engineering of all cell components. T.M.

N82-24717* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH VOLTAGE V-GROOVE SOLAR CELL Patent Application
A high voltage multijunction solar cell is disclosed. The cell is composed of a plurality of discrete voltage generating regions, or unit cells, which are formed in a single semiconductor wafer and are connected together so that the voltages of the individual cells are additive. The unit cells comprise doped regions of opposite conductivity types separated by a gap. V-shaped grooves are formed in the wafer and thereafter the wafer is oriented so that the ions of one conductivity type can be implanted in one face of the groove while the other face is shielded. A metallization layer is applied and selectively etched away to provide connections between the unit cells. NASA

N82-25638* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPACT OF UNIFORM ELECTRODE CURRENT DISTRIBUTION ON ETF
The design impacts on the ETF electrode consolidation network associated with uniform channel electrode current distribution are examined and the alternate consolidation design which occurs is presented (red to the baseline (non-uniform current) design with respect to performance, and hardware requirements. A rational basis is given for comparing the requirements for the different designs and the savings that result from uniform current distribution. Performance and cost impacts upon the combined cycle plant are discussed. Author

N82-26637* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA REDOX SYSTEM DEVELOPMENT PROJECT STATUS
NASA-Redox energy storage systems developed for solar power applications and utility load leveling applications are discussed. The major objective of the project is to establish the technical readiness of Redox energy storage for transfer to industry for product development and commercialization by industry. The approach is to competitively contract to design, build, and test Redox systems progressively from prototype to prototype until kW to megawatt systems and conduct supporting technology advancement tasks. The Redox electrode and membrane are fully adequate for multi-kW solar related applications and the viability of the Redox system technology as demonstrated for multi-kW solar related applications. The status of the NASA Redox Storage System Project is described along with the goals and objectives of the project elements. Author

N82-26790* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPTIMIZATION OF THE OXIDANT SUPPLY SYSTEM FOR COMBINED CYCLE MHD POWER PLANTS
An in-depth study was conducted to determine what, if any, improvements could be made on the oxidant supply system for combined cycle MHD power plants which could be reflected in higher thermal efficiency and a reduction in the cost of electricity. A systematic analysis of air separation process variations which showed that the specific energy consumption could be minimized when the product stream oxygen concentration is about 70 mole percent was conducted. The use of advanced air compressors, having variable speed and guide vane position control, resulted in additional power savings. The study also led to the conceptual design of a new air separation process, sized for a 500 MW sub-MHD plant, referred to a internal compression, having variable speed and guide vane position control, results in additional power savings. The study also led to the conceptual design of a new air separation process, sized for a 500 MW sub-MHD plant, referred to a internal compression, and to gather data on and evaluate the performance, environmental effects, and operation of a cluster as well as a single, large megawatt wind turbine. Information on the program objectives, a Mod-2 system description, a planned schedule, organizational roles, and responsibilities, is included. T.M.

N82-26807* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MOD-2 WIND TURBINE SYSTEM CLUSTER RESEARCH TEST PROGRAM, VOLUME 1: INITIAL PLAN E-1290 Final Report
Upon completion of the design and development of three Mod-2 wind turbines, a series of research experiments are planned to gather data on and evaluate the performance, environmental effects, and operation of a cluster as well as a single, large megawatt wind turbine. Information on the program objectives, a Mod-2 system description, a planned schedule, organizational roles, and responsibilities, is included. T.M.

N82-27838* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARATIVE ANALYSIS OF THE CONCEPTUAL DESIGN STUDIES OF POTENTIAL EARLY COMMERCIAL MHD POWER PLANTS (CSPEC)
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A conceptual design study of the MHD/steam plant that incorporates the use of oxygen enriched air preheated in a metallic heat exchanger as the combustor oxidant showed that this plant is the most attractive for early commercial applications. The variation of performance and cost was investigated as a function of plant size. The contractors' results for the overall efficiencies are in reasonable agreement considering the slight differences in their plant designs. NASA LeRC is reviewing cost and performance results for consistancy with those of previous studies, including studies of conventional steam plants. LeRC in house efforts show there are still many tradeoffs to be considered for these oxygen enriched plants and considerable variations can be made in channel length and level of oxygen enrichment with little change in overall plant efficiency.

A.R.H.


Special low-rolling-resistance tires were made for DOE's EVT-1 electric vehicle Tests were conducted on these tires and on a set of standard commercial automotive tires to determine the rolling resistance as a function of tire type, tire inflation pressure, tire speed, and tire load. The tests were conducted on a test track at ambient temperatures that ranged from 15 to 32 C (59 to 89 F) and with tire pressures of 207 to 276 kPa (30 to 40 psi). At a constant tire inflation pressure of 38 C (100 F) and a pressure of 207 kPa (30 psi) the rolling resistances of the electric vehicle tires and the standard commercial tires, respectively, were 0.0102 and 0.0089 kilogram per kilogram of vehicle weight. At a constant ambient temperature of 38 C (100 F) and a pressure of 276 kPa (40 psi) the rolling resistances were 0.009 and 0.0074 kilogram per kilogram of vehicle weight, respectively. Author.

John C. Evans, Jr., An-Ti Choi, and Chandr< P. Gorada, inventors materials that may have applications in stationary powerplant.


A flexible porous battery separator comprising a coating applied to a porous flexible substrate is described. The coating comprises: (1) a thermoplastic rubber-based resin which is insoluble and unreactive in the alkaline electrolyte; (2) a polar organic plasticizer which is reactive with the alkaline electrolyte to produce a reaction product which contains a hydroxyl group and/or a carboxylic acid group; and (3) a mixture of polar particulate filler materials which are unreactive with the electrolyte, the mixture comprising at least one first filler material having a surface area greater than 25 meters squared per gram, at least one second filler material having a surface area of 10 to 25 square meters per gram, wherein the volume of the mixture of filler materials is less than 45% of the total volume of the fillers and the binder, the second filler material having a surface area of 25 square meters per gram, and the amount of plasticizer is sufficient to bond all filler particles. A method of forming the battery separator is also described. Official Gazette of the U.S. Patent and Trademark Office.


The contractors' results for the overall efficiencies be made in channel length and level of oxygen enrichment with little change in overall plant efficiency.
material: the ratio of feed fuel to sorbent material; the ratio of feed fuel to combustion airflow; the depth of the fluidized reaction bed; the temperature and pressure in the reaction bed; and the type of test unit that was exposed to the combustion exhaust gases.

S.L.

N82-30710/§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

EXPERIENCE AND ASSESSMENT OF THE DOE-NASA MOD-1 2000-KILOWATT TURBINE GENERATOR AT BOONE, NORTH CAROLINA Final Report


The Mod 1 program objectives are defined. The Mod 1 wind turbine is described. In addition to the steel blade operated on the wind turbine, a composite blade was designed and manufactured. During the early phase of the manufacturing cycle of Mod 1A configuration was designed that identified concepts such as partial span control, a soft tower, and upwind teetered rotors that were incorporated in second and third generation industry designs. The Mod 1 electrical system performed as designed, with voltage flicker characteristics within acceptable utility limits. Power output versus wind speed equaled or exceeded design predictions. The wind turbine control system was operated successfully at the site and remotely from the utility dispatcher's office. During wind turbine operations, television interference was experienced by the local residents. As a consequence, operations were restricted. Although not implemented, two potential solutions were identified. In addition to television interference, a few local residents complained about objectionable sound, particularly the 'shripping' as the turbine passed by the tower. To eliminate these objections, the sound generation level was reduced by 10 dB by reducing the rotor speed from 35 rpm to 23 rpm. Bolts in the drive train fractured. A solution was identified but not implemented. The public reaction toward the Mod 1 wind turbine program was overwhelmingly favorable. S.L.

N82-30713/§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

INTEGRATED GASIFIER COMBINED CYCLE POLYGENERATION SYSTEM TO PRODUCE LIQUID HYDROGEN


An integrated gasifier combined cycle (IGCC) system which simultaneously produces electricity, process steam, and liquid hydrogen was evaluated and compared to IGCC systems which cogenerate electricity and process steam. A number of IGCC plants, all employing a 15 MWe turbine and producing from 0 to 20 tons per day of liquid hydrogen and from 0 to 20 MWe of process steam were considered. The annual revenue required to own and operate such plants was estimated to be significantly lower than the potential market value of the products. The results indicate a significant potential economic benefit to configuring IGCC systems to produce a clean fuel in addition to electricity and process steam in relatively small industrial applications.

Author

N82-30714/§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ASSESSMENT OF A 40-KILOWATT STIRLING ENGINE FOR UNDERGROUND MINING APPLICATIONS

James E. Cairelli, Gary G. Kelm, and Jack G. Sibey Jun, 1982 75 p refs (Contract DI-BM-JO-100026) E.A.K. 75 p refs fuels. The NOx emissions ranged from 0.2 to 4 g NO2 kg fuel.

Emission and temperature results are compared with the characteristics of current diesel engines and other Stirling engines. External surf Mack results are presented. External surf Mack results are also presented. Emission and temperature results are compared with the Federal requirements for diesel underground mine engines. The durability potential of Stirling engines is discussed on the basis of the experience gained during the engine tests. Author

N82-30715/§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SYNTHETIC BATTERY CYCLING TECHNIQUES


Synthetic battery cycling makes use of the fast growing capability of computer graphics to illustrate some of the basic characteristics of operation of individual electrodes within an operating electrochemical cell. It can also simulate the operation of an entire string of cells that are used as the energy storage subsystem of a power system. One group of such cells have been referred to as Synthetic Battery Cycling is developed in part to try to bridge the gap of understanding that exists between single cell characteristics and battery system behavior.

Author

N82-30717/§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

NICKEL-HYDROGEN BIPOLAR BATTERY SYSTEMS

Lawrence H. Thaller 1982 8 p refs Proposed for presentation at the 4th ESTEC Spacecraft Power Conditioning Seminar, Noordwijk, Netherlands, 9-11 Nov, 1982; sponsored by ESA (NASA-TM-82946; E-1352; NAS 1.15:82946) Avail: NTIS HC A02/MF A01 CSCL 10A

Nickel-hydrogen cells are currently being manufactured on a semi-experimental basis. Rechargeable nickel-hydrogen systems are described that more closely resemble a fuel cell system than a traditional nickel-cadmium battery pack. This has been stimulated by the currently emerging requirements related to large manned and unmanned low earth orbit applications. The resultant nickel-hydrogen battery system should have a number of features that would lead to improved reliability, reduced costs as well as superior energy density and cycle lives as compared to battery systems constructed from the current state-of-the-art nickel-hydrogen individual pressure vessel cells. B.W.

N82-31764/§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

HIGH VOLTAGE PLANAR MULTIJUNCTION SOLAR CELL Patent

A high voltage multijunction solar cell is provided wherein a plurality of discrete voltage generating regions or unit cells are formed in a single generally planar semiconductor body. The unit cells are comprised of doped regions of opposite conductivity type separated by a gap or undiffused region. Metal contacts connect adjacent cells together in series so that the output voltages of the individual cells are additive. In some embodiments, doped field regions separated by a overlie the unit cells but the cells may be formed in both faces of the wafer.

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


A combustor or burner system in which the ash resulting from burning a coal in oil mixture is of submicron particle size is described. The burner system comprises a burner section, a flame exit nozzle, a fuel nozzle section, and an air tube by which preheated air is delivered into the burner section. Regulated air pressure is delivered to a fuel nozzle. Means are provided for directing a mixture of coal particles and oil from a drum to a nozzle at a desired rate and pressure while means returns excess fuel to the fuel drum.

N82-31776* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. GAS TURBINE CRITICAL RESEARCH AND ADVANCED TECHNOLOGY (CRT) SUPPORT PROJECT Annual Report, Fiscal Year 1980


The technical progress to provide a critical technology base for utility gas turbine systems capable of burning coal-derived fuels is summarized. Project tasks include the following: (1) combustion - to investigate the combustion of coal-derived fuels and the conversion of fuel-bound nitrogen to NOx; (2) materials - to understand and prevent the hot corrosion of turbine hot section materials; and (3) system studies - to integrate and guide the technological efforts. Technical accomplishments include: an extension of flame tube combustion testing of propane - Toluene Fuel Mixtures to vary H2 content from 9 to 18 percent by weight and the comparison of results with that predicted from a NASA Lewis General Chemical Kinetics Computer Code; the design and fabrication of combustor test section to test current and advanced combustor concepts; Testing of Catalytic combustors with residual and coal-derived liquid fuels; testing of high strength super alloys t%) evaluate their resistance to potential fuel impurities by ion implanted units, doped clean fuels and coal-derived liquids; and the testing and evaluation of thermal barrier coatings and bond coatings on conventional turbine materials.


A model is presented that explains the 'flat-spot' (FS) power loss phenomenon observed in silicon solar cells operating deep space (low temperature, low intensity) conditions. Evidence is presented suggesting that the effect is due to localized metalurgical interactions between the silicon substrate and the contact metallization. These reactions are shown to result in localized regions in which the PN junction is destroyed and replaced with a metal-semiconductor-like interface. The effects of thermal treatment, crystallographic orientation, junction depth, and metallization are presented along with a method of preventing the effect through the suppression of vacancy formation at the free surface of the contact metallization. Preliminary data indicating the effectiveness of a TiN diffusion barrier in preventing the effect are also given. Author

N82-32853# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DETERMINATION OF OPTIMUM SUNLIGHT CONCENTRATION LEVELS FOR SPACE FOAM CASCADE SOLAR CELLS Henry B. Curtis 1982 14 p refs Presented at the 3rd European Symp. on Photovoltaic Generators in Space, Bath, Engl., 4-6 May 1982; sponsored by RAE and ESA (NASA-TM-82899; E-1282; NAS 1.15:82899) Avail: NTIS HC A02/MF A01 CSCL 10A

The optimum range of concentration in space for III-V cascade cells has been calculated using a realistic solar cell diode equation. Temperature was varied with concentration using several models and ranged from 55 deg at one sun to between 80 deg and 200 deg C at 100 suns. A variety of series resistance and internal resistances were used. Coefficients of the diffusion and recombination terms are strongly temperature dependent. The study indicates that the maximum efficiency of 30 percent occurs in the 50 to 100 X sun concentration range provided series resistance is below 0.015 ohm sq cm and cell temperature is about 80 C at 100 suns.

N82-32854# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LARGE AREA LOW-COST SPACE SOLAR CELL DEVELOPMENT C. R. Baraona and J. L. Cioni (NASA. Johnson Space Center, Houston, Tex.) 1982 9 p refs Presented at the 3rd European Symp. on Photovoltaic Generators in Space, Bath, Engl., 4-6 May 1982; sponsored by RAE and ESA (NASA-TM-82902; E-1285; NAS 1.15:82902) Avail: NTIS HC A02/MF A01 CSCL 10A

A development program to produce large-area (5.9 x 5.9 cm) space quality silicon solar cells with a cost goal of 30 $/watt is described. Five cell types under investigation include wraparound dielectric, mechanical wraparound and conventional contact configurations with combinations of 2 or 10 ohm-cm resistivity, back surface reflectors and/or fields, and diffused or ion implanted junctions. A single step process to cut cell and cover-glass simultaneously is being developed. A description of cell development at Applied Solar Energy Corp., Spectrolab and Spire is included. Results are given for cell and array tests, performed by Lockheed, TRW and NASA. Future large solar arrays that might use cells of this type are discussed. Author

N82-33828# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DESIGN DESCRIPTION OF THE TANGAYE VILLAGE PHOTOVOLTAIC POWER SYSTEM James E. Martz and Anthony F. Ratajczak Jun. 1982 113 p refs (NASA-TM-82917; E-1305; NAS 1.15:82917) Avail: NTIS HC A06/MF A01 CSCL 10A

The technical progress to provide a critical technology base for utility gas turbine systems capable of burning coal-derived fuels is summarized. Project tasks include the following: (1) combustion - to investigate the combustion of coal-derived fuels and the conversion of fuel-bound nitrogen to NOx; (2) materials - to understand and prevent the hot corrosion of turbine hot section materials; and (3) system studies - to integrate and guide the technological efforts. Technical accomplishments include: an extension of flame tube combustion testing of propane - Toluene Fuel Mixtures to vary H2 content from 9 to 18 percent by weight and the comparison of results with that predicted from a NASA Lewis General Chemical Kinetics Computer Code; the design and fabrication of combustor test section to test current and advanced combustor concepts; Testing of Catalytic combustors with residual and coal-derived liquid fuels; testing of high strength super alloys t%) evaluate their resistance to potential fuel impurities by ion implanted units, doped clean fuels and coal-derived liquids; and the testing and evaluation of thermal barrier coatings and bond coatings on conventional turbine materials.

N82-33828# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DESIGN DESCRIPTION OF THE TANGAYE VILLAGE PHOTOVOLTAIC POWER SYSTEM James E. Martz and Anthony F. Ratajczak Jun. 1982 113 p refs (NASA-TM-82917; E-1305; NAS 1.15:82917) Avail: NTIS HC A06/MF A01 CSCL 10A

ORIGIAL PAGE IS OF POOR QUALITY
A 1-kW preprototype redox storage system that has undergone characterization tests and been operated as the storage device for a 5-kW (peak) photovoltaic array is described and performance data are presented. Loss mechanisms are discussed, and simple design changes leading to appreciable increases in efficiency are suggested. The effects on system performance of nonequilibrium between the predominant species of complexed chromic ion in the negative electrode reactant solution are summarized. It is noted that with the aid of the prototype system, control concepts have been shown to be valid and trouble free and some insight has been gained into interactions at the mutual interfaces of the redox system, the photovoltaic array, the load, and the control devices.

C.R. 


Solar cells have been fabricated from 0.1 ohm-cm, p-type silicon by means of a two-step diffusion process of emitter formation in order to delineate the factors limiting Voc in conventionally structured cells with the goal of achieving 700 mV. The cells are 200 microns thick and 2 by 2 cm in area with a planar front surface that has an anti-reflection coating of tantalum oxide, as well as Cr-Au-Ag contact metallization on both sides of the cell. The Cr-Au-Ag is applied over an aluminum diffused layer on the back, while it is applied through small holes in the anti-reflection coating on the front. Results show that the best of these cells exhibits an open-circuit voltage of 654 mV under AM0 illumination. N.B.


To fabricate 50 microns thick, coplanar back contact (CBC) silicon solar cells, wraparound junction design was selected and proved to be effective. The process sequence used, the cell design, and the cell performance are described. CBC cells with low solar absorptance have shown AMO efficiencies to 13%, high cells up to 14%; further improvements are projected with predictable optimization.

(Author)


Standard integrated circuit technology has been developed for the design and fabrication of planar multijunction (PMJ) solar cell chips. Each 1 cm x 1 cm solar chip consisted of six n+/p, back contacted, internally series interconnected unit cells. These high open circuit voltage solar cells were fabricated on 0.1 ohm-cm, p-type 75 microns thick, silicon substrates. A five photomask level process employing contact photolithography was used to pattern for boron diffusions, phosphorus diffusions, and contact metallization. Fabricated devices demonstrated an open circuit voltage of 3.6 volts and a short circuit current of 80 mA at 80 AMI suns. An equivalent circuit model of the planar multi-junction solar cell was developed.

(Author)
to optimize system performance and reduce system cost. The effects on system performance of various control schemes employing these concepts are presented. Analysis of water pumping and/or refrigeration systems and possible performance improvements of greater than 15% with the addition of controllable loads with product storage.

(Author)


A computational model has been developed, based on the analytical theory of the high base resistivity BSF n(+)(p)(p+)(p) or n(+)Si(n+)Si solar cell. The model makes very few assumptions and accounts for nonuniform optical generation, generation and recombination in the junction space charge region, and bandgap narrowing in the heavily doped regions. The paper presents calculated results based on this model and compares them to available experimental data. Also discussed is radiation damage in high base resistivity n(+)Si(p+) space solar cells.

(Author)


N82-10495# Gilbert/Commonwealth, Reading, Pa.


The estimated plant capital cost for a coal fired 200 MWE electric generating plant with open cycle magnetohydrodynamics is divided into principal accounts based on Federal Energy Regulatory Commission account structure. Each principal account is defined and its estimated cost subdivided into identifiable and major equipment systems. The cost data sources for compiling the estimates, cost parameters, allotments, assumptions, and contingencies, are discussed. Uncertainties associated with developing the costs are quantified to show the confidence level acquired. Guidelines established in preparing the estimated costs are included. Based on an overall milestone schedule related to conventional power plant scheduling experience and starting procurement of MHD components during the preliminary design phase there is a 6 1/2-year construction period. The duration of the project from start to commercial operation is 79 months. The engineering phase of the project is 4 1/2 years: the construction duration following the start of the main power block is 37 months.

A.R.H.

N82-10505# Stirling Thermal Motors, Inc., Ann Arbor, Mich.


A 150 hp four cylinder heavy duty Stirling engine was evaluated. The engine uses a variable stroke power control system, swashplate drive and ceramic insulation. The sensitivity of the design to engine size and heater temperature is investigated. Optimization shows that, with porous ceramics, indicated efficiencies as high as 52% can be achieved. It is shown that the gain in engine efficiency becomes insignificant when the heater temperature is raised above 200 degrees F.

E.A.K.

N82-10068# DHR, Inc., Washington, D.C.


The first year of cost-competitiveness, the market potential, and the environment in which PV systems were marketed and employed were examined. Market potentials and objectives for developing solar technologies are addressed include: (1) useful applications and estimates of the potential market for PV systems; (2) power requirements and load profiles for applications compatible with PV usage; (3) operating and cost characteristics of power systems that compete against PV; (4) national development goals in rural electrification and rural services, technology programs and government policies that influence the demand for PV in Mexico; (5) financing mechanisms and available cost-share programs; (6) channels for distribution, installation and maintenance of PV systems; and (7) appropriate methods for conducting business in Mexico. A.R.H.

N82-11545# Stonehart Associates, Inc., Medison, Conn.


The processes which contribute to the decay in performance of electrodes used in phosphoric acid fuel cell systems are discussed. Loss of catalytic surface area, corrosion of the carbon support, electrode structure degradation, electrolyte degradation, and impurities in the reactant streams are identified as the major areas for concern. I.M.S.

N82-11546# Spire Corp., Bedford, Mass.


Methods to improve the radiation tolerance of silicon cells for spacecraft use are described. The major emphasis of the program was to reduce the process-induced carbon and oxygen impurities in the junction and base regions of the solar cell, and to measure the effect of reduced impurity levels on the radiation tolerance of cells. Substrates of 0.1, 1.0 and 10.0 ohm-cm float-zone material were used as starting material in the process sequence. High-dose low-energy ion implantation was used to form the junction in n-p structures. Implant annealing was performed by conventional furnace techniques and by pulsed laser and pulsed electron beam annealing. Cells were tested for radiation tolerance at Spire and NASA-LERC. After irradiation by 1 MeV electrons to a fluence of 10 to the 16th power per sq cm, the cells tested at Spire showed no significant process induced variations in radiation tolerance. However, for cells tested at Lewis to a fluence of 10 to the 15th power per sq cm, ion-implanted cells annealed in vacuum by pulsed electron beam consistently showed the best radiation tolerance for all cell resistivities. Author

N82-11547# Munising Paper Div., Neenah, Wis.


Improved inorganic-organic separators developed by NASA were commercially prepared. A single-ply asbestos substrate was developed, as well as alternative substrates based on cellulose and on polypropylene fibers. The single-ply asbestos was bound with butyl rubber and was functionally superior to the formerly used polyphenylene oxides. Separators tested exhibited better measured separator properties than the NASA standard. Cycle life in Ni/Zn and Ag/Zn cells was...
related to substrate, decreasing in the order: asbestos > cellulose paper > metal paper. The cycle life of solvent-coated separators was better than aqueous in Ni/Zn cells, while aqueous coatings were better in Ag/Zn cells. T.M.

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**MAGNETOHYDRODYNAMICS (MHED) ENGINEERING TEST FACILITY (ETF) 200 MW POWER PLANT. CONCEPTUAL DESIGN ENGINEERING REPORT (CDER). VOLUME 1: EXECUTIVE SUMMARY**

Final Report

Sept. 1981 48 p

(Contracts DENS-224; DE-A101-77ET-10769)

(NASA-CR-165452; DOE/NASA-0224/1-Vol-1) Avail:

NTIS HC A03/MF A01 CSCL 10B

Main elements of the design are identified and explained, and the rationale behind them was reviewed. Major systems and plant facilities are listed and discussed. Construction cost and schedule estimates are presented, and the engineering issues that should be reexamined are identified. The latest (1980-1981) information from the MHED technology program is integrated with the elements of a conventional steam power electric generating plant. T.M.

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**TESTING OF SOLAR CELL COVERS AND ENCAPSULANTS CONDUCTED IN A SIMULATED SPACE ENVIRONMENT**

Final Report

D. A. Russell Nov. 1981 287 p

(Contract NAS2-22222)

(NASA-CR-165475: D180-26590-1) Avail:

NTIS HC A12/MF A01 CSCL 10A

The materials included in the evaluation were 0211 microsheet, FEP-A used as a cover and as an adhesive, DC 93-500 adhesive, PFA 'hard coat' used as a cover, GE 615/UV-24 used as a cover, GR 650 used as a cover, and electrostatically bonded 7070 glass. Test environments were 1 MeV electron irradiation interspersed with thermal cycling, 0.5 MeV proton irradiation interspersed with thermal cycling and UV exposure interspersed with thermal cycling. Summary data is given describing the response of the test materials both visually and electrically to the three different environments. T.M.

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**LOW NO SUB X HEAVY FUEL COMBUSTOR CONCEPT PROGRAM** Final Report


(Contracts DENS-149; DE-A101-77ET-13111)

(NASA-CR-165512: DOE/NASA/O149-1: GTR-3236) Avail:

NTIS HC A05/MF A01 CSCL 10B

A gas turbine technology program to improve and optimize the staged rich lean low NOx combustor concept is described. Subscale combustor tests to develop the design information for optimization of the fuel preparation, rich burn, quench/cir quench, and lean burn steps of the combustion process were run. The program provides information for the design of high pressure and high temperature combustors for providing of combustible of minimum of excessively processed and synthetic fuels. The combustor environments were liquid fuel atomization and mixing, rich zone stoichiometry, rich zone liner cooling, rich zone residence time, and quench zone stoichiometry are important considerations in the design and scale up of the rich lean combustor. E.A.K.
ENDURANCE TEST AND EVALUATION OF ALKALINE WATER ELECTROLYSIS CELLS, Annual Report
K. A. Burke and F. H. Schubert Nov. 1981 48 p refs
(Contract NAS3-21287)
HC A02/MF A01 CSCL 10C

Utilization in the development of multi-kW low orbit power systems is discussed. The following technological developments of catalytic reactor systems for space power applications were demonstrated: (1) four 92.9 cm² single water electrolysis cells, two using LST's advanced anodes and two using LST's super anodes; (2) four single cell endurance test stands for life testing of alkaline water electrolyte cells; (3) the solid performance of the advanced electrode and 355 K; (4) the breakthrough performance of the super electrode; and (5) the four single cells for over 5,000 hours each significant cell deterioration or cell failure. It is concluded that the static feed water electrolysis concept is reliable and due to the inherent simplicity of the passive water feed mechanism coupled with the use of alkaline electrolyte has greater potential for regenerative fuel cell system applications than alternative electrolyzers. A rise in cell voltage occurred after 2,000-3,000 hours which was attributed to deflection of the polysulfone end plates due to creepage of the thermoplastic. More end plate support was added, and the performance of the cells was restored to the initial performance level.

N82-13510
DEVELOPMENT OF A HIGH-TEMPERATURE DURABLE CATALYST FOR USE IN CATALYTIC COMBUSTORS FOR ADVANCED AUTOMOTIVE GAS TURBINE ENGINES Final Report
(Contracts DEN3-83: DE-AIOI.77CS-51040)
HC A08/MF A01 CSCL 10B

Durable catalytic reactors for advanced gas turbine engines were developed. Objectives were to evaluate furnace aging as a cost effective catalytic reactor screening test, measure reactor degradation as a function of furnace aging, demonstrate 1,000 hours of combustion durability, and define a catalytic reactor system with a high probability of successful integration into an automotive gas turbine engine. Fourteen different catalytic reactor concepts were evaluated, leading to the selection of one for a durability combustion test with diesel fuel for combustion conditions. Eight additional catalytic reactors were evaluated and one of these was successfully combustion tested on propane fuel. This durability reactor used graded cell honeycombs and a combination of noble metal and metal oxide catalysts. The reactor was catalytically active and structurally sound at the end of the durability test.

N82-13511
Westinghouse Research and Development Center, Pittsburgh, Pa.
(Contracts DEN3-161: DE-A01-80ET-17068)
(NASA-CR-185462; DOE/NASA/0181-9)
Rept: B-91-ND1-MARED-R1) Avail: NTIS HC A04/MF A01 CSCL 10A

The results of pretesting and performance testing of Stack 564 are reported. The design features, progress in fabrication, and plans for assembly of Stack 800 are given. The status of endurance testing of Stack 560 is reported. The design, fabrication, test procedures, and preliminary tests of the 10 kW direct countercflow reformer and the reformer test stand are described. Results of vendor contacts to define the performance and cost of fuel conditioning system components are reported. The results of burner tests and continuing development of the BOLSTAR program are reported.

N82-14679
DHR, Inc., Washington, D.C.
MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS FOR AGRICULTURAL APPLICATIONS IN MOROCCO Final Report

PHOTOVOLTAIC SPACE POWER SYSTEMS. VOLUME 1: EXECUTIVE SUMMARY
D. M. Peterson and R. L. Pleasant 1 Aug. 1981 28 p
(Contract NAS3-21951)
(NASA-CR-185333-Vol-1; Rept-111-2401-204) Avail: NTIS
HC A03/MF A01 CSCL 10A

Possible missions requiring multimegawatt photovoltaic space power systems in the 1990's time frame and associated power system technology needs are examined. The following concepts for photovoltaic power approaches are considered: planar arrays, concentrating arrays, hybrid systems using Rankine engines, thermophotovoltaic, and AC/DC power management systems. Both manned and unmanned geosynchronous Earth orbit applications were examined for photovoltaic space power systems. The results of pretesting and performance testing of Stack 564 are reported. The design features, progress in fabrication, and plans for assembly of Stack 800 are given. The status of endurance testing of Stack 560 is reported. The design, fabrication, test procedures, and preliminary tests of the 10 kW direct countercflow reformer and the reformer test stand are described. Results of vendor contacts to define the performance and cost of fuel conditioning system components are reported. The results of burner tests and continuing development of the BOLSTAR program are reported.

N82-14677
DHR, Inc., Washington, D.C.
MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS FOR AGRICULTURAL APPLICATIONS IN MOROCCO Final Report

PHOTOVOLTAIC SPACE POWER SYSTEMS. VOLUME 1: EXECUTIVE SUMMARY
D. M. Peterson and R. L. Pleasant 1 Aug. 1981 28 p
(Contract NAS3-21951)
(NASA-CR-185333-Vol-1; Rept-111-2401-204) Avail: NTIS
HC A03/MF A01 CSCL 10A

Possible missions requiring multi-megawatt photovoltaic space power systems in the 1990's time frame and associated power system technology needs are examined. The following concepts for photovoltaic power approaches are considered: planar arrays, concentrating arrays, hybrid systems using Rankine engines, thermophotovoltaic, and AC/DC power management systems. Both manned and unmanned geosynchronous Earth orbit applications were examined for photovoltaic space power systems. The results of pretesting and performance testing of Stack 564 are reported. The design features, progress in fabrication, and plans for assembly of Stack 800 are given. The status of endurance testing of Stack 560 is reported. The design, fabrication, test procedures, and preliminary tests of the 10 kW direct countercflow reformer and the reformer test stand are described. Results of vendor contacts to define the performance and cost of fuel conditioning system components are reported. The results of burner tests and continuing development of the BOLSTAR program are reported.
Possible missions requiring multimegawatt photovoltaic space power systems in the 1980's time frame and power system technology needs associated with these missions are examined. Four specific task areas were considered: (1) missions requiring power in the 10-100 megawatt average power region; (2) alternative power systems and component technologies; (3) technology planning and sensitivity trades and analyses; and (4) technology recommendations. Specific concepts for photovoltaic power approaches considered were: planar arrays, concentrating arrays, hybrid systems using space engines, thermophotovoltaic approaches; all with various photovoltaic cell component technologies. Various AC/DC power management approaches, and battery, fuel cell, and flywheel energy storage concepts are evaluated. Interactions with the electrical ion engine injection and stationkeeping system are also considered.

The use of three types of directly fired ceramic heaters for preheating oxygen enriched air to an intermediate temperature of 1144K was investigated. The three types of ceramic heaters are: (1) a fixed bed, periodic flow ceramic brick regenerative heater; (2) a ceramic pebble regenerative heater. The heater design, performance, and operating characteristics under conditions in which the particulate matter is not solidified are evaluated. A comparison and overall evaluation of the three types of ceramic heaters and temperature range determination at which the particulate matter in the MHD exhaust gas is estimated to be a dry powder are presented.

The results of a preliminary system test on a reformer/stack/inverter combination are reported. An initial design for a 25 kW stack is presented. Experimental plans are outlined for data acquisition necessary for design of a 50 kW methanol/steam reformer. Activities related to complete mathematical modelling of the integrated power system, including wastheat utilization, are described.

T.M.

NBS-16425* Energy Research Corp., Danbury, Conn.

TECHNOLOGY DEVELOPMENT FOR PHOSPHORIC ACID FUEL CELL POWERPLANT, PHASE 2 Final Technical Report

Larry Christner Dec. 1981 159 p refs

(Contracts DEN3-67; DE-A103-78ET-11272)


The development of materials, cell components, and reformers for on site integrated energy systems is described. Progress includes: (1) heat-treatment of 25 sq cm, 350 sq cm and 1200 sq cm cell test hardware was accomplished. Performance of fuel cells is improved by using this material; (2) electrochemical and chemical corrosion rates of heat-treated and as-molded graphite/phenolic resin composites in phosphoric acid were determined; (3) three cell, 5 in. x 16 in. stacks operated for up to 10,000 hours and 12 in. x 17 in. five cell stacks were tested for 5,000 hours; (4) a three cell 5 in. x 15 in. stack with 0.12 mg Pt/sq cm anodes and 0.25 mg Pt/sq cm cathodes was operated for 4,600 hours; and (5) an ERC proprietary high bubble pressure matrix, MAT-1, was tested for up to 10,000 hours.

A.R.H.
ADVANCED GAS TURBINE (AGT) POWERTRAIN SYSTEM INITIAL DEVELOPMENT REPORT Progress Report, 20 May - 24 Sep, 1979


(NASA-CR-165130; DOE/NASA/0037-80/2; DDA-ADR-10086) Avail: NTIS HC A07/MF A01 CSCL 10B

The powertrain consists of a single shaft regenerated gas turbine engine utilizing ceramic hot section components, coupled to a shiftable gear box with a variable stator torque converter and an available Ford integral overpower four-speed automatic transmission. Predicted fuel economy using gasoline fuel over the combined federal driving cycle (CFDC) is 18.3 km/l, which represents a 59% improvement over the spark-ignition-powered baseline vehicle. Using DF2 fuel, CFDC mileage estimates are 17.43 km/l. Zero to 58.6 km/hr acceleration time is 11.8 seconds with a four-way speed of 125 km/hr and a 0.8 m radius cornering distance of 21.0 m. The ceramic radial turbine rotor is discussed along with the control system for the powertrain. T.M.

INTERNATIONAL MARKET ASSESSMENT OF STAND-ALONE PHOTOVOLTAIC POWER SYSTEMS FOR COTTAGE INDUSTRY APPLICATIONS Final Report Therese M. Philipp Nov 1981 250 p refs

(NASA-CR-165287; DOE/NASA/0197-1; ITRJ-J06519) Avail: NTIS HC A13/MF A01 CSCL 10B

The final result of an international assessment of the market for stand-alone photovoltaic systems in cottage industry applications is reported. Nonindustrialized countries without centrally planned economies were considered. Cottage industries were defined as small rural manufacturers, employing less than 50 people, producing consumer and simple products. The date to support this analysis were obtained from secondary and expert sources in the U.S. and in-country field investigations of the Philippines and Mexico. The near-term market for photovoltaics for rural cottage industry applications appears to be limited to demonstration projects and pilot programs, based on an in-depth study of the nature of cottage industry, its role in the rural economy, the energy requirements of cottage industry, and a financial analysis of stand-alone photovoltaic systems compared to their most viable competitors, diesel driven generators. Photovoltaics are shown to be a better long-term option only for very low power requirements. Some of these uses would include clay mixers, grinders, centrifuges, lathes, power saws and lighting of a workshop.

SPECIALIZED ENGINEERING TEST FACILITIES: ELECTRICAL PERFORMANCE OF A LARGE SIZED INDUSTRIAL ELECTRIC MOTOR Final Report

Sep, 1981 593 p refs


The reference conceptual design of the magnetohydrodynamic (MHD) Engineering Test Facility (ETF), a prototype 200 MWe coal-fired electric generating plant designed to demonstrate the commercial feasibility of open cycle MHD, is summarized. Main elements of the design, systems, and plant facilities are illustrated. System design descriptions are included for closed cycle cooling water, industrial gas systems, fuel oil, boiler flue gas, coal management, seed management, slag management, plant industrial waste, fire service water, oxidant supply, MHD power train, magnet, heat recovery/seed recovery, inverter, heating, ventilating, and air conditioning, and electrical. N.W.

ELECTROCATALYSTS FOR PHOSPHORIC ACID FUEL CELLS Quarterly Report, Oct.—Dec, 1981

Paul Stonehart, John Baris, John Hochmuth, and Peter Pagliaro Dec, 1981 44 p refs

(NASA-CR-165259; MSNW-1169) Avail: NTIS HC A15/MF A01 CSCL 10B

Space power technologies are reviewed to determine the state-of-the-art and to identify advanced or novel concepts which promise large increases in performance. The potential for increased performance is judged relative to benchmarks based on technologies which have been flight tested. Space power technology concepts selected for their potentially high performance are prioritized in a list of R & D topical recommendations for the NASA program on Advanced Energetics. The technology categories studied are solar collection, nuclear power sources, energy conversion, energy storage, power transmission, and power processing. The emphasis is on electric power generation in space for satellite on board electric power, for electric propulsion, or for beamed power to spacecraft. Genetic mission categories such as low Earth orbit missions and geosynchronous orbit missions are used to distinguish general requirements placed on the performance of power conversion technology. Each space power technology is judged on its own merits without reference to specific missions or power systems. Recommendations include 31 space power concepts which span the entire collection of technology categories studied and represent the critical technologies needed for higher power, lighter weight, more efficient power conversion in space. Author
(Contract DEN3-176, Contract DE-AIO3-80ET-17088)
NASA-CR-165584; DOE/NASA-176-81/5, Q.R-B) Avail:
NTIS HC A03/MF A01 CSCL 10A

Two cooperative phenomena are required the development of highly efficient porous electrocatalysts: (1) is an increase in the electrocatalytic activity of the electrocatalyst particle; and (2) is the availability of that electrocatalyst particle for the electrochemical reaction. The two processes interact with each other so that improvements in the electrochemical activity must be coupled with improvements in the availability of the electrocatalyst for reaction. Cost effective and highly reactive electrocatalysts were developed. The utilization of the electrocatalyst particles in the porous electrode structures was analyzed. It is shown that a large percentage of the electrocatalyst in anode structures is not utilized. This low utilization translates directly into a noble metal cost penalty for the fuel cell.

E.A.K.

N82-18688#* Gilbert/Commonwealth, Reading, Pa.
MAGNETOHYDRODYNAMICS (MHD) ENGINEERING TEST FACILITY (ETF) 200 MW POWER PLANT. CONCEPTUAL DESIGN ENGINEERING REPORT (CDER). VOLUME 4: SUPPLEMENTARY ENGINEERING DATA
Sep 1981 548 p reft
(Contract DEN3-224; DOE-A101-77ET-10769)
(NASA-CR-165452-Vol-4; DOE/NASA-02241-Vol-4) Avail:
NTIS HC A23/MF A01 CSCL 10B

The reference conceptual design of the Magnetohydrodynamics Engineering Test Facility (ETF), a prototype 200 MW coal-fired electric generating plant designed to demonstrate the commercial feasibility of open cycle MHD is summarized. Main elements of the design are identified and explained, and the rationales behind them is reviewed. Major systems and plant facilities are listed and discussed. Construction cost and schedule estimates, and identification of engineering issues that should be reexamined are also given. The latest (1980-1981) information from the MHD technology program is integrated with the elements of a conventional steam power electric generating plant. Supplementary Engineering Data (Issues, Background, Performance Assurance Plan, Design Details, System Design Descriptions and Related Drawings) is presented.

M.D.K.

F. Ho and P. A. Iles Nov. 1981 43 p refts
(Contract NAS3-22228)
(NASA-CR-165570) Avail: NTIS HC A03/MF A01 CSCL 10A

The state of the art technologies was applied to fabricate 50 micro thick 2x4 cm, coplanar back contact (CBC) solar cells with AMO efficiency greater than 12%. A requirement was that the solar absorptance values of 0.73. Space/cell environmental tests were performed on these cells and the thin CBC cells performed well. The optimized design configuration and process sequence were used to make 50 deliverable CBC cells. These cells were all above 12 percent efficiency and had an average efficiency of 13 percent. Results of environmental tests (humidity-temperature, thermal shock, and contact adherence) are also given.

E.A.K.

N82-18690#* United Technologies Corp., South Windsor, Conn.
Thomas Rosfjord and Richard Sederquist Jan. 1982 43 p refts
(Contract DEN3-148; DO-AIO1-77ET-13111)
(NASA-CR-165577; DOE/NASA/0149-2; GTR-3932) Avail:

NTIS HC A03/MF A01 CSCL 10B

The performance and emissions from a rich lean combustor fired on simulated coal gas fuels were investigated using a 12.7-cm diameter axially-staged burner originally designed for operation with high heating value liquid fuels. A simple, tubular fuel injector was substituted for the liquid fuel nozzle; no other combustor modifications were made. Four test fuels were studied including those three chemically bound nitrogen-free gas mixtures with higher heating values of 88, 227, and 308 kJ/mol (103, 258 and 349 Btu/scf), and a 227 kJ/mol (258 Btu/scf) heating value doped with ammonia to produce a fuel nitrogen content of 0.6% (w/w). Stable, ultra-low nitrogen oxide, smoke-free combustion was attained for the nitrogen-free fuels. Results with the doped fuel indicated that less than 5% conversion of NH3 to nitrogen oxide levels below Environmental Protection Agency limits could be achieved. In some instances, excessive CO levels were encountered. It is shown that use of a burner design employing a fuel rich primary zone than that found optimum for liquid fuels would yield more acceptable CO emissions.

R.J.F.

N82-18693#* Structural Composites Industries, Inc., Azusa, Calif.
DESIGN, EVALUATION, AND FABRICATION OF LOW-COST COMPOSITE BLADES FOR INTERMEDIATE-SIZE WIND TURBINES Final Report
Oscar Weingart Sep. 1981 210 p refts
(Contracts DEN3-100, DO-AIO1-79ET-20320)
(NASA-CR-165342; DOE/NASA-00101; SCI-81520) Avail:
NTIS HC A10/MF A01 CSCL 10A

Low cost approaches for production of 60 ft long glass fiber/resin composite rotor blades for the MOD-DA wind turbine were identified and evaluated. The most cost-effective configuration was selected for detailed design. Subelement and subassembly specimens were fabricated for testing to confirm physical and mechanical properties of the composite blade materials, to develop and evaluate blade fabrication techniques and processes, and to confirm the structural adequacy of the root and joint. Full-scale blade tooling was constructed and a partial blade for tool and process tryout was built. Then two full scale blades were fabricated and delivered to NASA-LARC for installation on a MOD-DA wind turbine at Clayton, New Mexico for operational testing. Each blade was 60 ft. long with 4.5 ft. chord at root and 2575 lbs weight including metal hub adapter. The selected blade configuration was a three cell design constructed using a resin impregnated glass fiber tape winding process that allows rapid wrapping of primarily axially oriented fibers onto a tapered mandrel, with a tapered wall thickness. The ring windings/ transverse filament tape process combination was used for the first time on this program to produce entire rotor blade structures. This approach permitted the complete blade to be wound on stationery mandrels, an improvement which alleviated some of the tooling and process problems encountered on previous composite blade programs.

Author

N82-18698# DHR, Inc., Washington, D.C.
MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS FOR AGRICULTURAL APPLICATIONS IN NIGERIA Final Report
(Contracts DEN3-180; DE-AIO1-78ET-20485)
(NASA-CR-165511: DOE/NASA/0180-4: C4100-50) Avail:
NTIS HC A06/MF A01 CSCL 10A

The market potential for stand-alone photovoltaic systems in agriculture was studied. Information is presented on technical and economically feasible applications, and assessments of the business, government and financial climate for photovoltaic sales. It is concluded that the market for stand-alone systems will be large because of the availability of capital and the high premium placed on high reliability, low maintenance power systems. Various specific applications are described, mostly related to agriculture.

R.J.F.

N82-18699# Arizona State Univ., Tempe
SOCIOECONOMIC IMpACT OF PHOTOVOLTAIC POWER AT SCHUCHULI, ARIZONA Final Report
(Contracts DEN3-50: DE-AIO1-78ET-20485)

133 ORIGINAL PAGE IS OF POOR QUALITY
The social and economic impact of photovoltaic power on a small, remote native American village is studied. Village history, group life, energy use in general, and the use of photovoltaic-powered appliances are discussed. No significant impacts due to the photovoltaic power system were observed. R.J.F.

The efforts performed to develop a phosphoric acid fuel cell (PAFC) stack design having a 10 kW power rating for operation at higher than atmospheric pressure based on the existing Mark II design configuration described in the work involves: (1) Performance of pertinent functional analysis, trade studies and thermodynamic cycle analysis for requirements definition and system operating parameter selection purposes, (2) characterization of fuel cell components and materials, and performance testing and evaluation of the repeating electrode components, (3) establishment of the state-of-the-art manufacturing technology for all fuel cell components at Westinghouse and the fabrication of short stacks of various sites, and (4) development of a 10 kW PAFC stack design for higher pressure operation utilizing the top down systems engineering approach. Author

The effects of depth of discharge, average current chopper frequency, and chopper duty cycle. It is shown that battery life is primarily and inversely related to depth of discharge and discharge current. Failure mode is characterized by a gradual capacity loss with consistent evidence of cell aging. E.A.K.
and small irrigation, rural telephones, rural health posts, and vaccine refrigeration. Market size would be in the 1200 to 2500 kWp range in the 1981 to 86 timeframe. Positive factors influencing the market size include a lack of electrical services, potential for developing the Llano Orientales Territory, high fuel costs in remote areas, balance of system availability, the presence of wealthy land owners, and a large government-sponsored contract for photovoltaic (PV)-powered rural telephone systems. The anticipated eligibility of photovoltaic equipment for loans would be a further positive factor in market potential. Important negative factors include relatively inexpensive energy in developed locations, reliance on hydropower, lack of familiarity with PV equipment, a lack of financing, and established foreign competition in PV technology. Recommendations to American PV manufacturers attempting to develop the Colombian market are given. R.J.F.

N82-23702# Massachusetts Inst of Tech., Cambridge Dept of Aeronautics and Astronautics

REVIEW OF ANALYSIS METHODS FOR ROTATING SYSTEMS WITH PERIODIC COEFFICIENTS John Dugundji and John H. Wendell In NASA Lewis Research Center Wind Turbine Dyn May 1981 p 165-172 refs (For primary document see N82-23684 14-44)
(Grant NoG-3303)
Avail NTIS HC A18/ MF A01 CSCL 10B

Two of the more common procedures for analyzing the stability and forced response of equations with periodic coefficients are reviewed the use of Floquet methods, and the use of multistep coordinate and harmonic analysis methods. The analysis procedures of those periodic coefficient systems are compared with those of the more familiar constant coefficient systems. Author

N82-24646# Jet Propulsion Lab., California Inst of Tech., Pasadena

(Contracts NAS7-10; DE-A704-81AL-16228)
(NASA-CR-168941; DOE/JPL-1600-51; JPL-Pub-82-22; NAS 126:168941) Avail. NTIS HC A03/ MF A01 CSCL 10A

The development of the solar thermal power systems parabolic dish activities are summarized. Subsystem designs of concentrators, receivers, engines, power converters, and thermal transport are discussed. Analyses, test results, field tests, small community system development and the parabolic dish test site are also included. Author

N82-24648# Engelhard Industries, Inc., Edison, N.J.

(NASA-CR-165666; DOE/NASA/241-3; NAS 126:165666: Or-3) Avail. NTIS HC A04/ MF A01 CSCL 10B

The development of a commercially viable and cost-effective photocatalytic acid fuel cell powered on-site integrated energy system (OS/IES) is described. The fuel cell offers energy efficiencies in the range of 35-40% of the higher heating value of available fuels in the form of electrical energy. In addition, by utilizing the thermal energy generated for heating, ventilating and air-conditioning (HVAC), a fuel cell OS/IES could provide total energy efficiencies in the neighborhood of 80%. Also, the Engelhard fuel cell O/E/I/ES offers the important incentive of replacing imported oil with domestically produced methanol, including coal-derived methanol.

T.M.

N82-24649# Parsons (Ralph M.) Co., Pasadena, Calif.


A fuel quality processing study to provide a data base for an intelligent tradeoff between advanced turbine technology and liquid fuel quality, and also, to guide the development of specifications of future synthetic fuels anticipated for use in the time period 1985 to 2000 is given. Four technical performance tests are discussed: on-site pretreating, existing refineries to upgrade fuels, new refineries to upgrade fuels, and data evaluation. The base case refinery is a modern Midwest refinery processing 200,000 BPD of a 60/40 domestic/import petroleum crude mix. The synthetic crudes used for upgrading to marketable products and turbine fuel are shale oil and coal liquids. Of these synocrudes, 50,000 BPD are processed in the existing petroleum refinery, requiring additional process units and reducing petroleum feed, and in a new refinery designed for processing each syn crude to produce gasoline, distillate fuels, resid fuels, and turbine fuel, JPSGs and coke. An extensive collection of synfuel properties and upgrading data was prepared for the application of a linear program model to investigate the most economical production slate meeting petroleum petroleum sludge specifications and turbine fuels of various quality grades. Technical and economic projections were developed for 36 scenarios, based on 4 different crude feeds to either modified existing or new refineries operated in 2 different modes to produce 7 differing grades of turbine fuels. A required product selling price of turbine fuel for each processing route was calculated. Procedures and projected economics were developed for on-site treatment of turbine fuel to meet limitations of impurities and emission of pollutants. R.J.F.
The collection and dissemination of thermal energy storage (TES) system technology for the pulp and paper industry with the intent of reducing fossil fuel usage is discussed. The Phase 1 plan is described and a description presented of example TES systems.

Author


(Contracts DEN3-146; DO-101-77ET-13111)

(NASA-CR-165482; DOE/NASA/0146-1; NAS 1.26:165482) Avail: NTIS HC AM7/MF AO1 CSCL 10A

The viability of low emission nitrogen oxide (NOx) gas turbine combustors for industrial and utility application. Thirteen different concepts were evolved and most were tested. Acceptable performance was demonstrated for four of the combustors using ERBS fuel and ultralow NOx emissions were obtained for lean catalytic combustor. Residual oil and coal derived liquids containing fuel bound nitrogen (FBN) were also used at test fuels, and it was shown that staged rich/lean combustion was effective in minimizing the conversion of FBN to NOx. The rich/lean concept was tested with both modular and integral combustors. While the ceramic lined modular configuration produced the best results, the advantages of the all metal integral burners make them candidates for future development. An example of scaling the laboratory sized combustor to a 100 MW size engine is included in the report as are recommendations for future work.

Author


(Contracts DEN3-148; DE-101-77ET-13111)

(NASA-CR-165367; NAS 1.26:165367; DDA-EDR-10594; DOE/NASA/0148-1) Avail: NTIS HC AM7/MF AO1 CSCL 10B

The development of the technology required to operate an industrial gas turbine combustion system on minimally processed, heavy petroleum or residual fuels having high levels of fuel-bound nitrogen (FBN) while producing acceptable levels of exhaust emissions is discussed. Three combustor concepts were designed and fabricated. Three fuels were supplied for the combustor test demonstrations: a typical middle distillate fuel, a heavy residual fuel, and a synthetic coal-derived fuel. The primary concept was an air staged, variable-geometry combustor designed to produce low emissions from fuels having high levels of FBN. This combustor used a long residence time, fuel-rich primary combustion zone followed by a quick-quench air mixer to rapidly dilute the fuel rich products for the fuellean final burnout of the fuel. This combustor, called the rich quench lean (RQL) combustor, was extensively tested using each fuel over the entire power range of the model 570 K engine. Also, a series of parameter tests was conducted to determine the combustor's sensitivity to rich-zone equivalence ratio, lean-zone equivalence ratio, rich-zone residence time, and overall system pressure drop. Minimum nitrogen oxide emissions were measured at 10 to 55 ppmv at maximum continuous power for all three fuels. Smoke was less than a 10 SAE smoke number.

M.G.

Vinod Jalan, Herbert Stark, and Jose Giner. Sep. 1981 82 p refs

(NASA-CR-167867; DOE/NASA/0131-1; NAS 1.26:167867) Avail: NTIS HC A11/MF AO1 CSCL 10A

Platinum sintering on phosphoric acid fuel cell cathodes is discussed. The cathode of the phosphoric acid fuel cell uses a high surface area platinum catalyst dispersed on a conductive carbon support to minimize both cathode polarization and fabrication costs. During operation, however, the active surface area of these electrodes decreases, which in turn leads to decreased cell performance. This loss of active surface area is a major factor in the degradation of fuel cell performance over time.

S.L.


(Grant NASA-111; Contract DE-AIO-85ET-17088)

(NASA-CR-167867; DOE/NASA/0131-1; NAS 1.26:167867) Avail: NTIS HC A11/MF AO1 CSCL 10A

Legal and institutional factors affecting the development and commercial diffusion of phosphoric acid fuel cells are discussed. Issues for future research and action are suggested. Perceived barriers and potential opportunities for fuel cells in central and dispersed utility operations and on-site applications are reviewed, as well as the general concept of commercialization as applied to emerging energy technologies.

Author


(Grand NASA-111; Contract DE-AIO-85ET-17088)

(NASA-CR-167867; DOE/NASA/0131-1; NAS 1.26:167867) Avail: NTIS HC A11/MF AO1 CSCL 10A

Legal and institutional factors affecting the development and commercial diffusion of phosphoric acid fuel cells are discussed. Issues for future research and action are suggested. Perceived barriers and potential opportunities for fuel cells in central and dispersed utility operations and on-site applications are reviewed, as well as the general concept of commercialization as applied to emerging energy technologies.

Author
APPLICATION OF PHOTOVOLTAIC ELECTRIC POWER TO
DEVELOPING COUNTRIES

Anil Cabral, David Delansanta, and George Burrill

An environmental assessment of the potential application sectors
of electricity to meet critical needs. The suitability of cost competitiveness and reliability of
photovoltaic (PV) power systems for rural applications in developing countries is considered. Potential application sectors
include health delivery, education and communication, where small
amounts of electricity are needed to meet critical needs. Author

Garry Bollanbacher May 1982 160 p refs

(Cong DE-A101-80ET-17088; NASA Order C-42701D)

(DOE/NASA/2701-1; NASA-CR-167923) Avail: NTIS
HC AO4/MF AO1 CSCL 10B

The environmental assessment examines the potential
environmental consequences, both adverse and beneficial, of
the 40 kW fuel cell system field test operation. The assessment
is of necessity generic in nature since actual test sites were not
selected. This assessment provides the basis for determining the
need for an environmental impact statement. In addition, this
assessment provides site criteria to avoid or minimize
environmental impacts and standards for determining candidate
sites, if any, for which site specific assessments may be
required.

Engelhard Industries, Inc., Edison, N.J.

DEVELOPMENT AND TEST FUEL CELL POWERED ON-SITE
INTEGRATED TOTAL ENERGY SYSTEMS. PHASE 3:
FULL-SCALE POWER PLANT DEVELOPMENT


(Cong DE-A101-80ET-17088)

(NASA-CR-167898: DOE/NASA/0241-4; NAS 1.26:167898; QR-4)

Avail: NTIS HC AO4/MF AO1 CSCL 10B

The on-site system application analysis is summarized.
Preparations were completed for the first test of a full-sized single cell. Emphasis of the methanol fuel processor development
program shifted toward the use of commercial shell-and-tube
heat exchangers. An improved method for predicting the
carbon-monoxide resistance of anodic corrosion is described. Carbon
anode support areas reported include improved ABA bipolar plate
bonding technology, improved electrical measurement techniques
for specification-testing of stack components, and anodic corrosion
behavior of carbon materials.


DEVELOPMENT OF A LARGE AREA SPACE SOLAR CELL

M. S. Spitzer May 1982 771 p refs

(Contr DE-A101-80ET-17088)

(NASA-CR-167929: NASA AO4/MF AO1 CSCL 10A)

The development of a large area high efficiency solar cell
assembly is described. The assembly consists of an ion implanted silicon solar cell and glass cover. The important attributes of
fabrication are the use of a back surface reflector, and integration of
coverglass application and cell fabrications. Cell development experiments
concerned optimization of ion implantation processing of 2.0 ohm-cm boron-doped silicon. Process parameters were selected
based on these experiments and cells with area of 34.3 sq cm were fabricated. The average AM0 efficiency of the twenty-five
best cells was 13.9% and the best bell had an efficiency of
14.4%. An important innovation in cell encapsulation was also
developed. In this technique, the coverglass is applied before
the cell is sawed to final size. The coverglass and cell are then
saved as a unit. In this way, the cost of the coverglass is
reduced, since the tolerance on glass size is relaxed, and costly
coverglass/ cell alignment procedures are eliminated. Adhesive
investigations were EVA, FEP-Teflon sheet and DC 93-500. Details
of processing and results are reported.

Tanksley (W. L.) and Associates, Inc., Brook
Park, Ohio.

VIBRATION ANALYSIS OF THREE GUUED TOWER
DESIGNS FOR INTERMEDIATE SIZE WIND TURBINES

Robert J. Christie Mar. 1982 113 p refs

(Contr NAS3-21909)

(NAS 1.26:165589; DOE/NASA/1900-1; NASA-CR-165589)

Avail: NTIS HC AO6/MF AO1 CSCL 10A

Three gued tower designs were analyzed for intermediate
size wind turbines. The four lowest natural frequencies of vibration
of the three towers concepts were estimated. A parametric study
was performed on each tower to determine the effect of varying
such tower properties as the inertia and stiffness of the tower
and guys, the inertia values of the nacelle and rotor, and the
rotational speed of the rotor. Only the two lowest frequencies
were in a range where they could be excited by the rotor blade
passing frequencies. There two frequencies could be tuned by
varying the guy stiffness, the guy attachment point on the tower,
the tower and mass stiffness, and the nacelle/rotor/power train
to masses.

Westinghouse Research and Development Center,
Pittsburgh, Pa.

CELL MODULE AND FUEL CONDITIONER DEVELOPMENT

D. O. Hoover, Jr. Feb. 1982 75 p

(Contr DEN3-241; DE-A101-80ET-17088)


Avail: NTIS HC AO4/MF AO1 CSCL 10A

The phosphoric acid fuel cell module (stack) development
which culminated in an 80 cell air-cooled stack with separated
gas cooling and treated cooling plates is described. The performance
of the 80 cell stack was approx, 100 mV per cell higher than
that attained during phase 1. The components and materials
performed stably for over 8000 hours in a 5 cell stack. The
cost concept design of a fuel conditioning system is described.

National Bureau of Standards, Washington, D.C.

NON-NOBLE CATALYSTS AND CATALYST SUPPORTS FOR
1979 - Sep. 1981

A. J. McAlister Sep. 1981 38 p refs

(NASA Order C-46229-D: DE-A101-80ET-17088)
GALLIUM ARSENIDE SOLAR ARRAY SUBSYSTEM STUDY
F. G. Miller Feb. 1982 221 p refs
(Contract NAS3-20067)
(NASA-CR-176869; NAS 1.26:167669) Avail: NTIS HC A10/ MF A01 CSCL 10A

The effects on life cycle costs of a number of technology areas are examined for a gallium arsenide space array. Four specific configurations were addressed: (1) a 250 KWe LEO mission planar array; (2) a 250 KWe GEO mission planar array; (3) a 50 KWe GEO mission planar array; (4) a 50 KWe GEO mission - concentration. For each configuration, a baseline system conceptual design was developed and the life cycle costs estimated in detail. The baseline system requirements and design technologies were 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 costs.

LOW AND MEDIUM HEATING VALUE COAL GAS CATALYTIC
COMBUSTOR CHARACTERIZATION
John A. Schwab Nov. 1982 137 p refs
(Contracts DEN3-277; DE-A01-77ET-10350)
(NASA-CR-165560; DOE/NASA/0277-1; NAS 1.26:165560) Avail: NTIS HC A07/MF A01 CSCL 10B

Catalytic combustors with both low and medium heating value coal gases obtained from an operating gasifier were demonstrated. A practical operating range for efficient operation was determined, and also to identify potential problem areas were identified for consideration during stationary gas turbine engine design. The test rig consists of fuel injectors, a fuel-air premixing section, a catalytic reactor with thermocouple instrumentation and a single point, water cooled sample probe. The test rig included inlet and outlet transition pieces and was designed for installation into an existing test loop.

S.L.

LOW NOx HEAVY FUEL COMBUSTOR CONCEPT PROGRAM
Final Report
David J. White, Richard T. LeCren, and Anthony P. BatAakis Nov. 1981 93 p refs
(Contracts DEN3-145; DE-A01-77ET-13111)
(NASA-CR-165481; DOE/NASA/0145-1; NAS 1.26:165481; SR81-R-4471-21) Avail: NTIS HC A05/MF A01 CSCL 10B

A total of twelve low NOx combustor configurations, embodying three different combustion concepts, were designed and fabricated as modular units. These configurations were evaluated experimentally for exhaust emission levels and for mechanical integrity. Emissions data were obtained in depth on two of the configurations.

R.J.F.
45 ENVIRONMENT POLLUTION

Includes air, noise, thermal and water pollution; environment monitoring; and contamination control.

Maintenance Operations Center.
AN AUTOMATED SYSTEM FOR GLOBAL ATMOSPHERIC
SAMPLING USING S-747 AIRLINERS Final Report
1981 31 p refs
(Contract NAS3-17867)
(NASA-CR-165264: UAL-C-80-31-33) Avail: NTIS
HC A03/MF A01 CSCL 13B
The global air sampling program utilizes commercial aircraft in scheduled service to measure atmospheric constituents. A fully automated system designed for the 747 aircraft is described. Airline operational constraints and data and control subsystems are treated. The overall program management, system monitoring, and data retrieval from four aircraft in global service is described.
E.A.K.

COMPUTATIONS OF SOOT AND NO SUB X EMISSIONS FROM GAII TURBINE COMBUSTORS Final Report
S. K. Srivatsa May 1982 300 p refs
(Contract NAS3-22512)
HC A13/MF A01 CSCL 13B
An analytical program was conducted to compute the soot and NOx emissions from a combustor and the radiation heat transfer to the combustor walls. The program involved the formulation of an emission and radiation model and the incorporation of this model into the Garrett 3-D Combustor Performance Computer Program. Computations were performed for the idle, cruise, and take-off conditions of a JT8D can combustor. The predicted soot and NOx emissions and the radiation heat transfer to the combustor walls agree reasonably well with the limited experimental data available.
Author

Twenty-three filter sampling flights of the NASA Lewis F-106 aircraft were conducted in the Great Lakes region between June 4 and Dec. 23, 1980, following the major eruption of Mount St. Helens on May 18. The IPC-1478 filters were exposed over an altitude range spanning the local tropopause. A filter sample exposed above the tropopause on June 5 indicated a sulfate level 50 times the baseline measurements, which is consistent with the trajectory predictions of the leading edge of the cloud on its second transit around the earth. Subsequent measurements over a period of 7 months revealed the existence of a layer of sulfate above the tropopause that decayed to a level of about 4 times previously measured background levels by the beginning of August. Concentration of nitrate above the tropopause exhibited considerable variability and showed some enhancement compared with previously measured concentration levels. On the basis of the null results of X-ray fluorescence measurements, there is no evidence of ash particle concentrations of greater than 3.4 microns/cm³ persisting in the layer above the tropopause following the second transit of the cloud. (Author)


Plasma measurements from the University of California at San Diego auroral particles experiment on the geosynchronous Applied Technology Satellite 6 in the midnight region show that the low-energy ion fluxes (1-100 eV) are field aligned and are well characterized as thermal populations (1-10 eV) with a streaming velocity of 30-100 km/s along the magnetic field line. The lowest energies are found prior to injections, on quiet days, with an increase of the streaming velocity evident when an injection occurs near the satellite. Multiple peaks in the ion distribution functions are attributed to the presence of different ions species (H⁺, He⁺, O⁺, O₂⁺) streaming at similar velocities, both during quiet times and as the plasma velocity increases in response to an injection. (Author)


The presence of a cold ion population in the magnetosphere which is normally hidden from particle detector observation by the positive charging of the spacecraft is reported. Ion and electron data were obtained from particle detectors on the ATS 6 and SCATHA satellites designed to measure the 1-eV to 80-keV plasma population. The cold, isotropic ion population, with temperature 1 eV and density 10-100/cm³, was detected only when the spacecraft were in eclipse, when spacecraft potential had dropped from +10 V in sunlight to +4 to +5 V. The hidden ion population was found at geosynchronous altitude only during geomagnetically quiet times and when there has been an absence of geomagnetic activity for several hours, and appears to consist with the plasma sheet. More consistent measurements of the cold ion population at midnight or at other local times would require the biasing of the ion detector with respect to the spacecraft, or the controlling of spacecraft potential. A.L.W.
The unit was designed to be easily modified so that certain features that influence the output current and particle size distribution could be examined. An experimental program was designed to measure the performance of the unit. The program described includes measurements in a fog chamber and in the field. Features of the nozzle and estimated nozzle characteristics are presented.

T.M.
A highly thromboresistant blood contacting interface for use in implantable blood pumps is investigated. Biomaterials mechanics, dynamics, durability, surface morphology, and chemistry are among the critical considerations pertinent to the choice of an appropriate blood pump bladder material. The use of transfer cast biopolymers from ion beam textured surfaces is investigated to detect subtle variations in blood pump surface morphology using Biomer as the biomaterial of choice. The efficacy of ion beam sputtering as an acceptable method of fabricating textured blood interfaces is evaluated. Aortic grafts and left ventricular assist devices were implanted in calves; the blood interfaces were fabricated by transfer casting methods from ion beam textured polytetrafluoroethylene mandrels. The mandrels were textured by superimposing a 15 micron screen mesh; ion sputtering conditions were 300 volts beam energy, 40 to 50 mA beam, and a mandrel to source distance of 25 microns.
A HYDRODYNAMIC MODEL OF AN OUTER HAIR CELL
(NASA-TM-82773: E-1098) Avail: NTIS HC A02/MF A01 CSCL 06P

On the model it is possible to measure the force and the force direction for each individual hair as a function of the flow direction and velocity. Measurements were made at the man flow velocity .01 m/s, which is equivalent to a flow velocity in the real ear of about 1 micrometer/s. The kinematic viscosity of the liquid used in the model was 10,000 times higher than the viscosity of perilymph to attain hydrodynamic equality. Two different geometries for the stereocilia pattern were tested. First the force distribution for a W-shaped stereocilia pattern was recorded. This is the stereocilia pattern found in all real ears. It is found that the forces acting on the hairs are very regular and perpendicular to the legs of the W when the flow is directed from the outside of the W. When the flow is reversed, the forces are not reversed, but are much more irregular. This can eventually explain the half wave rectification of the nerve signals. As a second experiment, the force distribution for a V-shaped stereocilia pattern was recorded. Here the forces were irregular both when the flow was directed into the V and when it was directed against the edge of the V.

T.M.
CONSTRUCTION OF SOLUTIONS FOR SOME NONLINEAR TWO-POINT BOUNDARY VALUE PROBLEMS


Constructive existence and uniqueness results for boundary value problems associated with some simple special cases of the second order equation $y'' = f(x,y,y')$, $0 < x < 1$, are sought. The approach considered is to convert the differential equation and boundary conditions to an integral equation via Green's functions, and then to apply fixed point and contraction map principles to a sequence of successive approximations. The approach is tested on several applied problems. Difficulties in trying to prove general theorems are discussed. M.G.
60 COMPUTER OPERATIONS AND HARDWARE

Includes computer graphics and data processing.
For components see 33 Electronics and Electrical Engineering.

N82-16748**# Virginia Polytechnic Inst. and State Univ., Blacksburg.

(Contract NAS3-21051)
(NASA-CR-165539; TRW-32680-8001-RU-01) Avail: NTIS HC A10/MF A01 CSCL 09B

The computer programs and derivations generated in support of the modeling and design optimization program are presented. Programs for the buck regulator, boost regulator, and buck-boost regulator are described. The computer program for the design optimization calculations is presented. Constraints for the boost and buck-boost converter were derived. Derivations of state-space equations and transfer functions are presented. Computer lists for the converters are presented, and the input parameters justified.

R.J.F.

N82-17879**# Case Western Reserve Univ., Cleveland, Ohio.

(Grant NAG3-101) Avail: NTIS HC A07/MF A01 CSCL 09B

The program for the DC 8-D3 flight planning was slightly modified for the three dimensional flight planning for DC 10 aircrafts. Several test runs of the modified program over the North Atlantic and North America were made for verifying the program. While geopotential height and temperature were used in a previous program as meteorological data, the modified program uses wind direction and speed and temperature received from the National Weather Service. A scanning program was written to collect required weather information from the raw data received in a packed decimal format. Two sets of weather data, the 12-hour forecast and 24-hour forecast based on 0000 GMT, are used for dynamic processes in testruns. In order to save computing time only the weather data of the North Atlantic and North America is previously stored in a PCF file and then scanned one by one.

R.J.F.

N82-17880**# Case Western Reserve Univ., Cleveland, Ohio.

(Grant NaG-3207) Avail: NTIS HC A02/MF A01 CSCL 09B

Mathematical models which predict the behavior of fluid flow in different experiments are simulated using digital computers. The simulations predict values of parameters of the fluid flow (pressure, temperature and velocity vector) at many points in the fluid. Visualization of the spatial variation in the value of these parameters is important to comprehend and check the data generated, to identify the regions of interest in the flow, and for effectively communicating information about the flow to others. The state of the art imaging techniques developed in the field of three dimensional shaded computer graphics is applied to visualization of fluid flow. Use of an imaging technique known as 'SCAN' for visualizing fluid flow, is studied and the results are presented.

S.L.
61 COMPUTER PROGRAMMING AND SOFTWARE

Includes computer programs, routines, and algorithms.

**NASA-31974**<sup>a</sup> National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. A GENERALIZED MEMORY TEST ALGORITHM Edward J. Milner Jul. 1982 11 p refs (NASA-TM-82874; E-1250; NAS 1.15:82874) Avail: NTIS HC A02/MF A01 CSCL 09B

A general algorithm for testing digital computer memory is presented. The test checks that (1) every bit can be cleared and set in each memory work, and (2) bits are not erroneously cleared and/or set elsewhere in memory at the same time. The algorithm can be applied to any size memory block and any size memory word. It is concise and efficient, requiring the very few cycles through memory. For example, a test of 16-bit-word-size memory requires only 384 cycles through memory. Approximately 15 seconds were required to test a 32K block of such memory, using a microcomputer having a cycle time of 133 nanoseconds. Author

**NASA-31990**<sup>b</sup> National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. AUTOMATED PROCEDURE FOR DEVELOPING HYBRID COMPUTER SIMULATIONS OF TURBOFAN ENGINES. PART I: GENERAL DESCRIPTION John R. Szuch, Susan M. Krosel, and William M. Bruton Aug. 1982 120 p refs (NASA-TP-1851; E-779; NAS 1.60:1851) Avail: NTIS HC A06/MF A01 CSCL 09B

A systematic, computer-aided, self-documenting methodolgy for developing hybrid computer simulations of turbofan engines is presented. The methodology that is presented makes use of a host program that can run on a large digital computer and a machine-dependent target (hybrid) program. The host program performs all the calculations and data manipulations that are needed to transform user-supplied engine design information to a form suitable for the hybrid computer. The host program also trims the self-contained engine model to match specified design-point information. Part I contains a general discussion of the methodology, describes a test case, and presents comparisons between hybrid simulation and specified engine performance data. Part II, a companion document, contains documentation, in the form of computer printouts, for the test case. Author


Extensions and revisions to a computer code that comprehensively analyzes problems of spacecraft charging (NASCAP) are documented. Using a fully three dimensional approach, it can accurately predict spacecraft potentials under a variety of conditions. Among the extensions are a multiple electron/ion gun test tank capability, and the ability to model anisotropic and time dependent space environments. Also documented are a greatly extended MATCHG program and the preliminary version of NASCAP/LEO. The innovative MATCHG code was developed into an extremely powerful tool for the study of material-environment interactions. The NASCAP/LEO, a three dimensional code to study current collection under conditions of high voltages and short Debye lengths, was distributed for preliminary testing. M.G.
The approaches used to develop real-time engine simulations are reviewed. Both digital and hybrid (analog and digital) techniques are discussed and specific examples of each are cited. These approaches are assessed from the standpoint of their usefulness for digital engine control development. A number of NASA-sponsored simulation research activities, aimed at exploring real-time simulation techniques, are described. These include the development of a microcomputer-based parallel processor system for real-time engine simulation.

M.G.
A82-30992* / National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

AESOP: A COMPUTER-AIDED DESIGN PROGRAM FOR LINEAR MULTIVARIABLE CONTROL SYSTEMS
(NASA-TM-82871; E-1246; NAS 1.15:82871) Avail: NTIS HC A02/MF A01 CSCL 09

An interactive computer program (AESOP) which solves quadratic optimal control and is discussed. The program can also be used to perform system analysis calculations such as transient and frequency responses, controllability, observability, etc., in support of the control and filter design computations.

M.G.


This paper discusses the effects of imperfect modeling on the detection and isolation of sensor failures. For systems with non-zero set points, deterministic inputs or non-zero noise biases, the model mismatch appears as a bias on the stochastic innovation process. This bias, if left unaccounted for, would be sufficient to declare a false alarm failure in one or more sensors. A practical design procedure based upon the Generalized Likelihood Ratio (GLR) form uses a finite data window sequential t-test to detect and isolate model mismatch effects and soft sensor failures. Application to an eighth order model of the QCSEE turbofan engine is discussed. (Author)


Model following control methodology plays a key role in numerous application areas. Cases in point include flight control systems and gas turbine engine control systems. Typical uses of such a design strategy involve the determination of nonlinear models which generate requested control and response trajectories for various commands. Linear multivariable techniques provide trim about these motions; and protection logic is added to secure the hardware from excursions beyond the specification range. This paper reports upon experience in developing a general class of such nonlinear models based upon the idea of the algebraic tensor product. (Author)
64 NUMERICAL ANALYSIS

Includes iteration, difference equations, and numerical approximation.

N82-14649# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
APPLICATION OF INTEGRATION ALGORITHMS IN A
PARALLEL PROCESSING ENVIRONMENT FOR THE
SIMULATION OF JET ENGINES
Susan M. Krosel and Edward J. Milner 1982 25 p refs To
be presented at the 15th Ann. Simulation Symp., Tampa, Fla.,
17-19 Mar., 1982
(NASA-TM-82746; E-1059) Avail: NTIS HC A02/MF A01
CSCL 12A
The application of Predictor corrector integration algorithms
developed for the digital parallel processing environment are
investigated. The algorithms are implemented and evaluated
through the use of a software simulator which provides an
approximate representation of the parallel processing hardware.
Test cases which focus on the use of the algorithms are presented
and a specific application using a linear model of a turbofan
engine is considered. Results are discussed and the effects of
integration step size and the number of processors on simulation
accuracy. Real-time performance, interprocessor communication,
and algorithm startup are also discussed.

B.W.

N82-22822# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MULTIPLE-GRID ACCELERATION OF LAX-WENDROFF
ALGORITHMS
Gary M. Johnson Mar. 1982 22 p refs
(NASA-TM-82843; E-1213; NAS 1.16.82843) Avail: NTIS
HC A02/MF A01 CSCL 12A
A technique for accelerating the convergence of a one-step
Lax-Wendroff method to a steady-state solution is discussed
and its applicability extended to the more general class of two-step
Lax-Wendroff methods. Several two-step methods which lead
to quite efficient multiple grid algorithms are discussed. Computational
results are presented using the full two dimensional Euler
equations for both subcritical and shocked supercritical flows.
Extensions and generalizations are mentioned.

M.G.

N82-24859# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
RELAXATION SOLUTION OF THE FULL EULER EQUA-
TIONS
Gary M. Johnson 1982 9 p refs Presented at the 8th Inter.
Conf. on Numerical Methods in Fluid Dyn., Aachen, West
Germany, 28 Jun. - 2 Jul., 1982; sponsored by Deutsche
Forschungsgemeinschaft, Dowler G.m.b.H., Messerschmitt-
Boelkow-Blohm G.m.b.H., ONR and ERO
(NASA-TM-82889; E-1265; NAS 1.15.82889) Avail: NTIS
HC A02/MF A01 CSCL 12A
A numerical procedure for the relaxation solution of the full
steady Euler equations is described. By embedding the Euler
system in a second order, surrogate system, central differencing
may be used in subsonic regions while retaining matrix forms
well suited to iterative solution procedures and convergence
acceleration techniques. Hence, this method allows the develop-
ment of stable, fully-conservative differencing schemes for the
solution of quite general inviscid flow problems. Results are
presented for both subcritical and shocked supercritical internal
flows. Comparisons are made with a standard time dependent
solution algorithm.

Author

N82-29075# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
ACCELERATION OF CONVERGENCE OF VECTOR SE-
QUENCES
Avram Sidi (Technion-Israel Inst. of Technology, Haifa), William
F. Ford, and David A. Smith (Duke Univ.) 1982 10 p refs
Presented at the 30th Anniv. Meeting of the Soc. for Ind. and
(NASA-TM-82931; E-1324; NAS 1.15.82931) Avail: NTIS
HC A02/MF A01 CSCL 12A
A general approach to the construction of accelerated
convergence methods for vector sequences is proposed. A
simplified version of minimal polynomial extrapolation is empha-
sized. The convergence of this method is analyzed and it is
shown that it is especially suitable for accelerating the convergence
of vector sequences that are obtained when one solves linear
systems of equations iteratively.

M.G.

A82-31438# Numerical comparisons of nonlinear conver-
gence accelerators. D. A. Smith (Duke University, Durham, NC) and
W. F. Ford (NASA, Lewis Research Center, Computer Services Div.,
491-499, 23 refs. Grant No. NFG-3160.
As part of a continuing program of numerical tests of
convergence accelerators, the iterated Aitken's Delta-squared meth-
od, Wynn's epsilon algorithm, Brezinski's theta algorithm, and
Levin's u transform are compared on a broad range of test problems:
linearly convergence alternating, monotone, and irregular-sign series,
logarithmically convergent series, power method and Bernoulli
method sequences, alternating and monotone asymptotic series, and
some perturbation series arising in applications. In each category
either the epsilon algorithm or the u transform gives the best results
of the four methods tested. In some cases differences among
methods are slight, and in others they are quite striking.

(B)

A new approach is presented to diffraction problems involving plane strip barriers or slit apertures. These are problems that display the effects of multiple interacting edges. The approach taken here provides exact, compact solutions. The theory is introduced through a series of examples that are, in fact, the 'standard' problems of the subject, diffraction of a plane oblique wave by a slit, for example. In each case, the solutions are found to depend explicitly on a single 'special' function and its Fourier transform. These fundamental functions are described, with the emphasis placed on practical computational methods. The example problems are all couched in the language of acoustics. C.R.
71 ACOUSTICS
Includes sound generation, transmission and attenuation.
For noise pollution see 45 Environment Pollution.

N82-12890*§ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
NUMERICAL TECHNIQUES IN LINEAR DUCT ACOUSTICS,
1980-81 UPDATE
Kenneth J. Baumster. 1981 51 p refs. Presented at the
sponsored by ASME
(NASA-TM-82730; E-1034) Avail: NTIS HC A04/MF A01
CSCL 20A.
A review is presented covering finite element and finite
difference analysis of small amplitude (linear) sound propagation
in straight and variable area ducts. A brief discussion of earlier
work is also included. Emphasis is placed on the latest state of the art in numerical techniques.

N82-12891*§ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
VERIFICATION OF AN ACOUSTIC TRANSMISSION
MATRIX ANALYSIS OF SOUND PROPAGATION IN A
VARIABLE AREA DUCT WITHOUT FLOW
J. H. Miles. 1981 15 p refs. Presented at the 102 Meeting of the
Acoustical Soc. of Am.. Miami Beach, Fla., 1-4 Dec.
1981
(NASA-TM-82741; E-1053) Avail: NTIS HC A02/MF A01
CSCL 20A.
A predicted standing wave pressure and phase angle profile
for a hard wall rectangular duct with a region of converging-
diverging area variation is compared to published experimental
measurements in a study of sound propagation without flow.
The factor of 1/2 area variation used is sufficient magnitude to
produce large reflections. The prediction is based on a transmission
matrix approach developed for the analysis of sound propagation
in a variable area duct with and without flow. The agreement
between the measured and predicted results is shown to be
excellent.

N82-14881*§ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
MODE PROPAGATION IN NONUNIFORM CIRCULAR
DUCTS WITH POTENTIAL FLOW
(NASA-TM-82776; E-1086; AIAA-Paper-82-0122) Avail: NTIS
HC A02/MF A01 CSCL 20A.
A previously reported closed form solution is expanded to
determine effects of isentropic mean flow on mode propagation
in a slowly converging-diverging duct, a circular coss duct. On
the assumption of uniform steady fluid density, the mean flow
increases the power transmission coefficient. The increase is
directly related to the increase of the cutoff ratio at the duct
throat. With the negligible transverse gradients of the steady
fluid variables, the conversion from one mode to another is
negligible, and the power transmission coefficient remains
unchanged with the mean flow direction reversed. With a proper
choice of frequency parameter, many different modes can be made
subject to a single value of the power transmission loss.
A systematic method to include the effects of the gradients of
the steady fluid variables is also described.

N82-15647*§ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
APPLICATION OF STEADY STATE FINITE ELEMENT AND
TRANSIENT FINITE DIFFERENCE THEORY TO SOUND
PROPAGATION IN A VARIABLE AREA DUCT: A COMPARISON
WITH EXPERIMENT
Kenneth J. Baumster, W. Everman (Missouri Univ., Rolla), R.
J. Astley (Missouri Univ., Rolla), and J. W. White (Tennessee
Univ., Knoxville) 1981 14 p refs. Presented at the 7th
Aeroacoustics Conf.. Palo Alto, Calif., 5-7 Oct. 1981; sponsored
by AIAA
(NASA-TM-82678; E-960) Avail. NTIS HC A02/MF A01
CSCL 20A.
Sound propagation without flow in a rectangular duct with
a converging-diverging area variation was studied experimentally
and theoretically. The area variation was of sufficient magnitude
and angles to produce large reflections and induce modal scattering. The
rms (root-mean-squared) pressure and phase angle on both the
flat and curved surface were measured and tabulated. The steady
state finite element theory and the transient finite difference
theory are in good agreement with the data. It is concluded that
numerical finite difference and finite element theories appear
ideally suited for handling duct propagation problems which
encounter large area variations.

N82-16808*§ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
NOISE OF THE SR-3 PROPELLER MODEL AT 2 DEG AND
4 DEG ANGLE OF ATTACK
refs (NASA-TM-82736; E-1051) Avail: NTIS HC A03/MF A01
CSCL 20A.
The noise effect of operating supersonic tip speed propellers
at angle of attack with respect to the incoming flow was
measured. Increases in the maximum blade passage noise were
observed for the propeller at an angle of attack. The noise
increase was not symmetrical with one wall of the wind tunnel
having significantly more noise increase than the other wall.
This was apparently the result of the rotational direction of the
propeller. The lack of symmetry of the noise at angle of attack
to the use of oppositely rotating propellers on opposite sides of
an airplane fuselage as a way of minimizing the noise due to
operation at angle of attack.

N82-16809*§ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
A SHOCK WAVE APPROACH TO THE NOISE OF SUPERSONIC
PROPELLERS
(NASA-TM-82752; E-1068) Avail: NTIS HC A02/MF A01
CSCL 20A.
To model propeller noise expected for a turboprop aircraft,
the pressure ratio across the shock at the propeller tip was
calculated and compared with noise data from three propellers.
At helical tip Mach numbers over 1.0, using only the tip shock
wave, the model gave a fairly good prediction of the noise for
a bladed propeller and for a propeller swept for aerodynamic
purposes. However for another propeller, which was highly swept
and designed to have noise cancellations from the inboard
propeller sections, the shock strength from the lip over predicted
the noise. In general the good agreement indicates that shock theory
is a viable method for predicting the noise from these super-
sonic propellers but that the shock strengths from all of the
blade sections need to be properly included.

N82-19944*§ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
EFFECT OF FACILITY VARIATION ON THE ACOUSTIC
CHARACTERISTICS OF THREE SINGLE STREAM NOZ-
ZLES
Orlando A. Gutierrez. 1980 38 p refs. Presented at the
100th Meeting of the Acoust. Soc. of A., Los Angeles,
17-21 Nov. 1980
(NASA-TM-81635; E-646) Avail: NTIS HC A03/MF A01
CSCL 20A.
The characteristics of the jet noise produced by three single
stream nozzles were investigated statistically at the NASA-Lewis
Research Center outdoor jet acoustic facility. The nozzles consisted
of a 7.6 cm diameter convergent conical, a 10.2 cm diameter
convergent conical and an I-lobe daisy nozzle with 7.6 cm
equivalent diameter flow area. The same nozzles were tested
previously at cold flow conditions in other facilities such as the
Royal Aircraft Establishment (RAE) 7.3 m acoustic wind tunnel.
The acoustic experiments at NASA covered pressure ratios from
1.4 to 2.5 at total temperatures of 811 K and ambient.
The data obtained with four different microphone arrays are compared
The results are also compared with data taken at the RAE facility
and with a NASA prediction procedure.

Author
FORWARD ACOUSTIC PERFORMANCE OF A MODEL TURBOFAN DESIGNED FOR A HIGH SPECIFIC FLOW (IN DEVICES)

James G. Lucas, Richard P. Woodward, and Charles J. Michels
Mar. 1982 20 p refs (NASA-TP-19668; E-777; NAS 1.60:1968) Avail: NTIS HC A02/MF A01 CSCL 20A

Forward noise and overall aerodynamic performance are presented for a high-tip-speed fan having an exceptionally high average axial Mach number at the rotor inlet. A high Mach number is intended to attenuate forward noise at both the design-speed takeoff point, and at the unconventional low-pressure-ratio, design-speed approach point. As speed was increased near design, all forward noise components were reduced, and noise in the discharge duct was increased. Indications are that the high Mach number flow at the rotor face is attenuating forward noise at takeoff. The fan at takeoff is some 5.5 to 11 dB quieter than several reference fans. Data at the points closest to approach indicated tentatively that the design-speed approach mode was 3 dB quieter than the conventional mode.

A PRELIMINARY COMPARISON BETWEEN THE SR-3 PROPELLER NOISE IN FLIGHT AND IN A WIND TUNNEL

James H. Dittmar and Paul L. Lasagna

The noise generated by supersonic-tip-speed propellers is addressed. Models of such propellers were tested for acoustics in the Lewis 8-by-6-foot wind tunnel. One of these propeller models, SR-3, was tested in flight on the Jetstar airplane and noise data were obtained. Preliminary comparisons of the maximum blade passing tone variation with helical tip Mach number taken in flight with those taken in the tunnel showed good agreement when corrected to the same test conditions. This indicated that the wind tunnel is a viable location for measuring the noise of these propeller models. Comparisons of the directivities at 0.6 and 0.7 axial Mach number showed reasonable agreement. At 0.76 and 0.8 axial Mach number the relation of the noise data fell off more towards the front than did the airplane data. A possible explanation for this is boundary layer refractive which could be different in the wind tunnel from that in flight. This may imply that some corrections should be applied to both the airplane and wind tunnel data at the forward angles. At and aft of the peak noise angle the boundary layer refractive does not appear to be significant and no correction appears necessary.

ROUGH ANALYSIS OF INSTALLATION EFFECTS ON TURBOPROP NOISE

Paul A. Durbin and John F. Groeneweg
1982 17 p refs Proposed for Presentation at the Acoust. Soc. of Am., Orlando, Fla., 8-12 Nov. 1982 (NASA-TM-52924; E-1316; NAS 1.15:52924) Avail: NTIS HC A02/MF A01 CSCL 20A

A rough analysis of noise from a propeller operated at angle of attack, and in the nonuniform flow due to a line vortex approximating a wing flow field suggests installation can significantly affect turboprop noise levels. On one side of the propeller, where the blades approach the horizontal plane from above, decreases of noise occur; while on the other side noise increases. The noise reduction is due to negative interference of steady and unsteady sources. An angle of attack, or distance between propeller and vortex, exists for which noise is a minimum.

AEROCOUSTIC PERFORMANCE OF AN EXTERNALLY BLOWN FLAP CONFIGURATION WITH SEVERAL FLAP NOISE SUPPRESSION DEVICES

Daniel J. McKinzie, Jr.
May 1982 30 p refs (NASA-TP-19955; E-573; NAS 1.60:19955) Avail: NTIS HC A03/MF A01 CSCL 20A

TL Small scale model acoustic experiments were conducted to measure the noise produced in the flyover and sideline planes by an engine under the wing externally blown flap configuration in its approach attitude. Broadband low frequency noise reductions as large as 9 dB were produced by reducing the separation distance between the nozzle exhaust plane and the flaps. Experiments were also conducted to determine the noise suppression effectiveness in comparison with a reference configuration of three passive types of devices that were located on the jet impingement surfaces of the reference configuration. These devices produced noise reductions that varied up to 10 dB at reduced separation distances. In addition, a qualitative estimate of the noise suppression characteristics of the separate devices was made. Finally static aerodynamic performance data were obtained to evaluate the penalties incurred by these suppression devices. The test results suggest that further parametric studies are required in order to understand more fully the noise mechanisms that are affected by the suppression devices used.

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excitation than would be experienced by the aircraft fuselage side wall exposed to propeller-generated noise, ultimately transmitting this structural response to incident dynamic pressure to the cabin interior. Even if structureborne excitations are less efficient than airborne excitations in the creation of cabin noise, the higher level of the former could still govern cabin noise levels.

O.C.

N82-21031*# Avco Lycoming Div., Stratford, Conn.

Craig A. Wilson and James M. O'Connell Sep. 1981 63 p refs

(SAA-CN-165662; NASA-AD-165662-1; LYS-165662-1) Avail: NTIS HC A07/AF A01 CSCL 20A

The internal noise generated by an Avco Lycoming YF-102 engine combustor installed in a test rig was recorded. Two configurations were tested one with and one without the first stage turbine nozzle installed. Acoustic probes and accessories were used. Internal dynamic pressure level measurements were made at ten locations within the combustor. The combustor rig, the test procedures, and data acquisition and reduction systems are described. Tables and plots of narrow band and one third octave band pressure level spectra are included.

S.L.

Lyc-81-32-Vol-2 Avail: NTIS HC A11/MF A01 CSCL 20A

The internal noise generated by an Avco Lycoming YF-102 engine combustor installed in a test rig was recorded. The one third octave band pressure level spectra is presented.

S.L.

N82-27090*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.


(Grant NAG2-3036)

(NASA-CR-165016; NASA 1.26:165016) Avail. NTIS HC A02/MF A01 CSCL 20A

The acoustic field within a duct containing a nonuniform steady flow was predicted. This approach had been made on the method to calculate the velocity potential within the duct.

S.L.


THE VELOCITY FIELD NEAR THE ORIFICE OF A HELMHOLTZ RESONATOR IN GRAZING FLOW
Andrew F. Charvat and Bruce E. Walker Mar. 1981 53 p refs

(Grant NAG2-3238)

(NASA-CR-168548; UCLA-ENG-81-101) Avail: NTIS HC A04/MF A01 CSCL 20A

Measurement of the time-dependent velocities induced inside and outside the opening of acoustically excited, two-dimensional Helmholtz resonator imbedded in a grazing flow are presented. The remarkably clear structure of the perturbation field which evokes a pulsating source and a coherently pulsating vortex-image pair is described. The simple phenomenological 'lid-model' which correlates the variation in the components of the acoustic impedance with the velocity of the grazing flow is discussed and extended.

Author


Results are presented of an analytical and experimental study of the attenuation and propagation of harmonically excited sound waves in an extended reaction lined cylindrical duct. The duct geometry considered consisted of an annular outer region of bulk material surrounding an inner cylinder of air. The coupled wave equations governing the motion of the sound in both the inner and annular regions were solved numerically. The numerically predicted attenuation and propagation constants were in excellent agreement with measured values using Kevlar as the liner material for plane-wave mode (0,0) excitation over the frequency from 100 to 7,000 Hz. Although the numerical model was verified using Kevlar, it can be used with any fibrous constructed bulk liner. The results of this study demonstrated that a good start has been made on the numerical modelling of the acoustic performance of extended reaction liners.

(Author)


Discrete tone sound generation in a subsonic fan subject to three-dimensional disturbances is investigated. The analytical model used treats the fan rotor and stator as linear cascades of thin airfoils in a rectangular duct subject to a three-dimensional gust for which a complete aerodynamic theory already exists. The sound pressure can then be cast as the sum of a finite number of discrete sound waves (modes) the magnitude of which depends on an unknown function satisfying a singular integral equation. Similarity rules are derived to reduce the problem to that of a two-dimensional gust. Three-dimensional effects on the cut-off condition, the sound pressure, and the acoustic power are first investigated for each mode. The theory is then applied to noise generated by typical rotor-wake-defect and rotor-tip-vortex disturbances interacting with a stator.

(Author)


A survey is made of the methods available for the calculation of axial wave numbers in lined ducts. Rectangular and circular ducts with both uniform and non-uniform flow are considered as are ducts with peripherally varying liners. A historical perspective is provided by a discussion of the classical methods for computing attenuation when no mean flow is present. When flow is present these techniques
The problem of acoustical transmission in lined ducts with subsonic mean flow is of considerable practical interest in the context of fan noise attenuation in the ducted inlet regions of turbofan aircraft engines. If nonaxisymmetric liners are present, a loss of axial symmetry results, and the study of acoustic transmission involves the solution of a full two-dimensional eigenvalue problem. The reported investigation is concerned with such an eigenvalue problem. The employed method of solution is effectively a two-dimensional analog of an approach considered by Astley and Eversman (1979). The approach makes use of a Galerkin Finite Element Method whereby the weighting and basis functions are generated automatically by the discretization.
The internal noise generated by an Avco Lycoming YF-102 engine combustor installed in a test rig was recorded. The narrow band pressure level spectra is presented.

S.L.
The role that optical computers play in aircraft control is determined. The optical computer has the potential high speed capability required, especially for matrix/matrix operations. The optical computer also has the potential for handling nonlinear simulations in real time. They are also more compatible with fiber optic signal transmission. Optics also permit the use of passive sensors to measure process variables. No electrical energy need be supplied to the sensor. Complex interfacing between optical sensors and the optical computer is avoided if the optical sensor outputs can be directly processed by the optical computer.

S.L.
END REGION AND CURRENT CONSOLIDATION EFFECTS UPON THE PERFORMANCE OF AN MHD CHANNEL FOR THE ETF CONCEPTUAL DESIGN


The effects of MHD channel end regions on the overall power generation were considered. The peak plant thermodynamic efficiency was found to be slightly lower than for the active region (41%). The channel operating point for this peak efficiency was shifted to the supersonic mode (Mach No., Mach sub c approx., 1.1) rather than the previous subsonic operation (M sub c approx., 0.9). The sensitivity of the channel performance to the B-field, diffuser recovery coefficient, channel load parameter, Mach number, and combustor pressure is also discussed. In addition, methods for operating the channel in a constant-current mode are investigated. This mode is highly desirable from the standpoint of simplifying the current and voltage consolidation for the inverter systems. This change could result in significant savings in the cost of the equipment. The initial results indicate that this simplification is possible, even under a strict Hall field constraint, with reasonable plant thermodynamic efficiency (40.5%). N.W.

EFFECT OF VACUUM EXHAUST PRESSURE ON THE PERFORMANCE OF MHD DUCTS AT HIGH D-FIELD


The effect of area ratio variation on the performance of a supersonic Hall MHD duct is investigated. Results indicate that for a given combustion pressure there exists an area ratio below which the power generating region of the duct is shock free and the power output increases linearly with the square of the magnetic field. For area ratios greater than this, a shock forms in the power generating region which moves upstream with increasing magnetic field strength resulting in a less rapid raise in the power output. The shock can be moved downstream by either increasing the combustion pressure of decreasing the exhaust pressure. The influence of these effects upon duct performance is presented. B.W.

RESULTS AND COMPARISON OF HALL AND DW DUCT EXPERIMENTS


Experimental data from recent tests of a 415-kV diagonal wall duct are presented and compared with the results of a similar Hall duct. It is shown that while the peak power density of the two devices is approximately equal that the diagonal wall duct produces greater total power output due to its ability to better utilize the available magnetic field. Author

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It is noted that operating conditions which yielded a peak thermodynamic efficiency (41%) for an ETF-size MHD/steam power plant were previously (Wang et al., 1981; Stulger, 1981) identified by considering only the active region (the primary portion for power production) of an MHD channel. These previous efforts are extended here to include an investigation of the effects of the channel end regions on overall power generation. Considering these effects, the peak plant thermodynamic efficiency is found to be slightly lowered (40.7%); the channel operating point for peak efficiency is shifted to the supersonic mode (Mach number of approximately 0.9); and combustor operating pressure is also discussed. (Author)


A basic reason for the complexity and shear volume of electrode consolidation hardware in the MHD ETF Powertrain is the channel electrode current distribution, which is non-uniform. If the channel design is altered to provide uniform electrode current distribution, the amount of hardware required decreases considerably, but at the possible expense of degraded channel performance. This paper explains the design impacts on the ETF electrode consolidation network associated with uniform channel electrode current distribution, and presents the alternate consolidation designs which occur. They are compared to the baseline (non-uniform) current design with respect to performance, and hardware requirements. A rational basis is presented for selecting the required electrode hardware for the different designs and the savings that result from uniform current distribution. Performance and cost impacts upon the combined cycle plant are discussed. (Author)


The effect of area ratio variation on the performance of a supersonic Hall MHD duct showed that for a given combustion pressure there exists an area ratio below which the power generating region of the duct is shock free and the power output increases linearly with the square of the magnetic field. For area ratios greater than this, a shock forms in the power generating region which moves upstream with increasing magnetic field strength resulting in a less rapid raise in the power output. The shock can be moved downstream by either increasing the combustion pressure or decreasing the exhaust pressure. The influence of these effects upon duct performance is presented in this paper. (Author)


The phenomenon of unexpectedly large leakage currents collected by small exposed areas of high voltage solar arrays operating in a plasma environment was investigated. Polyimide (Kapton) was the insulating material used in all tests. Both positive bias (electron collection) and negative bias (ion collection) tests
were performed. A mode change in the electron collection mechanism was associated with a glow discharge process and was found to be related to the neutral background density. Results indicate that the glow discharge collection mode does not occur in a space environment where the background density is considerably lower than that of the vacuum facility used. B.W.

**ABSTRACT**

A three-dimensional confined flow model is presented. The flow field is calculated by computing velocity and enthalpy along a set of streamlines. The finite difference equations are obtained for the body force terms, the approach computes three-dimensional viscous flow through a rectangular duct, with the duct cross-sectional area specified along the axis. Various electrical load parameters, pressure ratios, and magnetic field profiles are considered for a baseload MHD generator, with a finding that a decelerating flow rate yields slightly higher power in argon at gas pressures. A listing of a computer code, based on this approach is presented in FORTRAN IV language. The code computes three-dimensional compressible viscous flow through a rectangular duct, with the duct cross section specified along the axis.

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NS2-11965# Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Electrical Computer and Systems Engineering.


Progress in the low temperature growth of oxides and layers on GaAs and the detailed electrical characterization of these oxides is reported. A plasma anodization system was designed, assembled, and put into operation. A measurement system was assembled for determining capacitance and conductance as a function of gate voltage for frequencies varying from 1 Hz to 1 MHz. Initial measurements were carried out in SiO2/Si structures in order to test the system and in GaAs MIS capacitors fabricated using liquid anodization.


Recent advances in GaAs bulk crystal growth using the LEC (liquid encapsulated Czochralski) technique are described. The background of the dependence of the dislocation density and the dislocation density distribution on the materials synthesis and growth conditions were investigated. Background impurity concentrations as low as 4 x 10^15 cm^-3 were obtained in undoped LEC GaAs. The dislocation density in selected regions of individual ingots was very low, below the 3000 cm^-3 level, and was .3000/cm^2 threshold. The average dislocation density over a large annular ring on the wafer fell below the 10000/cm^2 level for 3 inch diameter ingots. The diameter control during the program advanced to a diameter variation along the 3 inch ingot less than 2 mm.


Undoped semi-insulating GaAs grown by the high-pressure liquid encapsulated Czochralski (LEC) method has been produced for use in direct ion implantation in several laboratories. Critical examination of the factors controlling impurity transport and compensation in these materials has been lacking to date. In this work, detailed characterization has been performed on undoped semi-insulating crystals grown from both SiO2 and PBN crucibles followed by a proposed impurity model and compensation mechanism.


The activation energy for impurity atom (adatom) surface diffusion can be determined from the temperature dependence of the spacing of sputter cones. These cones are formed on the surface during sputtering while simultaneously adding impurities. The impurities form clusters by means of surface diffusion, and these clusters in turn initiate cone formation. Values are given for the surface diffusion activation energies for various materials on polycrystalline Cu, Al, Pb, and Ni. The values for different impurity species on each of these substrates are approximately independent of impurity species within the experimental uncertainty, suggesting the absence of strong chemical bonding effects on the diffusion. (Author)


The quasi-liquid properties that have been observed on surface structures developed by means of ion beam microtexturing. The structures include cones, pyramids, or wavelike formations. The observed liquid-like effects are drips and ripples on the sides of cones, droplet formation, the apparent flow and coalescence of closely packed structures, wetting angle and other surface tension effects, and the bending of cones by additional heating. The bulk temperatures are in the range of 50-600°C. These effects are seen to some extent on Cu, Al, Au, Pb, and Ni substrates.


It is shown how a superconductor-insulator-superconductor (SIS) mixer when inductively terminated at the IF port has inductive reactance at the signal port. This reactance may be used to compensate for the geometric capacitance of a conventionally operated SIS mixer over twice the bandwidth available through signal port resonance techniques. (Author)


The epitaxial growth of Mg-doped GaAs by the organometallic vapor phase epitaxial process (OM-VPE) has been achieved for the first time. The doping is controllable over a wide range of input fluxes of bis(cyclopentadienyl) magnesium, (C5H5)2Mg, the organometallic precursor to Mg.

A82-41546 \* Electron beam induced damage in ITO coated Kapton. L. Kramsky, W. L. Gordon, and R. W. Hoffman (Case Western Reserve University, Cleveland, OH), Applications of Surface Science, vol. 9, 1981, p. 39-46, 17 refs. (Grant No. NAG3-3197).

Data for the stability of thin conductive indium tin oxide films on 0.003 inch thick Kapton substrates during exposure of the surface to electron beams are reported. The electron beam energy was 3 keV and the diameter was about 0.8 mm. Thermal effects and surface modifications are considered. For primary current greater than 0.6 microamperes, an obvious dark discoloration with diameter approximately that of the beam was produced. The structure of the discolored region was studied with the scanning electron microscope, and the findings are stated. Surface modifications were explored by AES, obtaining spectra and secondary emission coefficient as a function of time for different beam intensities. In all cases beam exposure results in a decrease of the secondary yield but because of thermal effects this change, as well as composition changes, cannot be directly interpreted in terms of electron beam dosage.


A model applicable to normal metal tunnel junctions is presented. This model, referred to herein as the stationary state model, is an extension of the extended basis function theory of Kleinman and Duke (1974). Under this assumption that elastic tunneling is the dominant transport mechanism under static bias, the theory has been extended to include the case where there is an ac component of bias potential, and the fluctuation spectrum has been derived. In this approach strong temperature dependences are used as the basis, allowing observables to be evaluated without recourse to the perturbation theory inherent in the transfer Hamiltonian model. Comparison is made to the appropriate results of the first order transfer
Hamiltonian model, and it is found that there is close but not always exact agreement to lowest order in the tunneling exponential. The stationary state model should be accurate with large barrier transmission, as it includes all orders of the tunneling exponential. The model as presented here should be applicable to normal metal tunnel junctions, where elastic tunneling is the dominant transport mechanism (under static bias), up to infrared excitation frequencies. (Author)


It is pointed out that the development of surface topography along with enhanced surface and bulk diffusion processes accompanying ion bombardment have generated growing interest among users of ion beams and plasmas for thin film or material processing. Interest in these processes stems both from attempts to generate topographic changes for specific studies or applications and from the need to suppress or control undesirable changes. The present investigation provides a summary of the current status of impurity-induced texturing, with emphasis on recent developments. Particular attention is given to the texturing accompanying deposition of an impurity material onto a solid surface while simultaneously etching the surface with an ion beam. A description of experimental considerations is provided, and a thermal-diffusion model is discussed along with the development of sputter cones, and aspects of impact-enhanced surface diffusion.

G.R.


It is shown that the incidence of twin formation in large diameter, undoped, (100) LEC GaAs is reduced when the melt composition is slightly As-rich. Twenty GaAs crystals were grown from stoichiometric and nonstoichiometric melts. The results suggest that the barrier to twin formation is related to the stoichiometry of the solid at the solidification front.

C.D.
Thermodynamics and Statistical Physics
Includes quantum mechanics; and Bose and Fermi statistics.
For related information see also Inorganic and Physical Chemistry and 34 Fluid Mechanics and Heat Transfer.

N82-32186# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air. Part 1: Properties in SI Units
Sanford Gordon Jul. 1982 397 p refs
(NASA-TP-1906; E-946; NAS 1.60:1906) Avail: NTIS
HC A17/MF A01 CSCL 20M
Thermodynamic and transport combustion properties were calculated for a wide range of conditions for the reaction of hydrocarbons with air. Three hydrogen-carbon atom ratios (H/C = 1.7, 2.0, 2.1) were selected to represent the range of aircraft fuels. For each of these H/C ratios, combustion properties were calculated for the following conditions: Equivalence ratio: 0, 0.25, 0.5, 0.75, 1.0, 1.25 Water - dry air mass ratio: 0, 0.03 Pressure, kPa: 1.01325, 10.1325, 101.325, 1013.25, 5066.25 (or in atm: 0.01, 0.1, 1, 10, 50) Temperature, K: every 10 degrees from 200 to 900 K; every 50 degrees from 900 to 3000 K Temperature, R: every 20 degrees from 360 to 1600 R; every 100 degrees from 1600 to 6400 R. The properties presented are composition, density, molecular weight, enthalpy, entropy, specific heat at constant pressure, volume derivatives, isentropic exponent, velocity of sound, viscosity, thermal conductivity, and Prandtl number. Property tables are based on composites that were calculated by assuming both: (1) chemical equilibrium (for both homogeneous and heterogeneous phases) and (2) constant compositions for all temperatures. Properties in SI units are presented in this report for the Kelvin temperature schedules.

N82-32187# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air, Part 4: Compositions Corresponding to Rankine Temperature Schedules in Part 3
Sanford Gordon Jul. 1982 281 prefs
(NASA-TP-1909; E-947; NAS 1.60:1907) Avail: NTIS
HC A18/MF A01 CSCL 20M
The equilibrium compositions corresponding to the thermodynamic and transport combustion properties for a wide range of conditions for the reaction of hydrocarbons with air are presented. The compositions presented correspond to Rankine temperature schedules.

N82-32188# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air, Part 2: Compositions Corresponding to Kelvin Temperature Schedules in Part 1
Sanford Gordon Jul. 1982 281 prefs
(NASA-TP-1907; E-945; NAS 1.60:1907) Avail: NTIS
HC A13/MF A01 CSCL 20M
The equilibrium compositions that correspond to the thermodynamic and transport combustion properties for a wide range of conditions for the reaction of hydrocarbons with air are presented. Initially 55 gaseous species and 3 condensable species were considered in the calculations. Only 17 of these 55 gaseous species had equilibrium mole fractions greater than 0.000005 for any of the conditions studied and therefore these were the only ones retained in the final tables.

N82-32189# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
Thermodynamic and Transport Combustion Properties of Hydrocarbons with Air. Part 3: Properties in U.S. Customary Units
Sanford Gordon Jul. 1982 362 prefs
(NASA-TP-1908; E-948; NAS 1.60:1908) Avail: NTIS
HC A16/MF A01 CSCL 20M
Thermodynamic and transport properties are presented for a wide range of conditions for the reaction of hydrocarbons with air. The values given are in U.S. customary units.

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ADMINISTRATION AND MANAGEMENT
Includes management planning and research.

LOCAL AND NATIONAL IMPACT OF AEROSPACE RESEARCH AND TECHNOLOGY
(NASA-TM-82775; E-1104) Avail. NTIS HC A02/MF A01

An overview of work at the NASA Lewis Research Center in the areas of aeronautics, space, and energy is presented. Local and national impact of the work is discussed. Some aspects of the U.S. research and technology base, the aerospace industry, and foreign competition are discussed. In conclusion, U.S. research and technology programs are cited as vital to U.S. economic health.

Author
85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems, I.A.C.: Jology transport; technology assessment; and surface and mass transportation.

For related information see J3 Air Transportation and Safety, 16 Space Transportation, and 44 Energy Production and Conversion.

NB-13013*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

RESULTS AND FACILITY DESCRIPTION FOR A 40-KILOWATT STIRLING ENGINE Final Report


Contract DE-A101-77CS-51040


A 40 kilowatt Stirling engine, its test support facilities, and the experimental procedures used for these tests are described. Operating experience with the engine is discussed, and some initial test results are presented.

S.L.

NB-26051# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PRELIMINARY ANALYSIS OF A DOWNSIZED ADVANCED GAS-TURBINE ENGINE IN A SUBCOMPACT CAR


Contract DE-A101-77CS-51040

(NASA-TM-82848; E-1218; NAS 1.1582848; DOE/NASA/51040-40) Avail: NTIS HC AO2/MF AO1 CSCL 13F

Relative fuel economy advantages exist for a ceramic turbine engine when it is downsized for a small car. We investigated a 75 kW (100 hp) single shaft engine that was downsized to 37 kW (50 hp) and analyzed with a natural variable transmission in a synthesized car. With gasoline, a 25% advantage was calculated over that of a similar diesel engine, using the same transmission and car. With diesel fuel, a 21% advantage was calculated over that of a similar diesel engine vehicle.

Author

NB-27191# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1981


Technical reporting that resulted from the scientific and engineering work performed and managed by the Lewis Research Center in 1981 are indexed and abstracted. All the publications were announced in the 1981 issues of STAR (Scientific and Technical Aerospace Reports) and/IAA (International Aerospace Abstracts). Included are the technical reports, journal articles, conference presentations, patent applications, and theses. A total of 384 technical publications is listed.

Author

NB-31160*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PROGRESS ON ADVANCED AC AND DC INDUCTION DRIVES FOR ELECTRIC VEHICLES


Contract DE-A101-77CS-51044

(NASA-TM-82895; E1273; NAS 1.1582895; DOE/NASA/51044-27) Avail: NTIS HC AO2/MF AO1 CSCL 13F

Progress is reported in the development of complete electric vehicle propulsion systems, and the results of tests on the Road Load Simulator of two such systems representative of advanced ac and dc drive technology are presented. One is the system used in the DOE's ETV-1 integrated test vehicle which consists of a shunt wound dc traction motor under microprocessor control using a transistorized controller. The motor drives the vehicle through a fixed ratio transmission. The second system uses an ac induction motor controlled by transistorized pulse width modulated inverters which drives through a two speed automatically shifted transmission. The inverter and transmission both operate under the control of a microprocessor. The characteristics of these systems are also compared with the propulsion system technology available in vehicles being manufactured at the inception of the DOE program and with an advanced, highly integrated propulsion system upon which technology development was recently initiated.

Author


JET IMPINGEMENT HEAT TRANSFER ENHANCEMENT FOR THE GPU-3 STIRLING ENGINE


(NASA-TM-82727; DOE/NASA/51040/33) Avail: NTIS HC AO3/MF AO1 CSCL 13F

A computer model of the combustion-gas-side heat transfer was developed to predict the effects of a jet impingement system and the possible range of improvements available. Using low temperature (316 C (600 F)) pretest data in an updated model, a high temperature (1100 C (2000 F)) impingement jet was used to calculate the heat transfer coefficient.

Author


Contract DEn3-167

(NASA-CR-165175; DOE/NASA/0167-01) Avail: NTIS HC AO1/MF AO1 CSCL 13F

Progress in the development of a gas turbine engine to improve fuel economy, reduce gaseous emissions and particulate levels, and compatible with a variety of alternate fuels is reported. The powertrain is designated AGT101 and consists of a regenerative single shaft gas turbine engine, a split differential gearbox and a Ford Automatic Overdrive production transmission. The powertrain is controlled by an electronic digital microprocessor and associated actuators, instrumentation, and sensors. Standard automotive accessories are driven by engine power provided by an accessory pack on the gearbox. Component/subsystem development progress is reported in the following areas: compressor, turbine, combustion system, regenerator, gearbox/transmission, structures, ceramic components, foil gas bearings, bearings and seals, rotor dynamics, and control and accessories.

J.M.S.

NB-16938# Boeing Computer Services Co., Tukwila, Wash.

HYBRID AND ELECTRIC ADVANCED VEHICLE SYSTEMS (HEAVY) SIMULATION Report


Contract DEn3-151; DE-A101-77CS-51044


A computer program to simulate hybrid and electric advanced vehicle systems (HEAVY) is described. It is intended for use early in the design process: concept evaluation, alternative comparison, preliminary design, control and management strategy development, component sizing, and sensitivity studies. It allows the designer to quickly, conveniently, and economically predict
the performance of a proposed drive train. The user defines the system to be simulated using a library of predefined component models that may be connected to represent a wide variety of propulsion systems. The development of three models are discussed as examples. 

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Engineering drawings for the stirling engine, external heat, hot and cold engine, engine drive, and control systems and auxiliaries are provided. Vehicle integration is also illustrated. N.W.

The subject of surface potentials on natural and artificial bodies in space is reviewed with particular emphasis on recent developments. Following a brief survey of work done up to the early 1970s on the charging of astrophysical objects in interstellar and interplanetary space and spacecraft charging, the various charging mechanisms in space are examined, including the collection of plasma particles, photoemission, and secondary electron emission by electron impact and ion impact, and the effects on charging of nonisotropic plasmas, wakes, and environmental magnetic and electric fields are considered.

The concept of equilibrium potential is discussed, along with differential charging, potential barriers and discharge processes. The measurement of spacecraft potentials is then considered, and recent work on spacecraft potential modification and control by active and passive means is presented. Finally, astrophysical applications where charging effects may be important are discussed, and areas for further work are indicated.

A.L.W.
92 SOLAR PHYSICS
Includes solar activity, solar flares, solar radiation and sunspots.


Synthesized maps of two solar active regions obtained from observations with the Very Large Array (VLA) with 9-arcsec resolution are presented. The most intense sources in these regions are found to be associated with filamentary structures and magnetic neutral lines as shown in H-alpha and photospheric magnetograms. These sources are not located directly over sunspots in disagreement with earlier observations. EUV and X-ray observations have suggested that similar structures should be visible at cm wavelengths around but, outside of, sunspots if the magnetic field is sufficiently strong. These results are consistent with the locations of hot (greater than 1,000,000 K) plasmas in active regions expected from generalization based on optical photographs. Given the sizes of the radio sources, the volume emission measures of soft X-rays observed from OSO-8 rule out the possibility of thermal bremsstrahlung being of any significance, as far as the 6 cm emission is concerned. Therefore, gyroresonance absorption process is the most likely cause of 6 cm emission from these sources, and its likelihood is enhanced by the magnetic field geometry that is known to exist over filaments and neutral lines.


Results are presented of a detailed study of quiet sun emitting regions at 6 cm and their correspondence with regions observed at optical wavelengths. The Westerbork Synthesis Radio Telescope was used to obtain a 12-hr synthesis map of a quiet sun region with a resolution of 6 arcsec. Comparison of this map with a Ca(+) K filtergram indicates the features on the 6-cm map to correspond to Ca(+) K chromospheric networks and cells. In addition, about 72% of the magnetic field enhancements observed on photospheric magnetograms coincides with 6-cm emissive regions. Intercomparison of the 12-hr synthesis map, a 4-hr synthesis map and 6-cm fan beam scans along with the Ca(+) K and magnetogram results reveals all of the time-varying 6-cm elements to be located on Ca(+) K networks, and about 40% of them to be coincident with magnetogram enhancements. Lifetimes of the time-varying sources vary from a few minutes to several tens of minutes, and intensity varies by factors of 2 to 7.


Using VLA observations of the 1B/M1 flare of June 25, 1980, 6-cm 'snapshot' maps are synthesized. The spatial and temporal resolutions during the 9 minutes of the impulsive phase were, respectively, 1 arcsec x 2 arcsec and 10 s. Some displacement is noted between the locations of the burst source and the preflare loop structures seen in the preflare map. The burst peak occurred on the neutral line of the preflare polarization map, between the two oppositely polarized microwave 'loop' structures approximately 40 arcsec long. Concurrent hard X-ray observations were made of the burst, although these had no spatial resolution. The 6-cm maps show the locations of a number of the X-ray burst spikes. The 6-cm burst was fully resolved into at least eight components, many of which were bipolar.
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