NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.
Bibliography of
Lewis Research Center
Technical Publications
Announced in 1981

May 1982
PREFACE

In 1981, Lewis Research Center’s 899 research authors published 384 technical publications which were announced to and reached the worldwide scientific community. Although the number of reports published this year has decreased just as the staff has decreased, the number of reports published per person per year has increased slightly. Each year the number of technical presentations given at seminars, society symposia, and Lewis-hosted conferences increases. In 1981, Lewis authors published approximately 66 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 1981 Lewis Distinguished Paper Award was presented to Krishna Rao V. Kaza and Robert E. Kielb for their paper entitled “Effects of Mistuning on Bending-Torsion Flutter and Response of a Cascade in Incompressible Flow.” This paper was presented at the Dynamics Specialists Conference sponsored by the American Institute of Aeronautics and Astronautics held in Atlanta, Georgia, April 9–11, 1981. A description of the paper is given in abstract A81-29465 (p. 92) in this bibliography.


The Society of Automotive Engineers’ Oral Presentation Award was given to Brent A. Miller for his outstanding presentation of the paper “The NASA High-Speed Turboprop Program” by J. F. Dugan, B. A. Miller, E. J. Graber, and D. A. Sagerser at the SAE Aerospace Congress and Exposition in Los Angeles, California, October 13–16, 1980. The paper is described in abstract A81-34156 (p. 21) of this bibliography.

In 1981, 312 contractor-authored research reports were produced, an increase over the previous year’s output of 307. In addition, 25 patent applications were filed and 18 patents were issued.

All the publications in this collection were announced in the 1981 issues of STAR (Scientific and Technical Aerospace Reports) and IAA (International Aerospace Abstracts).

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

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

George Mandel
Chief, Management Services Division
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SUPERSONIC CRUISE AIRCRAFT
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These results were verified statistically at large scale on a variable
cycle engine (VCE) testbed A preliminary assessment of potential
VCE noise sources such as fan and core noise is m=^c based
on the tested data. Recent advances in the urm. j using of
flight effects are reviewed. The status of com, ^ ,
nois prediction methods is assessed on the basis of recent test data,
and the remaining problem areas are outlined. M.G.

ADVANCED TECHNOLOGY FOR CONTROLLING POL-
LUTANT EMISSIONS FROM SUPERSONIC CRUISE
AIRCRAFT
Robert A. Duerr and Larry A. Diethi In NASA Langley Research
p 535-549 (For primary document see NB1-19781 09-01)
Avail. NTIS HC A23/MF A01 CSCL 20A
Gas turbine engine combustion technology for the reduction
of pollutant emissions is summarized. Variations of conventional
combustion systems and advanced combustor concepts are
discussed Pertinent free stream pressure and temperature 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.

A81-29052 * / The future of aeronautical propulsion. W. L.
Stewart (NASA, Lewis Research Center, Cleveland, Ohio). In:
International Symposium on Air Breathing Engines, 5th, Bangalore,
India, February 16-22, 1981, Proceedings. (A81-29051 12-07) Ban-

This keynote address discusses some of the future challenges and
opportunities confronting aeronautics where propulsion is a key
factor. The discussion covers various aircraft types including com-
mercial transports, general aviation and military aircraft and identi-
fies propulsion technology required to accommodate further ad-
ancements in these types of aircraft. This is then followed by a
discussion of some of the emerging technologies that, ^ properly
exploited, will have significant effect on the engines o. the '90's.
Some comments on further advancements in the traditional tech-
nologies are also included. (Author)

A81-30003 * NASA research in aeropropulsion. W. L.
Stewart and R. J. Weber (NASA, Lewis Research Center, Cleveland,
Ohio). American Society of Mechanical Engineers, Gas Turbine
Conference and Products Show, Houston, Tex., Mar. 9-12, 1981,
Paper 81-GT-96. 11 p. Members, $2.00; nonmembers, $4.00.

A NASA research activity in the development of civilian and
military aircraft are discussed. The advances made in subsonic and
supersonic transports, commuter aircraft, rotorcraft, V/STOL, and
high-performance engines are reviewed, and the problems facing
general aviation are considered. Comments on some new areas of
technology are also presented. L.S.

NB1-18002‡ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

STATUS OF NOISE TECHNOLOGY FOR ADVANCED
SUPERSONIC CRUISE AIRCRAFT
James R. Stone and Orlando A. Gutierrez In NASA Langley
Research Center Supersonic Cruise Res. 1979. Pt 1. Mar
1980 p 493-518 (For primary document see NB1-19781 09-01)
Avail. NTIS HC A23/MF A01 CSCL 20A
Developments in acoustic technology applicable to advanced
supersonic cruise aircraft, particularly those which relate to at
and its suppression are reviewed. The noise reducing
potential of high radius ratio, inverted velocity profile coaxial
jets is demonstrated by model scale results from a wide range
of nozzle geometries, including some simulated flight cases.
These results were verified statistically at large scale on a variable
cycle engine (VCE) testbed. A preliminary assessment of potential
VCE noise sources such as fan and core noise is m=^c based
on the tested data. Recent advances in the urm. j using of
flight effects are reviewed. The status of com, ^ ,
nois prediction methods is assessed on the basis of recent test data,
and the remaining problem areas are outlined. M.G.

NB1-18004‡ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ADVANCED TECHNOLOGY FOR CONTROLLING POL-
LUTANT EMISSIONS FROM SUPERSONIC CRUISE
AIRCRAFT
Robert A. Duerr and Larry A. Diethi In NASA Langley Research
p 535-549 (For primary document see NB1-19781 09-01)
Avail. NTIS HC A23/MF A01 CSCL 13B
Gas turbine engine combustion technology for the reduction
of pollutant emissions is summarized. Variations of conventional
combustion systems and advanced combustor concepts are
discussed Pertinent free stream pressure and temperature 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.

NB1-17997‡ Pratt and Whitney Aircraft, East Hartford, Conn.
Commercial Products Div.

PROGRESS WITH VARIABLE CYCLE ENGINES
John S. Westmoreland In NASA Langley Research Center
refs (For primary document see NB1-19781 09-01)
(Contracts NAS5-20048. NAS3-20081. NAS3-20602)
Avail. NTIS HC A23/MF A01 CSCL 21E
The evaluation of components of an advanced propulsion system for a future supersonic cruise vehicle is discussed. These com-
oonents, a high performance duct burner for thrust augmenta-
in and a low jet noise coaxial exhaust nozzle, are part of the
variable stream control engine. An experimental test program involving both isolated component and complete engine
tests was conducted for the high performance, low emissions
duct burner with excellent results. Nozzle model tests were
completed which substantiate the inherent jet noise benefit
associated with the unique velocity profile possible of a coaxial
exhaust nozzle system on a variable stream control engine.
Additional nozzle model performance tests have established high
thrust efficiency levels at takeoff and supersonic cruise for this
nozzle system. Large scale testing of these two critical components
is conducted using an F100 engine as the testbed for simulating
the variable stream control engine. M.G.

NB1-22012‡ Nielsen Engineering and Research, Inc., Mountain
View, Calif.

A RAPID PERTURBATION PROCEDURE FOR DETERMIN-
ing NONLINEAR FLOW SOLUTIONS: APPLICATI-
ON TO TRANSONIC TURBOMACHINERY FLOWS
Final Report
Stephen S. Stahra, James P. Elliott, and John R. Spralter
Washington NASA May 1981 95 p refs
(Contract NAS3-20825)
(NASA CR-3425 NEAR-TR-227) Avail. NTIS
HC A05/MF A01 CSCL 20D
Perturbation procedures and associated computational codes
determined nonlinear flow solutions were developed to
establish a method for minimizing computational requirements
associated with parametric studies of transonic flows in
0 turbomachines. The procedure that was developed and evaluated
was found to be capable of determining highly accurate
approximations to families of strongly nonlinear solutions which
are either continuous or discontinuous, and which represent
variations in some arbitrary parameter. Coordinate straining is
employed to account for the movement of discontinuities and
maxima of high gradient regions due to the perturbation. The
development and results reported are for the single parameter
perturbation problem. Flows past both isolated airfoils and
compressor cascades involving a wide variety of flow and geometry
parameter changes are reported. Attention is focused in particular on transonic flows which are strongly supercritical and exhibit large surface shock movement over the parametric range studied, and on subsonic flows which display large pressure variations in the stagnation and peak suction pressure regions. Comparisons with the corresponding 'exact' nonlinear solutions indicate a remarkable accuracy and range of validity of such a procedure.

J.M.S.
02 AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors and control surfaces, and internal flow in ducts and turbomachinery.
For related information see also 34 Fluid Mechanics and Heat Transfer.

N81-13019*† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
NASA CONTRIBUTIONS TO RADIAL TURBINE AERODYNAMIC ANALYSES
(NASA-TM-81644: E-9356-1) Avail. NTIS HC A02/MF A01 CSCL 01A
A brief description of the radial turbine and its analysis needs is followed by discussions of five analytical areas: design geometry, fluid flow, and duct flow. The functions of the programs, areas of applicability, and limitations and uncertainties are emphasized. Both past contributions and current activities are discussed.

N81-14977*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
FINITE ELEMENT ANALYSIS OF INVIScid SUBSONIC BOATTAIL FLOW
(NASA-TM-81850: E-651) Avail. NTIS HC A02/MF A01 CSCL 01A
A finite element code for analysis of inviscid subsonic flows over arbitrary nonlifting planar or axisymmetric bodies is described. The code solves a novel primitive variable formulation of the coupled irrotationality and compressibility continuity equations. Results for flow over a cylinder, a sphere, and a NACA 0012 airfoil verify the code. Computed subcritical flows over an axisymmetric boattailed afterbody compare well with recent finite difference results and experimental data. Interactive coupling with an integral turbulent boundary layer code shows strong viscous effects on the inviscid flow. Improvements in code efficiency and extensions to transonic flows are discussed.

N81-14978*§ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
SUPersonic STALL FLUTTER OF HIGH SPEED FANS
(NASA-TM-81613: E-612) Avail. NTIS HC A02/MF A01 CSCL 01A
An analytical model is developed for predicting the onset of supersonic stall bending flutter in axial flow compressors. The analysis is based on a modified two-dimensional, compressible unsteady actuator disk theory. It is applied to a rotor blade row by considering a cascade of airfoils whose geometry and dynamic response coincide with those of a rotor blade element at 85 percent of the span height (measured from the hub). The rotor blades are assumed to be unshrouded (i.e. free standing) and to vibrate in their first flexural mode. The effects of shock waves and flow separation are included in the model through quasi-steady, empirical, rotor total-pressure-loss and deviation-angle correlations. The actuator disk model predicts the unsteady aerodynamic force acting on the cascade blading as well as the geometry and dynamic response of the cascade. Calculations show that the present model predicts the existence of a bending flutter mode at supersonic inlet Mach numbers. This flutter mode is suppressed by increasing the reduced frequency of the system or by reducing the steady state aerodynamic loading on the cascade. The validity of the model for predicting flutter is demonstrated by correlating the measured flutter boundary of a high-speed fan stage with its predicted boundary. This correlation uses a level of damping for the blade row (i.e. the log decrement of the rotor system) that is estimated from the experimental flutter data. The predicted flutter boundary is shown to be in good agreement with the measured boundary.

N81-14979*‘ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
SOLUTION OF PLANE CASCADE FLOW USING IMPROVED SURFACE SINGULARITY METHODS
(NASA-TM-81509: E-568) Avail. NTIS HC A02/MF A01 CSCL 01A
A solution method was developed for calculating compressible inviscid flow through a linear cascade of arbitrary blade shapes. The method uses advanced surface singularity formulations which were adapted from those in current external flow analyses. The resulting solution technique provides a fast flexible calculation for flows through turbomachinery blade rows. The solution method and some examples of the method’s capabilities are presented.

N81-21027*† National Aeronautics and Space Administration. Langley Research Center, Hampton, Va
FLUID MECHANICS MECHANISMS IN THE STALL PROCESS OF HELICOPTERS
(NASA-TM-81956: USAAVRACOM-TR-81-B-1) Avail. NTIS HC A02/MF A01 CSCL 01A
Recent experimental results from airfoils in the Mach number, Reynolds number, or reduced frequency ranges typical of helicopter rotor blades have identified the most influential flow mechanisms in the dynamic stall process. The importance of secondary shedding vortices, downstream wake action, and the flow in the separated region is generally acknowledged but poorly understood. By means of surface pressure cross-correlations and flow field measurements in static stall, several new hypotheses have been generated. It is proposed that vortex shedding may be caused by acoustic disturbances propagating forward in the lower (pressure) surface boundary layer, that wake closure is a misnomer, and that the shed vortex leaves a trail of vorticity that forms a turbulent free shear layer. The known dynamic stall flow mechanisms are reviewed and the potential importance of recently proposed and hypothetical flow phenomena with respect to helicopter blade aerelastic response are assessed.

N81-21028*‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
LOW AND HIGH SPEED PROPELLERS FOR GENERAL AVIATION: PERFORMANCE POTENTIAL AND RECENT WIND TUNNEL TEST RESULTS
(NASA-TM-81745: E-799) Avail. NTIS HC A03/MF A01 CSCL 01A
The performance of lower speed, 5 foot diameter model general aviation propellers, was tested in the Lewis wind tunnel. Performance was evaluated for various levels of airfoil technology and activity factor. The difference was associated with inadequate modeling of blade and spinner losses for propellers round shank blade designs. Suggested concepts for improvement are: (1) advanced blade shapes (airfoils and sweep); (2) tip devices (proplets); (3) integrated propeller/nacelles, and (4) composites.

3
Several advanced aerodynamic concepts were evaluated in the Lewis wind tunnel. Results show that high propeller performance can be obtained to at least Mach 0.8. E.A.K.

N81-28020# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**SHOCKLESS DESIGN AND ANALYSIS OF TRANSITIONAL BLADE SHAPES**


A fast computer program was developed to eliminate the shock by slightly altering portions of the contour of a given airfoil in the cascade. The program can be used in two basic modes: (1) An analysis for steady, transonic, potential flow through a given planar cascade of airfoils and (2) a design for converting a given cascade into a shockless transonic cascade. The design mode can automatically be followed by the analysis mode, which confirms that the flow field is shock free. The program generates its own multilevel boundary conforming computational grids and solves in a fully conservative form. The shockless design is performed by implementing Sobieczky's fictitious-gas elliptic continuation concept. E.A.K.

N81-27042# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**FACTORS INFLUENCING THE PREDICTED PERFORMANCE OF ADVANCED PROPELLER DESIGNS**


The assumptions on which conventional propeller aerodynamic performance analyses are based can be seriously violated when advanced high speed propellers are analyzed. Studies were performed using a lifting line representation for the propeller to determine the sensitivity of predicted propeller performance to various assumptions in the analysis. Items studied include the method of determining blade section lift and the effects of blade section drag, camber and blade sweep. The effects of nonuniform flow into the propeller and compressibility were also studied. Comparisons of analytical and experimental results are presented to demonstrate the overall validity of the results. Author

N81-28045# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**COLD-AIR PERFORMANCE OF COMPRESSOR-DRIVE TURBINE OF DEPARTMENT OF ENERGY UPGRADED AUTOMOBILE GAS TURBINE ENGINE, 1: VOLUME MANIFOLD AND STATOR PERFORMANCE**


The aerodynamic performance of the inlet manifold and stator assembly of the compressor drive turbine was experimentally determined with cold air as the working fluid. The investigation included measurements of mass flow and static pressure as well as radial surveys of total pressure and flow angle at the stator inlet and annulus surveys of total pressure and flow angle at the stator exit. The stator-exit averaged flow conditions and overall stator efficiency were obtained and compared with their design values and the experimental results from three other stators. In addition, an analysis was made to determine the constituent aerodynamic losses that made up the stator kinetic energy loss. Author

N81-28056# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**SOME ASPECTS OF CALCULATING FLOWS ABOUT THREE-DIMENSIONAL SUBSONIC INLETS**


Based on the potential flow model, computations were carried out for several three-dimensional inlet models. Some of these calculated results are presented in the forms of surface static pressure, flow angle, surface flow pattern, and inlet flow field. Comparisons with experimental data are also made. M.G.

N81-31126# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**STALL FLUTTER EXPERIMENT IN A TRANSSONIC OBLI-
LATIN LINEAR CASCADE

Donald R. Boldman, Alvin E. Buggele, and George M. Michelson
(NASA-TM-83656, E-918) Avail. NTIS HC A02/MF A01 CSSCL 01A

Two dimensional biconvex airfoils were oscillated at reduced frequencies up to 0.5 based on semi-chord and a free stream Mach number of 0.80 to simulate resonance stall flutter in rotor. Steady-state periodicity was confirmed through end-wall pressure measurements, exit flow traverses, and flow visualization. The initial flow visualization results from Pitter tests indicated that the oscillating shock on the airfoils lifted the airfoil motion by as much as 80 deg. These initial data exhibited an appreciable amount of scatter; however, a linear fit of the results indicated that the greatest shock phase lag occurred at a 90-deg interblade phase angle. Photographs of the steady-state and unsteady flow fields reveal some of the features of the lambda shock wave on the suction surface of the airfoils.

T.M.

N81-31129*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
GRID3D: COMPUTER PROGRAM FOR FAST GENERATION OF MULTIPLEV THREE-DIMENSIONAL BOUNDARY-
CONFORMING O-TYPE COMPUTATIONAL GRIDS

Jorgie S. Dukhrovich Sep. 1979 4 p refs. (NASA-TP-1920 E-580) Avail. NTIS HC A02/MF A01 CSSCL 01A

A fast algorithm was developed for accurately generating boundary conforming, three-dimensional, successively refined computational grids applicable to axisymmetric and axial turbomachinery geometries. The method is based on using an analytic function to generate two-dimensional grids on a number of coaxial axisymmetric surfaces positioned between the centerbody and the outer radial boundary. These grids are of the C type and are characterized by quasi-orthogonality, geometric periodicity, and an adequate resolution throughout the flow field. Because the built-in nonorthogonal coordinate stretching and shearing cause the grid lines leaving the blade or wing trailing edge to end at downstream infinity, the numerical treatment of the three-dimensional trailing vortex sheets is simplified. Author

N81-31129*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio. BURFROATE-EQUATION TECHNIQUE FOR SIMULATION OF STEADY INVISCOUS FLOW Final Report

Gary M. Johnson and Washington NASA Sep 1980 40 p refs. (NASA-TP-1865, E-583) Avail. NTIS HC A03/MF A01 CSSCL 01A

A numerical procedure for the iterative solution of inviscid flow problems is described, and its utility for the calculation of steady subsonic and transonic flow fields is demonstrated. Application of the surrogate equation technique defined herein allows the use of the conservative type dependent, finite difference equations for use in obtaining numerical solutions to systems of first order partial differential equations, such as the steady state Euler equations. Steady, two dimensional solutions to the Euler equations for both subsonic, rotational flow and supersonic flow and to the small disturbance equations for transonic flow are presented. Author


Many proposed advanced aircraft — but especially tilt-nacelle, subsonic-cruise, V/STOL aircraft — require nacelles that operate over a wide range of aerodynamic conditions. The optimum design of such nacelles and their inlets is described, including how the inlet low-speed design conditions are selected, the conditions for which the various regions of the inlet are designed, and appropriate criteria of merit. For low-speed operation the optimum internal surface velocity distributions and skin friction distributions are described for three categories of inlets; those without boundary-layer control (BLC), those with BLC, and those with blow-in door slots and retractable slots. Experimental results are presented that show the performance of the various types of inlets. At cruise speed the effect of factors that reduce the nacelle external surface area and the local skin friction is illustrated. These factors are cruise Mach number, inlet throat size, fan-face Mach number, and nacelle contour. The interrelation of these cruise-related factors with the design requirements for good low-speed performance is discussed. Finally an inlet design without BLC and an optimized inlet design with slots and slats is compared to illustrate the possible reductions in nacelle size. (Author)


A single stage axial compressor with distorted inflow is studied. The inflow distortion occurs far upstream and may be a distortion in stagnation temperature, stagnation pressure or both. The blade rows are modeled as semi-actuator disks. Losses, quasi-steady deviation angles, and reference incidence correlations are included in the analysis. Both subsonic and transonic relative Mach numbers are considered. A parameter study is made to determine the influence of such variables as Mach number and swirl angle on the attenuation of the distortion. (Author)


The study concerns the influence of the three-dimensional cross flows on the compressible turbulent boundary layer development and flow separation prediction around V/STOL engine inlets at high incidence. The governing equations for the three-dimensional boundary layer flow with small-cross approximation are solved numerically on an intrinsic streamline coordinate system. Results are presented to illustrate the effects of small cross-flow, compressibility and streamline curvatures on the flow. Comparisons of the results with the wind tunnel data for scaled model and with data obtained from another existing compressible axisymmetric turbulent boundary layer scheme are included in the analysis. (Author)


The experimental verification of an inviscid, incompressible through-flow analysis method is presented. The primary component of this method is an axisymmetric streamline curvature technique which is used to compute the hub-to-tip flow field of a given turbine. To analyze the results of the flow analysis of the machine, the potential flow solution of an infinite cascade of airfoils is also computed using a source model technique. To verify the accuracy of such an analysis method an extensive experimental
verification investigation was conducted using an axial flow research fan. Detailed surveys of the blade-free region of the cascade along with intra-blade surveys using rotating pressure sensing probes and blade surface static pressure taps provide a one-to-one relationship between measured and predicted data. The results of this investigation indicate the ability of this inviscid analysis method to predict the design flow field of the axial flow fan test rotor to within a few percent of the measured values.


The rotor wake properties at several downstream distances behind the rotor of a loaded 1.2 pressure ratio fan were measured with a cross film anemometer in an anechoic wind tunnel. Mean wake characteristics in the midspan and near tip region were determined utilizing an ensemble averaging technique. The upwash and streamwise components of the velocity behind the rotor indicate a complex structure superimposed on the major velocity defects at a downstream spacing of 0.5 rotor chords. Spectral analysis indicates high levels of the second and fourth harmonics of the blade passage frequency in the midspan region while the blade passage frequency and its second and third harmonic are predominant in the tip region.


A finite element code for analysis of inviscid subsonic flows over arbitrary nonlifting planar or axisymmetric bodies is described. The code solves a novel primitive variable formulation of the coupled irrotationality and compressible continuity equations. Results for flows over a cylinder, a sphere, and a NASA 0C12 airfoil verify the code. Computed subcritical flows over an axisymmetric boattailed afterbody compare well with finite difference results and experimental data. Iterative coupling with an integral turbulent boundary layer code shows strong viscous effects on the inviscid flow. Improvements in code efficiency and extensions to transonic flows are discussed.


The results of an inviscid flow analysis are presented. The flow field, including molecular transport, is computed with the aid of a bicharacteristic method. The bow shock wave and the internal shock wave are computed with the aid of a three-dimensional shock wave fitting procedure. Characteristic equations are presented, and numerical integration procedure is discussed. Here, an inverse marching scheme is employed in which the solution is obtained on space-like planes of constant x and on space curves defined by the intersections of the internal shock wave with the solid boundaries. The distance between solution planes is arrived at by the Courant-Friedrichs-Lewy stability criterion. C.R.


Wind-tunnel pressure data and flow pictures obtained for two two-dimensional inlet models have been examined to study the internal flow structure and separation at large incidence angles. The inlet models were 12-in. high (diffuser exit height) and had internal contraction ratio of 1.21 and 1.17. They were tested at low forward speeds over a wide range of Mach numbers (inlet mass flow rates) and angles of incidence. Characteristic features of the internal flow such as a drastic change of pressure gradient near the highlight, local separation bubbles and shock/boundary-layer interactions have been indicated and discussed. For a few specific cases, the experimental surface pressure distributions have been compared with theoretical predictions.


A reliable method is presented for calculating the flowfield about a cascade of arbitrary 2-D airfoils. The method approximates the three-dimensional flow in a turbomachinery blade row by correcting for streamtube convergence and radius change in the flowthrough direction. The method is a fully conservative solution of the full potential equation incorporating the finite volume technique on a body-fitted periodic mesh, with an artificial density imposed in the transonic region to ensure stability and the capture of shock waves. Comparison of results for several supercritical blades shows good agreement with their hodograph solutions. Other calculations for these profiles as well as standard NACA blade sections indicate that this is a useful scheme for analyzing both the design and off-design performance of turbomachinery blading.


A solution method has been developed for calculating compressible inviscid flow through a linear cascade of arbitrary blade shapes. The method uses advanced surface singularity formulations which were adapted from those found in current external flow analyses. The resulting solution technique provides a fast flexible calculation for flows through turbomachinery blade rows. The solution method and some examples of the method's capabilities are presented.


A clarification is presented on recent work concerning the application of unsteady airfoil theory to rotary wings. The application of this theory may be seen as consisting of four steps: (1) the selection of an appropriate unsteady airfoil theory; (2) the resolution of the
of that velocity which is the resultant of aerodynamic and dynamic velocities at a point on the elastic axis into radial, tangential and perpendicular components, and the angular velocity of a blade section about the deformed axis, (3) the expression of lift and pitching moments in terms of the three components; and (4) the derivation of explicit expressions for the components in terms of flight velocity, induced flow, rotor rotational speed, blade motion variables, etc. O.C.


As a consequence of the growing interest in the development of V/STOL aircraft technology, efforts are being made to create new designs for a propulsion system which can be operated over a wide range of flight speeds, incidence angles, and throttle settings. In connection with these efforts, various inlet configurations have been proposed. The high experimental costs incurred in the study of various inlet geometries, led to the employment of a computational method for the investigation of inlets. Attention is given to the computer program, paneling and surface static pressure, surface flow pattern, and the inlet flow field. The reported investigation demonstrates that useful information for initial screenings may be obtained from potential flow calculations.


The assumptions on which conventional propeller aerodynamic performance analyses are based can be seriously violated when advanced high speed propellers are analyzed. Studies have been performed using a lifting line representation for the propeller to determine the sensitivity of predicted propeller performance to various assumptions in the analysis. Items which have been studied include the method of determining blade section lift and the effects of blade section drag, camber and blade sweep. The effects of nonuniform flow into the propeller and compressibility have also been studied. Comparisons of analytical and experimental results are presented to demonstrate the overall validity of the results.


Non-intrusive measurements of velocity about a spinpropeller-nacelle configuration at a Mach number of 0.8 have been performed. A laser velocimeter, specifically developed for these measurements in the NASA Lewis B-8 by 6-foot Supersonic Wind Tunnel, was used to measure the flow-field of the advanced swept SR-3 propeller. The laser velocimeter uses an argon ion laser and a 2nd order optics system to allow simultaneous measurements of 2 components of velocity. The axisymmetric nature of the propeller-nacelle flow-field permits two separate 2-dimensional measurements to be combined into 3-dimensional velocity data. Presented are data ahead of and behind the propeller blades and also a limited set in between the blades. Aspects of the observed flow-field such as the tip vortex are discussed.


A two-dimensional cascade of harmonically oscillating airfoils was designed to model a near tip section from a rotor which was known to have experienced supercritical transition and model flutter. This five bladed cascade had a solidity of 1.52 and a setting angle of 0.90 rad. Unique graphite epoxy airfoils were fabricated to achieve the realistic high reduced frequency levels of 0.15. The cascade was tested over a range of static pressure ratios approximating the blade element operating conditions of the rotor along a constant speed line which penetrated the flutter boundary. The time steady and time unsteady flow field surrounding the center cascade airfoil were investigated. Author


A method for determining highly accurate approximations to families of strongly nonlinear solutions which are either continuous or discontinuous, and which represent variations in some arbitrary parameters, is developed and evaluated. The procedure consists of defining a unit perturbation by employing two or more nonlinear solutions which differ from one another by a nominal change in some geometric or flow parameter, and then using that unit perturbation to predict a family of related nonlinear solutions over a range of parameter variation. Coordinate straining is used in determining the unit perturbation to account for the movement of discontinuities and maxima of high-gradient regions due to the perturbation. Although the procedure is generally applicable, results are presented here for nonlinear aerodynamic applications. Attention
is focused in particular on transonic flows which are strongly supercritical and exhibit large surface shock movement over the parametric range studied, and on subsonic flows which display large pressure variations in the stagnation and peak suction pressure regions. Flows past both isolated airfoils and compressor cascades involving a variety of flow and geometry parameter changes are considered. Comparisons with the corresponding 'exact' nonlinear solutions indicate a remarkable accuracy and range of validity of such a procedure. Computational time is trivial. (Author)


A method for computing three-dimensional turbulent subsonic flow in curved ducts is being developed. A set of tube-like surface oriented coordinates is employed for a general class of geometries applicable to subsonic diffusers with offset bends. The geometric formulation is complex and no previous treatment of this class of viscous flow problems is known to the authors. The duct centerline is a space curve specified by piecewise polynomials. A Frenet frame is located on the centerline at each axial location. The cross sections are described by superellipses imbedded in the Frenet frame. Duct surfaces are also coordinate surfaces, which greatly simplifies the boundary conditions. The resulting coordinates are nonorthogonal. An approximate set of governing equations is employed for viscous flows having strong flow in a primary flow direction. The derivation is coordinate invariant and the resulting equations are expressed in tensor form. These equations are solved by an efficient alternating direction implicit (ADI) method. This numerical method is generally stable and permits solution in difficult geometries using the general tensor formulation. (Author)


The results of a study supported by NASA under the Energy Efficient Engine Program, conducted to investigate the development of boundary layers under the influence of velocity distributions that simulate the suction sides of two state-of-the-art turbine airfoils, are presented. One velocity distribution represented a forward loaded airfoil ('squared-off' design), while the other represented an aft loaded airfoil ('slewed-off' design). These velocity distributions were simulated in a low-speed, high-aspect-ratio wind tunnel specifically designed for boundary layer investigations. It is intended that the detailed data presented in this paper be used to develop improved turbulence model suitable for application to turbine airfoil design. (Author)
AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations, and aircraft accidents.

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

N81-190021# National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

OZONE CONTAMINATION IN AIRCRAFT CABINS: RESULTS FROM GASP DATA AND ANALYSES


The global atmospheric sampling program pertaining to the problem of ozone contamination in commercial airplane cabins is described. Specifically, accumulative and GASP data have confirmed the occurrence of high ozone levels in airplane cabins and documented the ratio of ozone inside and outside the cabins of two 747 airliners, including the effects of air conditioning modifications on that ratio. Ambient ozone climatology, effects on commercial airplane cruise altitudes, including tabulation of encounter frequency data which were not available from GASP, and outlined procedures for estimating the frequency of flights encountering high cabin ozone levels using climatological ambient ozone data, and verified these procedures against cabin measurements.

Author

N81-190096# National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

PNEUMATIC BOOT FOR HELICOPTER ROTOR DEICING


Pneumatic deicer boots for helicopter rotor blades were tested. The tests were conducted in the 6 by 9 ft ice research tunnel on a stationary section of a UH-1H helicopter main rotor blade. The boots were effective in removing ice and in reducing aerodynamic drag due to ice. E.D.K.

N81-190097# National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

AIRCRAFT OPERATING EFFICIENCY ON THE NORTH ATLANTIC: A CHALLENGE FOR THE 1980'S


A number of changes are expected to occur in the near future which could have important consequences for Atlantic flight operations for the next decade. These changes are identified and their impact on aircraft operating efficiency is discussed. Possible alternatives for North Atlantic air carriers are reviewed and strategies and actions are suggested which may give a considerable impact on fuel savings for years to come. E.D.K.

N81-190039# National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

THE USE OF ANTIMISTING KEROSENE (AMK) IN TURBOJET ENGINES


The effect of antimisting kerosene (AMK) flow characteristics on fan jet engines and the impact of degradation requirements on the fuel system was evaluated. It was determined from the present program that AMK fuel cannot be used without predegradation, although some degradation occurs throughout the fuel feed system, especially in the fuel pumps. There is a tendency toward FM-9 AMK additive agglomeration and gel formation when the liquid flows at a critical velocity, through very small passages. The data indicate this phenomenon to be a function of the degree of degradation, the passage size the differential pressure, the fluid temperature, and the accumulated flow time. Additionally, test results indicate that the long term cumulative effects of this phenomenon may require more degradation than the theoretical requirement determined from short term tests. E.D.K.

N81-190072# National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

RECENT DEVELOPMENTS IN AIRCRAFT ENGINE NOISE REDUCTION TECHNOLOGY


Some of the more important developments and progress in jet 2nd fan noise reduction and flight effects are reviewed. Experiments are reported which show that nonaxisymmetric conical nozzles have the potential to reduce jet noise for conventional and inverted velocity profiles. It is shown that an improved understanding of suppressive linear behavior, coupled with the new understanding of fan source noise, will soon allow the joint optimization of acoustic liner and fan design for low noise. It is also shown that fan noise source reduction concepts are applicable to advanced turboprops. Advances in inflow control device design are reviewed that appear to offer an adequate approach to the ground simulation of inflight fan noise. R.C.T.
AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

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


The paper reviews results from the NASA Global Atmospheric Sampling Program (GASP) pertaining to the problem of ozone contamination in commercial aircraft cabins. Specifically, analyses of GASP data have (1) confirmed the high ozone levels in aircraft cabins and documented the ratio of ozone inside and outside the cabins of two B747 airliners, including the effects of air conditioning modifications on that ratio; (2) defined ambient ozone climatology at commercial aircraft cruise altitudes, including tabulation of encounter frequency data; and (3) outlined procedures for estimating the frequency of flights encountering high cabin ozone levels using climatological ambient ozone data and verified these procedures against cabin measurements. (Author)


It is now generally agreed that an external disturbance field, such as an incident acoustic wave, can effectively couple to instabilities of a flow past a trailing edge. One purpose of the present paper is to show that there are situations where a similar coupling can occur at a leading edge. The process is analyzed and the effects of experimentally controllable parameters are assessed. It is important to account for such phenomena when evaluating the effect of external disturbances on transition. (Author)


A short term and a long term icing research and technology program plan was drafted for NASA LeRC based on 33 separate research items. The specific items listed resulted from a comprehensive literature search, organized and assisted by a computer management file and an industry/Government agency survey. Assessment of the current facilities and icing technology was accomplished by presenting summaries of ice sensitive components and protection methods, and assessments of penalty evaluation, the experimental data base, ice accretion prediction methods, research facilities, new protection methods, ice protection requirements, and icing instrumentation. The intent of the research plan was to determine what icing research NASA LeRC must do or sponsor to ultimately provide for increased utilization and safety of light transport and general aviation aircraft. (Author)
EVALUATION OF A PNEUMATIC BOOT DEICING SYSTEM ON A GENERAL AVIATION WING MODEL

Alan E Albright (Kansas Univ., Lawrence), David L Kohlman (Kansas Univ., Lawrence), William G Schweikhard (Kansas Univ., Lawrence), and Peggy Evanich Jun. 1981 35 p refs
(Grant NASA-71)
(NASA-TM-82363; KU-FRL-464-2) Avail. NTIS
HC AO3/MF AO1 CSCL 01C

The aerodynamic characteristics of a typical modern general aviation airfoil were investigated with and without a pneumatic boot ice protection system. The ice protection effectiveness of the boot was studied. This includes the change in drag on the airfoil with the boot inflated and deflated, the change in drag due to primary and residual ice formation, drag change due to cumulative residual ice formation, and parameters affecting boot effectiveness. Boot performance was not affected by tunnel total temperature or velocity. Marginal effect in performance was associated with angle of attack. Significant effects on performance were caused by variations in droplet size, LWC, ice cap thickness, inflation pressure, and surface treatment.

AB1-20837 * # Icing tunnel tests of a glycol-exuding porous leading edge ice protection system on a general aviation airfoil. D. L. Kohlman, W. G. Schweikhard (Kansas, University, Lawrence, Kan.), and P. Evanich (NASA, Lewis Research Center, Cleveland, Ohio).
Tests were conducted in the Icing Research Tunnel at the NASA Lewis Research Center to determine the characteristics of an ice protection system that distributes a glycol solution onto the leading edge of an airfoil through a porous surface material. Minimum fluid flow rates required to achieve anti-icing (no ice formation) were determined for various flight conditions and angles of attack. The ability of the system to remove ice formed on the airfoil before system activation was also investigated.

(Author)
AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices and flight instruments.

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

N81-31190// National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

FIBER OPTICS FOR AIRCRAFT ENGINE/INLET CONTROL
1981; sponsored by the Society of Photo-Optical Instrumentation
Engineers.
(NASA-TM-82654; E-917) Avail: NTIS HC A02/MF A01 CSCL
010

NASA programs that focus on the use of fiber optics for aircraft engine/inlet control are reviewed. Fiber optics for aircraft control is attractive because of its inherent immunity to EMI and RFI noise. Optical signals can be safely transmitted through areas that contain flammable or explosive materials. The use of optics also makes remote sensing feasible by eliminating the need for electrical wires to be connected between sensors and computers. Using low-level optical signals to control actuators is also feasible when power is generated at the actuator. Each application of fiber optics for aircraft control has different requirements for both the optical cables and the optical connectors. Sensors that measure position and speed by using slotted plates can use lossy cables and bundle connectors if data transfer is in the parallel mode. If position and speed signals are multiplexed, cable and connector requirements change. Other sensors that depend on changes in transmission through materials require dependable characteristics of both the optical cables and the optical connectors. A variety of sensor types are reviewed, including rotary position encoders, tachometers, temperature sensors, and blade tip clearance sensors for compressors and turbines. Research on a gallium arsenide photoswitch for optically switched actuators that operate at 250 °C is also described.

Author
TYPES FOR FUTURE GENERAL AVIATION AIRCRAFT

Projected aircraft cost, total ownership cost, and mission fuel accomplishment fixed missions. The primary evaluation criteria include comparing these four powerplant types in several general aviation applications of interest. The evaluation consisted of installing each powerplant type in rubberized aircraft which are sized to accomplish fixed missions. The primary evaluation criteria include projected aircraft cost, total ownership cost, and mission fuel.

COMPARISONS OF FOUR ALTERNATIVE POWERPLANT TYPES FOR FUTURE GENERAL AVIATION AIRCRAFT

T. J. Wickheiser, G. Knip, R. M. Planconer, and W. C. Strack


Recently completed NASA sponsored conceptual studies were culminated in the identification of promising new technologies for future spark ignition, diesel, rotary, and turbine engines. The results of a NASA in-house preliminary assessment study that compares these four powerplants types in several general aviation applications are presented. The evaluation consisted of installing each powerplant type in rubberized aircraft which are sized to accomplish fixed missions. The primary evaluation criteria include projected aircraft cost, total ownership cost, and mission fuel.

Author

N81-10067* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-SPEED AERODYNAMIC PERFORMANCE OF 50.8-CENTIMETER-DIAMETER NOISE-SUPPRESSING INLETS FOR THE QUIET, CLEAN, SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE)

John M. Abbott, James H. Diedrich, and Robert C. Williams

Aug. 1978 37 p. refs (NASA-TP-1178; E-9542) Avail. NTIS HC A03/MF A01 CSCL 21E

Two basic inlet concepts, a high throat Mach number (0.79) design and a low throat Mach number (0.60) design, were tested with four diffuser acoustical treatment designs that had face sheet porosity ranging from 0 to 24 percent for the high Mach number inlet and 0 to 28 percent for the low Mach number inlet. The tests were conducted in a low speed wind tunnel at free stream velocities of 0.41 and 62 m/sec and angles of attack to 50 deg. Inlet throat Mach number was varied about the design value. Increasing the inlet diffuser face sheet porosity resulted in an increase in total pressure loss in the boundary layer for both the high and low Mach number inlet designs. The overall effect on inlet total pressure recovery of 0.991 at the design throat Mach number, a free stream velocity of 41 m/sec, and an angle of attack of 50 deg; inlet flow separation at an angle of attack of 50 deg was encountered with only one inlet configuration the high Mach number design with the highest diffuser face sheet porosity (24 percent) A.R.H.

Author

N81-11037* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-SPEED AERODYNAMIC PERFORMANCE OF 50.8-CENTIMETER-DIAMETER NOISE-SUPPRESSING INLETS FOR THE QUIET, CLEAN, SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE)

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Author

N81-11038* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

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

Peter L. Meiner and Arthur J. Glassman

Nov. 1980 15 p. refs (NASA-TP-1708; AVRADCOM-TR-80-C-13; E-455) Avail. NTIS HC A02/MF A01 CSCL 21E

An off-design performance loss model was developed for variable stator (pivoted vane) radial turbines through analytical modeling and experimental data analysis. Stator loss is determined by a viscous loss model; stator vane end-clearance leakage effects are determined by a clearance flow model. Rotor loss coefficient were obtained by analyzing the experimental data from a turbine rotor previously tested with six stators having throat areas from 20 to 144 percent of design area and were correlated with stator-to-rotor throat area ratio. An incidence loss model was selected to obtain best agreement with experimental results. Predicted turbine performance is compared with experimental results for the design rotor as well as with results and cutback versions of the rotor. Sample calculations were made to show the effects of stator vane end-clearance leakage.

Author

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SURFACE PYROMETRY IN PRESENCE OF RADIATION FROM OTHER SOURCES WITH APPLICATION TO TURBINE BLADE TEMPERATURE MEASUREMENT

Donald R. Buchele

Nov. 1980 19 p. refs (NASA-TP-1754; E-396) Avail. NTIS HC A02/MF A01 CSCL 21E

Surface pyrometry is feasible even when the amount of surface radiation is exceeded by radiation from surrounding sources. To measure and correct for this interfering radiation, several methods that use multiple wavelength pyrometry were compared by an error analysis. For a specific application, a turbine blade temperature measurement in a turbofan engine, a two wavelength method was best. Auxiliary measurements at the same wavelengths substantially improve the accuracy of the method.

Author

N81-12084 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-SPEED AERODYNAMIC PERFORMANCE OF 50.8 CENTIMETER-DIAMETER NOISE-SUPPRESSING INLETS FOR THE QUIET, CLEAN, SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE)

John M. Abbott, James H. Diedrich, and Robert C. Williams

Aug. 1978 37 p. refs (NASA-TP-1178; E-9542) Avail. NTIS HC A03/MF A01 CSCL 21E

Two basic inlet concepts, a high throat Mach number (0.79) design and a low throat Mach number (0.60) design, were tested with four diffuser acoustical treatment designs that had face sheet porosity ranging from 0 to 24 percent for the high Mach number inlet and 0 to 28 percent for the low Mach number inlet. The tests were conducted in a low speed wind tunnel at free stream velocities of 0.41 and 62 m/sec and angles of attack to 50 deg. Inlet throat Mach number was varied about the design value. Increasing the inlet diffuser face sheet porosity resulted in an increase in total pressure loss in the boundary layer for both the high and low Mach number inlet designs. However, the overall effect on inlet total pressure recovery of 0.991 at the design throat Mach number, a free stream velocity of 41 m/sec, and an angle of attack of 50 deg; inlet flow separation at an angle of attack of 50 deg was encountered with only one inlet configuration the high Mach number design with the highest diffuser face sheet porosity (24 percent) A.R.H.

Author

N81-12089 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF HOLE GEOMETRY AND ELECTRIC-DISCHARGE MACHINING (EDM) ON AIRFLOW RATES THROUGH SMALL DIAMETER HOLES IN TURBINE BLADE MATERIAL

Steven A. Hippensteil and Reeves P. Cochran

Nov. 1980 14 p. refs (NASA-TP-1716; E-417) Avail. NTIS HC A02/MF A01 CSCL 21E

The effects of two design parameters, electrode diameter and hole angle, and two machine parameters, electrode current and current-on time, on air flow rates through small-diameter (0.257 to 0.462 mm) electric-discharge machined holes were measured. The holes were machined individually in rows of 14 each through 1.6 mm thick IN100 strips. The data showed linear increase in air flow rate with increases in electrode cross sectional area and current-on time and little change with changes in hole angle and electrode current. The average flow rate deviation (from the mean flow rate for a given row) decreased linearly.
MULTIVARIABLE IDENTIFICATION USING CENTRALIZED FIXED MODES

Define system response in the third step. These excess or redundant states are removed by using minimal realization theory. The remaining states are related to system centralized fixed modes and are observed. The PSL algorithm was applied to the quiet, clean, short haul experimental engine. Engine control set points were modified for component degradations in order to restore the nominal net thrust. Results show convergence to the optimum value can be obtained within 60 to 90 seconds, which makes the program acceptable to on line operation with present state of the art minicomputers. Tests indicate that in most cases the PSL algorithm offers some improvement in thrust specific fuel consumption over the manual throttle.

Author

References

A. R. H.
COLD-AIR INVESTIGATION OF FIRST STAGE OF 4:1/2 STAGE, FAN DRIVE TURBINE WITH AVERAGE STAGE LOADING FACTOR OF 0.46

Warren J. Whitney, Thomas P. Moffitt, and Frank P. Behning

Jan. 1981 15 prefs

The design procedure and the development of the blading geometry for the 4 and 1/2 stage turbine are discussed. Results obtained with the first stage, operated as a single stage turbine, are presented. A free vortex design meets the design requirements without incurring problems such as excessive turning, negative reaction, or high Mach number. Cold air tests of the single stage turbine showed that the turbine developed design work (stage loading factor of 5.26) at an efficiency of 0.86, which was the efficiency predicted by a reference method. The mass flow at this condition was 0.88, which occurred at design speed and a pressure ratio of 1.407, corresponding to a stage loading factor of 4.35. The efficiency at this condition was 0.003 higher than that predicted by the reference method.

AN OVERVIEW OF GENERAL AVIATION PROPULSION RESEARCH PROGRAMS AT NASA LEWIS RESEARCH CENTER

Edward A. Willis and William C. Strack 1981 48 p ref


The review covers near-term improvements for current-type piston engines, as well as studies and limited corroborative research on several advanced g/a engine concepts, including diesels, small turboprops and both piston and rotary stratified-charge engines. Also described is basic combustion research, cycle modeling and diagnostic instrumentation work that is required to make new engines a reality.

MEAN ROTOR WAKE CHARACTERISTICS OF AN AERODYNAMICALLY LOADED 0.5 m DIAMETER FAN

L M. Shaw and F W. Glaser 1981 18 p ref


Mean rotor wake properties at several downstream distances behind the rotor of a loaded 1.2 pressure ratio fan were measured with a cross film anemometer in an anechoic wind tunnel. Mean wake characteristics in the midspan and near tip region were determined utilizing an ensemble averaging technique. The upwash and streamwise components of the velocity behind the rotor indicate a complex structure superimposed on the major velocity defects at a down stream spacing of 0.5 rotor chords. Spectral analysis indicates high levels of the second and fourth harmonics of the blade passage frequency in the midspan region while the blade passage frequency and its second and third harmonic are predominant in the tip region.

EXPIMENTAL ANALYSIS OF IMEP IN A ROTARY COMBUSTION ENGINE

H J. Schouk, W J. Rice, and P R Meng 1981 44 p ref


A real time indicated mean effective pressure measurement system is described which is used to judge proposed improvements in cycle efficiency of a rotary combustion engine. This is the first self contained instrument that is capable of making real time measurements of IMEP in a rotary engine. Previous methods used require data recording and later processing using a digital computer. The unique features of this instrumentation include its ability to measure IMEP on a cycle by cycle, real time basis and the elimination of the need to differentiate volume function in real time. Measurements at two engine speeds (2000 and 3000 rpm) and a full range of loads are presented, although the instrument was designed to operate to speeds of 9000 rpm.
A control system for a turbofan engine receives signals from a number of engine sensors and from the engine operator, and generates control signals. One control signal regulates the fan exhaust nozzle area in order to control inlet thrust Mach number to maintain a low level of engine noise. Additional control signals regulate the fuel control engine thrust and fan pitch to control engine speed. A number of schedules are utilized to maintain a predetermined relationship between the controlled parameters and a number of fixed and calculated limits can override the control signals to prevent unsatisfactory engine performance.

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


An experimental investigation was conducted to determine the effects of fuel type, fuel-air ratio, and inlet-air pressure on the spectral flame radiance emanating from a JTBD combustor. Spectral radiance measurements from 1.55 to 5.5 micrometers of wavelength were recorded and analyzed to determine soot concentration and flame temperature at various axial locations in the combustor. Two fuels differing in volatility, viscosity, and chemical composition were used in this investigation. Author


The reasons for the low aerodynamic performance of a 13.5 cm tip diameter aircraft engine starter turbine were investigated. Both the stator and the stage were evaluated. Approximately 10 percent improvement in turbine efficiency was obtained when the honeycomb shroud over the rotor blade tips was filled to obtain a solid shroud surface. Efficiency improvements were obtained for three rotor configurations when the shroud was filled. It is suggested that the large loss associated with the open honeycomb shroud is due primarily to energy loss associated with gas transportation as a result of the blade to blade pressure differential at the tip section. E.A.K.


Emissions of carbon monoxide, total oxides of nitrogen, unburned hydrocarbons, and carbon dioxide from an F100, afterburning; two speed turbofan engine at simulated flight conditions were reported. For each flight condition emission measurements were made for two or three pressure levels from intermediate power (nonafterburning) through maximum afterburning. The data showed that emissions vary with flight speed, altitude, power level, and radial position across the nozzle. Carbon monoxide emissions were low for intermediate power (nonafterburning) and partial afterburning, but regions of high carbon monoxide were present downstream of the flame holder at maximum afterburning. Unburned hydrocarbon emissions were low for most of the simulated flight conditions. The local NOx concentrations and their variability with power level increased with increasing flight Mach number at constant altitude, and decreased with increasing altitude at constant Mach number. Carbon dioxide emissions were proportional to local fuel air ratio for all conditions. Author


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 were analyzed. The analysis was made to determine the feasibility of using this concept for cooling very small turbines, primarily for short duration applications such as in missile engines. The analysis was made for gas conditions of approximately 10 and 40 atm and 1644 K and with turbine vanes made of felt type porous metals with relative densities from 0.2 to 0.6 and ceramic coating thicknesses of 0.078 to 0.264 mm. J.M.S.

N81-34088# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. FUNDAMENTAL HEAT TRANSFER RESEARCH FOR GAS TURBINE ENGINES Darryl E. Metzger, ed. (Arizona State Univ.) 1980 88 p refs Presented at a workshop held at Cleveland 8-9 Oct. 1980 (NASA-CP-2178; E-666) Avail. NTIS HC A04/MF A01 CSCL 21E

Thirty-seven experts from industry and the universities joined 24 NASA Lewis staff members in an exchange of ideas on trends in aeropropulsion research and technology, basic analyses, computational analyses, basic experiments, near-engine environment experiments, fundamental fluid mechanics and heat transfer, and hot technology as related to gas turbine engines. The workshop proceedings described include pre-workshop input from participants, presentations of current activity by the Lewis staff, reports of the four working groups, and a workshop summary. A.R.H.

N81-24088# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ANALYSIS OF EFFECT OF FLAMEHOLDER CHARACTERISTICS ON LEAN, PREMIXED, PARTIALLY VAPORIZED FUEL-AIR MIXTURES QUALITY AND NITROGEN OXIDES EMISSIONS Larry P. Cooper May 1981 18 p refs (NASA-TP-1842; E-663) Avail. NTIS HC A02/MF A01 CSCL 21E

An analysis was conducted of the effect of flameholding devices on the precombustion fuel-air characteristics and on oxides of nitrogen (NOx) emissions for combustion of premixed partially vaporized mixtures. The analysis includes the interactions of flameholder droplet collection efficiency, reactivation efficiency and blockage, and the initial droplet size distribution and accounts for the contribution of droplet combustion in partially vaporized mixtures to NOx emissions. Application of the analytical procedures is illustrated and parametric predictions of NOx emissions are presented. Author.


The extent and magnitude of performance deterioration of the Pratt and Whitney TF30 and the General Electric CF6 engine models is presented. Overall engine and contributing module performance deterioration with respect to flight cycles and/or time are analyzed. The overall engine performance deterioration analyses are based on data obtained from historical records.
special engine tests, and tests for specific effects. Hardware inspection data from overhaul shops and special module tests are the basis for the modular performance deterioration used in the analyses. Various damage mechanisms such as seal rubs, erosion, surface roughness and thermal distortion, and how they contribute to performance deterioration are included in the modular analyses. Results indicate that early performance deterioration and offer new insight into the final physics of these engines is less than 1 percent in cruise specific fuel consumption (SFC), that it is event oriented, and that it is the result of increased blade tip clearances. This performance deterioration gradually increases to about 2.5 to 3.0 percent (including the initial short term deterioration) after 2500 to 3000 flights where increased blade tip clearances, airfoil quality degradation, and thermal distortion are the contributing causes. R.C.T.

The aerodynamics and acoustics of the over-the-wing (OTW) Quiet, Clean, Short Haul Experimental Engine (QCSEE) were tested. A boilerplate (nonflight weight), high-throat Mach number, acoustically treated inlet and a D-shaped OTW exhaust nozzle with variable position side doors were used. Some acoustic directivity results for the type D nozzle and acoustic effects of variations in the nozzle side door positions are included. It was found that the results are in agreement with those previously obtained. E.A.K.

Stationary high response pressure and displacement measurements are used to describe the flutter characteristics of the first fan rotor of a turbofan engine. Flutter occurred at part speed and at high incidence. Several forward and backward traveling waves were identified in a predominantly torsional flutter mode. Positive aerodynamic work contribution was confined to the region close to the leading edge and was mainly due to modes corresponding to forward traveling waves of nodal diameters in the range 3 to 5. Author

The ability of a part span variable inlet guide vane (VIGV) to modulate the thrust of a high bypass turbofan engine was evaluated at altitude/Mach number conditions of 4572 m/0.6 and 9144 m/0.93. Fan tip, gas generator and supercharger performance were also determined, both on operating lines and during fan duct throttling. The evaluation was repeated with the bypass splitter extended forward to near the fan blade trailing edge. Gross thrust attenuation of over 50 percent was achieved with 50 degree VIGV closure at 100 percent corrected fan speed. Gas generator supercharger performance fell off with VIGV closure, but this loss was reduced when a splitter extension was added. The effect of VIGV closure on gas generator performance was minimal. Author

The results of testing to identify the effects of simulated aerodynamic flight loads on JTBD engine performance are presented. The test results were also used to refine previous analytical studies on the impact of aerodynamic flight loads on performance losses. To accomplish these objectives, a JTBD-7AH engine was assembled with average production clearances and new seals as well as extensive instrumentation to monitor engine performance, case temperatures, and blade tip clearance changes. A special loading device was designed and constructed to permit application of known moments and shear forces to the engine by the use of cables placed around the flight inlet. The test was conducted in the Pratt & Whitney Aircraft X-Ray Test Facility to permit the use of X-ray techniques in conjunction with laser-foil tip proximity probes to monitor important engine clearance changes. Upon completion of the test program, the test engine was disassembled, and the condition of gas path parts and final clearances were documented. The test results indicate that the engine lost 1.1 percent in thrust specific fuel consumption (TSFC), as measured under sea level static conditions, due to increased operating clearances caused by simulated flight loads. This compares with 0.9 percent predicted by the analytical model and previous study efforts. Author

Combustion research at Lewis is organized to provide a balanced program responsive to national needs and the gas turbine industry. The results of this research is a technology base that assists the gas turbine engine manufacturers in developing new and improved combustion systems for advanced civil and military engines with significant improvements in performance, durability, fuel flexibility and control of exhaust emissions. Research efforts consist of fundamentals and modeling, and applied component and combustor research. T.M.

High response measurements of a Pratt and Whitney F100(3) turbofan engine at a simulated Mach number and altitude of 1.2 and 3000 m (10,000 ft) respectively were recorded during a nonrecoverable stall. The nonrecoverable stall occurred as a result of incorrect scheduling of the high compressor variable vanes (RCV) during an experimental engine control investigation. Recorded data indicates rotating stall originating in the high
and engine weight on engine performance and mission range

CONCEPT IN SUPERSONIC CRUISE PROPULSION

The supersonic fan engines could be 10 to 20 percent better than other engines. They are shown to improve performance and mission range with each of the fuel injection techniques and effect of fuel type on small gas turbine combustors. Performance and pollutant emission levels are documented over a range of simulated flight conditions for a reverse flow combustor configuration using simple pressure atomizing, swirl-flow return, and splash cone airblast injectors. A parametric evaluation of the effect of increased combustor loading with each of the fuel types was obtained. Jet A and an experimental reference broad specification fuel were used to determine the effect of fuel type.

INJECTOR EVALUATION

As part of a continuing effort at the Lewis Research Center to improve performance, emissions, and reliability of turbine machinery, an investigation of fuel injection technique and effect of fuel type on small gas turbine combustors was undertaken. Performance and pollutant emission levels are documented over a range of simulated flight conditions for a reverse flow combustor configuration using simple pressure atomizing, swirl-flow return, and splash cone airblast injectors. A parametric evaluation of the effect of increased combustor loading with each of the fuel injection types was obtained. Jet A and an experimental reference broad specification fuel were used to determine the effect of fuel type.

SMALL GAS TURBINE COMBUSTOR STUDY: FUEL INJECTOR EVALUATION


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MIXING EFFECTIVENESS TEST OF AN EXHAUST GAS MIXER IN A HIGH BYPASS TURBOFAN AT ALTITUDE


The design, fabrication, and initial testing of energy efficient engine combustors, developed for the next generation of turbofan engines for commercial aircraft, are described. The combustor designs utilize an annular configuration with two zone combustion for low emissions, advanced liners for improved durability, and short, curved-wall, dump diffusers for compactness. Advanced cooling techniques and segmented construction characterize the advanced liners. Linear segments are made from castable, turbine-type materials.

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An overview of research to develop and improve the accuracy of current analysis methods so that increased durability can be designed into future engines is presented. Emphasis is placed on improved accuracy in life prediction. Component design, including description of the thermal and aerodynamic environments, material's mechanical response, the interactions between environmental and structural response, and high temperature instrumentation capable of measuring near-engine environment effects are addressed. Component tests, improved modeling of the physical phenomena, and tests to verify the proved models are also discussed. J.M.S.

An investigation was conducted to determine the feasibility of superhybrid composite blades for meeting the mechanical design and impact resistance requirements of large fan blades for aircraft turbine engine applications. Two design concepts were evaluated: (1) leading edge spar (TiCom) and (2) center spar (TiCore), both with superhybrid composite shells. The investigation was both analytical and experimental. The results obtained show promise that superhybrid composites can be used to make light, rigid, high-quality, large fan blades with good structural integrity. The blades tested successfully demonstrated their ability to meet steady-state operating conditions, overspeed, and small bird impact requirements. (Author)


The results of an experimental atmospheric rig test program developed to define a low NO(x) lean premixed annular combustor of 0.66 m diameter for high-altitude aircraft applications are presented. The test program strategy adopted evaluates the emission characteristics of a baseline configuration and subsequently examines the sensitivity of the emission signatures to variations in the key design features. The lean premixed combustor in an asymmetric annular form demonstrates the capability of operating at reduced-pressure, simulated high-altitude, supersonic cruise conditions with NO(x) emissions below 1.0 g NO2/kg fuel. The testing shows that for the full range of low emissions operation from idle to cruise, a variable dilution port system is necessary, but that fuel-switching can be avoided and a single fuel injection system used. L.S.


The feasibility of various low NO(x) emission gas turbine combustor configurations was evaluated. The configurations selected for fabrication and testing was full pressure and temperature involved rich-lean staged combustion utilizing diffusion flames, rich-lean pre vaporized/premix flames, and staged catalytic combustion. The test rig consisted of a rich burner module, a quench module, and a lean combustion module. The test results are obtained for the combustor while burning petroleum distillate fuel, a coal derived liquid, and a petroleum residual fuel. The results indicate that rich-lean diffusion flames with low fuel-bound nitrogen conversion are achievable with very high combustion efficiencies. L.S.


Results of an experimental investigation of the aerodynamic performance of a split duct annular combustor inlet diffuser system are presented. Several diffuser configurations were investigated in 3x-scale water table tests and the preferred design was evaluated in full-scale annular airflow model tests. Pressure recovery and flow losses were determined as a function of pre diffuser inlet velocity, profile, flow extraction at the pre diffuser exit, and distribution of flow in the combustor. Inlet velocity profile and turbulence levels were found to have a pronounced effect on system performance. Flow extraction at the pre diffuser exit was found to have little influence on system performance. Generally, the annular split duct diffuser system was found to satisfy the performance objectives for the engine. (Author)


Candidate external vaporizer designs for an aircraft gas turbine engine are evaluated with respect to fuel thermal stability, integration of the vaporizer system into the aircraft engine, engine and vaporizer dynamic response, startup and altitude restart, engine performance, control requirements, safety, and maintenance. The selected concept is shown to offer potential gains in engine performance in terms of reduced specific fuel consumption and improved engine thrust/weight ratio. The thrust/weight improvement can be traded against vaporization system weight. V.L.


An analytical model is proposed for predicting the onset of supersonic stall bending flutter in high-speed rotors. The analysis is based on a modified two-dimensional, compressible, unsteady actuator disk theory. The stability boundary predicted by the analysis is shown to be in good agreement with the measured boundary of a high speed fan. The prediction that the flutter mode would be forward traveling wave sensitive to wheel speed and aerodynamic loading is confirmed by experimental measurements. In addition, the analysis shows that reduced frequency and dynamic head also play a significant role in establishing the supersonic stall bending flutter boundary of an unshrouded fan. L.S.


This paper offers a systematic, computer-aided, self-documenting methodology for developing hybrid computer simulations of turbomachinery engines. The methodology is that presented in a 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 of 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. A test case is described and comparisons between hybrid simulation and specified engine performance data are presented. (Author)

A finite difference procedure was used to compute the mixing for three experimentally tested mixer geometries. Good agreement was obtained between analysis and experiment when the mechanisms responsible for secondary flow generation were properly modeled. Vorticity generation due to flow turning and vorticity generated within the centerbody-lobe passage were found to be important. Results are presented for two different temperature ratios between fan and core streams and for two different free-stream turbulence levels. It was concluded that the dominant mechanisms in turbofan mixers is associated with the secondary flows arising within the lobe region and their development within the mixing section. (Author)


NASA programs for developing fuel saving technology include the Engine Component Improvement Project for short-term improvements in existing air engines. The Performance Improvement section is to define component technologies for improving fuel efficiency for CF6, JT9D and JT8D turbofan engines. Sixteen concepts were developed and nine were tested while four are already in use on airlines. If all sixteen concepts are successfully introduced in the engine will be fuel savings of more than 6 billion gallons over the lifetime of the engines. The improvements include modifications in fan, mounts, exhaust nozzles, turbine clearance and turbine blades. D.B.


NASA programs for improving aircraft engine fuel efficiency include the Engine Component Improvement Project of which the Engine Diagnostics section is to identify performance deterioration factors for the JT9D and CF6 high-bypass ratio turbofan engines and to develop technology for fuel consumption reduction. The program tests and inspects engines, examines deteriorated elements, formulates deterioration trends and models, identifies specific causative events or modules and determines mechanisms. Results show that long-term performance deterioration is less than 1% of cruise specific fuel consumption and is caused by flight loads or thermal damage due to rubbing of turbine blade tips against shrouds. Long-term deterioration is 2.5-3% of cruise specific fuel consumption after 2500-3000 flights and mechanisms are thermal damage to blade tips with rubbing and damaged airfoils and parts. D.B.


The Energy Efficient Engine (EE] Project is directed at providing, by 1984, the advance technologies which could be used for a new generation of fuel conserving turbofan engines. This paper summarizes the scope of the entire project and the current status of these efforts. Included is a description of the preliminary designs of the fully developed engines, the potential benefits of these advanced engines, and highlights of some of the component technology efforts conducted to date. (Author)


NASA's Advanced Turboprop Project is a three-phase effort initiated in 1978 to provide technology for a high-speed turboprop-powered aircraft with the potential for fuel savings and DOC reductions of up to 30 and 15%, respectively, relative to current in-service aircraft. This paper reviews the status of Phase I in the areas of propeller aerodynamics, propeller structures, turboprop installed performance, aircraft cabin environment, and turboprop engine and aircraft studies. Current plans to establish large-scale propeller characteristics and to conduct high-speed propeller flight research tests using a modified testbed aircraft are also presented. (Author)


An off-design performance loss model for a radial turbine with pivoting, variable-area stator is developed through a combination of analytical modeling and experimental data analysis. A viscous model is used for the variation in stator loss with setting angle, and stator vane end-clearance leakage is predicted by a clearance flow model. The variation of rotor loss coefficient with stator setting angle is obtained by means of an analytical matching of experimental data for a rotor that was tested with six stators, having throat areas from 20 to 144% of the design area. An incidence loss model is selected to obtain best agreement with experimental data. The stator vane end-clearance leakage model predicts increasing mass flow and decreasing efficiency as a result of end-clearances, with changes becoming significantly larger with decreasing stator area. O.C.


An experimental investigation is presented to determine the aerodynamic performance deficit of a 13.5 centimeter tip-diameter aircraft engine starter turbine. The two-phase experimental component consisted of both the stator and the stage performance, and the experimental design is described in detail. Data obtained from the investigation of three honeycomb shrouds clearly showed that the filled honeycomb reduced a total efficiency of 0.686, 8.2 points higher than the open honeycomb shroud, at design equivalent conditions of speed and blade jet speed ratio. It was concluded that the use of an open honeycomb shroud caused the large performance deficit for the starter turbine. Further research is suggested to ascertain stator inlet boundary layer measurements. E.B.


The variables affecting the design of a composite turbine shroud, consisting of a metal base, an interlayer of porous metal, and an outer layer of yttria-stabilized zirconia, are analyzed. Results show that significant reductions in the cooling-air to gas-flow ratio are
indicated for the composite shrouds compared to an all-metal shroud that was only impingement air cooled. The good insulating properties of the ceramic reduced the temperatures of the porous metal and support wall significantly. For a given porous metal density and coolant- to-gas-flow ratio, decreasing the thickness of the porous metal and increasing ceramic thickness resulted in lower support wall temperatures. To maintain given allowable inter-layer temperatures and coolant- to-gas-flow ratios, porous-metal density or thermal conductivity must increase as the ratio of the thickness of the ceramic-to-porous metal decreases. It is concluded that a 1.78 mm thickness of porous material with a density of 0.2 and a 1.78 mm thickness of ceramic appears to be a good composite wall configuration for the assumed conditions.

E.B.


A survey of propulsion control requirements forming part of an advanced V/STOL control requires these to be determined from other findings: (1) that the dependence of V/STOL flying qualities on propulsive lift makes it necessary to identify propulsion control requirements early in a development program; (2) that V/STOL control of the future should relieve the pilot of control functions and elevate him to the position of a flight operations manager, with substantial gains in capability and/ or safety; and (3) that research is required to define the V/STOL control system reliability requirements and specific component reliability allocations. An interactive, integrated design process for the realization of these objectives is also described. O.C.


Because liquid methane may be obtained from existing natural gas sources or produced synthetically from a range of other hydrocarbon sources (coal, bitumen, shale, organic waste), it is considered as an aviation fuel in a simplified cycle analysis of the performance of a turboprop engine intended for operation at Mach 0.8 and 10,688 m altitude. Performance comparisons are given for four cases in which the turbine cooling air is either not cooled or cooled to -111, 222, and -333 K, and the advantages and problems that may be expected from direct use of the cryogenic fuel in turbine cooling are discussed. It is shown that while (1) methane combustion characteristics are appreciably different from those of Jet A fuel and will require the development of different combustor designs, and (2) the safe integration of methane cryotanks into transport aircraft structures poses a major design problem, a highly fuel-efficient turboprop engine fueled by methane appears to be feasible. O.C.


A real-time digital simulation technique providing the capabilities needed to evaluate propulsion system performance and aircraft system interaction on NASA manned flight simulators, is discussed. A parameter correlation technique is used with real and pseudo-dynamics in a stable integration convergence loop. The cycle time reported was 2.0 ms on one computer and 5.7 ms on the simulator computer. The model was found to be stable and accurate with time up to 50 ms. It is concluded that the program has generated a valuable simulation technology and flight simulator experience by providing an adequate level of detail to evaluate propulsion systems in a simulated flight environment.


The ability of a part-span variable inlet guide vane to modulate the thrust of a high bypass turbofan engine was evaluated at altitude/Mach number conditions of 4572 m/0.6 and 9144 m/0.93. Fan-tip, gas generator and supercharger performance were also determined, both on operating lines and during fan duct throttling. The evaluation was repeated with the bypass splitter extended forward to near the fan blade trailing edge. Gross thrust attenuation of over 50% was achieved with 50 deg variable inlet guide vane closure at 100% corrected fan speed. Gas generator supercharger performance fell off with variable inlet guide vane closure but this loss was reduced when a splitter extension was added. The effect of variable inlet guide vane closure on gas generator performance was minimal. (Author)


Combustion research at Lewis is organized to provide a balanced program responsive to national needs and the gas turbine industry. The results of this research is a technology base that assists the gas turbine engine manufacturers in developing new and improved combustion systems for advanced civil and military engines with significant improvements in performance, durability, fuel flexibility and control of exhaust emissions. Research efforts consist of fundamentals and modeling, and applied component and combustor research. This paper reports on some of the progress and results that have been achieved recently in all three research areas. (Author)


This paper presents the results of testing to identify the effects of simulated aerodynamic flight loads on JT9D engine performance. The test results were also used to refine previous analytical studies on the impact of aerodynamic flight loads on performance losses. To accomplish these objectives, a JT9D-7AH engine was assembled with average production clearances and new seals as well as extensive instrumentation to monitor engine performance, case temperatures, and blade tip clearance changes. A special loading device was designed and constructed to permit application of known moments and shears to the engine by the use of cables placed around the flight inlet. The test was conducted in the Pratt and Whitney Aircraft X-Ray Test Facility to permit the use of X-ray techniques in conjunction with laser blade tip proximity probes to monitor important engine clearance changes. Upon completion of the test program, the test engine was disassembled, and the condition of gas path parts and final clearances were documented. The test results indicate that the engine lost 1.1 percent in thrust specific fuel consumption (TSFC), as measured under sea level static conditions, due to increased operating clearances caused by simulated flight loads. This compares with 0.8 percent predicted by the analytical model and previous study efforts. (Author)
AIAA-40971 * #  

Engine performance and mission studies were carried out for a single-spool turbine bypass engine (TBE) concept. Comparisons were made between the TBE, a conventional single-spool turbojet, and the Pratt and Whitney Variable Stream Control Engine (VSCE). The aircraft assumed for the study was a Mach 2.32 commercial supersonic transport. The nominal mission was a 4000 n mi total range with a 300 n mi subsonic cruise leg. The figure of merit was the mission takeoff gross weight for the mission. Comparisons of the three engines were also made for the 4000 n mi total range with longer subsonic cruise legs. (Author)

AIAA-40973 # 

Engine performance and mission studies were conducted for a novel turbofan engine concept incorporating a supersonic through-flow fan, and comparisons were made with two supersonic transport (SST) engine concepts of equivalent thrust and technological sophistication. It was found that in the case of an SST with a cruise speed of Mach 2.32, the through-flow fan engine may yield ranges 10 to 20% greater than the two alternatives considered. The engine has a conventional core, with the supersonic fan being driven by a concentric low-pressure turbine that is uncoupled with the single, high pressure turbine/compressor core spool. Among the topics discussed were the methods of analysis employed and perturbation studies concerning supersonic fan adiabatic efficiency, fan discharge characteristics and propulsion system weight. (O.C.)

AIAA-42176 # 

The technology programs for the Energy Efficient Engine (E3) combustors are outlined, status and test results to date are summarized, and present and future challenges indicated. The NASA-sponsored programs, which are being conducted at General Electric Company and Pratt & Whitney Aircraft, are making important technology advances. Both combustor designs utilize an annular configuration with two-zone combustion for low emissions, advanced liners for improved durability, and short, curved-wall, dump preheaders for compactness. Advanced cooling techniques and segmented construction characterize the advanced liners in both programs. Liner segments are made from castable, turbine-type materials. At this time, analysis and design activities have been completed; experimental evaluations are progressing. Test results are verifying both design concepts for combustion, cooling, and mechanical integrity. All goals appear capable of being met, with the exception of NO(x). (Author)

AIAA-4278 # 

A survey is presented of current research efforts in general aviation, low-speed propeller design and high-speed propfan design, with attention on such features as (1) advanced blade shapes, with novel airfoils and sweep, (2) tip devices, (3) inter-bladed propeller/nacelle designs, (4) area-ruled spinners, (5) lightweight, all-composite blade construction, and (6) contra-rotating propfan systems. The potential overall improvements associated with these design modifications are calculated to lie at 10-15% for low-speed rotors and 15-30% for high-speed ones. Emphasis is placed on noise reduction, blade drag, performance prediction methods and wind tunnel testing of alternative rotor configurations. Extensive use of graphs is made in performance comparisons between alternative blade and rotor designs. (O.C.)

AIAA-42778 * 

This paper presents a brief overview and technical highlights of general aviation (g/a) propulsion research efforts and studies which have been underway at NASA's Lewis Research Center (LERC) for the past several years. The review covers near-term improvements for current-type piston engines, as well as studies and limited corroboration of research on several advanced g/a engine concepts, including diesels, small turboprops and 200 piston and rotary stratified-charged engines. Also described is basic combustion research, cycle modeling and diagnostic instrumentation work that will be required to make the new engines a reality. The discussion emphasizes the most recently-completed studies and the basic underlying research work, which have not been reported previously. (Author)

AIAA-44225 * 

Thermal mixing effectiveness characteristics of an eighteen low-scalloped and unscalloped, partial, forced mixer were measured in a high-bypass turbofan engine. Data were also obtained without the mixer installed, i.e., free mixing. Tests were conducted at four combinations of simulated flight conditions from 0.3 to 0.8 Mach number and from 6,096 (20,000 ft) to 13,715 m (45,000 ft) altitude. Mixing chamber lengths of L/D = 0.52 and 0.65 were tested. For this range of test conditions and mixer configurations the forced mixing effectiveness varied from 59 to 68 percent. Values of mixing effectiveness and total pressure loss were calculated from temperature and pressure data obtained at the mixer inlet and exhaust nozzle exit. (Author)

AIAA-48621 * 

The AirResearch Quiet General Aviation Turboprop engine was tested on a vertical lift fan facility to measure the acoustic performance of two inflow control devices (ICD) of similar design, and three inlet lips of different external shape. Fan-field directivity patterns calculated by existing analyses were compared with the measured fan fundamental blade passing frequency (BPF/F) and broadband data. Installing an ICD on an engine with hardwall ducts reduced the BPF/F tone everywhere in the far-field. When the ICD was installed on an engine with active acoustic panels, tone reduction in the forward quadrant was comparable to that in the hardwall tests: in the aft quadrant, however, tone noise was attenuated by the large acoustic panels in the bypass duct to such a degree that the ICD had little effect. Tests to compare performance of ICDs with hardwall inlet ducts showed only minor differences in the BPF/F directivity patterns, while broadband noise was the same for both. Forward quadrant BPF/F and broadband directivity patterns were found to be similar for the inlet lips tested with a hardwall inlet duct. At high fan speeds, however, the shape of the analytical multimodal tone

A research fan stage is acoustically tested in an anechoic wind tunnel with a 41 m/sec tunnel flow. Two stator vane numbers giving cut-on and cut-off conditions are tested at three rotor stator spacings ranging from 0.5 to 2.0 rotor chords. Hot-film anemometer turbulence measurements are made at the leading edge of the stator for each spacing and a crossed film anemometer is radially traversed to define streamwise and upwash characteristics of the rotor blade wakes. Trends in the acoustic results are observed in the front and aft quadrants at 80% design fan speed. Aft quadrant results demonstrate a fundamental tone 9 dB lower for the 25 vane stator than for the 45 vane stator, while overtone levels are 3 dB higher. The cut-off criterion strongly controls fundamental tone level at all spacings, and spacing trends of the wake-deflect upwash component show good agreement with corresponding cut-on acoustic tone levels.

D.L.G.


Predicted engine core noise levels for subsonic CTOL aircraft engines are compared with measured total aircraft noise levels and to current and proposed federal noise certification requirements. Comparisons made at FAR-36 measuring stations and take into consideration bonnet full and cutback power operations at takeoff. The spectral shape used for the prediction of core noise is identified as the spectral envelope, with a peak at 400 Hz which is assumed to be shifted in flight by a Doppler shift in frequency. Precise noise levels are computed for appropriate engine power settings at desired flight conditions, and reductions in sideline noise levels are made to account for jet and airframe shielding effects. Results indicate that core noise can provide a barrier to the proposed EPA stage 4 and 5 tip speed fan, 2 Final Report C. R. Bosh Dec. 1980. 185 p. refs (Contract NAS3-20591)

Tests were conducted on a 0.5 hub/tip ratio single-stage fan designed to produce a pressure ratio of 2.26 at an efficiency of 83.9 percent with a rotor tip speed of 548.6 m/sec (1800 ft/sec). The rotor was designed utilizing a quasi three dimensional design system and four-pant, multiple-circular-arc airfoil sections. The rotor is the third in a series of single-stage fans that have included a precompression airfoil design and a multiple-circular-arc airfoil design. The stage achieved a peak efficiency of 82.8 percent after performance had deteriorated by 0.6% of a point. The design mass flow was achieved at the peak efficiency point, and the stage total pressure ratio was 2.20, which is lower than the design goal of 2.28. The surge margin of 13% from the peak efficiency point exceeded the design goal of 7%

Author


Cockpit cruise recordings and test cell data in conjunction with hardware inspection results from aircraft overhaul shops were analyzed to define the extent and magnitude of performance deterioration. The General Electric CF6-50 high bypass turbofan engine. The magnitude of short term deterioration was isolated from the long term and the individual damage mechanisms that were the cause for the majority of the performance deterioration was identified. It was determined that the long term engine performance deterioration characteristics were different for the 3 aircraft types currently powered by the CF6-50 engine, but these differences were due to operational considerations (flight length and takeoff derate) and not to differences associated with the aircraft type. Unrestored losses, that is, performance deterioration which remains after engine refurbishment, represents over 70 percent of the total performance deterioration at engine shop visit. Surface damage, such as, increased surface roughness, leading edge shape changes on airfoils, and increases in the average clearances between rotating and stationary components is the major contributor to performance deterioration. Seventy percent of the unrestored losses are cost effective to restore, and if implemented could reduce fuel consumption by CF6-50 engines by 28 million gallons in 1980.

R.C.T.


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Author


An endothermically heated technology was used to manufacture low cost, directionally solidified, uncooled nickel-alloy blades for the TF33-3 turbofan engine. The MAR-M 247 and MER-M 100+ Hf blades were finish processed through heat treatment, machining, and coating operations prior to 150 hour engine tests consisting of the following sequences: (1) 50 hours of simulated cruise cycling (high fatigue evaluation); (2) 50 hours at the maximum continuous power rating (stress rupture endurance low cycle fatigue). None of the blades visually showed any detrimental effects from the test. This was verified by post test metallurgical evaluation. The specific fuel consumption was reduced by 2.4% with the uncooled blades. A.R.H.
FOR A SUPERSONIC PROPULSION SYSTEM DESIGN OF A MULTIVARIABLE INTEGRATED CONTROL FOR A SUPERSONIC PROPULSION SYSTEM

Edward C. Beattie \[In NASA, Lewis Research Center.\] Propulsion Controls, 1979-1980 p 35-47 ref. (For primary document see N81-12090 03-07)

An inlet/engine/nozzle integrated control mode for the propulsion system of an advanced supersonic commercial aircraft was studied. Results show that integration of these control functions can result in both operational and performance benefits for the propulsion system. For example, this integrated control mode may make it possible to minimize the use of inlet bypass doors for shock position control. This may be of benefit to the aircraft as a result of minimizing: (1) bypass bleed drag effects; (2) perturbations to the aircraft resulting from the side thrust effect of the bypass bleeds; and (3) potential unstarts of the inlet. A conceptual integrated control mode was developed which makes use of many cross coupling paths between inlet and engine control variables and inlet and engine sensed variables. A multivariable control system is designed based upon linear quadratic regulator theory was applied to designing the feedback gains for this control to allow a simulation evaluation of the benefits of the integrated control mode.

Author

PROPULSION CONTROLS

Ronald D. Hartney \[In NASA, Lewis Research Center.\] Propulsion Controls, 1979-1980 p 49-59 ref. (For primary document see N81-12090 03-07)

Increased system requirements and functional integration with the aircraft have placed an increased demand on control system capability and reliability. To provide these at an affordable cost and weight and because of the rapid advances in electronic technology, hydromechanical systems are being phased out in favor of digital electronic systems. The transition is expected to be orderly from electronic trimming of hydromechanical controls to full authority digital electronic control. Future propulsion system control systems will be highly reliable full authority digital electronic with selected component and circuit redundancy to provide the required safety and reliability. Redundancy may include a complete backup control of a different technology for single engine applications. The propulsion control will be required to communicate rapidly with the various flight and fire control avionics as part of an integrated control concept.

A.R.H.

FUTURE AIR FORCE AIRCRAFT PROPULSION CONTROL SYSTEMS: THE EXTENDED SUMMARY PAPER

Charles A. Skaife \[In NASA, Lewis Research Center.\] Propulsion Controls, 1979-1980 p 63-87 ref. (For primary document see N81-12090 03-07)

Hydromechanical control technology simply cannot compete against the performance benefits offered by electronics. Future military aircraft propulsion control systems will be full authority, digital electronic microprocessor base systems. Anticipating the day when microprocessor technology will permit the integration and management of aircraft flight control, fire control and propulsion control systems, the Air Force Aero Propulsion Laboratory is developing control logic algorithms for a real-time adaptive control and diagnostic information system.

A.R.H.

SHOULD WE ATTEMPT GLOBAL (INLET ENGINE AIRFRAME) CONTROL DESIGN?

Christopher M. Carlin \[In NASA, Lewis Research Center.\] Propulsion Controls, 1979-1980 p 71-82 ref. (For primary document see N81-12090 03-07)

The feasibility of multivariable design of the entire airplane control system is briefly addressed. An intermediate step in that direction is to design a control for an inlet engine augmentor system by using multivariable techniques. The supersonic cruise, large scale inlet research program is described which will provide an opportunity to develop, integrate, and wind tunnel test a control for a mixed compression inlet and variable cycle engine. The integrated propulsion airframe control program is also discussed which will introduce the problem of implementing MVC within a distributed processing avionics architecture, requiring real time decomposition of the global design into independent modules in response to hardware communication failures.

M.G.

ROAD MAP TO ADAPTIVE OPTIMAL CONTROL

Robert Boyer \[In NASA, Lewis Research Center.\] Propulsion Controls, 1979-1980 p 83-97 ref. (For primary document see N81-12090 03-07)

A building block control structure leading toward adaptive, optimal control for jet engines is developed. This approach simplifies the addition of new features and allows for easier checkout of the control by providing a baseline system for comparison. Also, it is possible to eliminate certain features that do not have payoff by being selective in the addition of new building blocks to be added to the baseline system. The minimum acceptable approach specifically addresses the need for active identification of the plant to be controlled in real time and real time optimization of the control for the identified plant.

M.G.

ENGINE IDENTIFICATION FOR ADAPTIVE CONTROL

Robert G. Leonard and Eric M. Arens \[In NASA, Lewis Research Center.\] Propulsion Controls, 1979-1980 p 97-104 ref. (For primary document see N81-12090 03-07)

(Grant NAG3-3118)

An attempt to obtain a dynamic model for a turbofan gas turbine engine for the purpose of adaptive control is described. The requirements for adaptive control indicate that a dynamic model should be identified from data sampled during engine operation. The dynamic model identified was of the form of linear differential equations with time varying coefficients. A turbine engine is, however, a highly nonlinear system; so the identified model would be valid only over a small area near the operating point, thus requiring frequent updating of the coefficients in the model. Therefore it is necessary that the identifier use only recent information to perform its function. The identifier selected minimized the square of the equation errors. Known linear systems were used to test the characteristics of the identifier. It was found that the performance was dependent on the number of data points used in the computations and upon the time interval over which the data points were obtained. Preliminary results using an engine deck for the quiet, clean, shorthaul experimental engine indicated that the identified model predicts the engine motion well when there is sufficient dynamic information, that is when the engine is in transient operation.

M.G.
APPLICATION TO TURBOFAN ENGINE CONTROL
MULTIVARIABLE NYQUIST ARRAY METHOD WITH APPLICATION TO TURBOFAN ENGINE CONTROL
Gary L. Sachan
Propulsion Controls, 1979 Oct 1980 p 105-110 refs (For primary document see N81-12090 03-07)
Avail. NTIS HC A07/MF A01 CSCL 21E

Extensions to the multivariable Nyquist array (MNA) method are used to design a feedback control system for the quiet clean shashlet experimental engine. The results of this design are compared with those obtained from the deployment of an alternate control system design on a full scale nonlinear, real time digital simulation. The results clearly demonstrate the utility of the MNA synthesis procedures for highly nonlinear sophisticated design applications.

M.G.

MULTIVARIABLE SYNTHESIS WITH TRANSFER FUNCTION
Joseph L. Peckowski
In NASA Lewis Research Center Propulsion Controls, 1979 Oct 1980 p 111-127 refs (For primary document see N81-12090 03-07)
Avail. NTIS HC A07/MF A01 CSCL 21E

A transfer function design theory for multivariable control synthesis is highlighted. The use of unique transfer function matrices and two simple, basic relationships: a synthesis equation and a design equation... are presented and illustrated. This multivariable transfer function approach provides the designer with a capability to specify directly desired dynamic relationships between command variables and controlled or response variables. At the same time, insight and influence over response simplifications, and internal stability is afforded by the method. A general, comprehensive multivariable synthesis capability is indicated including nonminimum phase and unstable plants. Gas turbine engine examples are used to illustrate the ideas and method.

M.G.

MULTIVARIABLE CYCLE ENGINE CONCAVE EXHAUST SYSTEMS AT SIMULATED TAKEOFF AND CRUISE CONDITIONS
Final Report
D.P. Nelson
17 Dec. 1980 70 p refs
(Contract NAS3-20661)

Wind tunnel tests were conducted to evaluate the aerodynamic performance of a concave exhaust nozzle for a proposed variable stream control supersonic propulsion system. Tests were conducted with two simultaneous configurations differing primarily in the fan duct flowpaths: a short flat mechanism for fan stream control with an isentropic contoured flow splitter, and an iris nozzle with a conical flow splitter. Both designs feature a translating primary plug and an auxiliary inlet ejector. Tests were conducted at takeoff and simulated cruise conditions. Data were acquired at Mach numbers of 0.36, 0.9, and 2.0 for a wide range of nozzle operating conditions. At simulated supersonic cruise, both configurations demonstrated good performance, comparable to levels assumed in earlier advanced supersonic propulsion studies. However, at subsonic cruise, both configurations exhibited performance that was 6 to 7.5 percent less than the study assumptions. At takeoff conditions, the iris configuration performance approached the assumed levels, while the short flat design was 4 to 6 percent less.

Author

TEADYNE CONTINENTAL MOTORS, MOBILE, ALA. AIRCRAFT PRODUCTS DIV.
ADVANCED TECHNOLOGY SPARK-IGNITION AIRCRAFT PISTON ENGINE DESIGN STUDY Final Report
Kenneth J. Stuckas
Nov 1980 127 p refs
(Contract NAS3-21272)
(NASA-CR-165162) Avail. NTIS HC A07/MF A01 CSCL 21E

The advanced technology, spark ignition, aircraft piston engine design study was conducted to determine the improvements that could be made by taking advantage of technology that could reasonably be expected to be made available for an engine intended for production by January 1, 1990. Two engines were proposed to account for levels of technology considered to be moderate risk and high risk. The moderate risk technology engine is a homogeneous charge engine operating on gasoline and offers a 40% improvement in transportation efficiency over present designs. The high risk technology engine, with a stratified charge combustion system using kerosene-based jet fuel, projects a 55% improvement in transportation efficiency. Technology enablement program plans are proposed herein to set a timetable for the successful integration of each item of required advanced technology into the engine design.

Author

Pratt and Whitney Aircraft, East Hartford, Conn.
ENERGY EFFICIENT ENGINE DIFFUSER/COMBUSTOR MODEL TECHNOLOGY
W.B. Gardner
Jun 1980 62 p refs
(Contract NAS3-215157: PWA-5594-122) Avail. NTIS HC A04/MF A01 CSCL 21E

A full scale, full annular diffuser/combustor model test rig was tested to investigate how configurational changes affect pressure loss and flow separation characteristics. The rig was characterized by five major modules: inlet, prediffuser, strut, simulated combustor, and full combustor. The prediffuser featured a short, curved wall dump design. Performance goals included: (1) a separation-free prediffuser flow field; (2) total pressure loss limited to 3.0 percent in the prediffuser and shrouds, and (3) an overall section pressure loss of 5.5 percent at Mach 7.3 at the design airflow distribution. The results indicated that the prediffuser configurations operate well within the program goals for pressure loss and demonstrate separation free operation over a wide range of inlet conditions.

Author

Spectron Development Labs., Inc., Costa Mesa, Calif.
FUEL INJECTOR CHARACTERIZATION STUDIES Final Report
Michael J. Houser and William D. Bachalo
Oct. 1980 54 p refs
(Contract NAS3-21288)

The automation of several general aviation piston engine manifold port fuel injectors was investigated. The injectors were installed in a test rig and operated under simulated conditions. Laser interferometric techniques were used to optically probe the spray droplet fields for droplet size and velocity at numerous spatial locations throughout the field.
A computer simulation model for the J85-13/Planar Pressure Pulse Generator was developed. This model incorporates a novel technique for describing the unsteady blade lift force. The approach significantly enhanced the capability of the model to handle unsteady flows. In addition, the frequency response characteristics of the J85-13/P3G test installation were analyzed in support of selecting instrumentation locations to avoid standing wave nodes within the test apparatus and thus, low signal levels. The feasibility of employing explicit analytical expression for surge prediction was also studied.

The stability of the mass and momentum radial momentum and energy as well as change in radial on investment times probability of access were divided by development cost. A recommended final ranking of technologies was based primarily on consideration of Relative Values with secondary consideration given to changes in other economic parameters. Technologies studying the most promising cost/benefits were thermal barrier coated temperature nacelle/ engine system composite.

N81-15005† General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
(Contract NAS3-21259)
N81-15006# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div
COST/BENEFIT ANALYSIS OF ADVANCED MATERIALS TECHNOLOGIES FOR FUTURE AIRCRAFT TURBINE ENGINES Final Report
G. E. Stephens Aug 1980 49 p ref
(Contract NAS3-20584)
N81-15007# Avco Lycoming Div., Stratford, Conn.
Jon German, Philip W. Fogle, and Craig Wilson. Apr. 1980 226 p refs
(Contract NAS3-20584)
N81-15008# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div
COST/BENEFIT ANALYSIS OF ADVANCED MATERIALS TECHNOLOGIES FOR FUTURE AIRCRAFT TURBINE ENGINES Final Report
G. E. Stephens Aug 1980 49 p ref
(Contract NAS3-20584)
N81-15009# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
CORE COMPRESSOR EXIT STAGE STUDY. VOLUME 2: DATA AND PERFORMANCE REPORT FOR THE BASELINE CONFIGURATION
D. C. Wisler. Nov. 1980 176 p refs
(Contract NAS3-20070)
(Contract NAS3-20070)
modeling the cyclic thermomechanical response of a simulated combustor liner specimen. Cyclic life prediction technology for creep/tireture interaction is evaluated for a variety of state-of-the-art tools for crack initiation and propagation. The sensitivity of the initiation models to a change in the operating conditions is also assessed. A.R.H.


N81-17065* Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div. MODEL AERODYNAMIC TEST RESULTS FOR TWO VARIABLE CYCLE ENGINE COANNULAR EXHAUST SYSTEMS AT SIMULATED TAKEOFF AND CRUISE CONDITIONS. COMPREHENSIVE DATA REPORT. VOLUME 3: GRAPHICAL DATA BOOK 2 D. P. Nelson Jan. 1981 487 p refs (Contract NAS3-20061) (NASA-CR-158819-Vol-3-Bk-2: PWA-8550-50-Vol-3-Bk-2) Avail: NTIS HC A20/MF A01 CSCL 21E A graphical presentation of the aerodynamic data acquired during coannular nozzle performance wind tunnel tests is given. The graphical data consist of plots of nozzle gross thrust coefficient, fan nozzle discharge coefficient, and primary nozzle discharge coefficient. Normalized model component static pressure distributions are presented as a function of primary total pressure, fan total pressure, and ambient static pressure for selected operating conditions. In addition, the supersonic cruise configuration data include plots of nozzle efficiency and secondary-to-fan total pressure pumping characteristics. Supersonic and subsonic cruise data are given. M.G.

transported to the FPS, producing a fuel burn savings of 15 to 23% and a direct operating cost reduction of 5 to 12% depending on the mission and study aircraft characteristics relative to the reference engine.

Michael S. Hudson, Michael A. Jonovicz, and Franklin A. Rockwood
(Contract NAS3-20585)
Avail NTIS HC A15/MF A01 CSCL 21E

This report describes the design configuration and method used to design the forced engine exhaust to bypass air mixing.
components and subcomponents that could be adapted to use in different locations in the engine and the different engine sizes. A variety of materials and manufacturing methods were projected with a goal for the lowest number of parts at the lowest possible cost. After a preliminary evaluation of all four frame concepts, two designs were selected for an extended design and evaluation which narrowed the final selection down to one frame that was significantly lower in cost and slightly lighter than the other frame. An implementation plan for this lowest cost frame is projected for future development and includes prospects for reducing its weight with proposed unproven, innovative fabrication techniques. 


A model for predicting the distribution of liquid fuel droplets and fuel vapor in premixing-prevaporizing fuel-air mixing passages has been developed. The analysis involves the use of computer codes which calculate the two dimensional or axisymmetric air flow field; calculate the three dimensional fuel droplet trajectories and evaporation rates; and calculate the fuel vapor diffusion through a moving air stream. A description of the more important features of the model and the results of a design study on two premixing-fuel-air passages are presented. (Author)


This paper describes the theoretical methodology used in developing an analysis for the response of turbine engine fan blades subjected to soft body (bird) impacts and the computer program that was developed using this methodology as its basis. This computer program is an outgrowth of two programs that were previously developed for the purpose of studying problems of a similar nature (a three-mode beam impact analysis and a multi-mode beam impact analysis). The present program utilizes an improved missile model that is interactively coupled with blade motion which is more consistent with actual observations. It takes into account local deformation at the impact area, blade camber effects, and the spreading of the impacted missile mass on the blade surface. In addition, it accommodates plate-type mode shapes. The analysis capability in this computer program represents a significant improvement in the development of the methodology for evaluating potential fan blade materials and designs with regard to foreign object impact resistance. (Author)


An analytic evaluation of the dynamic effects of two flight load conditions of the JT9D-774F propulsion system is conducted. Predicted performance changes associated with a once-per-flight vertical gust and a typical revenue service landing are calculated. The predicted dynamic load effects on thrust specific fuel consumption are found to be negligible. The results indicate that the quasi-steady state approach to flight loads modeling is adequate to investigate factors important to the deterioration process.
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).


The two new facilities have been installed and operated at their design or rated conditions. The important feature of both of these facilities is that the ratio of turbine inlet temperature to coolant temperature encountered in high temperature engines can be duplicated at moderate turbine inlet temperature. Included in the discussion are the limits of the facilities with regard to maximum temperature, maximum pressure, maximum mass flow rate, turbine size, and dynamometer torque-speed characteristics. (Author)
12 ASTRONAUTICS (GENERAL)
For extraterrestrial exploration see 91 Lunar and Planetary Exploration.


This paper describes the preliminary concept, specifications, and requirements of a reusable Zero-Gravity Combustion Facility for use by experimenters aboard the Spacelab payload of the Space Transportation System Orbiter. The proposed facility allows a wide variety of combustion research experiments, from rapid burning to long term smoldering, in a low gravity environment. Included is the philosophy behind the design, the basic facility concept itself, and a description of the hardware required to implement the concept.

(Author)


A program of reduced gravity fluids research was initiated in the late 1950s. The primary motivations for this program was a need to characterize the behavior of propellants in a space environment. In the conduct of experiments, use was made of drop towers, aircraft, and ballistic rockets. There remained a core of problems which could not be solved with the aid of the employed approaches. Proposals for Spacelab experiments were, therefore, submitted. A committee came to the overall conclusion that there was a broad range of combustion experimentation that should be conducted in space. An examination of the analytical models which exist for numerous combustion phenomena reveals that these, are 'zero-G' theories. Experimentation in space will permit these theories to be tested and establish a firm basis upon which to build an understanding of more complicated combustion processes. Realistic in-space fire safety criteria are needed to eliminate the risk of major fire hazards in space. Such criteria can only be obtained through long-term reduced-gravity experimentation.

G.R.


A description is presented of the preliminary concept, specifications, and general requirements of a proposed Combustion Facility (CF) for the Spacelab payload of the Space Transportation System. The CF will permit an experimenter to use suitably contained liquid, gas, or solid fuels. He can specify and establish the composition and pressure level of the atmosphere in which the combustion will take place. It will be possible to characterize the experiment with common types of instrumentation as well as selected specialized equipment, to study the combustion process visually by direct observation and by motion picture coverage, and to obtain time histories of pertinent experimental parameters. During an experimental period, the CF will depend on Spacelab resources for power, heat rejection, and vacuum. Activating the CF and preparing it for the various experiments, performing the experiments, and shutting down the facility will be largely manual operations performed by flight personnel.

G.R.
15. LAUNCH VEHICLES AND SPACE VEHICLES

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

N81-12079# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

ELECTRIC PROPULSION - CHARACTERISTICS, APPLICATIONS, AND STATUS

A comparative review of the principles of thruster development and the specifications imposed on it by the Solar Electric Propulsion System program are discussed. The 30cm thruster operating range, efficiency, wear out lifetime, and interface requirements are described. T.M.

N81-12135# Dayton Univ., Ohio

APPLICATIONS TECHNOLOGY SATELLITE AND COMMUNICATIONS TECHNOLOGY SATELLITE USER EXPERIMENTS FOR 1967-1968 REFERENCE BOOK, VOLUME 1 Final Report

A description of each of the satellites is given and a brief summary of each user experiment is presented. A Cross Index of User Experiments sorted by various parameters and a listing of keywords versus Experiment Number are presented. Author

N81-12138# Dayton Univ., Ohio

APPLICATIONS TECHNOLOGY SATELLITE AND COMMUNICATIONS TECHNOLOGY SATELLITE USER EXPERIMENTS FOR 1967-1968 REFERENCE BOOK, VOLUME 2 Final Report

The experiments are grouped by type of service offered; for example, education, health services, and data transmission. A bibliography of reports on access number and by author are also presented. A listing of keywords versus report number is presented. Author

N81-12137# Dayton Univ., Ohio

APPLICATIONS TECHNOLOGY SATELLITE AND COMMUNICATIONS TECHNOLOGY SATELLITE USER EXPERIMENTS FOR 1967-1968 REFERENCE BOOK, VOLUME 3 Final Report

Questionnaires received from the satellite users are presented. Questionnaires were sent to users in 1976, 1977 and 1979. The forms reflect user viewpoints of the systems. Author

N81-12139# Columbus Univ., New York, Dept. of Electrical Engineering

NEXT GENERATION COMMUNICATIONS SATELLITES:

MULTIPLE ACCESS AND NETWORK STUDIES Final Report

Following an overview of issues involved in the choice of promising satellite architectures for efficient communication with multiple small inexpensive earth stations serving heterogeneous user populations, performance evaluation via analysis and simulation for six SS/TDMA (satellite-switched/time-division multiple access) system architectures is discussed. These configurations are chosen to exemplify the essential alternatives available in system design. Although the performance evaluation analyses are of fairly general applicability, whenever possible they are considered in the context of NASA's 30/20 GHz studies. Packet switched systems are considered, with the assumption that only a part of transponder capacity is devoted to packets, the integration of circuit and packet switched traffic being reserved for further study. Three types of station access are distinguished: fixed (FA), demand (DA), and random access (RA). Similarly, switching in the satellite can be assigned on a fixed (FS) or demand (DS) basis, or replaced by a buffered store-and-forward system (SF) onboard the satellite. Since not all access/switching combinations are practical, six systems are analyzed in detail: three FS SYSTEMS, FA/FS, DA/FS, RA/FS, one DS system, DA/DS, and two SF systems, FA/SF, DA/SF. Results are presented primarily in terms of delay-throughput characteristics. J.M.S.

N81-21106# Vought Corp., Dallas, Tex.

STUDY OF THERMAL MANAGEMENT FOR SPACE PLATFORM APPLICATIONS

Techniques for the management of the thermal energy of large space platforms using many hundreds of kilowatts over a 10 year life span were evaluated. Concepts for heat rejection, heat transport within the vehicle, and interfacing were analyzed and compared. The heat rejection systems were parametrically weight optimized over conditions for heat pipe and pumped fluid approaches. Two approaches to achieve reliability were compared for performance, weight, volume, and reliability; condition and operational characteristics. Technology needs are assessed and technology advancement recommendations are made. E.A.K.

N81-27189# Systems Science and Software, La Jolla, Calif.


The charging of a large object in polar Earth orbit was investigated in order to obtain a preliminary indication of the response of the shuttle orbiter to such an environment. Two NASCAP (NASA Charging Analyzer Program) models of SCATHA (Satellite Charging at High Altitudes) were used in simulations of charging events. The properties of the satellite's constituent materials were compiled and representations of the experimentally observed plasma spectra were constructed. Actual charging events, as well as those using test environments, were simulated. Numerical models for the simulation of particle emitters and detectors were used to analyze the operation of these devices onboard SCATHA. The effect of highly charged surface regions on the charging conductivity within a photosheath was used to interpret results from the onboard electric field experiment. Shadowing calculations were carried out for the satellite and a table of effective illuminated areas was compiled. J.D.H.
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.


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

NASA is continuing to pursue an aggressive satellite communications technology development program focused on the 30/20 GHz frequency band. A review of the program progress to date is presented. Included is a discussion of the technology program status as well as a description of the experimental system concept under study. Expected system performance characteristics together with spacecraft and payload configuration details including weight and power budget is presented. Overall program schedules of both the technology development and the flight system development are included.

Author
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.

N81-32187*# National Aeronautics and Space Administration 
Lewis Research Center, Cleveland, Ohio

REVIEW OF BIASED SOLAR ARRAY, PLASMA INTERACTION STUDIES
Intern Elec Propulsion Conf. Las Vegas. Nev. 21-23 Apr 1981, 
sponsored by AIAA. Japan Society for Aeronautical and Space 
Sciences and DGLR 
(NASA-TM-82693, E-973). Avail NTIS HC A02/MF A01 CSCL 
21C

The Solar Electric Propulsion System (SEPS) is proposed 
for a variety of space missions. Power for operating SEPS is 
obtained from large solar array wings capable of generating tens 
of kilowatts of power. To minimize resistive losses in the solar 
array bus lines, the array is designed to operate at voltages up 
to 400 volts. This use of high voltage can increase interactions 
between the biased solar cell interconnects and plasma environ 
ments. With thrusters operating, the system ground is maintained 
at space plasma potential which exposes large areas of the 
arrays at the operating voltages. This can increase interactions 
with both the natural and enhanced charged particle environments 
Available data on interactions between biased solar array surfaces 
and plasma environments are summarized. The apparent 
relationship between collection phenomena and solar cell size 
and effects of array size on interactions are discussed. The impact 
of these interactions on SEPS performance is presented. 

A81-20400 *# Engineering management and innovation. R. 
W. Graham (NASA, Lewis Research Center, Cleveland, Ohio). 

Although improved management methods can enhance the 
performance of some enterprises, they can lower that of research 
or ganizations. The prevalent use of cost-effectiveness criteria as 
a management tool overvalues identifiable short-term accomplishment 
at the expense of long-term research efforts, which often serve as the 
precedents upon which a new, seemingly unrelated technology is 
later founded. Medical instruments used in the treatment of 
emphysema, for example, evolved from NASA-sponsored research 
dedicated to the measurement of the composition of the atmospheres 
of the planets. The best manager is the manager who creates an 
environment that enables his research engineers to pursue ideas with 
a minimum of interference. Such an environment consists of broad 
research objectives, adequate facilities, and proper technical support. 
Within a framework of prudent spending, the manager's aim is to 
cultivate innovation. 

R.S.
19 SPACECRAFT INSTRUMENTATION

For related information see also 06 Aircraft Instrumentation and 35 Instruments and Photography.


A systematic, computer-aided, self-documenting methodology for developing hybrid computer simulations of turbofan engines is presented. The methodology 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 of the calculations and data manipulations needed to transform user-supplied engine design information to a form suitable for the hybrid computer. This test program also trims the self-contained engine model to match specified design point information. A test case is described and comparisons between hybrid simulation and specified engine performance data are presented.

S.F.


A workshop on spacecraft transmitter reliability was held at the NASA Lewis Research Center on September 25 and 26, 1979, to discuss present knowledge and to plan future research areas. Since formal papers were not submitted, this synopsis was derived from audio tapes of the workshop. The following subjects were covered: users' experience with spacecraft transmitters; cathodes; power supplies and interfaces; and specifications and quality assurance. A panel discussion ended the workshop. T.M.


A set of three instruments was developed that can provide early detection of potentially dangerous geomagnetic substorm conditions, and monitor the spacecraft response. Each of these instruments: A Surface Voltage Sensor that measures the characteristic energy of collected electrons or ions from +100 to -20,000 volts; a Nanoeameter or logarithmic current density sensor that measures local electron flux by measuring currents from 10 to the minus 9th power to 10 to the minus 5th power; and a Transient Events Counter that counts the spurious pulses from electrostatic discharges that are coupled into the spacecraft wiring harness. T.M.


The mechanical, thermal, electrical design and the ground test results of four types of detectors are explained. The IASP is designed to measure the thruster efflux material deposition and S/C potential relative to the local plasma in the vicinity of two 8 cm mercury ion thrusters. The DSS consists of two quartz crystal microbalances (QCM) detectors, one potential probe, nine solar cell arrays, seven ion collectors and two electronic packages. T.M.


A set of three instruments has been developed that can provide early detection of potentially dangerous geomagnetic substorm conditions, and monitor the spacecraft response. The set consists of three instruments: (1) a 'surface voltage sensor' that measures the characteristic energy of collected electrons or ions from +100 to -20,000 volts; (2) a 'nanoeameter' or logarithmic current density sensor that measures local electron flux by measuring currents from 10 to the 9th to 10 to the 5th A; and (3) a 'transient events counter' that counts the spurious pulses from electrostatic discharges that are coupled into the spacecraft wiring harness. Performance characteristics, specifications, and application of these instruments are discussed.

(Author)


Results of an assessment of a designer's data needs for solid rocket motor data obtained during static testing does not always agree with flight test data, and more quantitative data is necessary for motor design. The most promising new flight test instrumentation/data techniques for future flight programs are presented: microwave horns, ultrasonics, thermovision, in-situ transducers, isotopes, and paradigm recovery of flight hardware. It is noted that a development effort (minimum one to two years) and adequate funding will be required to have these concepts available for the design of future solid rocket motors. J.F.
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.

N81-19219# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A 17 cm diameter line-cusp ion thruster was evaluated with inert gases which are candidate propellants for on orbit and orbit transfer propulsion functions for Large Space Systems. A semiempirical relationship was generated to predict thruster performance and optimize the thruster without ion extraction and the associated large vacuum facilities. The sensitivity of performance to changes in discharge electrode configurations and magnetic circuit was evaluated and presented. After final optimization a specific impulse of 195 s and a discharge power expenditure of about 260 W per beam ampere was achieved. These performance parameters are the highest yet achieved with argon propellant.

N81-19220# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A preliminary characterization of the performance capabilities of the 8-cm thruster in order to initiate an evaluation of its application to LSS propulsion requirements is presented. With minor thruster modifications, the thruster was increased by about a factor of four while the discharge voltage was reduced from 39 to 22 volts. The thruster was operated over a range of specific impulses of 1850 to 3040 seconds and a maximum total efficiency of about 54 percent was attained. Preliminary analysis of component lifetimes, as determined by temperature and spectroscopic measurements, indicated acceptable thruster lifetimes are anticipated at the high power level operation.

T.M.

N81-19222# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

Single or dual ion beam sources were used to deposit thin films for different applications. Metal and metal oxide films were evaluated as protective coatings for the materials. Film adherence was measured and the most promising films were then tested under environmental similar to operating conditions. It was shown that some materials do protect die material (H-13 steel) and do reduce thermal fatigue. Diamondlike films have many useful applications. A series of experiments were conducted to define and optimize new approaches to the manufacture of such films. A dual beam system using argon and methane gases was developed to generate those films.

T.M.

N81-19223# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF COSTS OF GALLIUM ARSENIDE AND SILICON SOLAR ARRAYS FOR SPACE POWER APPLICATIONS Kent S. Jeffries Mar. 1981 18 p refs (NASA-TP-1811; E-536) Avail NTIS HC A02/MF A01 CSCL 10A

A parametric analysis was performed to compare the costs of silicon and gallium arsenide arrays for Earth orbital missions. The analysis included launch and purchase costs of the array. For the orbit transfer mission, the launch and purchase costs of the electric propulsion system were added. Radiation flux as a function of altitude and radiation tolerance as a function of cell type were used to determine power degradation for each mission. Curves were generated that show the sensitivity of launch-array cost and total mission cost to a variety of input parameters for each mission. These parameters included mission duration, cover glass thickness, array specific mass, and solar cell efficiency. Solar concentration was considered and the sensitivities of cost to concentration ratio, cown/transformer costs, and concentrator mass were also evaluated. Results indicate that solar cell development should give a high priority to reducing array costs and that the development of low cost, lightweight, solar concentrators should be pursued.

Author

N81-20178# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

The deformation process observed in the hot gas side wall of rocket combustion chambers is investigated for three different inner materials. Five thrust chambers were cycled to failure by using hydrogen and oxygen as propellants at a chamber pressure of 4.14 MN/ cu. m. The deformation was observed nondestructively at midlife points and destructively after failure occurred. The cyclic life results are presented with an accompanying discussion about the problems of life prediction associated with
the types of failures encountered in the present work. Data indicating the deformation of the thrust chamber liner as cycles are accumulated are presented for each of the test thrust chambers. From these deformation data and observation of the failure sites it is evident that modeling the failure process as classic low cycle thermal fatigue is inadequate as a life prediction method.

R.C.T.

SIMPLIFIED POWER SUPPLIES FOR ION THRUSTERS


The initial development and demonstration of power supplies with an order of magnitude reduction in parts count, leading to increased reliability at lower weight, while still maintaining thrust system performance are discussed. Two new self-regulating keeier power supply circuits were developed and tested. One supply increased reliability at lower weight while still maintaining thrust with an order of magnitude reduction in parts count, leading to 21C

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An experimental investigation of an rf ion thruster using an immersed coupler in an argon discharge is reported. The conical coil, used to couple rf power into the discharge, is placed inside the discharge vessel. The discharge was self-sustained by 100-150 MHz rf power at low environmental pressures. The ion extraction was accomplished by conventional accelerated grid optics from an unoptimized 8 cm diameter ion thruster. T.M.

EXPERIMENTAL DETERMINATION OF THE CHAMBER LINEARITY


A study of the chamber linearity for an ion thruster operating with xenon, neon, argon, and krypton under different discharge conditions and pressure levels is described. The data was obtained by using optical techniques to determine the discharge parameters and by using a laser interferometer to measure the chamber deformation. T.M.

PARTICLE AND FIELD MEASUREMENTS ON TWO J-SERIES 30-CENTIMETER MERCURY ION THRUSTERS


Tests were performed to characterize the particles and fields associated with two 30 cm mercury ion thrusters operating independently and simultaneously. Flux rates and energies of ions and their distribution around the thrusters were determined. Facility effect ions were measured and the effect on thruster created flux measurements was assessed. The flux rate and distribution of sputtered metal atoms was determined and compared with theory and previous measurements. Mapping of the potential fields in the near vicinity of the thrusters was accomplished. The technology development of the 30 centimeter J series mercury ion thruster for prime propulsion application in solar electric propulsion systems is described. Thruster design is reviewed. A standardized set of test and data recording procedures formulated to allow for the characterization of the J series thruster is described. Characteristics measured are the magnetic baffle characterization, the neutralizer characterization, perveance, the minimum eV/ion measurement, and the electrical and propellant utilization efficiency measurements. Test results are presented. J.D.H.
Determination of optimum sunlight concentration level in space for gallium arsenide solar cells


The solar cell diode equation was used to calculate the optimum values, or range of values of concentration ratios. A variety of temperature vs. concentration assumptions were used and cell area and series resistance were varied. The coefficients of the diffusion and recombination terms vary strongly with temperature while the light generated current is a weak function of temperature and proportional to concentration. The study indicates that the cell characteristic vs. concentration ratio assumption is critical. It appears that concentration levels of approximately 100X are feasible in space.

Technology transfer: still ticking after eleven years


The performance and durability of the ion thruster system and components are discussed. Interactions between the ion thruster and the space plasma-spacecraft interfaces were examined. The application of the results of testing the thruster to designing future ion thrusters is emphasized.

A case history of technology transfer

Aug 1981 28 p refs

A sequence of events occurring over the last 25 years are described that chronicle the evolution of ion bombardment electric propulsion technology. Emphasis is placed on the latter phases of this evolution, where special efforts were made to pave the way toward the use of this technology in operational space flight systems. These efforts consisted of a planned program to focus the technology toward its end applications and an organized process that was followed to transfer the technology from the research-technology NASA Center to the user-development NASA Center and its industry team. Major milestones in this evolution, which are described, include the development of thruster technology across a large size range, the successful completion of two space electric rocket tests, SERT I and SERT II, development of power-processing technology for electric propulsion, completion of a program to make the technology ready for flight system development, and finally the technology transfer events.

Development and design of three monitoring instruments for spacecraft charging

John C. Sturman Sep 1981 28 p refs

A set of instruments which provide early detection of potentially dangerous electromagnetic storm conditions and monitor the spacecraft response are discussed. The set consists of a sensor that measures the characteristic energy of collected electrons, or uses a current density sensor that measures local electron flux and a transient events counter that counts the spurious pulses from electrostatic discharges that couple into the spacecraft wiring harness. Design details and performance characteristics of the three instruments are given. Size, weight, and power requirements are minimized.

Radiation damage annealing mechanisms and possible low temperature annealing in silicon solar cells

I. Weinberg and C. K. Swartz (NASA, Lewis Research Center, Cleveland, Ohio).


Deep level transient spectroscopy and the Shockley-Read-Hall recombination theory are used to identify the defect responsible for reverse annealing in 2 ohm-cm n+ p silicon solar cells. This defect, with energy level at Ev + 0.30 eV, has been tentatively identified as a boron-oxygen-vacancy complex. It has been also determined that calculation that the removal of this defect could result in significant annealing at temperatures as low as 200 °C for 2 ohm-cm and lower resistivity cells.

Simplified power supplies for ion thrusters


A program addressing less complex and potentially lower cost ion thruster systems has been started at the NASA Lewis Research Center. This paper discusses the initial development and demonstration of power supplies with an order of magnitude reduction in parts count, leading to increased reliability at lower weight, while still maintaining thrust system performance. Two new self-regulating keeper power supply circuits were developed and tested. One supply comprises 14 parts and uses an input voltage range of 18 to 36 volts, the other operates from 200 to 400 volts and requires 22 components. A new technique for controlling heater power is also demonstrated.

Extended operating range of the 30-cm ion thruster with simplified power processor requirements


A 30-cm-diameter Hg ion thruster similar in design to the S-series thruster was operated at fixed conditions with only five power supplies and was throttled over the baseline power range with six supplies. An analysis of the functional model power processor showed that the component mass and parts count would be reduced.
by about 14 and 35% respectively, and the electrical efficiency would be increased about 1.5% by replacing power supplies with relays. By introducing new circuit designs, additional reductions in the component mass and parts, as well as an increase in electrical efficiency would be expected. The impact on thruster performance of reducing the number of power supplies was to lower the propellant utilization efficiency about 1.0% and raise the electrical efficiency values from 0.2 to 1.3% over the throttle range.

L.S.


The concept of a free radical propulsion system, utilizing the recombination energy of dissociated low molecular weight gases to produce thrust, is analyzed. The system, operating at a theoretical impulse with hydrogen, as high as 2200 seconds at high thrust to power ratio, is hypothesized to bridge the gap between chemical and electrostatic propulsion capabilities. A comparative methodology is outlined by which characteristics of chemical and electric propulsion for orbit raising mission can be investigated. It is noted that free radicals proposed in rockets previously met with difficulty and complexity in terms of storage requirements; the present study proposes to eliminate the storage requirements by using electric energy to achieve a continuous flow product of free radicals which are recombined to produce a high velocity propellant. Microwaves energy used to dissociate a continuously flowing gas is transferred to the propellant via three-body-recombination for conversion to propellant kinetic energy. Microwave plasma discharge was found in excess of 90 percent over a broad range of pressure in preliminary experiments, and microwave heating compared to electrothermal heating showed much higher temperatures in gasdynamic equations.

E.B.


Preliminary results of an RF ion thruster using an immersed coupler in an argon discharge are presented. Conventional ion accelerator optics are used to extract an ion beam. An account is given of the operation of an unaccelerated thruster over a range of input powers, propellant flow rates, frequencies, and magnetic field strengths. It is noted that lifetime and overall efficiency factors have not yet been extensively investigated. The results obtained establish the feasibility of this approach and the potential for future improvements. The conical coil employed to couple RF power into the discharge is placed inside the discharge vessel. The discharge is self-sustained by 100-150 MHz RF power at low environmental pressures (approximately 0.00001 torr). The ion extraction is accomplished by conventional accelerator grid optics from an unoptimized 8 cm diameter ion thruster.

C.R.


The technology development of the 30-cm J-series mercury ion thrusters has been conducted at NASA-Lewis Research Center. This development included the fabrication and testing of the 30-cm thruster. The present J-series thruster design is the result of an intensive effort to eliminate real and potential design deficiencies that were uncovered during initial endurance, structural, and performance tests. A standardized set of test and data recording procedure was formulated to allow for the characterization of the J-series thruster. This paper briefly reviews the design of the J-series thruster and presents a compilation of recent test results that define the J-series thruster characteristics.


In 1975 the NASA's Lewis Research Center initiated a technology specific spinoff program to more broadly utilize benefits resulting from ion thruster technology. An Ion Beam Applications Research (IBAR) program was organized to enable the development of new or improved materials, products, and processes through the nonpropulsive application of ion thruster technology. Focused efforts to identify, evaluate, and transfer applications to the user community were conducted. A summary of the NASA Lewis Research Center's in-house, grant, and contract projects involving IBAR is given. Specific application efforts utilizing ion beam sputter etching, deposition, and texturing are discussed as well as ion source and component technology applications.


The experimental design of a Diagnostic Subsystem (DSS) as part of an Ion Auxiliary Propulsion System (IAPS) to be flown on P80-1 spacecraft in May 1982, is discussed. The DSS is composed of several detectors measuring thruster efflux, material deposition and spacecraft potential relative to the local space plasma in the vicinity of two 8 cm mercury ion thrusters. The detectors consist of two OCM units measuring frequency in the range of two to 65 KHz. Nine solar cell arrays have the capability of measuring current and voltage from 0-600 mA and 0.0-9 V. Seven ion collectors can measure ion currents with bias voltages of 0, 25, 55 and 96 V. The potential probe can measure current at 16 different commandable levels varying from one to 5 K microamperes within a voltage range of 25 to 175 V. The analysis of the ground-based data indicates that the hardware is qualified for flight, with the detectors and electronic units having passed all functional and environmental tests. Block diagrams are given and the functional parameters of the different design configurations are described.


The performance of a 17-cm diameter line-cusp argon ion thruster, using argon and xenon propellants, is investigated. Basic optimization of the thruster was accomplished without ion extraction and tests were conducted with small vacuum facilities and power supplies. The evaluation of the sensitivity of the performance to changes in discharge electrode configurations and the magnetic circuit is discussed. Final optimization results show that an argon propellant utilization efficiency of 0.9, at 260 W of discharge power per beam amperes, was obtained with a thruster having 20 rows of magnets and 10 tubular anodes. The average ion beam current densities were as high as 13 mA/mm². The results are considered to be the highest yet achieved with argon propellant.

E.B.
An experimental investigation under complete computer control of the characteristics of particles and fields emanating from mercury bombardment ion thrusters (J-series, 30 cm diameter), operating independently and simultaneously, is discussed. Results show that the flux rate of sputtered metal atoms leaving a single thruster has been determined and a data set is in agreement with previous test results. The flux rate and energies of ions leaving single and two-thruster configurations have been established for a variety of beam current levels and combinations involving the two thrusters, and the data are sufficient to establish upper bounds. Floating potential measurements made in the near vicinity of the thrusters indicate that the fields are weak, plus or minus a few volts. The tests may be significant for the Solar Electric Propulsion System (SEPS) planners.


The Space Electric Rocket Test II (SERT II) spacecraft was launched in 1970 with a primary objective of demonstrating long-term operation of a space electric thruster system. An overview is presented of all the SERT II testing conducted during the time from 1970 to 1981. Thruster testing and interaction results are considered, taking into account ion beam thrusting, distant neutralization, and the plasma beam thrust. In a discussion of durability testing, attention is given to the main cathodes, the neutralizer cathode, the main keeper insulator, the H.V. grid insulators, the neutralizer propellant tanks, and the main propellant tanks. The most important result of the study is related to the confidence gained that mercury bombardment ion thruster systems can be built and operated in space on a routine basis with the same lifetime and performance as measured in ground testing.


Low thrust chemical propulsion systems (LTTPs) will be required for orbital transfer of large space systems (LSS). The work reported in this paper was conducted to determine the propellant requirements, preferred propellant management technique, and propulsion system sizes for the LTTPs. Propellants were liquid oxygen (LO2) combined with liquid hydrogen (LH2), liquid methane or kerosene. Thrust levels of 100, 500, and 1000 lbf were combined with 1, 4, and 8 perigee burns for transfer from low earth orbit to geosynchronous earth orbit. A matrix of systems was evaluated with a multilayer insulation (MLI) or a spray-on foam insulation. Vehicle sizing results indicate that a toroidal tank configuration is needed for the LO2/LH2 system. Multiple perigee burns and MLI allow far superior LSS payload capability. Propellant settling, combined with a single screen device, was found to be the lightest and least complex propellant management technique.

An analytical study evaluating thrust chamber cooling engine cycles and preliminary engine design for low thrust chemical rocket engines for orbit transfer vehicles is described. Oxygen/hydrogen, oxygen/methane, and oxygen/RP-1 engines with thrust levels from 444.8 to 13345 N and chamber pressures from 13.8 N/sq cm to 889.5 N/sq cm were evaluated. The physical and thermodynamic properties of the propellant theoretical performance data, and transport properties are documented. The thrust chamber cooling limits for regenerative/ radiation and film/radiation cooling are defined and parametric heat transfer data presented. A conceptual evaluation of a number of engine cycles was performed and a 2224.1 N oxygen/hydrogen engine cycle configuration and a 2224.1 N oxygen/methane configuration chosen for preliminary engine design. Updated parametric engine data, engine design drawings, and an assessment of technology required are presented.

An analytical feasibility investigation of an electric propulsion concept for space application is described. In this concept,
quasistatic thrust due to inertial reaction to repetitively accelerated pellets by an electric rail gun is used to propel a spacecraft. The study encompasses the major subsystems required in an electric rail gun propulsion system. The mass, performance, and configuration of each sub-system are described. Based on an analytic model of a cycle, mass and performance, the electric rail gun mission performance as a reusable orbital transfer vehicle (OTV) is analyzed and compared to a 30 cm ion thruster system (BIMOD) and a chemical propulsion system (IUS) for payloads with masses of 1150 kg and 2300 kg. For system power levels in the range from 25 kW(e) to 100 kW(e) an electric rail gun OTV is more attractive than a BIMOD system for low Earth orbit to geosynchronous orbit transfer durations in the range from 20 to 120 days.


Evaluations of O2/H2 engine candidates in the 10K to 30K lb thrust class for Manned Orbit Transfer Vehicles (MOTV) and engine candidates using O2/H2, O2/RP-1, and O2/CH4 in the 10 to 30000 lb thrust range for Cargo Orbit Transfer Vehicles (COTV) are discussed. Both space vehicles are part of the larger SPS concept. It is shown that the Advanced Expander Cycle O2/H2 engine for MOTV merits further study and investigations. COTV engine study has so far indicated that conventionally cooled O2/H2 and O2/CH4 engine candidates should be evaluated further, while advanced cooling schemes are required for O2/RP-1 concepts. With regard to MOTV, it is concluded that while no existing system meets the requirements of the Orbit Transfer Vehicles, the need for twin expander cycle engines is established because a single engine cannot provide a tolerable man-safety profile. With regard to COTV, it is stressed that advanced cooling concepts must be considered if other propellant combinations are to become competitive with O2/H2. Multistage centrifugal pumps are seen as the most promising concept.

C.R.


The use of high-voltage solar arrays in space is discussed in connection with the draining of array power by currents flowing between exposed surfaces through the surrounding plasma. The possibility of reducing the power loss by arranging solar cell strings in repeated small-area modules to eliminate any large areas at high potentials is investigated. It is found that the difference in power loss between modular and linear patterned high-voltage arrays is fairly small. Although the use of modular patterns can reduce the effective mean potential by about 10%, for the type of configuration being considered there is also a 10% increase in sheet area, leading to only a few percent change in total power loss. It is concluded that plasma power loss should not be a primary consideration in designing the physical arrangement of high-voltage arrays.

C.R.


A series of long term test segments of 30 cm diameter mercury bombardment thrusters is being conducted as the Mission Profile Life Test. The first 4000 hour segment has been completed with the J series thruster. J1. Thruster and power processing units were controlled by computer with software algorithms governing normal functions of startup, throttle, and shutdown as well as automatically handling a variety of off-normal conditions. Thruster operation includes a discussion of the test chronology describing notable events and their significance. Post-test examination provides insight into thruster lifetime. Results are consistent with mission requirements of 15,000 hours at 2A.


Solar electric propulsion is a leading candidate for many upcoming space missions. Under many circumstances plasma produced by charge-exchange reactions within the ion beam dominates the ambient environment near the spacecraft. The calculations presented here contain a predictive hydrodynamic model for the charge-exchange plasma expansion, and a fully three-dimensional model for the structure of the plasma sheath around the solar array wing. Results of calculations for several configurations and voltage levels indicate that with kilovolt biases plasma power losses of approximately 10 percent or more are likely, even with only one engine in operation, and that ameliorative measures should focus on the inboard portion of the solar arrays.
23 CHEMISTRY AND MATERIALS  
(GENERAL)

Includes biochemistry and organic chemistry.

NB1-18123* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

NEW ION EXCHANGE MEMBRANES

A technique for the preparation of ion exchange films composed of radiation crosslinked polyacrylic acid and crosslinked polycrylate salts is presented. Results suggest that radiolytic crosslinking occurs at the alpha carbon on polyacrylic acid via hydrogen abstraction by hydrogen atoms produced by the radiolytic decomposition of water. Conditions of reaction media and radiation dose are discussed for optimum crosslinking. Practical use of crosslinked polycrylate ion exchange films for the removal of metal cations from dilute solutions was demonstrated on a laboratory scale. The wet strength of membranes comprising various polycrylate salts is correlated with water content of the swelled membrane.

J. M. S.

NB1-21129§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ION BEAM APPLICATIONS RESEARCH. A SUMMARY OF LEWIS RESEARCH CENTER PROGRAMS

A summary of the ion beam applications research (IBAR) program organized to enable the development of materials, products, and processes through the nonpropulsive application of ion thruster technology is given. Specific application efforts utilizing ion beam sputter etching, deposition, and texturing are discussed as well as ion source and component technology applications.

E. D. K.

NB1-29160§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

CROSS-LINKED POLYVINYL ALCOHOL AND METHOD OF MAKING SAME Patent


A film-forming polyvinyl alcohol polymer is mixed with a polyaldehyde polysaccharide cross-linking agent having at least two monosaccharide units and a plurality of aldehyde groups per molecule, preferably an average of at least one aldehyde group per monosaccharide unit. The cross-linking agent, such as a polyaldehyde starch, is used in an amount of about 2.5 to 20% of the theoretical amount required to cross-link all of the available hydroxyl groups of the polyvinyl alcohol polymer. Reaction between the polymer and cross-linking agent is effected in aqueous acidic solution to produce the cross-linked polymer. The polymer product has low electrical resistivity and other properties rendering it suitable for making separators for alkaline batteries.

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


Inert gas tests are conducted with several magnetoelectrostatic containment discharge chamber geometries. The configurations tested include three discharge chamber lengths; three boundary magnet patterns; two different flux density magnet materials; hemispherical and conical shaped thrusters having different surface-to-volume ratios; and two and three grid ion optics. Argon mass utilization of 60 to 79% are attained at 210 to 280 eV/ion in different test configurations. Short hemi thruster configurations are found to produce 70 to 92% xenon mass utilization at 185 to 220 eV/ion.

C. R.


The paper presents an initial characterization of the performance capabilities and constraints of the 9-cm Hg ion thruster system with a view to evaluating its application to large space system propulsion requirements. With minor thruster modifications, the thrust was increased by about a factor of four, while the discharge voltage was reduced from 39 to 22 volts. The thruster was operated over a range of specific impulses of 1950 to 3040 seconds, and a maximum total efficiency of about 54% was attained at a discharge voltage of 24 volts and thruster input power of 0.49 kW.

V. L.
COMPOSITE MATERIALS

Includes laminates.

N81-12171* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

Studies were performed to achieve a lower-curing-temperature PMR polyimide. The use of m-aminostyrene as the end-cap instead of the monoalkyl ester of 5-normbornene-2,3 dicarboxylic acid was investigated in typical PMR formulations. Model composite studies were also performed. Differential scanning calorimetry studies were performed on model compounds and neat resins to establish their melting and curing characteristics. The elevated temperature weight loss characteristics of neat resins and graphite fiber composites were determined. The room temperature and short-time 280 C (500 F) mechanical properties of the composites were also determined. The use of m-aminostyrene end-caps reduced the final cure temperature of PMR resins by about 55 C (100 F), but the composites prepared with these resins are limited to use temperatures of about 260 C (500 F).

N81-1632* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PREDICTION OF COMPOSITE THERMAL BEHAVIOR MADE SIMPLE


A convenient procedure is described to determine the thermal behavior (thermal expansion coefficients and thermal stresses) of angleplied fiber composites using a pocket calculator. The procedure consists of equations and appropriate graphs for various (+ or - theta) ply combinations. These graphs present reduced stiffness and thermal 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 interply and intraply hybrids. The versatility and generality of the procedure is illustrated using several step-by-step numerical examples.

N81-17170* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METHOD FOR ALLEVIATING THERMAL STRESS DAMAGE IN LAMINATES Patent

A method is provided for alleviating the stress damage in metallic matrix composites, such as laminated sheet or foil composites. Discontinuities are positively introduced into the interface between the layers so as to reduce the thermal stress produced by unequal expansion of the materials making up the composite. Although a number of discrete elements could be used to form one of the layers and thus carry out this purpose, the discontinuities are preferably produced by simply drilling holes in the metallic matrix layer or by forming grooves in a grid pattern in this layer.

N81-21174* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ION BEAM SPUTTER ETCHING OF ORTHOPEDIC IMPLANTED ALLOY MP35N AND RESULTING EFFECTS ON FATIGUE

The effects of two types of argon ion sputter etched surface structures on the tensile stress fatigue properties of orthopedic implant alloy MP35N were investigated. One surface structure was a natural texture resulting from direct bombardment by 1 keV argon ions. The other structure was a pattern of square holes milled into the surface by a 1 keV argon ion beam through a Ni screen mask. The etched surfaces were subjected to tensile stress only in fatigue tests designed to simulate the cyclic load conditions experienced by the stems of artificial hip joint implants. Both types of sputter etched surface structures were found to reduce the fatigue strength below that of smooth surface MP35N.
A nonlinear laminate analysis is described for predicting the mechanical behavior (stress-strain relationship) of angled plies in which the matrix is strained nonlinearly by both the residual stress and the mechanical load and in which additional nonlinearities are induced due to progressive fiber fractures and ply relative rotations. The nonlinear laminate analysis (NLA) is based on linear composite mechanics and a piecewise linear laminate analysis to handle the nonlinear responses. Results obtained by using this nonlinear analysis on boron fiber/aluminum matrix angled plies agree well with experimental data. The results shown illustrate the influence of stress-strain behavior and synergistic strength enhancement.

A computer program is described for intraply hybrid composite design (INHYD). The program includes several composite micromechanics theories, intraply hybrid composite theories, and a hygrothermomechanical theory. These theories provide INHYD with considerable flexibility and capability which the user can exercise through several available options. Key features and capabilities of INHYD are illustrated through selected samples.

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nonlinear analysis on boron-fiber/aluminum-matrix angle-ply laminates agree well with experimental data. The results shown illustrate the in situ ply stress-strain behavior and synergistic strength enhancement. (Author)


Kevlar 49 aramid organic fiber reinforced PMR-15 polyimide laminates were characterized to determine the applicability of the material to high temperature aerospace structures. Kevlar 49/350-1-6 epoxy laminates were fabricated and characterized for comparison with the Kevlar 49/PMR-15 polyimide material. Flexural strengths and moduli and interlaminar shear strengths were determined from 75 to 600°F for the PMR-15 and from 75 to 450°F for the Kevlar 49/350-1-6 epoxy material. The study also included the effects of hydrothermal and long-term elevated temperature exposures on the flexural strengths and moduli and the interlaminar shear strengths. (Author)


Recent graphite fiber developments have resulted in high strength, intermediate modulus graphite fibers having improved thermo-oxidative resistance. These improved fibers, obtained from various commercial suppliers, were used to fabricate PMR-15 and PMR-11 polyimide composites. Studies were performed to investigate the effects of the improved high strength graphite fibers on composite properties after exposure in air at 600°F. The use of the more oxidatively resistant fibers did not result in improved performance at 600°F. Two of the improved fibers were found to have an adverse effect on the long-term performance of PMR composites. The influence of various factors such as fiber physical properties, surface morphology and chemical composition are also discussed. (Author)


This preliminary study explores the influence of 1-10 percent molar excess MDA on the molecular weight distribution and rheological properties of an imidized PMR system. Molecular weight distribution is characterized by gel permeation chromatography of the imidized molding compound, shear viscosity is related to changes in average molecular weight. The thermo-oxidative stability at 600°F glass transition temperature, flexural and interlaminar shear properties of PMR polyimide/Onilon 6000 graphite fiber composites are compared as a function of the percent excess MDA in the monomer reactant mixture. (Author)


A computer program has been developed and is described herein for intraply hybrid composite design (INHYD). The program includes several composite micromechanics theories, intraply hybrid composite theories and a hygrothermomechanical theory. These theories provide INHYD with considerable flexibility and capability which the user can exercise through several available options. Key features and capabilities of INHYD are illustrated through selected samples. (Author)


An investigation of the physical and mechanical effects of thermal treatment in a controlled oxygen-argon atmosphere on boron fibers is reported, with attention to the optimization of such treatment as a secondary processing method for improvement of fiber strength. The strengthening mechanism is comprised of an oxidation-induced axial contraction of the fiber, accompanied by axial compression of strength-limiting flaws within the fiber's tungsten boride core. It was found that after an oxidation contraction of 0.3% near 900°C and a slight surface pyrolysis at 100°C, the average tensile strength of 203-micron fibers increased from 500 to 800 ksi. Various physical observations are used to develop mechanistic models of oxidation, contraction, and the formation of new flaws in the boron sheet at contractions greater than 0.3%. O.C.


After a review of refractory metal fiber/allyl matrix composite development, a discussion is presented of the fabrication techniques used in production of tungsten fiber reinforced superalloys (TFRS), their most significant properties, and their potential applications in the hot section components of gas turbine engines. Emphasis is given to the development of airfoil-fabrication technology, with a view to the production of TFRS turbine blades, and attention is given to the first-generation TFRS material, a tungsten alloy fiber/Fe-C/AlY composite currently under evaluation. Detailed properties, design criteria and cost data are presented for this material. Among the properties covered are stress-rupture strength, high and low cycle fatigue, thermal fatigue, impact strength, oxidation and corrosion resistance and thermal conductivity. O.C.


Various combinations of fiber and matrix materials were fabricated and evaluated for the purpose of selecting a specific combination that exhibited the best overall properties for a turbine blade application. A total of seven matrix alloys, including Hastelloy X, Nimonic 80A, Inconel 600, Inconel 625, In-102, Fe-C/AlY, were investigated reinforced with either 218CS tungsten, or W-Hf-C fibers. Based on preliminary screening studies, Fe-C/AlY, Inconel 600 and Inconel 625 matrix composites systems were selected for extended thermal cycle tests and for property evaluations which included stress rupture, impact, and oxidation resistance. Of those investigated, the Fe-C/AlY matrix composite system exhibited the best overall properties required for a turbine blade application. The W-Hf-C/Fe-C/AlY system was selected for further property evaluation. Tensile strength values of up to 724 MPa (105,000 psi) were obtained for this material at 982°C and 607 MPa at 1093°C. Author
FABRICATION OF ALUMINUM OXIDE FIBER REINFORCED ALUMINUM MATRIX COMPOSITES

Static identification tests were performed to determine the law of contact between a steel ball and glass/epoxy and graphite/epoxy laminated composites. For both composites the power law with an index of 1.5 was found to be adequate for the loading curve. Substantial permanent deformations were noted after the unloading. A high order beam finite element was used to compute the dynamic contact force and response of the laminated composite subjected to the impact of an elastic sphere. This program can be used with either the classical Hertzian contact law or the measured contact law. A simple method is introduced for estimating the contact force and contact duration in elastic impacts.

The mechanical fabrication of polycrystalline alumina fiber reinforced aluminum composites was accomplished. Wire preform material was prepared by liquid metal infiltration of alumina fiber bundles. The wires were subsequently fabricated into bulk composite material by hot drawing. Extensive mechanical, thermal and chemical testing was conducted on preform bulk material to develop a process and materials data base. In addition, a preliminary investigation of mechanical forming of bulk alumina fiber reinforced aluminum composite material was conducted.

A technique for producing boron filaments with an average tensile strength of 6.89 GPa has been developed which involves longitudinal splitting of the filament and core (substrate) removal by etching. Splitting is accomplished by a pinch wheel device which continuously splits filaments in lengths of 3.0 m by applying a force to the side of the filament to create a crack which is then propagated along the axis by a gentle sliding action. To facilitate the splitting, a single 10 mil tungsten substrate is used instead of the usual 0.5 mil substrate. A solution of hot 30% hydrogen peroxide is used to remove the core without attacking the boron. An alternative technique is to alter the residual stress by heavily etching the filament. Average strengths in the 4.83-5.82 GPa range have been obtained by etching an 8 mil filament to 4 mil.


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V.L.
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.

NB-1-13106® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

IMPROVEMENT AND SCALE-UP OF THE NASA REDOX STORAGE SYSTEM

A prototype 1.0 kW redox system (2 kW peak) with 11 kWh storage capacity was built and integrated with the NASA/DOE photovoltaic test facility at NASA Lewis. This full function redox system includes four substacks of 39 cells each (1/3 cu ft active area) which are connected hydraulically in parallel and electrically in series. An open circuit voltage cell and a set of recharge cells are used to continuously monitor the system state of charge and automatically maintain the anode and cathode reactants electrochemically in balance. Recent membrane and electrode advances are summarized and the results of multiecell stack tests of 1 cu ft are described. R.C.T.

NB-1-13107® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ACCURACY OF TRACE ELEMENT DETERMINATIONS IN ALTERNATE FUELS

A review of the techniques used at Lewis Research Center (LeRC) in trace metals analysis is presented, including the results of Atomic Absorption Spectrometry and D.C. Arc Emission Spectrometry of blank levels and recovery experiments for several metals. The design of an Interlaboratory Study conducted by LeRC is presented. Several factors were investigated, including: laboratory, analytical technique, fuel type, concentration, and ashing additive. Conclusions drawn from the statistical analysis will help direct research efforts toward those areas most responsible for the poor interlaboratory analytical results. Author.

NB-1-17100® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ACCEPTANCE TESTS AND MANUFACTURER RELATIONSHIPS FOR 20 AMPERE-HOUR SEALED NICKEL-CADMIUM CELLS USING DISCHARGE PARAMETERS

One hundred and forty-six 20 ampere-hour sealed nickel-cadmium cells from five manufacturers were detected using preliminary tests which do not require life testing and do not reduce the expected life of the cells. Differences between individual cells were also detected using these tests, allowing a comparison of variability of cell construction by and between manufacturers. Author.

NB-1-8248® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

HEAT PIPES TO REDUCE ENGINE EXHAUST EMISSIONS Patent Application

A fuel combustor employing heat transfer devices for improving combustion efficiency and reducing engine exhaust emissions is described. The fuel combustor consists of an elongated casing with an air inlet conduit portion at one end. An elongated heat pipe is mounted longitudinally in the casing and is offset from and extends alongside an intermediate combustion space. The heat pipe is in heating transmitting relationship with the air intake conduit for heating incoming air. A fuel conduit has a portion engaged in heat transfer relationship of the heat pipe for preheating the fuel. The offset position of the heat pipe relative to the combustion space minimizes the quenching effect of the heat pipe on the gaseous products of combustion, as well as reducing coking of the fuel on the heat pipe, thereby improving the efficiency of the combustor. NASA.

NB-1-25100® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

SYNTHETIC BATTERY CYCLING

The use of interactive computer graphics is suggested as an aid in battery system development. Mathematical representations of simplified but fully representative functions of many electrochemical concepts of current practical interest will permit battery level charge and discharge phenomena to be analyzed in a qualitative manner prior to the assembly and testing of actual hardware. This technique is a useful addition to the variety of tools available to the battery system designer as he bridges the gap between interesting single cell life test data and reliable energy storage subsystems. E.D.K.

NB-1-28203® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ZIRCONIUM CARBIDE AS AN ELECTROCATALYST FOR THE CHROMOUS/CHROMIC REDOX COUPLE Patent Application

Zirconium carbide is used as a catalyst in a REDOX cell for the oxidation of chromous ions to chromic ions and for the reduction of chromic ions to chromous ions. The zirconium carbide is coated on an inert electronically conductive electrode which is present in the anode fluid of the cell. NASA.

NB-1-31308® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

DESIGN AND ASSEMBLY CONSIDERATIONS FOR REDOX CELLS AND STACKS Patent Application

Individual redox flow cells are arranged electrically in series and hydraulically in parallel to form a single assembly called a stack. The hardware currently being tested in the laboratory has an active electrode area of either 310 sq cm or 928 sq cm. Four 310 sq cm stacks, each consisting of 39 active cells, were
incorporated into a 1.0 kW preprototype system. The physical design of the stack is very critical to the performance and efficiency of the redox storage system. This report will discuss the mechanical aspects of the cell and stack design for the current Redox hardware, with regard to sealing the stack internally as well as externally, minimizing shunt currents and minimizing the electrical resistance of the stack.

E.D.K.

PERSPECTIVE SOLUTIONS OF COMBUSTION INSTABILITY PROBLEMS
A. Googedy, J. Parkin, Jr., and M. Venkatesh Oct. 1979
66 p refs
(Grant NGR-43-003-015)
(NASA-CR-158643) Avail. NTIS HC A04/MF A01 CSCL
218

A method involving approximate modal analysis using the Galerkin method followed by an approximate solution of the resulting modal-amplitude equations by the two-variable perturbation method (method of multiple scales) is applied to two problems of pressure-sensitive nonlinear combustion instability in liquid-fuel rocket motors. One problem exhibits self-coupled instability while the other exhibits mode-coupled instability. In both cases it is possible to carry out the entire linear stability analysis and significant portions of the nonlinear stability analysis in closed form. In the problem of self-coupled instability the nonlinear stability boundary and approximate forms of the limit-cycle amplitudes and growth and decay rates are determined in closed form while the exact limit-cycle amplitudes and growth and decay rates are found numerically. In the problem of mode-coupled instability the limit-cycle amplitudes are found in closed form while the growth and decay rates are found numerically. The behavior of the solutions found by the perturbation method are in agreement with solutions obtained using complex numerical methods.

Author

114 p refs
(Contract NAS3-21030)
(NASA-CR-165177) Avail. NTIS HC A06/MF A01 CSCL
218

The analysis, design, fabrication and testing of several engine configurations are discussed with respect to the combustion and heat transfer characteristics of LOX/RP-1 at chamber pressures between 6895 and 13790 kPa (1000 and 2000 psia). The different engine configurations discussed include: 8274 kPa and 13790 kPa (1200 psia and 2000 psia) chamber pressure injectors with like doublet and prestomized triplet elements, cooled and uncooled acoustic resonators, and graphite, regeneratively cooled and caninometric chambers ranging in length from 27.8 to 37.5 cm (11 to 15 in.) A high pressure LOX/RP-1 spark igniter is also evaluated.

R.C.T.
26 METALLIC MATERIALS

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

N81-11117† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

COMPLETION OF EVALUATION OF MANUFACTURING PROCESSES FOR B/Al COMPOSITES CONTAINING 0.2mm DIAMETER TORON FIBERS

Thomas J. Moore and Paul E. Moorhead Sep 1980 39 p refs
(NASA-TM-81573, E-543) Avail NTIS HC A03/MF A01 CSCL 11F

Four fabricators produced a total of 54 9/1100 Al, 8/061 Al, and 8/2024 Al panels for evaluation. The 9 ply unidirectional, 45° to 90° volume percent, panels were made using 0.20 mm diameter boron fibers which were obtained from a single supplier. Hot press consolidation was carried out in vacuum except for one set of dry woven tape panels which were hot pressed in air. A single testing contractor conducted nondestructive inspection, metallography, fractography and mechanical property tests. The mechanical property tests included 21 and 260 C tensile tests and 21 C shear tests. Panel quality, as measured by nondestructive evaluation, was generally good as were the tests. The mechanical property tests included 21 and 260 C tensile strength tests. The panels hot pressed in air delaminated in the shear tests. Shear strength values were lower in these panels. 

Both tensile strengths were not affected by the delaminations because of the relation between the tensile loading direction and the delaminations. Composite tensile strength was found to be proportional to the volume percent boron and the aluminum matrix rather than to the tape used or fabrication technique. Suitability of these composites for 280 C service was confirmed by tensile tests. R.K.G.

N81-11178† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECT OF MECHANICAL SURFACE AND HEAT TREATMENTS ON EROSION RESISTANCE

Joshua Salik and Donald H. Buckley 1980 10 p refs Proposed for presentation at the Intern. Conf. on Wear of Materials, San Francisco, 30 Mar - 1 Apr 1980
(NASA-TM-81540, E-326) Avail NTIS HC A02/MF A01 CSCL 11F

The effects of mechanical surface treatments as well as heat treatments on the erosion resistance of 6061 aluminum alloy and 1045 steel were studied. Mechanical surface treatments were found to have little or no effect on the erosion resistance. This is due to the presence of a particle impact damage of an already hardened surface layer regardless of the initial surface condition. The erosion resistance of 1045 steel was found to be independent of orientation. This is due to destruction of the surface microstructure and formation of a polycrystalline surface layer by the impact of erodent particles as observed by X-ray diffraction. While upon solution treatment of annealed 6061 aluminum the increase in hardness is accompanied by an increase in erosion resistance, precipitation treatment which causes a further increase in hardness results in slightly lower erosion resistance. Using two types of erodent particles, glass beads and crushed glass, the erosion rate was found to be strongly dependent on erodant particle shape, being an order higher for erosion with crushed glass as compared to glass beads. While for erosion with glass beads heat treatment of 1045 steel had a profound effect on its erosion resistance, little or no such effect was observed for erosion with crushed glass.

N81-12210† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

THE ROLE OF OXIDATION IN THE FRETTING WEAR PROCESS


OXIDATION RESISTANCE Patent Application

C. A. Barrett, inventor (to NASA) Filed 23 Oct 1980 6 p
(NASA Case-LEW-13399-1) US-Patent Appl-SN 199769 Avail NTIS HC A02/MF A01 CSCL 11F

Ni/Cd alloys were improved by the addition of zirconium. These alloys are in the beta or gamma/gamma prime + beta region of the ternary system. Zirconium was added in a very low amount between 0.06 and 0.20 weight percent. There was a narrow optimum zirconium level at the low value of 0.13 weight percent. Maximum resistance to cyclic oxidation was achieved when the zirconium addition was at =: 0.5 weight percent. NASA Development Command, Cleveland, Ohio

N81-11221† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

Ni/Cd TERNARY ALLOY HAVING IMPROVED CYCLIC OXIDATION RESISTANCE Patent Application

C. A. Barrett, inventor (to NASA) Filed 23 Oct 1980 6 p
(NASA Case-LEW-13399-1) US-Patent Appl-SN 199769 Avail NTIS HC A02/MF A01 CSCL 11F

Ni/Cd alloys were improved by the addition of zirconium. These alloys are in the beta or gamma/gamma prime + beta region of the ternary system. Zirconium was added in a very low amount between 0.06 and 0.20 weight percent. There was a narrow optimum zirconium level at the low value of 0.13 weight percent. Maximum resistance to cyclic oxidation was achieved when the zirconium addition was at =: 0.5 weight percent. NASA Development Command, Cleveland, Ohio.

N81-15068† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EVALUATION OF CANDIDATE STIRLING ENGINE HEATER TUBE ALLOYS FOR 1000 HOURS AT 760 C Final Report

John A. Mienczak Nov 1980 35 p refs
(Contract EC-77-A-31-1040)
(NASA-TM-81787, E-490) Avail NTIS HC A02/MF A01 CSCL 11F

Six tubing alloys were endurance tested in a diesel fired, Stirling engine simulator materials test rig for 1000 hours of 760 C while pressurized at 17 to 21 MPa with either hydrogen or helium. The alloys tested were 1155, 1 266, Incoloy 800, 19 BD, Nitronic 40 and 316 stainless steel. The alloys were in the form of thin wall tubing: Hydrogen permeated rapidly through the tube walls of all six alloys and the effect of these materials tested for 1000 hours in hydrogen, helium. The tubes were heated to 1070 C. Helium was readily contained. Creep rupture failures occurred in four of the six alloys in hydrogen, helium. Hydrogen permeated rapidly through the tube walls of all six alloys and the effect of these materials tested for 1000 hours in hydrogen, helium. The alloys tested were 1155, 1266, Incoloy 800, 19 BD, Nitronic 40 and 316 stainless steel. The alloys were in the form of thin wall tubing: Hydrogen permeated rapidly through the tube walls of all six alloys and the effect of these materials tested for 1000 hours in hydrogen, helium. The tubes were heated to 1070 C. Helium was readily contained. Creep rupture failures occurred in four of the six alloys in hydrogen, helium. Only two alloys survived the 1000 hour endurance test with no failures. Simultaneous exposure to either hydrogen or helium and the combustion environment did not seriously degrade the high strength of the tubes in room temperature or 760 C tests after exposure. Decreases in room temperature ductility were observed and are attributed to aging rather than to hydrogen embrittlement in three of the alloys. However, there may be a hydrogen embrittlement effect in the N 155, 19 BD, and Nitronic 40 alloys.

N81-15069† National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

DEPOSITION AND MATERIAL RESPONSE FROM MACH 0.3 BURNER RIG COMBUSTION OF SRC 2 FUELS Final Report

(Contract EF-77-A-01-2593)
(NASA-TM-81534, E-847) DOE/NASA/2593-20) Avail NTIS HC A02/MF A01 CSCL 11F

Collectors at 1173K (900 C) were exposed to the combustion products of a Mach 0.3 burner rig fueled with various industrial turbine liquid fuels from solvent refined coal. Four fuels were employed: a naphtha, a light oil, a wash solvent and a mid heavy
distillate blend. The response of four superalloys (IN-100, U700, IN 782 and AI-509) to exposure to the combustion gases from the SRC-2 naphtha and resultant deposits was also determined. The SRC-2 fuel analysis and insights obtained during the combustion experience are discussed. Particular problems encountered were fuel instability and reactions with the fuel with hard-to-wet particulates. The major metallic elements which contributed to the deposits were copper, iron, chromium, calcium, aluminium, nickel, silicon, titanium, zinc, and sodium. The deposits were found to be mainly metallic oxides. An equilibrium thermodynamic analysis was employed to predict the chemical composition of the deposits. The agreement between the predicted and the found compounds was excellent. No hot corrosion was observed. This was expected because the deposits contained very little sodium or potassium and consisted mainly of the unreactive oxides. However, the amounts of deposits formed indicated that fouling is a potential problem with the use of these fuels.

**Author**


(NASA-TM-8187B; DOE/NASA/S293-22) Avail: NTIS HC A03/MF A01 CSCL 11F

The effects of trace metal impurities in coal-derived liquids on deposition, high temperature corrosion and fouling were examined. Alloys were burned in test fired from 800 to 1100 C and corrosion was evaluated as a function of partial impurities. Actual and doped fuel test were used to define an empirical life prediction equation. An evaluation of inhibitors to reduce or eliminate accelerated corrosion was made. Chromium and phosphorus were found to limit attack. Interruption application of the inhibitors or silicon additions were found to be effective techniques for controlling corrosion without losing the inhibitor benefits. A computer program was used to predict the dew points and compositions of deposits. These predictions were confirmed in deposition test. The potential for such deposits to plug cooling holes of turbine foils was indicated that, while a potential problem exists, it strongly depended on minor impurity variations.

**Author**

M.G.
TERISTICS OF Ti-6Al-4V
EFFECTS OF GEOMETRIC VARIABLES ON PUMP CHARACTERISTICS OF CAST SUPERALLOYS AND OXIDE DISPERSION STRENGTHENED ALLOYS

J. Daniel Wittenbinger
Feb 1981 68 p refs

Results of etching, to study ion beam sputter polishing of Ti-6Al-4V, were extensively studied, while limited testing was conducted on the ODS nickel-base alloy STCA. Elevated temperature testing was conducted from 114 to 1477 K except for STCA and the iron-base ODS alloy MA-856 (Fe-20Cr-5Al-0.8Y203) which were only tested at 1388 K. The residual tensile properties of B-1800 and MAR-M200 are reduced by prior creep testing, strain at 1737 K up to 1 percent, while the room temperature tensile properties of ODS nickel-base alloys can be reduced by small amounts of prior creep strain (less than 0.5 percent). The iron-base ODS alloy MA-856 does not appear to be susceptible to creep degradation at least up to strains of about 0.25 percent. However, MA-856 exhibits unusual creep behavior which apparently involves crack nucleation and growth.

Author

MATERIALS

N81-18279**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

EFFECTS OF GEOMETRIC VARIABLES ON RUB CHA RACT E RISTICS OF Ti-6Al-4V
Robert C. Bill, Jan Wolak (Washington Univ., Seattle), and Donald W. Weand (Apr 1981 21 p refs)
Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio

Experiments simulating rub interactions between Ti-6Al-4V blade tips and various seal materials were conducted. The number of blade tips and the blade tip geometry were varied to determine their effects on rub forces and on wear phenomena. Contact was found to be quite unsteady for all blade tip geometries except for those incorporating deliberately rounded blade tips. The unsteady contact was characterized by long periods of rubbing contact and increasing blade tip that terminated in sudden rapid metal removal, sometimes accompanied by tearing and disruption of porous seal material under the rub surface. A model describing the blade tip loading is proposed and is based on the propagation of an elastic stress wave through the seal material as the seal material is dynamically compressed by the blade tip leading edge.

Author

N81-21178**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

SPUTTERED PROTECTIVE COATINGS FOR DIE CASTING

Michael J. Mirtich, Cuo-Yo Nish (Case Western Reserve Univ.), and John F. Wallace (Case Western Reserve Univ.)
1981 14 p refs
Presented at the 1981 Intern Conf. on Met. Coatings. San Francisco, 6-10 Apr 1981

This investigation determined whether selected ion beam sputtered coatings on H-13 die steel would have the potential of improving the thermal fatigue behavior of the steel used as a die in aluminum die casting. The coatings were selected to test candidate insulators and metals capable of providing protection of the die surface. The studies indicate that 1 micrometer thick W and Pt coatings reduced the thermal fatigue more than any other coating tested and are candidates to be used on a die surface to increase die life.

Author

N81-21193**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

STEADY-STATE BOUNDARY LUBRICATION WITH FORMULATED C-ETHERS TO 280 C

William R. Loomis Apr 1981 16 p refs

Results were compared with those obtained with a formulated MIL L 27502 candidate and the other candidate insulators and metals capable of providing protection of the die surface. The studies indicate that 1 micrometer thick W and Pt coatings reduced the thermal fatigue more than any other coating tested and are candidates to be used on a die surface to increase die life.

Author

N81-22181**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

EFFECTS OF PLASMA SPRAY PARAMETERS ON TWO LAYER THERMAL BARRIER

Stephen Secura Mar 1981 22 p refs

The power level and the type of arc gas used during plasma spraying of a two layer thermal barrier system (TBS) were found to affect the life of the system. Life at 1095 C in a cyclic furnace test was improved by about 140 percent by increasing the power during plasma spray applications of the bond and thermal barrier coatings. This improvement is due to increments in the densities of the bond and thermal barrier coatings by 3 and 5 percent, respectively. These increases in densities are equivalent to about 48 and 30 percent reduction in mean porosities, respectively. The addition of hydrogen to the argon arc gas had the same effect as the reduction in power level and caused a reduction in TBS life.

Author
allows both interpolation and extrapolation of the data. As anticipated, corrosion increased rapidly with Na and K, and a marked maximum in the temperature response was noted for many conditions. In contrast, corrosion decreased somewhat as the Ca, Mg and Cl content increased. Extensive corrosion was observed at concentrations of Na and K as low as 0.1 PPM at long times.
in the program involve hydrogen permeability testing, doping of the hydrogen working fluid to reduce permeability rates, oxidation/corrosion studies, creep-fatigue evaluation, and assessing effects of hydrogen on mechanical properties. Emphasis is placed on the materials challenges that result from the use of hydrogen as the working fluid. S.F.

N81-27259†
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
MATERIAL RESPONSE FROM MACH 0.3 BURNER RIG COMBUSTION OF A COAL-OIL MIXTURE
G. J. Santoro, F. D. Caffo, and F. J. Kohl, June 1981. 24 p refs
(Contract EF-77-A-01-2593)
HC A02/ MF A01 CSCL 11 F
Wedge shaped specimens were exposed to the combustion gases of a Mach 0.3 burner rig fueled with a mixture of 40 weight percent micron size coal particles dispersed in No. 2 fuel oil. Exposure temperature was about 900°C and the test duration was about 44 hours. The alloys tested were the nickel base superalloys, IN-100, U-700, and IN-792, and the cobalt base superalloy, Mar-M509. The deposits on the specimens were analyzed and the extent of corrosion/erosion was measured. The chemical compositions of the deposits were compared with the predictions from an equilibrium thermodynamic analysis. The experimental results were in very good agreement with the predictions. Author

N81-27259†
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
ADVANCED AIRCRAFT ENGINE MATERIALS TRENDS
Sponsored by ASME
(NASA-TM-82626, E-879) Avail. NTIS HC A02/MF A01 CSCL 11 F
Recent activities of the Lewis Research Center are reviewed which are directed toward developing materials for rotating hot section components for aircraft gas turbine engines. Turbine blade materials activities are directed at increasing metal temperatures approaches 1000°C compared to current directionally solidified alloys by use of oxide dispersion strengthening or tungsten alloy wire reinforcement of nickel or iron base superalloys. The application of thermal barrier coatings offers a promise of increasing gas temperatures an additional 100°C with current cooling technology. For turbine disk alloys, activities are directed toward reducing the cost of turbine disks by 50 percent through near net shape fabrication of prealloyed powders as well as towards improved performance. In addition, advanced alloy concepts and fabrication methods for dual alloy disks are being studied as having potential for improving the life of future high performance disks and reducing the amount of strategic materials required in these components. E.D.K.

N81-28231†
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
BURNER RIG EVALUATION OF THERMAL BARRIER COATINGS
Michael A. Goddwill, Feb 1981. 23 p refs
(Contract EF-77-A-01-2593)
HC A02/MF A01 CSCL 11 F
Eight plasma sprayed bond coatings were evaluated for their, potential use with ZO2-Y2O3 thermal barrier coatings (TBCs) which are being developed for coal fired fuel gas turbines. One or TBC lives in cyclic burner rig oxidation to 1050°C were achieved with the more oxidation resistant bond coatings. These were Ni-14Cr-13AA1-0.10Ar, Ni-14Cr-14AA1-0.16Y, and Ni-15Cr-12AA1-0.38Y on Rene 41. The TBC systems performed best when 0.015-in thick bond coatings were employed that were sprayed at 20 kV using argon 3 sV/a hydrogen. Cycling had a more life limiting influence on the TBC than accumulated time at 1050°C. Author

N81-28233†
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
ADHESION AND FRICTION OF TRANSITION METALS IN CONTACT WITH NONMETALLIC HARD MATERIALS
Kazuhisa Miyoshi and Donald H. Bucy, 1981. 19 p refs
(NASA-TM-82605, E-853) Avail. NTIS HC A02/MF A01 CSCL 11 F
Sliding friction experiments were conducted with the metals yttrium, titanium, tantalum, zirconium, vanadium, neodymium, iron, cobalt, nickel, tungsten, platinum, rhenium, rutilhenium, and rhodium in sliding contact with single crystal diamond, silicon carbide, pyrolytic boron nitride, and ferrite. Auger electron spectroscopy analysis was conducted with the metals and nonmetals to determine the surface chemistry and the depth of surface cleanliness. The results of the investigation indicate the adhesion and friction of the transition metals in contact with diamond, silicon carbide, boron nitride, and ferrite are related to the relative chemical activity of the metal. The more chemically active the metal, the higher the coefficient of friction and the greater amount of transfer to the nonmetal. E.D.K.

N81-28206†
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
NASA'S ACTIVITIES IN THE CONSERVATION OF STRATEGIC AEROSPACE MATERIALS
Joseph R. Stephens, 1981. 24 p refs
(NASA-TM-81617, E-823) Avail. NTIS HC A02/MF A01 CSCL 11 F
The primary objective of the Conservation of Strategic Aerospace Materials (COSAM) Program is to help reduce the dependency of the United States aerospace industry on strategic metals by providing the materials technology needed to minimize the strategic metal content of critical aerospace components with prime emphasis on components for gas turbine engines. Initial emphasis was placed in the area of strategic element substitution. Specifically, the role of cobalt in nickel base and cobalt base superalloys vital to the aerospace industry is being examined in great detail by means of cooperative university-industry-government research efforts. Investigations are underway in the area of new classes of alloys. Specifically, a study was undertaken to investigate the mechanical and physical properties of intermetallics that contain a minimum of the strategic metals. Current plans for the much larger COSAM Program are also presented. E.D.K.

N81-28206†
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
COBALT: A VITAL ELEMENT IN THE AIRCRAFT ENGINE INDUSTRY
Joseph R. Stephens, 1981. 15 p refs
(NASA-TM-82662, E-834) Avail. NTIS HC A02/MF A01 CSCL 11 F
Recent trends in the United States consumption of cobalt indicate that superalloys for aircraft engine manufacture require increasing amounts of this strategic element. Superalloys consume a lion's share of total U.S. cobalt usage which was about 16 million pounds in 1980. In excess of 90 percent of the cobalt used in this country was imported, primarily from the African countries of Zaire and Zambia. Early studies on the roles of cobalt as an alloying element in high temperature alloys concentrated on the simple Ni-Cr and Nimoncr alloy series. The role of cobalt in current complex nickel base superalloys is not well defined and indeed, the need for the high concentration of cobalt in widely used nickel base superalloys is not firmly established. The current cobalt situation is reviewed as it applies to superalloys and the opportunities for research to reduce the consumption of cobalt in the aircraft engine industry are described. E.D.K.

55
A NEW DIFFUSION-INHIBITED OXIDATION-RESISTANT COATING FOR SUPERALLOYS

Michael A. Goddow, Thomas K. Glasgow, and Stanley R. Levine

A concept for enhanced protection of superalloys consists of adding an oxidation- and diffusion-resistant cermet layer between the superalloy and the outer oxidation-resistant metallic alloy coating. Such a duplex coating was compared with a physical-vapor-deposited (PVD) NiCrAlY coating in cyclic oxidation at 1150°C. The substrate alloy was MA 754 - an oxide-diffusion-strengthened superalloy that is difficult to coat. The duplex coating, applied by plasma spraying, outperformed the PVD coating on the basis of weight change and both macroscopic and metallographic observations.

C. B A Cowles, D L Sims, J R Warren (United Technologies Corp. Pratt and Whitney Aircraft Group, West Palm Beach, Fla.). And R. V. and very markedly so for the dwell cycle (Author)

Advantage was somewhat smaller for the creep fatigue cycle. CVdic

increasing tensile yield strength among the alloys, though the

formation of molybdenum plates at the grain boundary and an

increase in temperature is illustrated through a sequence of pictures.

The change in the structure near the grain boundary with the

increase of the gamma phase in relation to the gamma prime phase.


The mechanical characteristics of the directed solid eutectic Ni-Al-Mo (gamma/gamma prime-alpha alloy at high temperatures make it useful in the blades of gas turbines. Structural changes are observed for the alloy under isothermal annealing, particularly the formation of molybdenum plates at the grain boundary and an increase of the gamma phase in relation to the gamma prime phase. Molybdenum lamellas appear at the grain boundary above 1100°C which can have a negative influence on the mechanical properties. The change in the structure near the grain boundary with the increase in temperature is illustrated through a sequence of pictures.

R.C.


Five gas turbine disk alloys represent a range of strengths and processing methods were tested for resistance to both cyclic crack initiation and propagation at 650°C using a 0.33 Hz fatigue cycle and a cycle incorporating a 900-s tensile dwell. At the low strain ranges pertinent to disks, resistance to crack initiation increased with increasing tensile yield strength among the alloys, though the advantage was somewhat smaller for the creep fatigue cycle. Cyclic crack growth resistance, however, decreased with increasing strength and very markedly so for the dwell cycle.

(Anh)

The elevated temperature tensile, stress-rupture and creep properties and residual tensile properties after creep straining have been determined for two cast superalloys and several wrought Ni-16Cr-4Al-yttria oxide dispersion strengthened (ODS) alloys. The creep behavior of the ODS alloys is similar to that of previously studied ODS nickel alloys. In general, the longitudinal direction is stronger than the long transverse direction, and creep is at least partially due to a diffusional creep mechanism as dispersoid-free zones were observed after creep-rupture testing. The tensile properties of the nickel-base superalloy B-1900 and cobalt-base superalloy MAR-M509 are not degraded by prior elevated temperature creep straining (at least up to 1 pct) between 1144 and 1436 K. On the other hand, the room temperature tensile properties of ODS nickel-base alloys can be reduced by prior creep strains of 0.5 pct or less between 1144 and 1477 K, with the long transverse direction being more susceptible to degradation than the longitudinal direction. (Author)


The effects of both mechanical surface treatments and heat treatments on the erosion resistance of 6061 aluminum alloy were studied in order to gain a better understanding of material properties which affect erosion behavior. It was found that mechanical surface treatments have little or no effect on the erosion resistance. This is due to the formation by particle impact of a work-hardened surface layer, independent of the initial surface condition. The erosion resistance of aluminum single crystals was found to be independent of orientation, which is due to destruction of the surface microstructure and formation of a polycrystalline surface layer by the particle impact as observed by X-ray diffraction. Although on solution treatment of annealed aluminum 6061 the increase in hardness is accompanied by an increase in erosion resistance, precipitation treatment (which causes a further increase in hardness) results in a slightly lower erosion resistance. (Author)


The results of an investigation of the effect of operating conditions and fuel properties on emission for the two-stage combustion of fuels with significant organic nitrogen content are presented. The way in which the emissions of nitrogen oxides and carbon monoxide are affected by the decreased hydrogen content and the increased organic nitrogen content of coal-derived fuels is discussed. Limited measurements of smoke from the rich lean combustion of simulated sycnrcude fuels indicate relatively high smoke emissions in spite of the very lean second-stage burning. This fact, together with the high observed carbon monoxide emissions, suggests that trade-offs will be necessary between the conditions that minimize NOx and those that control CO and smoke emissions. C.R.


Specimens of gamma/gamma-prime-alpha (Mo) eutectic alloy were thermally cycled or isothermally exposed at temperatures of 1075 to 1100 C. Transmission electron microscopy examination of cycled specimens indicated that even an exposure of 10 minutes affected noticeable changes in the shape of the alpha phase, and that the changes were cumulative as more cycles were added. The cross sections of fine, smooth fibers changed from rectangles to octagons, while lamellae and irregular shapes spheroidized. These effects are attributed to the differences in thermal expansion coefficients between the alpha phase and the gamma/gamma-prime matrix due to the higher diffusion rates prevailing at elevated temperatures. Where the configuration of the alpha phase is a simple shape, such as a cube, increasing the temperature eventually brings about a stress-free interface between the alpha phase and the matrix by differential thermal expansion. Where the shape of the alpha phase is more complex, a stressed interface persists to higher temperatures where diffusion produces the more drastic morphological changes. (Author)


Ion plated metallic films in contrast to films applied by other deposition techniques offer a lower friction coefficient, longer endurance lives and exhibit a gradual increase in friction coefficient after the film has been worn off. The friction coefficients of metallic films are affected by the degree of adherence, thickness and nucleation and growth characteristics. The effective film thickness for the minimum friction coefficient was established for Au and Pb films. The nucleation and growth characteristics during ion plating lead to a fine, continuous crystalline structure, which contributes to a lower friction coefficient. (Author)


Three experimental research designs investigating candidate materials and processes involved in protective die surface coating procedures by sputter deposition, using ion beam technologies, are discussed. Various pre-test results show that none of the coatings remained completely intact for 15,000 test cycles. The longest lifetime was observed for coatings such as tungsten, platinum, and molybdenum which reduced thermal fatigue, but exhibited oxidation and suppressed crack initiation only as long as the coating did not fracture. Final test results confirmed earlier findings and coatings with Pt and W proved to be the candidate materials to be used on a die surface to increase die life. In the W-coated specimens, which remained intact on the surface after thermal fatigue testing, no oxidation was found under the coating, although a few cracks formed on the surface where the coating broke down. Further research is planned. E.B.
Cyclic hot corrosion and oxidation of an experimental oxide dispersion strengthened (ODS) superalloy MA 755E were conducted in a hot gas stream at Mach 0.3. The presence of the ODS alloy, bare or with protective coatings, was similar to that of a conventional cast alloy, if -792, in hot corrosion at 900 C. However, during oxidation at 1100 and 1150 C the ODS alloy differed from the cast alloy by developing a greater amount of subsurface porosity. Compared with a diffused aluminate coating, an electron beam vapor deposited NiCrAlY coating offered superior oxidation protection and decreased porosity formation. In additional testing, the tendency to form porosity was associated with the large grains of recrystallized powder metallurgy alloys but was independent of the presence of an oxide dispersion.

A standardized method of testing the cyclic oxidation resistance of various alloys in static air up to 1200 C has been developed and routinely used at the NASA Lewis Research Center. Test samples are automatically raised and lowered into a resistance wound furnace for a series of fixed-interval heating and cooling cycles. Spall catchers collect the accumulated spall from each sample. The samples are weighed intermittently to generate specific weight change with time data. At various test times the samples and the accumulated spall are analyzed by X-ray diffraction. A computer program is used to print out the specific weight change versus time data and the X-ray data in tabular form and to plot the specific weight change versus time data in a publishable format. The data are also organized and indexed. So far several hundred Fe-, Ni-, and Co-base alloys have been tested using this basic procedure and will form the basis of a series of cyclic oxidation handbooks to be published by NASA. Such specific weight change/time data have been used to estimate the oxidative metal consumption by several computer modeling techniques both to rank alloys and to estimate life.


The current status of ceramic thermal barrier coatings for protection of turbine airfoils components is reviewed. Test results for an early duplex coating system ZrO2-12% Y2O3/Ni-16% Cr-6% Al-0.6% Y, improved system ZrO2-8% Y2O3/Ni-17% Cr-5% Al-0.35% Y, and air/fuel impurity tolerant systems based on ZrO2-8% Y2O3, 2CaO-SrO, and a MgO-NiCrAlY cermet are discussed. Preliminary test results at 800 C for a graded ZrO2-8% Y2O3/Ni-20% Cr-11% Al-0.4% Y coating system show that the coating can survive at least 500 h in the presence of 50 ppm V plus other fuel contaminants and additives.

The mechanisms by which metals and alloys are attacked by gaseous environments when deposits are present on their surface were determined. A large number of different metal and alloy specimens were exposed to an oxygen atmosphere with various salt coatings, and oxidized specimens were examined by ordinary light and scanning electron microscopy to characterize the morphology and structure of the scale developed at various stages of oxidation. Alloy microstructure and oxidation products were identified through X-ray diffraction, electron diffraction and EDAX analysis techniques in order to obtain a more conclusive picture of the mechanism of hot corrosion. Dissertation Abstr.
TURBINE BLADE TEMPERATURE MEASUREMENTS USING THIN FILM TEMPERATURE SENSORS

H. P. Grant, J. S. Przybyszewski, and R. G. Craign

17 Mar. 1981
65 p. refs

(Contract NAS3 20831, PWA 5604-31) Avail: NIS HC A04/MF A01 CSCL 11F

The development of thin film temperature sensors is discussed. The technology for sputtering 2 micron thin film platinum versus platinum 10 percent rhodium thermocouples on alumina forming coatings was improved and extended to applications on actual turbine blades. Good adherence was found to depend upon achieving a proper morphology of the alumina surface. Problems of adapting fabrication procedures to turbine blades were uncovered, and improvements were recommended. Testing at 1250 K at one atmosphere pressure was then extended to a higher Mach No. (0.5) in combustor flow for 80 hours and 71 thermal cycles. The mean time to failure was 47 hours accumulated during 1 hour exposures in the combustor. Calibration drift was about 0.1 percent per hour, attributable to oxidation of the rhodium in the thin films. An increase in film thickness and application of a protective overcoat are recommended to reduce drift in actual engine testing.

M. G.

PASSIVATION OF CARBON STEEL THROUGH MERCURY IMPLANTATION

Paul J. Wilbur and Raymond S. Robinson
Feb. 1981 36 p. refs

(Contract NAG3 25) Avail: NIS HC A03/MF A01 CSCL 11F

An experiment in which carbon steel samples were implanted with mercury ions from a broad beam ion source and their corrosion characteristics in air were evaluated, is described. Mercury doses of a few mA min/square cm at energies of a few hundred electron volts are shown to effect significant improvements in the corrosion resistance of the treated surfaces. In a warm moist environment the onset of rusting was extended from 15 min for an untreated sample to approximately 30 hrs for one implanted at a dose of 33 mA min/square cm with 1000 eV mercury ions. Author

MICROSTRUCTURE AND MECHANICAL PROPERTIES OF BULK AND PLASMA-SPRAYED Y2O3-PARTIALLY STABILIZED ZIRCONIA

Annual Report
Peter G. Valentine and Ralph D. Maer
Aug. 1980 46 p. refs
(Grant NAG3 3252) Avail: NIS HC A03/MF A01 CSCL 11F

Bulk 80 weight percent yttria partially stabilized zirconia (PSZ) was studied by light microscopy, transmission electron microscopy, X-ray analysis, microhardness testing, and fracture toughness testing. The as received PSZ contains tetragonal and grain boundary precipitates up to 4 micrometers in size. Spheroids up to 1.26 micrometers were metastable tetragonal, large spheroids were monoclinic. Grinding the PSZ into powder did not cause a significant amount of tetragonal to transform to monoclinic. This indicates that transformation toughness is not a significant mechanism in PSZ. Aging the PSZ at 1500 C caused the fine tetragonal precipitates to grow from 0.06 to 0.12 micrometers, in 250 minutes. A peak hardness of 1400 kg/sq mm was attained after 90 minutes. Solution annealing and quenching the as received PSZ eliminated the large precipitates, but fine tetragonal precipitates reformed on quenching. Aging at 1500 C caused the fine 0.03 micrometers tetragonal precipitates to grow into plates about 0.10 by 0.50 micrometers. A peak hardness of 1517 kg/sq mm was obtained after 250 minutes. On further aging, monoclinic precipitates formed along grain boundaries. The fracture toughness of the aged and unaged solution annealed and quenched PSZ was found to be between 2 and 3 MN/square root of m cubed. This range of fracture toughness is consistent with PSZ's that do not undergo transformation toughening.

Author

A81-10706 # Effect of TMP variables upon structure and properties in ODS alloy HDA 8077 sheet, M. F. Rothman and H. M. Tawancy
Contract No. NAS3-20072.

The effects of oxide content level and variations in thermomechanical processing upon the final structure and properties of HDA 8077 sheet have been systematically examined. It was found that creep strength and formability are substantially influenced by both oxide content and TMP schedule. Variations in creep properties obtained appear to correlate with observed microstructures. (Author)
27 NONMETALLIC MATERIALS

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

N81-10170* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECT OF SUBSTRATE SURFACE FINISH ON THE LUBRICATION AND FAILURE MECHANISMS OF MOBYDENUM DISULFIDE (LMS)


An optical microscope was used to study the lubrication and failure mechanisms of rubbed (burnished) MoS2 films applied to three substrate surface finishes: polished, sanded, and sandblasted - as a function of sliding distance. The lubrication mechanism was the plastic flow of thin films of MoS2 between flat plateaus on the rider and on the metallic substrate. If the substrates were rough, flat plateaus were created during run in and the MoS2 flowed across them. Wear life was extended by increasing surface roughness since valleys in the roughened substrate served as reservoirs for MoS2 and a deposit site for wear debris. In moist air, the failure mechanism was the transformation of metallic colored MoS2 films to a black, powdery material that was found by X ray diffraction to consist primarily of alpha iron and MoO3 powders. In dry argon, the failure mechanism was the gradual depletion of the MoS2 film from the contact region by transverse flow. Analysis of the wear debris on the wear track at failure showed it consisted mainly of alpha iron and some residual MoS2. No molybdenum oxides were found.

M G

N81-11214* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
POLYTETRAFLUOROETHYLENE TRANSFER FILM STUDIED WITH X-RAY PHOTOELECTRON SPECTROSCOPY


Polytetrafluoroethylene (PTFE) was rubbed against nickel in ultrahigh vacuum at loads up to 3.9 N and speeds up to 94 mm/sec. The transfer film formed on the nickel was analyzed using X-ray photoelectron spectroscopy. The film was indistinguishable from bulk PTFE except for the possible presence of a small amount of NaF. The transfer film was found to be about 1 molecule (0.5 nm) thick under all conditions; but at speeds above 10 mm/sec, there was evidence of bulk transfer in the form of fragments as well. The thickness measurements required a choice among conflicting published values of the inelastic mean free path for electrons in polymers. The values chosen gave internally consistent results.

Author

N81-1228* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECT OF LOAD, AREA OF CONTACT, AND CONTACT STRESS ON THE WEAR MECHANISMS OF A BONDED SOLID LUBRICANT FILM


A pin on disk type of friction and wear apparatus was used to study the effect of load, contact stress and slider area of contact on the friction and wear properties of polyniobium bonded graphite fluoride films. Different slider area contacts were obtained by initially generating flats (with areas of 0.0035, 0.0071, 0.0145, and 0.0240 cm) on 0.476 cm radius hemispherically tipped riders. Different projected contact stresses were obtained by applying loads of 2.5 to 58.8 N to the flats. Two film wear mechanisms were observed. The first was found to be a linear function of contact stress and was independent of slider area of contact. The second was found to increase exponentially as the stress increased. The second also appeared to be a function of slider contact area. Wear equations for each mechanism were empirically derived from the experiments and coefficients increased with increasing slider contact area and with sliding duration. This was related to the build up of thick slider transfer films.

Author

N81-13186* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECT OF MILLING AND LEACHING ON THE STRUCTURE OF SINTERED SILICON


Sintering was performed in He for 16 hours at 1200, 1250, and 1300 C. Compacts of as-received Si did not densely sinter. Milling reduced the average particle size to below 0.5 micrometer and enhanced densification (1.75 g/cc). Leaching milled Si further enhanced densification (1.90 g/cc max) and decreased structural coarsening. After sintering, the structure of the milled and leached powder compacts appears favorable for the production of reaction bonded silicon nitride.

Author

N81-14075* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
CHANGES IN SURFACE CHEMISTRY OF SILICON CARBIDE (0001) SURFACE WITH TEMPERATURE AND THEIR EFFECT ON FRICTION

Kazuhisa Miyoshi and Donald H. Buckley Nov. 1980 12 p refs (NASA-TM-1756; E-475) Avail NTIS HC A02/MF A01 CSCL 07D

Friction studies were conducted with a silicon carbide (0001) surface contacting polycrystalline iron. The surface of silicon carbide was pretreated: (1) by bombarding it with argon ions for 30 minutes at a pressure of 1.3 pascals; (2) by heating it at 800 C for 3 hours in vacuum at a pressure of 10 to the minus eighth power pascal; or (3) by heating it at 1500 C for 3 hours in a vacuum of 10 to the minus eighth power pascal. Auger emission spectroscopy was used to determine the presence of silicon and carbon and the form of the carbon. The surfaces of silicon carbide bombarded with argon ions or preheated to 800 C revealed the main Si peak and a carbide type of C peak in the Auger spectra. The samples preheated to 1500 C revealed only a graphite type of C peak in the Auger spectra, and the Si peak had diminished to a barely perceptible amount. The surfaces of silicon carbide preheated to 800 C gave a 1.5 to 3 times higher coefficient of friction than the surfaces of silicon carbide preheated to 1500 C. The coefficient of friction was lower in the <100> direction than in the <111> direction; that is, it was lower in the preferred crystallographic slip direction.

Author
admixture with the curing agent. The cured epoxy product retains the usual properties of cured epoxies and, in addition, has a higher char residue after burning, on the order of 45% by weight. The higher char residue is of value in preventing release to the atmosphere of carbon fibers from carbon fiber-epoxy resin composites in the event of burning of the composite.

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

N81-17264* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DYNAMICS OF SOLID DISPERSIONS IN OIL DURING THE LUBRICATION OF POINT CONTACTS. PART 1: GRA- 


A Hartmann contact was lubricated with dispersed graphite in mineral oils under boundary lubrication conditions. The contact was optically observed under pure rolling, combined rolling and sliding, and pure sliding conditions. The contact was formed with a steel ball on the flat surface of a glass disk. Photomicrographs of the distribution of the graphite in and around the contact. Friction and surface damage are also shown for conditions when the base oils are used alone and when graphite is added to the base oils. Under pure rolling and combined rolling and sliding conditions, it is found that, for low speeds, a graphite film can form which will separate the contacting surfaces. Under pure sliding conditions, graphite accumulates at the slip and sweeps around the contact, but very little of the graphite passes through the contact. The accumulated graphite appears to act as a barrier which reduces the supply of oil available to the contact for boundary lubrication. Friction data show no clear short term beneficial or detrimental effect caused by addition of graphite to the base oil. However, during pure sliding, more abrasion occurs on the polished balls lubricated with the dispersion than on those lubricated with the base oil alone. All observations were for the special case of a highly-polished ball on a glass surface and may not be applicable to other geometries and materials, or to rougher surfaces.

Author

N81-17265* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EVALUATION OF BOUNDARY LUBRICANTS USING STEADY-STATE WEAR AND FRICTION


A friction and wear study was made at 20 C to establish operating limits for improved reproducibility and reliability in boundary lubrication testing. Ester base and C-ester base fluids were used to lubricate a pure iron rider in sliding contact with a rotating M-50 steel disk in a pin-on-disc apparatus. Results of a parametric study with varying loads and speeds showed that satisfactory test conditions for studying the direction and wear characteristics in the boundary lubrication regime with this test device were found to be 1 kilogram load, 7 to 9 meter per minute (50 rpm) surface speed, dry air test atmosphere (less than 100 ppm H2O) and use of a time stepwise procedure for measuring wear. Highly reproducible steady-state wear rates resulted from the two fluid studies which had a linearity of about 99 percent after initially higher wear rates and friction coefficients during run-in periods of 20 to 40 minutes.

Author

N81-17266* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. COMMERICAL (TERRESTRIAL) AND MODIFIED SOLAR ARRAY DESIGN STUDIES FOR LOW COST, LOW POWER SPACE APPLICATIONS


The suitability of commercial (terrestrial) solar arrays for use in low Earth orbit is examined. It is shown that commercial solar arrays degrade under thermal cycling because of material failure, and that certain types of silicones used in the construction of these arrays outgas severely. Based on the results, modifications were made. The modified array retains the essential features of typical commercial arrays and can be easily built by commercial fabrication techniques at low cost. The modified array uses a metal tray for containment, but eliminates the high outgassing potting materials and glass cover sheets. Cells are individually mounted with an adhesive and a thin kapton cover slip, or clear plastic tape. The modified array is found to withstand severe thermal cycling for long intervals of time. M.G.
DYNAMIC OF SOLID DISPLACEMENT AND SECONDARY EMISSON CHARACTERISTICS OF SPUTTERED PYROLYTIC GRAPHT SURFACES

Edwin G. Wintucky, Arthur N. Curren, and James S. Sovey 1981

Low secondary and reflected primary electron emission from the collector electrode surfaces is important for optimum collector efficiency and hence for high overall efficiency of microwave amplifier tubes used in communication satellites and in military systems. Ion sputtering of the surface effectively suppresses electron emission from pyrolytic graphite, which is a promising collector electrode material. Secondary and reflected primary electron emission characteristics of sputter textured pyrolytic graphite surfaces with microstructures of various sizes and densities are presented. The microstructure with the lowest electron emission levels, less than those of soot, consists of a dense array of tiny, thin spires. E.D.K.

THERMAL SHOCK RESISTANCE OF PLASMA SPRAYED A $PUTTERED 21RCONIA PRIMER FOR IMPROVED CERAMIC TURBINE SEALS

A sputtered zirconia primer that is deposited on a metallic bond coat to improve the thermal shock resistance of the plasma sprayed ceramic film is described. The development of plasma sprayed yttria stabilized zirconia (YSZ) ceramic turbine blade tip components is discussed. The YSZ layers are quite thin (0.040 to 0.090 in.). The service potential of seal components with such thick ceramic layers is cyclic thermal shock limited. The most usual failure mode is ceramic layer delamination at or very near the interface between the plasma sprayed YSZ layer and the Ni(Cr)AlY bondcoat. Deposition of a thin RF sputtered YSZ primer to the bondcoat prior to deposition of the thick plasma sprayed YSZ layer was found to reduce laminar cracking in cyclic thermal shock testing. The cyclic thermal shock life of one ceramic seal design was increased by a factor of 5 to 6 when the sputtered YSZ primer was incorporated. A model based on thermal response of plasma sprayed YSZ particles impinging on the bondcoat surface with and without the sputtered YSZ primer provides a basis for understanding the function of the primer. M.G.
CONTACT ANGLE MEASUREMENTS OF A POLYETHYLENYL ETHER TO 190 C ON 50 STEEL


Contact angle measurements were performed for a polyethylene ether on steel in nitrogen. A tilting plate and a sessile drop apparatus were used. Surface tension was measured with a maximum bubble pressure apparatus. Critical surface energies of spreading were found to be 30.1 and 31.3 dynes/cm. It was concluded that the polyethylene ether is inherently autophobic and will not spread on its own surface film.

CROSS-LINKED POLYVINYL ALCOHOL AND METHOD OF MAKING SAME Patent Application


A method is described for producing cross-linked polyvinyl alcohol resin which is admixed in aqueous solution, with a dialdehyde-cross-linking agent which is capable of cross-linking the polyvinyl alcohol resin and a water soluble acid aldehyde. The acid aldehyde contains a reactive aldehyde group capable of reacting with hydroxyl groups in the polyvinyl alcohol resin, and an ionic acid hydrogen atom. The amount of acid aldehyde is from 1 to 5% by weight and is sufficient to reduce the pH of the aqueous admixture to 5 or less. The admixture is then heated and the shaped product is then heated to simultaneously dry and cross-link the article.

CORRELATION OF IDEAL AND ACTUAL SHEAR STRENGTHS OF METALS WITH THEIR FRICTION PROPERTIES

Kazuhiro Miyoshi and Donald H. Buckley Jul. 1981 12 p refs (NASA-TP-19811: E-701) Avail NTIS HC A02/MF A01 CSCL 11F

The relation between the ideal and actual shear strengths and friction properties of clean metals in contact with clean diamond, boron nitride, silicon carbide, manganese-zinc ferrite, and the metals themselves in vacuum is discussed. An estimate of the ideal shear strength for metals is obtained from the shear modulus. The repeat distance of atoms in the direction of shear of the metal, and the interplanar spacing of the shear plane. The coefficient of friction for metals is shown to be correlated with both the ideal and actual shear strength of metals. The higher the strength of the metal, the lower the coefficient of friction occurs.

AERIAL REFERENCE BETWEEN THE IDEAL TENSILE STRENGTH AND THE FRICTION PROPERTIES OF METALS IN CONTACT WITH NONMETALS AND THEMSELVES Final Report


The adhesion and friction properties of metals in contact with diamond, boron nitride, silicon carbide, manganese-zinc ferrite, and the metals themselves in vacuum were investigated. An estimate of the ideal uniaxial tensile was obtained in terms of the equilibrium surface energy, interplanar spacing of the planes perpendicular to the tensile axis, and the Young’s modulus of elasticity. The coefficient of friction for metals was found to be related to the ideal tensile strength of metals. The higher the strength of the metal, the lower the coefficient of friction.

EFFECT OF YTTRIA ADDITIVES ON PROPERTIES OF PRESSURELESS-SINTERED SILICON NITRIDE

Alan Ares Sep 1981 11 p refs (NASA-TP-19999. E-751) Avail NTIS HC A02/MF A01 CSCL 11G

Si3N4-base ceramics were made from milled Si3N4 containing 11.1 wt% SiO2 and oxide additives by pressureless sintering at 1760 C. The four-point average modulus of rupture were 460, 515, and 515 MPa at temperature 270, 258, and 227 MPa at 1400 C for compositions with 3.67, 7.22, and 11G wt% Y2O3, respectively. The oxidation resistance of these compositions decreased with increasing Y2O3 in the 600 to 1400 C range, and no surface oxide cracking or spalling was noted. Partial substitution of Al2O3 for Y2O3 reduced both strength and oxidation resistance.

EFFECT OF ELECTRONIC STRUCTURE OF THE DIAMOND INTERFACE


A diamond surface undergoes a transformation in its electronic structure by a vacuum anneal at approximately 900 C. The polished surface has no electronic states in the band gap, whereas the annealed surface has both occupied and unoccupied states in the gap and exhibits some electrical conductivity. The effect of this transformation on the strength of the diamond-metal interface was investigated by measuring the static friction force of an atomically clean metal sphere on a diamond flat in ultrahigh vacuum. It was found that friction (weak bonding) is associated with the diamond surface devoid of gap states whereas high friction (strong bonding) is associated with the diamond surface with gap states. Exposure of the annealed surface to excited hydrogen also leads to weak bonding. The interfacial bond is discussed in terms of interaction of the metal conduction band electrons with the band gap states on the diamond surface. Effects of surface electrical conductivity on the interfacial bond are also considered.

The effects of attrition milling and acid leaching on the sintering behavior and the resultant structures of two commercial silicon carbide powders were investigated. Sintering was performed in Hz for 16 hr at 1200, 1250, and 1300 C. Compacts of as-received SiC did not densify during sintering. Milling reduced the average particle size to below 0.5 microns and enhanced densification (1.75 g/cc). Leaching milled SiC further enhanced densification (1.90 g/cc max.) and decreased structural coarsening. After sintering, the structure of the milled and leached powder compacts appears favorable for the production of reaction bonded silicon nitride. (Author)


The sinterability of alpha Si3N4 with 9.07 equivalent per cent of CeO2, MgO, or Y2O3 has been studied in the temperature range 1650-1820 C by density measurements and X-ray diffraction analysis. Maximum densities were obtained in the range 1765-1820 C and were 99.5% of theoretical with 2.5% CeO2; 98.5% of theoretical with 1.24 to 1.87% MgO; and 99.2% of theoretical with 2.5% Y2O3. Densities 94% or more of theoretical value were obtained with as little as 0.82 equivalent per cent additive. (V. L.)


Short bar, short rod, and four-point-bend chevron-notch specimens were used to determine the plane strain fracture toughness of hot-pressed silicon nitride and sintered aluminum oxide brittle ceramics. The unique advantages of this specimen type are: (1) the production of a sharp natural crack during the early stage of test loading, so that no precracking is required; and (2) the load passes through a maximum at a constant, material-independent crack length-to-width ratio for a specific geometry, so that no post-test crack measurement is required. The plane strain fracture toughness is proportional to the maximum test load and functions of the specimen geometry and elastic compliance. Although results obtained for silicon nitride are in good mutual agreement and relatively free of geometry and size effects, aluminum oxide results were affected in both these respects by the rising crack growth resistance curve of the material. (O. C.)


An optical microscope was used to study the lubrication and failure mechanisms of rubbed (burnished) MoS2 films applied to three substrate surface finishes—polished, sanded, and sandblasted—as a function of sliding distance. The lubrication mechanism was the plastic flow of thin films of MoS2 between flat plateaus on the rider and on the metallic substrate. If the substrate was rough, flat plateaus were created during "run-in" and the MoS2 flowed across them. Wear life was extended by increasing surface roughness since valleys in the roughened substrate served as reservoirs for MoS2 and a deposit site for wear debris. In most cases, the failure mechanism was the transformation of metallic-colored MoS2 films to a black, powdery material that was found by X-ray diffraction to consist primarily of alpha-iron and MoS3 powders. In dry argon, the failure mechanism was the gradual depletion of the MoS2 film from the contact region by transverse flow. Analysis of the wear debris on the wear track at failure showed it consisted mainly of alpha-iron and some residual MoS2. No molybdenum oxides were found. (Author)


Sliding friction experiments were performed in vacuum at room temperature on a plane-type SiC surface in contact with iron-based binary alloys. Multispherical and spherical wear particles were found to form as a result of multipass sliding. The multispherical particles were produced by primary and secondary cracking of the 0001, 101-110, and 111-220 plane-type cleavage planes under the Hertzian stress field or local inelastic deformation zone. When alloy surfaces are in contact with silicon carbide under a load of 0.2 N, the alloy around the contact area is subjected to stresses that are close to the elastic limit in the elastic deformation region and/or exceed it. It was also found that spherical wear particles may be produced by two mechanisms: a penny-shaped fracture along the contact stress trajectories under the local inelastic deformation zone, and the attrition and fatigue of wear particles. (E. B.)
ABSTRACTS

ABSTRACT 1


Measurements are presented of secondary electron emission and reflected primary electron characteristics of sputter-textured pyrolytic graphite surfaces with microstructures of various sizes and densities, made with an Auger cylindrical mirror analyzer in a high-vacuum chamber at pressures below 1.33 x 10^-7 Pa. The size of the specimen is 0.6 mm x 0.6 mm x 0.06 mm, the most effective. The secondary electron emission from such a surface is lower than that of soot, whose secondary emission is among the lowest of any material. At a primary electron energy of 1000 eV, the secondary electron yield of smooth Cu is about 350% greater than the lowest value obtained for sputter-textured pyrolytic graphite. The reflected primary electron index of smooth Cu is a factor of 80 greater. If the secondary electron emission yield is reduced to 0.3, which is possible with sputter-textured pyrolytic graphite, the reflected wave tube collector efficiency could be improved by as much as 4% over that for smooth copper.

K.S.

ABSTRACT 2


An accurate chemical characterization of silicon nitride has become important in connection with current efforts to incorporate components of this material into advanced heat engines. However, there are problems concerning a chemical analysis of bulk silicon nitride. Current analytical methods require the pulverization of bulk specimens. A pulverization procedure making use of grinding media, on the other hand, will introduce contaminants. A description is given of a dissolution procedure which overcomes these difficulties. It has been found that up to at least 0.5 g solid pieces of various samples of hot pressed and reaction bonded silicon nitride can be decomposed in a mixture of 3 mL hydrofluoric acid and 1 mL nitric acid overnight at 150 °C in a Parr bomb. High-purity silicon nitride is completely soluble in nitric acid after treatment in the bomb. Following decomposition, silicon and hydrofluoric acid are volatilized and insoluble fluorides are converted to a soluble form.

G.R.

ABSTRACT 3


Thermal barrier coatings applied to the heated side of engine components such as seals, combustor, and turbines of a gas turbine offer a potential increase in efficiency through the use of higher gas temperatures or less cooling air or benefits arising from extended component life by reducing component metal temperatures. The considered investigation has the objective to show that while a thermal barrier coated (TBC) specimen can be brought to a fixed temperature using various fuel-air ratios (F/A) values, lower calculated stresses are associated with lower (F/A) values. This implies that control of (F/A) values (i.e., ratio of heat input) during the starting transient and to a lesser extent during shutdown and operation, offers a potential method of improving TBC lifetime through thermal cycle management.

G.R.

ABSTRACT 4


The development and evaluation of materials for potential application as heat resistant structures in automotive gas turbine engines is discussed. Test specimens in the form of small monolithic bars were evaluated for thermal expansion and dimensional stability before and after exposure to sea salt and sulfuric acid. Followed up short and long term cycling at temperatures up to 1200 °C. The material finally selected, GE-7808, consists of the oxides, ZrO2-MgO-Al2O3-SiO2, and is described generally as 2MAS. The original version was based on a commercially available ceramic, (MAS)3. However, a clay/fate mixture was demonstrated to be a satisfactory very low cost source of the corundite (MAS)3 phase. Several full size honeycomb regenerator cores, about 1.02 cm thick and 5.5 cm diameter were fabricated from both the fire and mineral versions of GE-7808. The honeycomb cells in these cores had rectangular dimensions of about 0.5 mm x 0.25 mm and a wall thickness of approximately 0.1 mm. The test data show that GE-7808 is significantly more stable at 1100 °C in the presence of sodium than the aluminum-silicate reference materials. In addition, thermal exposure up to 1100 °C, with and without sodium present, results in essentially no change in thermal expansion of GE-7808.

M.G.

ABSTRACT 5


Thirty-seven cured phenolic resin compositions were prepared and tested for their ability to provide improved char residues and moisture resistance over state of the art epoxy resin composite matrices. Cyanate, epoxy novolac and vinyl ester resins were investigated. Char promoter additives were found to increase the anisotropic char yield at 800 °C of epoxy novolac and vinyl ester. Moisture resistant cyanate and vinyl ester compositions were investigated as composite matrices with Thoral 300 graphite fiber. A cyanate composite matrix provided state of the art composite mechanical properties before and after humidity exposure and an anisotropic char yield of 46 percent at 800 °C. The outstanding moisture resistance of the matrix was not completely realized in the composite. Vinyl ester resins showed promise as candidates for improved composite matrix systems.

Author

Author
28 PROPELLANTS AND FUELS

Includes rocket propellants, igniters, and oxidizers.

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

N81-14103* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ATOMIC HYDROGEN STORAGE METHOD AND APPARATUS Patent

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

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

N81-24293* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

EFFECT OF HYDROPROCESSING SEVERITY ON CHARACTERISTICS OF JET FUEL FROM OBCO 2 AND PARANO DISTILLATES
George M. Prok, Francisco J. Flores, and Gary T. Sang Jun (NASA-TP-1768. E-617) Avail. NTIS HC A02/ MF A01 CSM 21D

Jet A boiling range fuels and broad-property research fuels were produced by hydrotreating shale oil distillates, and the properties were measured to characterize the fuels. The distillates were a fraction of whole shale oil boiling below 343 °C from TOSCO 2 and Parahcope resucrees. The TOSCO 2 was hydrotreated at medium severity, and the Parahcope was hydrotreated at high, medium, and low severities. Fuels meeting Jet A requirements except for the freezing point were produced from the medium severity TOSCO 2 and the high severity Parahcope. Target properties of a broad-property research fuel were met by the medium severity TOSCO 2 and the high severity Parahcope except for the freezing point and a high hydrogen content. Medium and low severity Parahcope jet fuels did not meet thermal stability and freezing point requirements.

E.D.K.

N81-28232* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

AVIATION TURBINE FUEL PROPERTIES AND THEIR TRENDS

Fuel property values and their trends were studied through a review of a recognized wide-ranging sample population from actual fuel inspection data. A total of 676 fuel samples of Jet A aviation turbine fuel were compiled over an eleven year period. Results indicate that most fuel samples have one to three near-specification properties, the most common being aromatics, smoke point, and freezing point.

R.C.T.

N81-29248* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PERFORMANCE TESTS OF A GAS BLENDING SYSTEM BASED ON MASS-FLOW CONTROLLERS

The system provides many of the gas mixtures required for calibrating analytical instruments used in engine exhaust gas analysis and is capable of blending from one to four additive gases with either of two carrier gases in concentrations from 20 ppm to 50%. Two mixtures can be flowing simultaneously. Performance tests were made to determine the stability accuracy of the system while it was in limited use for a period of 2 years. The accuracy of the blender was measured by comparing binary mixtures from the blender with National Bureau of Standards standard reference materials. Analytical instruments were used to make these comparisons. The expected accuracy of ±2% was obtained in some of the tests, by the majority showed a systematic bias of ±5%. Although these tests revealed subtle instabilities in the flow controllers that contributed to the random scatter of data, the accuracy of the flow test meters and bubble flowmeters used for calibration is marginal for this purpose. A simple procedure is recommended that should enable the full potential of the system to be realized.

E.D.K.

N81-31380* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

INFRARED SPECTROSCOPY FOR THE DETERMINATION OF HYDROCARBON TYPES IN JET FUELS

The concentration of hydrocarbon types in conventional jet fuels and synguels can be measured using a computerized infrared spectrophotometer. The computerized spectrophotometer is calibrated using a fuel of known aromatic and olefinic content. Once calibration is completed, other fuels can be rapidly analyzed using an analytical program built into the computer. The concentration of saturates can be calculated as 100 percent minus the sum of the aromatic and olefinic concentrations. The analysis of a number of jet fuels produced an average standard deviation of 1.76 percent for aromatic types and one of 3.99 percent for olefinic types. Other substances such as is and organic mixtures can be analyzed for their hydrogen content.

Author


Factors which will determine the future supply and cost of aviation turbine fuels are discussed. The most significant fuel properties of volatility, fluidity, composition, and thermal stability are discussed along with the boiling ranges of gasoline, naphtha jet fuels, kerosene, and diesel oil. Tests were made to simulate the low temperature of an aircraft fuel tank to determine fuel tank temperatures for a 9100 km flight with and without fuel heating; the effect of N content in oil-shale derived fuels on the Jet Fuel Thermal Oxidation Tester breakpoint temperature was measured; finally, compatibility of non-metallic gaskets, sealants, and coatings with increased aromatic content jet fuels was examined.

A.T.
Evaluation of concepts for controlling exhaust emissions from minimally processed petroleum and synthetic fuels.


Rich lean combustion concepts designed to enhance rich combustion chemistry and increase combustor flexibility for NOx reduction with minimally processed fuels are examined. Processes such as rich product recycling and the rich combustion, lean-rich annihilation, and graduated air addition or staged rich combustion to release bound nitrogen in steps of reduced equivalence ratio are discussed. Variations to the baseline rapid quench section are considered, and the effect of residence time in the rich zone is investigated. The feasibility of using uncooled nonmetallic materials for the rich zone combustion construction is also addressed. The preliminary results indicate that rich primary zone staged combustion provides environmentally acceptable operation with residual and/or synthetic coal-derived liquid fuels.

Safety management of complex research operations.


Complex research and technology operations present many varied potential hazards which must be addressed in a disciplined independent safety review and approval process. The research and technology effort at the Lewis Research Center is divided into programmatic areas of aeronautics, space, and energy. Potential hazards vary from high energy fuels to hydrocarbon fuels, high pressure systems to high voltage systems, toxic chemicals to radiative materials, and was determined in high-powered lasers. A Safety Permit System presently covers about 900 potentially hazardous operations. The Safety Management Program described in this paper is believed to be a major factor in maintaining an excellent safety record at the Lewis Research Center.

Experimental study of the stability of aircraft fuels at elevated temperatures.

Alexander Vranos and Pierre J. Marteney (NASA CR-165165) NTIS HC A07/MF A01 CSCL 21D

An experimental study of fuel stability was conducted in a apparatus which simulated an aircraft gas turbine fuel system. Two fuels were tested: Jet A and Number 2 Home Heating oil. Jet A is an aircraft gas turbine fuel currently in wide use. No.

The conceptual design of a Spacelab experiment to develop the technology associated with low gravity propellant management is presented. The proposed facility consisting of a supply tank, receiver tank, pressurization system, instrumentation, and supporting hardware, is described. The experimental objectives, the receiver tank to be modeled, and constraints imposed on the design by the space shuttle, Spacelab, and scaling requirements, are described. The conceptual design, including the general configurations, flow schematics, insulation systems, instrumentation requirements, and internal tank configurations for the supply tank and the receiver tank, is described. Thermal, structural, fluid, and safety and reliability aspects of the facility are analyzed. The facility development plan, including schedule and cost estimates for the facility, is presented. A program work breakdown structure and master program schedule for ten years of program are included.

Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
TEXTURING POLYMER SURFACES BY TRANSFER CASTING Patent Application

A surface of a fluorocarbon polymer is exposed to a beam of ions from a source 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 a negative replica of the textured surface. The microscopic surface texture provides large surface area as for adhesive bonding. In cardiovascular prosthesis applications the surfaces are relied on for the development of a thin adherent well nourished thrombus. NASA

MECHANICAL BONDING OF METAL Patent Application

The metal surfaces of the structures that are to be bonded are exposed to an ion beam together with a target of low sputtering yield material. This material deposits on the surfaces and creates sites of sputter resistance which evolve into peaks of a cone-like surface microstructure. The textured metal surfaces are arranged in face-to-face relationship and compressed together with plastic deformation which mechanically interlocks the cone. A large interface area is produced which minimizes thermal and electrical losses. Also, no electrical power or heat is required during metal joining. The process can be performed in either air or vacuum. NASA

SAFETY MANAGEMENT OF COMPLEX RESEARCH OPERATORS

Complex research and technology operations present varied potential hazards which are addressed in a disciplined, independent safety review and approval process. Potential hazards vary from high energy fuels to hydrocarbon fuels, high pressure systems to high voltage systems, toxic chemicals to radioactive materials and high speed rotating machinery to high powered lasers. A Safety Permit System presently covers about 600 potentially hazardous operations. The Safety Management Program described is believed to be a major factor in maintaining an excellent safety record. S F

The economic interaction of the terrestrial and satellite systems is considered. Parametric equations are formulated to allow examination of necessary user thresholds and growth rates. Transitions between satellite and terrestrial service systems are examined. User growth rate density (user/year/sq km) is shown to be a key parameter in the analysis of systems compatibility. The concept of system design matching the price-demand curves is introduced and examples are given. The role of satellite systems is critically examined and the economic conditions necessary for the introduction of satellite service are identified.

An experimental investigation of multiple signal operations using an octave bandwidth traveling wave tube (TWT) was conducted in order to approximate the behavior of a TWT being developed for multichannel digital communication. Test results include the intermodulation effects as well as collector and overall efficiency effects with two and three discrete signal operations. Data are presented for operations that cover approximately a 4 dB range in combined signal output power up to the maximum RF power achievable in each case. For multiple signal operation the term maximum power is more appropriate than saturation. The power associated with intermodulation products was small at operating levels 4 dB below maximum power, but it approached 15 percent of the total combined output at maximum power for the two signal case and 20 percent for the three signal case. The maximum RF output powers in the multiple signal cases were 20 to 25 percent lower than the saturated output level for any of the signals inserted individually. In general, both the collector and five stage depressed collector were used and overall tube efficiencies were adversely affected during multiple signal operation in a manner related to the power levels involved. At 4 dB below maximum, where the intermodulation effects were small, it was possible to achieve collector and overall efficiencies with multiple signals that are comparable to single signal efficiencies. This change gradually attains maximum RF output and collector efficiencies were several percentage points less and the overall efficiency as much as 10 percentage points less (a change of 25 percent) than single frequency values. The overall efficiency loss is partially due to the loss in collector efficiency but largely due to the loss in usable RF power that is associated with the intermodulation power. The three signal tests were always the more severely affected.

A review of the future options open to satellite system planners focuses attention on the use of the 30/20 GHz band. Very broad bandwidths available, coupled with a primary allocation for fixed satellite service, make the band very attractive. NASA, in concert with the system and service supplier industries, is planning a research and development program aimed at flight demonstration of 30/20 satellite systems which it is hoped will lead to operational system use in the early 1990's. The communication system concepts and the spacecraft systems necessary to support these for operational use in 1990 and beyond are discussed.


As the data rates required for digitally encoded television are reduced, satellite systems employing the transmission of digitally encoded television will become attractive. It is likely that telecommunication transmitted in this format will be adjacent to or in the same frequency bands as television transmissions in other modulation formats. A knowledge of carrier to interference power ratios as a function of assessed picture quality will be required for frequency sharing between these different modulation formats. This paper presents the results of subjective and quantitative tests describing the results of interference to a particular digital television system from a frequency modulated (FM) television system, and for interference to an FM television system from a digital television system. (Author)


This paper deals with the economic interaction of the terrestrial and satellite land-mobile radio service systems. The cellular, trunked and satellite land-mobile systems described have intermodulation products that are small at operating levels 4 dB below maximum power, but it approached 15 percent of the total combined output at maximum power for the two signal case and 20 percent for the three signal case. The maximum RF output powers in the multiple signal cases were 20 to 25 percent lower than the saturated output level for any of the signals inserted individually. In general, both the collector and five stage depressed collector were used and overall tube efficiencies were adversely affected during multiple signal operation in a manner related to the power levels involved. At 4 dB below maximum, where the intermodulation effects were small, it was possible to achieve collector and overall efficiencies with multiple signals that are comparable to single signal efficiencies. This change gradually attains maximum RF output and collector efficiencies were several percentage points less and the overall efficiency as much as 10 percentage points less (a change of 25 percent) than single frequency values. The overall efficiency loss is partially due to the loss in collector efficiency but largely due to the loss in usable RF power that is associated with the intermodulation power. The three signal tests were always the more severely affected.


The paper presents satellite system concepts that are likely in the 1990's and may bring a new dimension to satellite communication services. The NASA 30/20 GHz communications satellite demonstration program is discussed with emphasis on the related technology development. Two general types of services are examined: trunking services and customer premises services.

Thermionic energy conversion (TEC) and metallic-fluid heat pipes (MFHPs), offering unique advantages in terrestrial and space energy processing by virtue of operating on working-fluid vaporization/condensation cycles that accept great thermal power densities at high temperatures, share complex materials problems. Simplified equations are presented that verify and solve such problems, suggesting the possibility of cost-effective applications in the near term for TEC and MFHP devices. Among the problems discussed are the limitation of alkali-metal corrosion, protection against hot external gasses, external and internal vaporization, interfacial reactions and diffusion, expansion coefficient matching, and creep deformation.

SECOND YEAR TECHNICAL REPORT ON BOARD PROCESSING FOR FUTURE SATELLITE COMMUNICATIONS SYSTEMS
(Contract F19628-80-C-0001)
(NASA CR-165155, MTR-8164, TR-2) Avail. NTIS
HC A10/MF A01 CSCL 178

Advanced baseband and microwave switching techniques for large domestic communications satellites operating in the 30/20 GHz frequency bands are discussed. The nominal baseband processor throughput is one million packets per second (1.6 Gb/s) from one thousand T1 carrier rate customer premises terminals. A frequency reuse factor of sixteen is assumed by using 16 spot antenna beams with the same 100 MHz bandwidth per beam and a modulation with a one b/s per Hz bandwidth efficiency. Eight of the beams are fixed on major metropolitan areas and eight are scanning beams which periodically cover the remainder of the U.S. under dynamic control. User signals are regenerated (demodulated/encoded) and message packages are reformatted on board. Frequency division multiple access and time division multiplex are employed on the uplinks and downlinks, respectively, for terminals within the coverage area and dwell interval of a scanning beam. Link establishment and packet routing protocols are defined. Also described is a detailed design of a separate 100 x 100 microwave switch capable of handling nonregenerated signals occupying the remaining 2.4 GHz bandwidth with 60 dB of isolation, at an estimated weight and power consumption of approximately 400 kg and 100 W, respectively.

M.G.
ELECTRONICS AND ELECTRICAL ENGINEERING

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

For related information see also 60 Computer Operations and Hardware and 76 Solid-State Physics.

MODULAR INSTRUMENTATION SYSTEM FOR REAL-TIME MEASUREMENTS AND CONTROL ON RECIPROCATING ENGINES

William J. Rice and Arthur G. Bircheneough Nov. 1980 14 p refs (NASA-TP-1757; E-455) Avail. NTIS HC A02/MF A01 CSCL 14B

An instrumentation system was developed for reciprocating engines. Among the parameters measured are the indicated mean effective pressure, or theoretical work per cycle, and the mass fraction burned, i.e., a measure of the combustion rate in the cylinder. These computations are performed from measured cylinder pressure and crankshaft angle and are available in real time for the experimenter. A 100 or 200 consecutive-cycle sample is analyzed to reduce the effect of cyclic variations in the engine. Data are displayed in bargraph form, and the mean and standard deviation are computed. Other instruments are also described. Author

ELECTRIC VEHICLE MOTORS AND CONTROLLERS

Richard R. Secunde 1981 33 p refs Presented at the 5th Internat. Workshop on Rare Earth Cobalt Magnets and their Applications, Ranoke, Va., 7-10 Jun 1981 (Contract DE-AIOI-77CS-51044) (NASA-TP-18368; E-592) Avail. NTIS HC A03/MF A01 CSCL 09C

Improved and advanced components being developed include electronically commutated permanent magnet motors of both drum and disk configuration, an unconventional brush commutated motor, and ac induction motors and various controllers. Test results on development motors, controllers, and combinations thereof indicate that efficiencies of 80% and higher for individual components, and 80% to 90% for motor/controller combinations can be obtained at rated power. The simplicity of the development motors and the potential for ultimately low cost electronics indicate that one or more of these approaches to electric vehicle propulsion may eventually displace presently used controllers and brush commutated dc motors. Author

HIGH TEMPERATURE ELECTRONIC REQUIREMENTS IN AEROPROPULSION SYSTEMS


This paper discusses the needs for high temperature electronic and electrooptic devices as they would be used on aircraft engines in either research and development applications, or operational applications. 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 research and development or for operational applications. In research and development 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 devices be able to be burned-in at temperatures significantly higher than those at which they will function on the engine. The major parameter is that semiconductor technology must be pushed well beyond the level at which silicon will be able to function. Author

THREE-AXIS ELECTRON-BEAM TEST FACILITY

James A. Dayton, Jr. and Ben T. Ebihara Mar. 1981 8 p refs (NASA-TP-18386; E-582) Avail. NTIS HC A02/MF A01 CSCL 09C

An electron beam test facility, which consists of a precision multidimensional manipulator built into an ultra-high-vacuum bell jar, was designed, fabricated, and operated at Lewis Research Center. The position within the bell jar of a Faraday cup which samples current in the electron beam under test, is controlled by the manipulator. Three orthogonal axes of motion are controlled by stepping motors driven by digital indexers, and the positions are displayed on electronic totalizers. In the transverse directions, the limits of travel are approximately + 0.5 cm from the center with a precision of 0.1 measured in .0001 in. in the axial direction, approximately 15.0 cm of travel are permitted with an accuracy of 12.7 micron (0.0005 in). In addition, two manually operated motions are provided, the pitch and yaw of the Faraday cup with respect to the electron beam can be adjusted to within a few degrees. The current is sensed by pulse transformers and the data are processed by a digital signal processing system. The data are recorded and later processed by computer to obtain the desired graphical presentations. Author
A comparison of analytical and experimental results is presented for a high performance dual-mode traveling wave tube (TWT) operated over a wide range conditions. The computations are carried out with advanced multidimensional computer programs. These programs model the electron beam as a series of disks or rings of charge and follow their trajectories from the input of the TWT through the slow-wave structure focusing system to their points of impacts in the depressed collector. TWT performance, collector efficiency, and collector current distribution are computed and compared with measurements. Very good agreement was obtained between computed and measured TWT performance and collector efficiencies, and the computer design of a highly efficient collector was demonstrated.

Author

A computer-designed axysymmetric 4 cm-diameter four-stage depressed collectors was evaluated in conjunction with an octave bandwidth dual-mode traveling-wave tube (TWT). The TWT was operated over a wide range of conditions to simulate different applications. The collector performance was optimized within the constraint of fixed collector geometry which was designed to operate in the linear distortion range of the TWT operating conditions. For operation of the dual-mode TWT at saturation, average collector efficiencies of 81.1/2 and 82 percent for the high and low modes, respectively, were obtained across an octave bandwidth leading to a three-fold increase in the TWT overall efficiency. For operation of the TWT in the linear, low distortion range, collector efficiencies of 87 to 92 percent were obtained, leading to TWT overall efficiencies as high as 35 percent. For operation of the dual-mode TWT over a 10 to 1 range in output power, overall efficiencies of 14 to 41 percent were obtained.

Author

This paper discusses 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. 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 and for a period of time. On an operational engine, the reliability requirements dictate that the devices 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 the level at which silicon will be able to function.

Author

A unified design procedure is presented for selecting the key SCM control parameters for the given power stage configuration and parameter values, such that all regulator performance specifications can be met and optimized concurrently in a single design attempt. All key results and performance indices, for buck, boost, and buck/boost converters which are relevant to SCM design considerations are included to facilitate frequent references.

Author

To reach the goals of this program -- i.e., the realization of integrated RC circuits in AlTa-technology on one substrate two ways were investigated first the single layer technique with resistors and capacitors from one layer and then the double layer technique with a Ta-rich layer for the resistors and an Al-rich layer for the capacitors. The compensation of temperature coefficients of R and C is done by reactive smearing of AlTa-Oxide in a sandwich dielectric of AlTa-oxide and SiO2. The double layer technique was optimized with production equipment and reached preproduction standards. Samples of highly stable RC-circuits (active filters) were realized. The technology also includes the integration of crossovers.

Author
A 1 GHz waveguide latching switch with a bandwidth of 1400 MHz and an exceptionally low insertion loss of 0.26 dB was demonstrated. The RF and driver ferrites are separate structures and can be optimized individually. This analysis for each structure is separately detailed. Basically, the RF section features a dual turnstile junction. The circulator consists of a dielectric tube which contains two ferrite rods and a dielectric spacer separating the ferrite parts along the center of symmetry of the waveguide to form two turns. This subassembly is indexed and locked in the center of symmetry of a uniform junction of three waveguides by the metallic transformers installed in the top and bottom walls of the housing. The switching junction and its actuating circuitry met all RF performance objectives and all shock and vibration requirements with no physical damage or performance degradation. It exceeds thermal requirements by operating over a 100 C temperature range (44 C to +56 C) and has a high power handling capability allowing up to 100 W of CW input power.

Author A.R.H.
FLUID MECHANICS AND HEAT TRANSFER

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

For related information see also O2 Aerodynamics and Thermodynamics and Statistical Physics.

34

34FLUID MECHANICS AND HEAT TRANSFER

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

For related information see also O2 Aerodynamics and Thermodynamics and Statistical Physics.

TURBULENT SOLUTION OF THE NAVIER-STOKES EQUATIONS


The unaveraged Navier-Stokes equations are solved numerically in order to study the nonlinear physics of incompressible turbulent flow. Initial three-dimensional cosine velocity fluctuations and periodic boundary conditions are used. No mean gradients are present. The three components of the mean square velocity fluctuations are equal for the initial conditions chosen. The resulting solution shows characteristics of turbulence, such as the nonlinear excitation of small-scale fluctuations. For the higher Reynolds numbers the initially nonrandom flow develops into an apparently random turbulence.

CURVED FILM COOLING ADMISSION TUBE

Patent Application


Effective film cooling to protect a wall surface from a hot fluid which impinges on or flows along the surface is proposed. A film of cooling fluid having increased area is provided by changing the direction of a stream of cooling fluid through an angle of from 35 degrees to 165 degrees before injecting it through the wall into a hot flowing gas at an angle to form a cooling fluid film. Cooling fluid is supplied to the orifice from a cooling fluid source via a turbulence control passageway having a curved portion between two straight portions. The angle through which the direction of the cooling fluid is turned results in less mixing of the cooling fluid with the hot gas, thereby substantially increasing the length of the film in a downstream direction.

ANALYSIS FOR PREDICTING ADIABATIC WALL TEMPERATURES WITH SINGLE HOLE COOLANT INJECTION INTO A LOW SPEED CROSSFLOW


Assuming the local adiabatic wall temperature equals the local total temperature in a low speed coolant mixing layer, integral conservation equations with and without the boundary layer effects are formulated for the mixing layer downstream of a single coolant injection hole oriented at a 10 degree angle to the crossflow. These equations are solved numerically to determine the centerline local adiabatic wall temperature and the effective coolant coverage area. Comparison of the numerical results with an existing film cooling experiment indicates that the present analysis permits a simplified but reasonably accurate prediction of the centerline effectiveness and coolant coverage area downstream of a single hole crossflow streamwise injection at 30 degree inclination angle.

HEAT TRANSFER COEFFICIENTS FOR STAGGERED ARRAYS OF SHORT PIN FINS


Short pin fins are often used to increase that heat transfer to the coolant in the trailing edge of a turbine blade. Due primarily to limits of casting technology, it is not possible to manufacture pins of optimum length for heat transfer purposes in the trailing edge region. In many cases the pins are so short that they actually decrease the total heat transfer surface area compared to a plain wall. A heat transfer data base for these short pins is not available in the literature. Heat transfer coefficients on pin and endwall surfaces were measured for several staggered arrays of short pin fins. The measured Nusselt numbers when plotted versus Reynolds numbers were found to fall on a single curve for all surfaces tested. The mean transfer coefficients for the short pin fins (length to diameter ratios of 1/2 and 2) were found to be about a factor of two lower than data from the literature for longer pin arrays (length to diameter ratios of about 8).

CURVED DIFFUSERS WITH CROSS-SECTIONAL TRANSITIONING USING A THREE-DIMENSIONAL VISCOUS ANALYSIS


A three dimensional analysis for fully viscous, subsonic, compressible flow is evaluated. An approximate form of the Navier Stokes equations is solved by an implicit spatial marching technique. Calculations were made for flow in a circular duct and in the F 16 inlet duct. The computed total pressure contours and secondary flow velocity vectors are presented. Qualitative comparisons with experiment are shown for both ducts. The analysis is used to show how the cross section transitioning in the F 16 inlet suppresses the development of a secondary flow vortex.

NUMERICAL SIMULATION OF FLOWS IN CURVED TUBES WITH SINGLE HOLE COOLANT INJEC.


A finite difference procedure was used to compute the mixing for three experimentally tested mixer geometries. Good agreement was obtained between analysis and experiment when the mechanisms responsible for secondary flow generation were properly modeled. Vorticity generation due to flow turning and vorticity generated within the centerbody lobe passage were found to be important. Results are presented for two different temperature ratios between fan and core streams and for two different free stream turbulence levels. It was concluded that the dominant mechanisms in turbofan mixers is associated with the secondary flows arising within the lobe region and their development within the mixing section.

FACTORS WHICH INFLUENCE THE BEHAVIOR OF TURBOFAN FORCED MIXER NOZZLES


A finite difference procedure was used to compute the mixing for three experimentally tested mixer geometries. Good agreement was obtained between analysis and experiment when the mechanisms responsible for secondary flow generation were properly modeled. Vorticity generation due to flow turning and vorticity generated within the centerbody lobe passage were found to be important. Results are presented for two different temperature ratios between fan and core streams and for two different free stream turbulence levels. It was concluded that the dominant mechanisms in turbofan mixers is associated with the secondary flows arising within the lobe region and their development within the mixing section.
PERFORMANCE OF SUPERSONIC EJECTOR NOZZLES

THE EFFECT OF INFLOW VELOCITY PROFILES ON THE PERFORMANCE OF SUPERSONIC EJECTOR NOZZLES

CAPILLARY AND ACCELERATION WAVE BREAKUP OF LIQUID JETS IN AXIAL-FLOW AIRSTREAMS

A COMPOSITE OF A HEATER ELEMENT AND LIQUID CRYSTALS

FLOW THROUGH AXIALLY ALIGNED SEQUENTIAL APERTURES OF THE ORIFICE AND BORDA TYPES
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.

N81-22310*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
HEAT PIPES CONTAINING ALKALI METAL WORKING FLUID Patent Application
James F. Morris, inventor (to NASA) Filed 16 Mar. 1981 8 p
(NASA-Cese-LEW-12253-1; US-Patent-Appl-EW-243822) Avail:
NTIS HC AO2/MF A01 CSCL 20D

The improvement of high temperature evaporation condensation heat transfer devices which have important and unique advantages in terrestrial and space energy processing is discussed. The device is in the form of a heat pipe comprising a sealed container or envelope which contains a capillary wick. The temperature of one end of the heat pipe is raised by the input of extremely hot and corrosive heat from an external heat source. A working fluid of a corrosive alkali metal transfers this heat to a heat exchanger remote from the heat source. The container and wick are fabricated containing a small percentage of corrosion inhibiting or gettering element. Lanthanum, scandium, yttrium, thorium, and hafnium are utilized as the alloying metal.

N81-24382*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
SOME FLOW PHENOMENA ASSOCIATED WITH ALIGNED SEQUENTIAL APERTURES WITH BORDA-TYPE INLETS
Robert C. Hendrickson and T. Trent Statz. May 1981 83 p refs
(NASA-TP-1792: E-479) Avail NTIS HC A04/MF A01 CSCL 20D

Choked flow rate and pressure profile data were taken and studied for a configuration consisting of four axially aligned, sequential Borda tubes of 1.9 length diameter ratio with separation distances of 0.8 and 30 tube diameters. For either case the flow rate data could be represented by a flow coefficient and temperature plot. At a separation distance of 30 tube diameters the pressure profiles dropped sharply at the entrance and recovered within each Borda tube, except at low temperatures, where fluid jetting through the last Borda tube occurred. At a separation distance of 0.8 tube jetting was prevalent and application of a significant backpressure did not alter the jetting. These results agree with the data for tubes with Borda or sharp edge orifice inlets and with a water flow visualization study reported herein.

N81-24386*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
FORCED AND NATURAL CONVECTION IN LAMINAR-JET DIFFUSION FLAMES
John B. Haggard, Jr. Jun 1981 24 p refs
(NASA-TP-1841: E-487) Avail NTIS HC AO2/MF A01 CSCL 20D

An experimental investigation was conducted on methane, laminar-jet, diffusion flames with coaxial, forced-air flow to examine flame shapes in zero-gravity and in situations where buoyancy aida (normal-gravity flame--) or hinder, (inverted-gravity flames) the flow velocities. Fuel nozzles ranged in size from 0.95 to 5.4 cm diameter at the fuel exit plane. Fuel flow rates ranged from 0.35 to 10.3 cm/sec and air flow rate from 0 to 597 cm/sec. A computer program developed under a previous government contract was used to calculate the one-dimensional normal and zero-gravity flames. The results include a comparison between the experimental data and the computed axis flame length for normal gravity and zero gravity which shwed good agreement. Inverted-gravity flames were created with a nozzle with the ratio of fuel nozzle radius to average fuel velocity. Flame extinguishment upon entry into weightlessness was studied, and it was found that relatively low forced-air velocities (approximately 10 cm/sec) are sufficient to sustain methane flame combustion in zero gravity. Flame color is also discussed.

N81-28389*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
DEPRESSURIZATION AND TWO-PHASE FLOW OF WATER CONTAINING HIGH LEVELS OF DISSOLVED NITROGEN GAS
(NASA-TP-1839: E-218) Avail NTIS HC A03/MF A01 CSCL 20D

Depressurization of water containing various concentrations of dissolved nitrogen gas was studied. In a nonflow depressurization experiment, water with high nitrogen content was depressurized at rates from 0.99 to 0.50 MPa per second and a metastable behavior which was a strong function of the depressurization rate was observed. Flow rates were performed in an axisymmetric, converging diverging nozzle, a two dimensional, converging nozzle with glass sidewall, and a sharp edge orifice. The converging converging nozzle exhibited choked flow behavior even at nitrogen concentration levels as low as 4 percent of the saturation level. The flow rates were independent of concentration level. Flow in the two dimensional, converging, visual nozzle appeared to have a sufficient pressure drop at the throat to cause nitrogen to come out of solution, but choking occurred further downstream. The orifice flow motion pictures showed considerable oscillation downstream of the orifice, and parallel to the flow. Nitrogen bubbles appeared in the flow at back pressures as high as 3.28 MPa, and the level at which bubbles were no longer visible was a function of nitrogen concentration.

N81-28384*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF THERMAL BOUNDARY CONDITIONS ON HEAT TRANSFER FROM A CYLINDER IN CROSS FLOW
S. Stephen Papell. Aug 1981 10 p refs
(NASA-TP-1894: E-627) Avail NTIS HC AO2/MF A01 CSCL 20D

Local heat transfer data over the leading surface of a cylinder in crossflow were obtained for Reynolds number range of 50,000. The cylinder was operated at both uniform-wall-temperature and uniform-heat-flux thermal anse of 80 deg from the front stagnation point. The uniform-wall-temperature heat transfer coefficients were as much as 56 percent lower than the uniform-heat-flux data. Between the stagnation point and 80 deg around the cylinder, there were no significant differences in the data. This region of the cylinder was a curvature region of the front end of a real turbine so it was concluded that either thermal boundary condition could be used to model turbine flow over that region of the blade. Results of evaluating the exponent x in the fundamental relationship Nu=Fr x exp, which is used in data correlation showed the exponent varies as a function of local position on the cylinder in the laminar flow region. The value of x increases linearly from 0.5 at the stagnation point to 0.59 at 60 deg around the cylinder. This linear trend continued into the separation region at 80 deg for the uniform-wall-temperature data, but x increased markedly in the separation region for the uniform-heat-flux data.

A.R.H.

N81-30390*# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES ACCEPTANCE AND CHARACTERIZATION TESTS
(NASA-TM-82535: E-857) Avail NTIS HC A08/MF A01 CSCL 20D

A series of six heat pipes, similar in design to those flown on the Communications Technology Satellite Hermes, for use in a prototype Solar Electric Propulsion uIMOD thrust module are evaluated. The results of acceptance and characterization tests performed on the heat pipes were subassemblies are reported. The performance of all the heat pipes met or exceeded design specifications.

A.R.H.
OF THE ORIFICE AND BORDA TYPE


Choked flow rate and pressure profile data were taken on sequential axially aligned inlets of the orifice and Borda type. The configuration consisted of two to four inlets spaced at two nominal separation distances of 0.7 and 30 diameters. At the nominal 30 diameter spacing, the reduced flow rate follows a simple empirical relation based on the reduced flow rate for a single inlet. At the nominal 0.7 diameter spacing, fluid jetting was prevalent at low temperatures and flow rates were the same as for a single inlet.

Author


Short pin fins are often used to increase the heat transfer to the coolant in the trailing edge of a turbine blade. Due primarily to limits of casting technology, it is not possible to manufacture pins of optimum length for heat transfer purposes in the trailing edge region. In many cases the pins are so short that they actually decrease the total heat transfer surface area compared to a plain wall. A heat transfer data base for these short pins is not available in the literature. Heat transfer coefficients on pin and endwall surfaces were measured for several staggered arrays of short pin fins. The measured Nusselt numbers when plotted versus Reynolds numbers were found to fall on a single curve for all surfaces tested. The heat transfer coefficients for the short pin fins (length to diameter ratios of 1/2 and 2) were found to be a factor of two lower than data from the literature for longer pin arrays (length to diameter ratios of about 8).

Author


Assuming the local adiabatic wall temperature equals the local total temperature in a low speed coolant mixing layer, integral conservation equations with and without the boundary layer effects are formulated for the mixing layer downstream of a single coolant injection hole oriented at a 30 degree angle to the crossflow. These equations are solved numerically to determine the center-line local adiabatic wall temperature and the effective coolant coverage area. Comparison of the numerical results with an existing film cooling experiment indicates that the present analysis permits a simplified but reasonably accurate prediction of the center-line effectiveness and coolant coverage area downstream of a single hole crossflow streamwise injection at 30 deg inclination angle.

Author


Pressure spectra and cross-spectra at an area contraction in a liquid fuel, ducted, combustion noise test facility are analyzed.

Author
A COMPUTER SIMULATION OF THE TRANSIENT RESPONSE OF A 4 CYLINDER STIRLING ENGINE WITH BURNER AND AIR PREHEATER IN A VEHICLE Final Report


A series of computer programs are presented with full documentation which simulate the transient behavior of a modern 4 cylinder Siemens arrangement Stirling engine with burner and air preheater. Cold start, cranking, idling, acceleration through 3 gear changes and steady speed operation are simulated. Sample results and complete operating instructions are given. A full source code listing of all programs are included.


Hydrodynamic measurements of turbulence structure were performed with a triaxial hot wire in the full coverage and the recovery regions following an array of injection holes under isothermal conditions at ambient temperature and pressure for blowing ratios of 0.9 and 0.4. High levels of turbulence kinetic energy (TKE) were determined for low blowing, and low TKE levels were found for the high blowing levels; in the recovery region, the flow can be represented by a model with an outer boundary layer and a 2-dimensional inner boundary layer. Recovery region hydrodynamics can be modelled by considering that a new boundary layer started to grow immediately after the end of blowing; the Prandtl mixing length distributions calculated from the values of mean velocity and turbulent shear stresses were consistent with the presence of a dual boundary layer structure in the recovery region. The program used here contains a one-equation model of turbulence, using turbulence kinetic energy with an algebraic mixing length; this 2-dimensional, finite difference program can predict the mean velocity and turbulence kinetic energy profiles based on initial values, boundary conditions, and a closure condition.


The pressure differentials induced across three types of multilayer insulation systems during evacuation have been measured and compared with values predicted using an idealized parallel plate geometric model. The systems tested were double-aluminized Mylar with a Tissuglas or silk net spacer and crinkled single-aluminized Mylar. Test samples were circular. The influence of purge gas type, layer density, sample diameter, and temperature was systematically investigated. The experimental approach was to measure the absolute pressure history and corresponding pressure differential induced during the evacuation. The measured pressure differentials were nondimensionalized and compared with those predicted by the parallel plate model as a function of Knudsen number. It was concluded that the parallel plate model is adequate for making engineering analyses. The influence of all parameters, except layer density, is well represented by the model. Representation of the influence of layer density is less satisfactory, but can be improved by modification of the flat plate model to allow for the more obvious practical nondimensionalities, such as crinkling, or the presence of a net spacer.


Starting from the first principles, and with one experimentally obtained parameter, an expression for stagnation heat transfer is derived, applicable to round, impinging jets. The results obtained with a row of air jets impinging on an electrically-heated surface in a small-scale setup characteristic of a typical turbine blade have been found compatible with the average heat transfer from a geometrically similar, steam-heated surface scaled up ten times, and comparable with the results of other investigators. These findings were linked to the flow fields likely to exist in the gas turbine blades, internally cooled by a row of round jets or a single jet of equivalent width. The magnitude of heat-transfer coefficients obtained here with impinging jets approaches that normally associated with forced convection of water and evaporative cooling.

(Author)
35 INSTRUMENTATION AND PHOTOGRAPHY
Includes remote sensors, measuring instruments and gages; detectors, cameras and photgraphic supplies, and holography.
For aerial photography see 43 Earth Resources.
For related information see also 06 Aircraft Instrumentation, and 19 Spacecraft Instrumentation.

NB1-16428*# National Aeronautics and Space Administration.
MINIATURE DRAG-FORCE ANEMOMETER
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 lightly damped second order system with a natural frequency as high as 40 kilohertz depending on beam geometry and material. The anemometer is used in both forward and reversed flow.
Anemometer characteristics and several designs are presented along with discussoins of several applications.

NB1-16428*# National Aeronautics and Space Administration.
LEWIS RESEARCH CENTER, CLEVELAND, OHIO
SPECIFYING AND CALIBRATING INSTRUMENTATIONS FOR WIDEBAND ELECTRONIC POWER MEASUREMENTS
Proc. Test. calibration techniques are described in detail. Analytical methods used to determine the bandwidth requirements of instrumentation for switching circuit waveform are presented and illustrated with examples from electric vehicle type applications. Analog multiplier wattmeters, digital wattmeters and instrumentation for switching circuit waveform are presented. Electicc wattmeter calibration and specifications are discussed.

Rapid-duble exposure, diffuse-inulination holography is evaluated analytically and experimentally as a flow visualization method for time-varying shock waves. Conditions are determined that minimize the distance (localization error) between the surface or curve of interference-fringe localization and the shock surface. Treated specifically are the cases of shock waves in a transonic compressor rotor for which there is laser anemeter data for comparison and shock waves in a flutter cascade.

An unbaked calibration system is described that permits absolute calibration with a piston manometer in the range 0.0002 to 6 Pa, with a probable error of 5 microPa ± 0.5%, or in the range 0.00008 to 0.02 Pa, with a probable error of 2 microPa ± 1%. Procedures and techniques that permit this performance are detailed. For hot-cathode ion gauges, the magnitudes of systematic corrections for envelope temperature and grid current are also indicated.

Laser-scanned photoacoustic spectroscopy has been used to detect tightly closed surface cracks in three structural ceramic materials: sintered silicon nitride, reaction-bonded silicon nitride, and sintered silicon carbide. It is found that the amplitude of the photoacoustic signal from the flaws is greater for the silicon nitrides than for silicon carbide, which is attributed to the lower thermal diffusivity of silicon nitride as well as differences in the grain size distribution and chemical composition. Signal amplitude, reproducibility, and signal-to-noise ratio are acceptable for effective flaw detection.

Commercially available elements of a composite consisting of a plastic sheet coated with liquid crystal, another sheet with a thin layer of a conducting material (gold or carbon), and copper bus bar strips were evaluated and found to provide a simple, convenient, accurate, and low-cost measuring device for use in heat transfer research. The particular feature of the composite is its ability to obtain local heat transfer coefficients and isotherm patterns that provide visual evaluation of the thermal performances of turbine blade cooling configurations. Examples of the use of the composite are presented.

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79
37 MECHANICAL ENGINEERING

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

N81-113546# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ANISOTROPIC TRIBOLOGICAL PROPERTIES OF SILICON CARBIDE

The anisotropic friction, deformation and fracture behavior of single crystal silicon carbide surfaces was investigated in two categories. The categories were called adhesive and abrasive wear processes, respectively. In the adhesive wear process, the adhesion friction and wear of silicon carbide were markedly dependent on crystallographic orientation. The force to reestablish the shearing fracture of adhesive bond at the interface between silicon carbide and metal was the least in the preferred orientation of silicon carbide slip system. The fracturing of silicon carbide occurred near the adhesive bond to metal and it was due to primary cleavages of both prismatic (110-110) and basal (0001) planes.

R.C.T.

N81-113956# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECT OF TANGENTIAL TRACTION AND ROUGHNESS ON CRACK INITIATION/PROPAGATION DURING ROLLING CONTACT

Rolling fatigue tests of 0.45 percent carbon steel rollers were carried out using a four roller type rolling contact fatigue tester. Tangential traction and surface roughness of the harder mating rollers were varied and their effect was studied. The results indicate that the fatigue life decreases when fraction is applied in the same direction as that of rolling. When the direction of fraction is reversed, the life increases over that obtained with zero traction. The roughness of harder mating roller also has a marked influence on life. The smoother the mating roller, the longer the life. Microscopic observation of specimens revealed that the initiation of cracks during the early stages of life is more strongly influenced by the surface roughness, while the propagation of these cracks in the latter stages is affected mainly by the tangential traction.

Author

N81-133576# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

DESIGN STUDIES OF CONTINUOUSLY VARIABLE TRANSMISSIONS FOR ELECTRIC VEHICLES

Preliminary design studies were performed on four continuously variable transmission (CVT) concepts for use with a flywheel equipped electric vehicle of 1700 kg gross weight. Requirements of the CVTs were a maximum torque of 450 N-m/330 lb-ft, a maximum output power of 75 kW (100 hp), and a flywheel speed range of 28,000 to 14,000 rpm. Efficiency, size, weight, controllable, mountability, and controls were evaluated for each of the four concepts which included a steel V-belt type, a flat rubber belt type, a toroidal traction type, and a cone roller traction type. All CVTs exhibited relatively high calculated efficiencies (68 percent to 97 percent) over a broad range of vehicle operating conditions. Estimated weight and size of these transmissions were comparable to or less than equivalent automatic transmission. The design of each concept was carried through the design layout stage.

A.R.H.

N81-133586# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ELASTOHYDRODYNAMIC LUBRICATION OF ELLIPTICAL CONTACTS

The determination of the minimum film thickness within contact is considered for both fully flooded and starved conditions. A fully flooded conjunction is one in which the film thickness is not significantly changed when the amount of lubricant is increased. The fully flooded results presented show the influence of contact geometry on minimum film thickness as expressed by the ellipticity parameter and the dimensionless speed, load, and materials parameters. These results are applied to materials of high elastic modulus (hard EHL), such as metal, and to materials of low elastic modulus (soft EHL) such as rubber. In addition to the film thickness equations that are developed, contour plots of pressure and film thickness are given which show the essential features of elastohydrodynamically lubricated conjunctions.

The crescent shaped region of minimum film thickness, with its side lobes in which the separation between the solids is a minimum, clearly emerges in the numerical solutions. In addition to the 3 presented for the fully flooded results, 15 more cases are used for hard EHL contacts and 18 cases are used for soft EHL contacts in a theoretical study of the influence of lubricant starvation on film thickness and pressure. From the starved results for both hard and soft EHL contacts, a simple and important dimensionless film boundary distance is specified. This film boundary distance describes how the film is maintained in lubricated contacts.

Author

N81-143226# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

COMPARISONS OF MODIFIED VASCO X-2 AND AISI 9310 GEAR STEELS
Dennis P. Townsend and Erwin V. Zaretzky Nov. 1980 19 p refs (NASA-TP-1731, E-070) Avail NTIS HC A02/MF A01 CSCI 13I

Endurance tests were conducted with four groups of spur gears manufactured from three heats of consumable electrode vacuum melted (CV) modified Vasco X-2. Endurance tests were also conducted with gears manufactured from CVM AISI 9310. Bench type rolling element fatigue tests were conducted with both materials. Hardness measurements were made to 811 K. There was no statistically significant life difference between the two materials. Life differences between the different heats of modified Vasco X-2 can be attributed to heat treatment variation and resultant hardness. Carburation of gear flanks only can eliminate tooth fracture as a primary failure mode for modified Vasco X-2. However, on a tooth surface fatigue can act as a nucleus of a tooth fracture failure for the modified Vasco X-2.

Author

N81-153876# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

AXIAL FORCE AND EFFICIENCY TESTS OF FIXED CENTER VARIABLE SPEED BELT DRIVE

An investigation of how the axial force varies with the centerline force at different speed ratios, speeds, and loads and
how the drive's transmission efficiency is affected by these related forces is described. The tests intended to provide a preliminary performance and controls characterization for a variable speed belt drive continuously variable transmission (CVT). consisted of the design and construction of an experimental test rig geometrically similar to the CVT, and operation of that rig at selected speed ratios and power levels. Data are presented which show: how axial forces exerted on the driver and driven sheaves vary with the cente rline force at constant values of speed ratio, speed, and output power; how the transmission efficiency varies with cente rline force; and how it is also a function of the V belt coefficient; and the axial forces on both sheaves as normalized functions of the traction coefficient. T.M

N81-16474* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
SELF-ACTING GEOMETRY FOR NONCONTACT SEALs
U. P. Allen 1981 19 p refs Proposed for presentation at
Ann Meeting of ASLE Pittsburgh, 11-14 May 1981
(NA"-TM-81659; E-473) Avail NTIS HC AO2/MF AO1 CSCL
114
Performance of two self acting seal designs for a liquid oxygen (LOX) turbopump was predicted over ranges of pressure differential and speed. Predictions were made from test results. Performance of a radial face seal for LOX was predicted up to 448 N/cm and 147 m/sec. Performance of a segmented circumferential seal for helium was predicted up to 69 N/cm and 189 m/sec. Results confirm predictions of noncontact operation. Qualitative agreement between test and analysis was found. The LOX face seal evidently operated with mostly liquid in the sealing geometry and mostly gas across the dam.

N81-17435* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
COMPUTER PROGRAM DOCUMENTATION FOR THE DYNAMIC ANALYSIS OF A NONCONTACTING MECHANICAL FACE SEAL
(NASA-TM-81886; E-850) Avail NTIS HC AO3/MF AO1 CSCL
11A
A computer program is presented which achieves a numerical solution to the equations of motion of a noncontacting mechanical face seal. The flexibly-mounted primary seal ring motion is expressed by a set of second order differential equations for the three degrees of freedom. These equations are reduced to a set of first order equations and the GEAR software package is used to solve the set of first order equations. Program inputs include seal design parameters and seal operating conditions. Output from the program include velocities and displacements of the seal ring about the axis of an inertial reference system. One example problem is described.

N81-17439* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
DESIGN OF SPUR GEARS FOR IMPROVED EFFICIENCY
(NASA-TM-81625; E-630; AVRADCOM-TR-D1-C-3) Avail:
NTIS HC AO2/MF AO1 CSCL 131
A multi-stage spur gear system loss for a wide range of gear geometries and operating conditions was used to determine design requirements for an efficient gearbox. The effects of spur gear size, pitch, pitch line velocity and load on efficiency were determined. Peak efficiencies were found to be greater for larger diameter and fine pitched gears and those (no-load) losses were found to be significant. R.C.T

N81-18391* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
HISTORY OF BALL BEARINGS
Duncan Dowson (Leeds Univ. England) and Bernard J. Hamrock
Feb 1981 84 p refs
(NASA-TM-81889; E-209) Avail NTIS HC AO5/MF AO1 CSCL
13J
The familiar precision rolling-element bearings of the twentieth century are products of exacting technology and sophisticated science. Their very effectiveness and basic simplicity of form may discourage further interest in their history and development. Yet the full story covers a large portion of recorded history and surprising evidence of an early recognition of the advantages of rolling motion over sliding action and progress toward the development of rolling-element bearings. The development of rolling-element bearings is followed from the earliest civilizations to the end of the eighteenth century. The influence of general technological developments, particularly those concerned with the movement of large building blocks, road transportation, instruments, water-raising equipment, and windmills are discussed, together with the emergence of studies of the nature of rolling friction and the impact of economic factors. By 1800 the essential features of ball and rolling-element bearings had emerged and it only remained for precision manufacture and mass production to confirm the value of these fascinating machine elements.

N81-18392* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
INTRODUCTION TO BALL BEARINGS
Bernard J. Hamrock and Duncan Dowson
Feb 1981 86 p refs
(NASA-TM-81890; E-209) Avail NTIS HC AO5/MF AO1 CSCL
13J
The purpose of a ball bearing is to provide a relative positioning and rotational freedom while transmitting a load between two structures, usually a shaft and a housing. For high rotational speeds (e.g., in gyroscope ball bearings) the purpose can be expanded to include rotational freedom with practically no wear in the bearing. This condition can be achieved by separating the bearing parts with a coherent fluid known as an elastohydrodynamic film. This film can be maintained not only when the bearing carries the load on a shaft, but also when the bearing is preloaded to position the shaft to within micro- or nano-inch accuracy and stability. Background information on ball bearings is provided, different types of ball bearings and their geometry and kinematics are defined, bearing materials, manufacturing processes, and separators are discussed. It is assumed for the purposes of analysis, that the bearing carries no load.

N81-19455* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
METHOD OF COLD WELDING USING ION BEAM TECHNOLOGY Patent
5 p Filed 28 Jul 1978 Supersede: N78-28459 (16 - 199, p 2534)
US Patent and Trademark Office CSCL 13H
A method for cold welding metal joints is described. In order to remove the contamination layer on the surface of the metal, an ion beam generator is used in a vacuum environment. A gas, such as xenon or argon is ionized and accelerated toward the metal surface. The beam of gas effectively sputters away the surface oxides and contamination layer so that clean underlying metal is exposed in the area to be welded. The use of this method allows cold welding with minimal deformation. Both similar and dissimilar metals can be cold welded with this method Official Gazette of the U.S. Patent and Trademark Office
studies conducted under a NASA contract for DOE on four CVT of several specific CVT concepts are cited along with their

Discussion of general

FOR ELECTRIC AND HYBRID VEHICLES

ADVANCED CONTINUOUSLY VARIABLE TRANSMISSIONS

A brief survey of past and present continuously variable transmissions (CVT) which are potentially suitable for application

with electric and hybrid vehicles was presented. The arrangement and function of several specific CVT concepts are cited along with their current development status. Lastly, the results of preliminary design studies conducted under a NASA contract for DOE on four CVT concepts for use in advanced electric vehicles are reviewed.

A contact fatigue life analysis was performed for a constant ratio. Nasviva Multitroller Traction Drive. The analysis was based on the Lundberg-Palmgren method for rolling element bearing life prediction. It is shown that (1) the contribution of contact load is not significant, and (2) the hydrodynamic and contact load increase with surface roughness.

Author

EFFECT OF SURFACE ROUGHNESS ON HYDRODYNAMIC BEARINGS

A theoretical analysis on the performance of hydrodynamic oil bearings is made considering surface roughness effect. The hydrodynamic as well as static contact load is found. The contact pressure was calculated with the assumption that the surface height distribution was Gaussian. The average Reynolds equation of partially lubricated surface was used to calculate hydrodynamic load. An analytical expression for average gap was found and was introduced to modify the average Reynolds equation. The resulting boundary value problem was then solved numerically by finite difference methods using the method of successive over relaxation. The pressure distribution and hydrodynamic load capacity of plane slider and journal bearings were calculated for various design data. The effects of attitude and roughness of surface on the bearing performance were shown. The results are compared with similar available solution of rough surface bearings. It is shown that (1) the contribution of contact load is not significant, and (2) the hydrodynamic and contact load increase with surface roughness.

Author

LIFE ANALYSIS OF MULTIROLLER PLANETARY TRACTION DRIVE

Combat vibration of components and target destruction are the primary attributes of this technology. The mechanisms and present uses in the aerospace industry. Sputtering offers great versatility and flexibility in depositing any material or in the synthesis of new ones. The sputtering deposition process has two areas of interest: thin film and fabrication technology. Thin film sputtering technology is primarily used for aerospace mechanical components to reduce friction, wear, erosion, corrosion, high temperature oxidation, diffusion and fatigue, and also to sputter-conduct temperature and strain sensors for aircraft engines. Sputter fabrication is used in intricate aircraft component manufacturing. Ion plating applications are discussed in terms of the high energy evaporant flux and the high throwing power. Excel·lent adherence and 3 dimensional coverage are the primary attributes of this technology.
Circumferential Shaft Seal Patent

The mechanism controlling the combustion process was found to change from chemical process control at the 90 deg and 45 deg probe positions to mass transfer control at the 0 deg probe position at the top of the rod. Under the experimental conditions, carbon combustion was characterized by two surface reactions, 2C + O2 yields 2CO and CO2 + C yields 2CO, and a gas phase reaction, 2CO + O2 yields 2CO2. J M S

N81-22360** National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
MULTIPLE PLATE HYDROSTATIC VISCOUS DAMPER
Patent Application
L. P. Ludwig, inventor (to NASA) Filed 27 Feb. 1981 7 p
(NASA-CASE LEW-12445-1 US-Patent- Appl SN-238687) Avail NTIS HC A02/MF A01 CSCL 13A
A device for damping radial motion of a rotating shaft is described. The damper comprises a series of spaced plates extending in a radial direction. A hydraulic piston is utilized to place a load in these plates. Each annular plate is provided with a suitable hydrostatic bearing geometry on at least one of its faces. This structure provides a high degree of dampening in a rotor-cylinder system of turbomachinery in general. The damper is particularly useful in gas turbine engines.

N81-26642** National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
SELF-STABILIZING RADIAL FACE SEAL Patent
A self-stabilizing radial face seal comprises an axial member and a primary seal ring juxtapositioned to a seal seat. At least one primary seal ring and seal seat unit is affixed to the axial member so as to rotate with it. The primary seal ring has a front face which opposes a face of the seal seat. The seal has both high-pressure and low-pressure regions of fluid, and seal seat is provided with a porous ring-like circumferential structure in the face of the seal seat opposite the front face of the primary seal ring.

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

N81-26447** National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
CIRCUMFERENTIAL SHAFT SEAL Patent
A circumferential shaft seal comprising two sealing rings held to a rotating shaft by means of a surrounding elastomeric band is disclosed. The rings are segmented and are of a rigid sealing material such as carbon or a polyimide and graphite fiber composite.

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

N81-26489** National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
SURFACE GEOMETRY OF CIRCULAR CUT SPIRAL BEVEL GEARS


(NASA-TH-8 28222, E-873, AVRADCOM-TR-81-1-13) Avail NTIS HC A02/MF A01 CSCL 13I
The tooth surface principal radii of curvature of crown (flat) gears were determined. Specific results are presented for involute, straight, and hyperbolic cutter geometries. It is shown that the geometry of circular cut spiral bevel gears is somewhat simpler than a theoretical logarithmic spiral bevel gear. A R H

N81-27523** National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
SURFACE FILMS AND METALLURGY RELATED TO LUBRICATION AND WEAR Ph.D. Thesis - Tokyo Inst. of Technology
Donald H. Buckley Jul 1981 218 p Refs
(NASA-TH-8 26445, E-900) Avail NTIS HC A08/MF A01 CSCL 11H
The nature of the tribological surface is identified and characterized with respect to adhesion, friction, wear, and lubricating properties. Surface analysis is used to identify the role of environmental constituents on tribological behavior. The effect of solid to solid interactions for metals in contact with metals, ceramics, semiconductors, carbons, and polymers is discussed. The data presented indicate that the tribological surface is markedly different than an ideal solid surface. The environment is shown to affect strongly the behavior of two solids in contact. Results also show that small amounts of alloying elements in base metals can alter markedly adhesion, friction, and wear by segregating to the solid surface.

N81-27524** National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
OPTIMAL TOOTH NUMBERS FOR COMPACT STANDARD SPUR GEAR SETS
(NASA-TH-8 26214, E-865, AVRADCOM-TR-81-1-15) Avail NTIS HC A03/MF A01 CSCL 13I
The design of a standard gear mesh is treated with the objective of minimizing the gear size for a given ratio, pinion torque, and allowable tooth strength. Scoring, 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 on 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.

Author

N81-27525** National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
A METHOD OF SELECTING GRID SIZE TO ACCOUNT FOR HERZ scav DEFORMATION IN FINITE ELEMENT ANALYSIS OF SPUR GEARS
(NASA-TH-8 26223, E-728, AVRADCOM-TR-81-1-14) Avail
A method of selecting grid size for the finite element analysis of gear tooth deflection is presented. The method is based on a finite element study of two cylinders in line contact, where the criterion for establishing element size was that there be agreement with the classical Hertzian solution for deflection. The results are applied to calculate deflection for the gear specimen used in the NASA spur gear test rig. Comparisons are made between the present results and the results of two other methods of calculation. The results have application in design of gear tooth profile modifications to reduce noise and dynamic loads.


SIMPLIFIED SOLUTION FOR STRESSES AND DEFORMATION

Two dimensional photoelastic stress analyses were conducted for epoxy resin models containing a hole defect under the conditions of Hertzian contact. Stress concentrations around the defect were determined as a function of several parameters. The effect of tangential traction on the stress concentration was also determined. Sharp stress concentrations occur in the vicinity of both the left and the right side of the hole. The stress concentration becomes more distinct the larger the hole diameter and the smaller distance between the hole and the contact surface. The stress concentration is greatest when the disk imposing a normal load is located at the contact surface directly over the hole. The magnitude and the location of stress concentration varies with the distance between the Hertzian contact area and the hole. The area involved in a process of rolling contact fatigue is confined to a shallow region at both sides of the hole. It was found that the effect of tangential traction is comparatively small on the stress concentration around the hole.

E. A. K.

ENDURANCE TESTS WITH LARGE-BORE TAPERED-ROLLER BEARINGS TO 2.2 MILLION DN

Endurance life tests were run with standard design and optimized high-speed design 120.85-mm (4.750-in.) bore tapered-roller bearings at shaft speeds of 12,500 and 18,500 rpm, respectively. Standard design bearings of vacuum melted AISI 4320 and CBS-1000M, and high-speed design bearings of CBS-1000M and through-hardened AISI M-50 were run under heavy combined radial and thrust load until fatigue failure or until a preset cutoff time of 1100 hours was reached. Standard design bearings made from CBS 1000M material ran to a 10 percent life approximately six times rated catalog life. Twelve identical bearings of AISI 4320 material ran to ten times rated catalog life without failure. Cracking and fracture of the cones of AISI M-50 high-speed design bearings occurred at 18,500 rpm due to high hoop stresses. Four CBS 1000M high-speed design bearings ran to twenty-four times rated catalog life without any spalling, cracking or fatigue failures.

Author
EFFECTS OF ULTRA-CLEAN AND CENFUGAL FILTRATION ON ROLLING-ELEMENT BEARING LIFE
Stuart H. Loewenthal, Donald W. Moyer (Tribon Bearing Co.), and William M. Needleman (Pall Corp., Glen Cove, N.Y.) 1981
(NASA-TM-82660; E-928) Avail. NTIS HC A03/MF A01 CSCL 13i

Fatigue tests were conducted on groups of 65-millimeter bore diameter deep-groove ball bearings in a MIL-L-23699 lubricant under two levels of filtration. In one test series, the oil cleanliness was maintained at an exceptionally high level (better than a class '000' per NAS 1638) with a 3 micron absolute barrier filter. These tests were intended to determine the 'upper limit' in bearing life under the strictest possible lubricant cleanliness conditions. In the tests using a centrifugal oil filter, contaminants of the type found in aircraft engine filters were injected into the filter suction at 125 milligrams per bearing-hour. "Ultra-clean" lubrication produced bearing fatigue lives that were approximately twice that obtained in previous tests with contaminated oil using 3 micron absolute filtration and approximately three times that obtained with 49 micron filtration. It was also observed that the centrifugal oil filter had approximately the same effectiveness as a 30 micron absolute filter in preventing bearing surface damage.

A brief historical account of the evolution of continuous, variable transmissions (CVT) for automotive use is given. The CVT concepts which are potentially suitable for application with electric and hybrid vehicles are discussed. The arrangement and function of several CVT concepts are cited along with their current developmental status. The results of preliminary design studies conducted on four CVT concepts for use in advanced electric vehicles are discussed.

Author

This paper reviews material properties of adhesion, friction and wear of single-crystal silicon carbide in contact with metals and alloys involved in a metal removal process such as grinding. The tribological properties in the metal removal processes are divided into properties which remove metal by adhesion between sliding surfaces, and metal removal by silicon carbide sliding against a metal, indenting it, and plowing a series of grooves or furrows. The paper also deals with fracture and deformation characteristics of the silicon carbide surface; the adhesion, friction and metal transfer to silicon carbide is related to the relative chemical activity of the metals. Atomic size and content of alloying elements play a dominant role in controlling adhesion and friction properties of alloys. The friction and abrasive wear decrease as the shear strength of the bulk metal increases.


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


Operating characteristics for a 118-mm bore cylindrical roller bearing were calculated using the computer program CYBEAN. The predicted results of inner and outer-race temperatures and heat transferred to the lubricant generally compared well with experimental data for shaft speeds to 3 million DN (25,500 rpm), radial loads to 8900 N (2000 lb), and total lubricant flow rates to 0.0102 cu m/min (2.7 gal/min).


An asymmetric rotor (19N, 4.3 lb), supported radially and axially by compliant bearings is subjected to severe excitation by rotating unbalance in the "pitching" mode at speeds to 50,000 rpm. The resilient, air lubricated bearings provide very effective damping, so that regions of resonance and instability can be traversed with amplitudes and limit trajectories within acceptable bounds. A novel journal bearing is introduced, in which a resilient support is furnished...
by the outer turn of the coiled foil-element bent to form an open polygon. The experimental apparatus and procedure are described, and the response of the rotor and flexible support system are documented by oscilloscope records of motion. (Author)


Novel thrust bearings with spiral-groove flexible membranes mounted on resilient supports were designed and their performance demonstrated. Advantages of surface compliance were combined with the superior load capacity of the spiral-groove geometry. Loads of 127-150N were supported on an area 42 sq cm, at speeds of 43,000-45,000 rpm and mean clearances of 15-20 microns. Supportworthiness was proved when tested in conjunction with foil journal bearings and a 19N rotor, excited in a pitching mode by a total unbalance of 43 micron-N. (Author)


Sliding friction experiments were conducted with various iron-base alloys alloying elements were Ti, Cr, Ni, Rh, and W in contact with a single-crystal silicon carbide (0001) surface in vacuum. Results indicate atomic size misfit and concentration of alloying elements play a dominant role in controlling adhesion, friction, and wear properties of iron-base binary alloys. The controlling mechanism of the alloy properties is an intrinsic effect involving the resistance to shear fracture of cohesive bonding in the alloy. The coefficient of friction generally increases with an increase in solute concentration. The coefficient of friction increases as the solute-to-iron atomic radius ratio increases or decreases from unity. Alloys having higher solute concentration produce more transfer to the silicon carbide than do alloys having low solute concentrations. The chemical activity of the alloying element is also an important parameter in controlling adhesion and friction of alloys. (Author)


This paper is a broad survey of the lubrication of rolling-element bearings. Emphasis is on the critical design aspects related to speed, temperature, and ambient pressure environment. Types of lubrication including grease, jets, mist, spray, and through-the-race are discussed. The paper covers the historical development, present state of technology, and the future problems of rolling-element bearing lubrication. (Author)


Many of the currently, widely used tools available for surface analysis are described. Those which have the highest applicability for giving elemental and/or compound analysis for problems of interest in tribology and are truly surface sensitive (that is, less than 10 atomic layers) are presented. The latter group is evaluated in detail in terms of strengths and weaknesses. Emphasis is placed on post-test analysis of experiments performed under "real" conditions (e.g., in air with lubricants). It is further indicated that such equipment could be used for screening and quality control. (Author)


Nucleate boiling heat transfer is examined as a means of energy conservation. Nucleate boiling curves were obtained for ion beam textured copper surfaces, untreated copper surfaces, copper surfaces which had been polished and surfaces which had been coated with a plasma deposited polymer. Results show that texturing aids heat transfer while polishing has the opposite effect. The polymer coatings did not change nucleate boiling behavior. Aging effects were observed for untreated and for polished surfaces, while no such effects were noticed for textured surfaces. These data suggest that aging may be dependent on surface microgeometry, which is important in nucleate boiling heat transfer. D.K.


Sputter deposition of various geometric surfaces by ion beam sources is examined in order to evaluate three different types of protective coatings for die materials. In the first experiment, a 30 cm diameter argon ion source was used to sputter deposit adherent metallic films up to eight microns thick on H-13 steel, and a thermal fatigue test specimen sputter deposited with metallic coatings one micron thick was immersed in liquid aluminum and cooled by water for 15,000 cycles to simulate operational environments. Results show that these materials do protect the steel by reducing thermal fatigue and thereby increasing die lifetime. The second experiment generated diamond-like carbon films using a dual beam ion source system that directed an eight cm argon ion source beam at the substrates. These films are still in the process of being evaluated for crystallinity, hardness and infrared absorption. The third experiment coated a fiber glass beryllium incorporated in the eight-cm diameter mercury ion thruster with molybdenum to ensure proper electrical and thermal properties. The coating maintained its integrity even under acceleration tests. D.K.


Combustion at inlet air temperatures of 1100 to 1250 K was studied for application to advanced automotive gas turbine engines. Combustion was initiated by the hot environment, and therefore no external ignition source was used. Combustion was stabilized without a flameholder. The tests were performed in a 12-cm-diameter test section at a pressure of 250,000 Pa, with reference velocities of 32 to 60 m/s and at maximum combustion temperatures of 1350 to 1850 K. Number 2 diesel fuel was injected by means of a multiple-source fuel injector. Unburned hydrocarbon emissions were negligible for all test conditions. Nitrogen oxide emissions were less than 1.9 g NO2/kg fuel for combustion temperatures below 1800 K. Carbon
monoxide emissions were less than 16 g CO/kg fuel for combustion temperatures greater than 1600 K, inlet-air temperatures higher than 1150 K, and residence times greater than 4.3 ms. (Author)


The design characteristics are presented of a fuel tolerant variable geometry staged air combustor using regenerative/convective cooling. The rich/lean variable geometry combustor is designed to achieve low NOx emission from fuels containing fuel bound nitrogen. The dry heat input of the combustor was calculated for a can-annular combustion system with associated operating conditions for the Allison 550 K engine. Preliminary test results indicate that the concept has the potential to meet emission requirements at maximum continuous power operation. However, airflow sealing and improved fuel/air mixing are necessary to meet Department of Energy program goals. L.S.


A polytetrafluoroethylene (PTFE) sphere of radius 4.8 mm was rubbed against nickel and S-Monel at speeds from 0.94 to 94 mm/s and at loads from 0.19 to 3.9 N. The transfer film of PTFE on the metal was examined with X-ray photoelectron spectroscopy. In all cases the film was found to be indistinguishable from bulk PTFE. A trace of metal fluoride was observed whether the rubbing took place on oxidized or atomically clean metal. The film was of the order of a molecule thick for the entire range of loads and did not increase with repeated passes over the same rubbed area. An erratic increase in thickness at rubbing speeds above 10 mm/s was taken as evidence of random transfer of bulk material. (Author)


A computer aided design method for mechanical face seals is described. Based on computer simulation, the actual motion of the flexibly mounted element of the seal can be visualized. This is achieved by solving the equations of motion of this element, calculating the displacements in its various degrees of freedom vs. time, and displaying the transient behavior in the form of a motion picture. Incorporating such a method in the design phase allows one to detect instabilities and to correct undesirable behavior of the seal. A theoretical background is presented. Details of the motion display technique are described, and the usefulness of the method is demonstrated by an example of a noncontacting conical face seal. (Author)


The ion plating techniques are classified relative to the instrumental set up, evaporation media and mode of transport. Distinction is drawn between the low vacuum (plasma) and high vacuum (ion beam) techniques. Ion plating technology is discussed at the fundamental and industrial level. At the fundamental level, the capabilities and limitations of the plasma (evaporant flux) and film characteristics are evaluated. On the industrial level, the performance and potential uses of ion plated films are discussed. (Author)


Sputtering and ion plating technologies are reviewed in terms of their potential and present uses in the aerospace industry. Sputtering offers great universality and flexibility in depositing any material or in the synthesis of new ones. The sputter deposition process has two areas of interest: thin film and fabrication technology. Thin film sputtering technology is primarily used for aerospace mechanical components to reduce friction, wear, erosion, corrosion, high temperature oxidation, diffusion and fatigue, and also to sputter-construct temperature and strain sensors for aircraft engines. Sputter fabrication is used in intricate aircraft component manufacturing. Ion plating applications are discussed in terms of the high energy evaporation flux and the high throwing power. Excellent adherence and 3-dimensional coverage are the primary attributes of this technology. (Author)


The paper reviews, from both a technical and historic perspective, the results of research conducted using the NASA Five-Ball Fatigue Tester. The test rig was conceived by W. J. Anderson in late 1958. The first data was generated in March 1959. Since then a total of approximately 500,000 test hours have been accumulated on a group of eight test rigs which are capable of running 24 hours a day, 7 days a week. Studies have been conducted to determine the effect of rolling-element fatigue life of contact angle, material hardness, chemistry, hertzian treatment, and processing, lubricant type and chemistry, elastohydrodynamic film thickness, deformation and wear, vacuum, and temperature as well as Hertzian and residual stresses. Correlation was established between the results obtained using the five-ball tester and those obtained with full-scale rolling-element bearings. (Author)


The paper reviews studies of the role of the microenvironment in the adhesion, friction, and wear behavior of materials in solid-state contact. The microenvironment is defined as the environment on the surface of solids in solid-state contact. Properties of the environment are discussed which exert an influence on the adhesion, friction, wear, and lubrication of materials in contact. The effect of the environment on lubricants and their properties is considered with respect to the interaction of lubricants with material surfaces in contact; the effect on the ability of lubricants to provide protective surface films is also considered. It is concluded that naturally
A study was conducted within the thrust range 450 to 9000 N (100 to 2000 pounds). Performance analyses were made on centrifugal, axial, and propeller types of pumps, low thrust chemical propulsion systems, and axially impulsive turbines. Vane pumps, propeller, and unsteady flow were examined. The study was organized by the National Aeronautics and Space Administration (NASA). The results of this study provide valuable insights into the performance and design of various pumps and propulsion systems.

Friction and wear tests were conducted on optimised sputtered Cr2O3 and Cr2O3 with metallic binder coatings. The coatings were applied on the bearing surface of journal foil air bearings and were tested against chrome-carbide coated journal surfaces. The objective of the study was to develop a coating system which would withstand 9000 start-stops and high-speed runs (maximum acceleration, 100 g) in temperatures ranging from room temperature to 650 C. The Cr2O3 coating completed the test sequence and the coating consisting of Cr2O3 with metallic binders completed 3000 start-stops. The coefficient of friction of the coatings at 650 C was found to be about half that at room temperature. It was concluded, therefore, that the coatings should perform much better in a high temperature environment alone. The decrease in friction at high temperature is attributed to oxidation and interactions of the coating and substrates at the interface temperature. (Author)


A program was conducted to design, fabricate and test a durable, low cost, lightweight composite fan exit guide vane for high bypass ratio gas turbine engine applications. Eight candidate material/design combinations were evaluated by NASTRAN finite element analysis. Four of these candidate systems were selected for composite vane fabrication by two vendors. A core and shell vane design was chosen in which the unidirectional graphite core fiber was the same for all candidates. The shell material, fiber orientation and ply configuration were varied. Material tests were performed on raw
QUALITY ASSURANCE AND RELIABILITY
Includes product sampling procedures and techniques, and quality control.

ACOUSTO-ULTRASONIC CHARACTERIZATION OF FIBER REINFORCED COMPOSITES
The acousto-ultrasonic technique combines advantageous aspects of acoustic emission and ultrasonic methodologies. Acousto-ultrasonics operates by introducing a repeating series of ultrasonic pulses into a material. The waves introduced simulate the spontaneous stress waves that would arise if the material were put under stress as in the case of acoustic emission measurements. These benign stress waves are detected by an acoustic emission sensor. The physical arrangement of the ultrasonic (input) transducer and acoustic emission (output) sensor is such that the resultant waveform carries an imprint of morphological factors that govern or contribute to material performance. The output waveform is complex, but it can be quantized in terms of a 'stress wave factor'. The stress wave factor, which can be defined in a number of ways, is a relative measure of the efficiency of energy dissipation in a material. If flaws or other material anomalies exist in the volume being examined, their combined effect appears in the stress wave factor.

RELIABILITY AND QUALITY ASSURANCE ON THE MOD 2 WIND SYSTEM
The Safety, Reliability, and Quality Assurance (RQA) approach developed for the largest wind turbine generator, the Mod 2, is described. The RQA approach assures that the machine is not hazardous to the public or to the operating personnel, is operated unattended on a utility grid, demonstrates reliable operation, and helps establish the quality assurance and maintainability requirements for future wind turbine projects. The significant guideline consists of a failure modes and effects analysis (FMEA) during the design phase, hardware inspections during parts fabrication, and three simple documents to control activities during machine construction and operation. E.A.K. A81-19656

ULTRASONIC MEASUREMENT OF MATERIAL PROPERTIES
The state-of-the-art of ultrasonic methods is reviewed with reference to the basic measurements, signal acquisition and processing, strength property and morphological condition measurements, and industrial applications. The emphasis is placed on techniques that indicate quantitative ultrasonic correlations with material strength and morphology relevant to the reliability of load bearing structures.

V.L.
or weakly stable behavior can take caused by aerodynamic forces affecting stiffness and damping of the power generating system. Stability was determined by the eigenvalues of a wind speed rotor speed structural stiffness and damping the 2.5 megawatt wind turbine. Some of the parameters varied were presented principal elastic bending degrees of freedom one degree of power generating system. The aerodynamic loading was derived from blade element theory. Each rotor blade was permitted to produce wind turbines was examined. The analytical model investigated, the aerodynamic and structural coupling between the blades was considered. A digital computer program was developed to conduct parametric studies. Results indicate that the mistuning has a beneficial effect on the coupled bending torsion and uncoupled torsion flutter. On forced response however, the effect may be either beneficial or adverse, depending on the engine order of the forcing function. The results also illustrate that it may be feasible to utilize mistuning as a passive control to increase flutter speed while maintaining forced response at an acceptable level.

due to motion of the rotor blades and tower in the plane of rotation or by mechanical coupling between the rotor system and the tower.

**References**

N81-18492* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


Compliance and stress intensity coefficients were determined over crack length to width ratios from 0.1 to 0.8. Displacements were measured at the load points, load line, and crack mouth. Special fastening was devised to permit accurate measurement of load point displacement. The results are in agreement with the currently used results of boundary collocation analyses. The errors which occur in stress intensity coefficients or specimen energy input determinations made from load line displacement measurements rather than from load point measurements are emphasized. Author

N81-18484* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF MISTUNING ON BENDING-TORSION FLUTTER AND RESPONSE OF A CASCADE IN INCOMPRESSIBLE FLOW


The effect of small differences between the individual blades (mistuning) on the aeroelastic stability and response of a cascade were studied. The aerodynamic, inertial, and structural coupling between the bending and torsional motion of each blade and the aerodynamic coupling between the blades was considered. A digital computer program was developed to conduct parametric studies. Results indicate that the mistuning has a beneficial effect on the coupled bending torsion and uncoupled torsion flutter. On forced response however, the effect may be either beneficial or adverse, depending on the engine order of the forcing function. The results also illustrate that it may be feasible to utilize mistuning as a passive control to increase flutter speed while maintaining forced response at an acceptable level.

A R H

**References**

N81-12446* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.


The stability of large horizontal axis, axisymmetric, power producing wind turbines was examined. The analytical model used included the dynamic coupling of the rotor tower and power generating system. The aerodynamic loading was derived from blade element theory. Each rotor blade was permitted to have principal elastic bending degrees of freedom; one degree of freedom in torsion and controlled pitch as a rigid body. The rotor hub was mounted on a rigid nacelle which may yaw freely or in a controlled manner. The tower can bend in two principal directions and may twist. Also, the rotor speed can vary and may induce perturbation reactions within the power generating equipment. Stability was determined by the eigenvalues of a set of linearized constant coefficient differential equations. All results presented are based on a 3 bladed, 300 ft. diameter, 2.5 megawatt wind turbine. Some of the parameters varied were wind speed, rotor speed, structural stiffness and damping, the effective stiffness and damping of the power generating system, the bending and torsional directions of the rotor blades. Unstable or weakly stable behavior is caused due to aerodynamic forces.

The relationship between the R-curves and semipirical fracture analyses (SEFA) is investigated theoretically using a hypothetical material. Equivalent R-curves (ERC) are developed for real materials using data from the literature. It is shown that for each SEFA there is an ERC whose magnitude and shape are determined by the SEFA formulation and its empirical parameters. The ERC is equivalent in that it predicts exactly the same relationship between the fracture stress and the initial crack length (residual strength) as the SEFA. If the effective R-curve is unique, then the various empirical parameters cannot be constant, and vice versa. However, for one of the SEFA examined, Newman's SEFA, parameter variations are small enough to be within the range of normal data scatter for real materials.

V.L.


The stability of large horizontal-axis, asymmetric, power producing wind turbines is examined within the framework of an analytical model which includes dynamic coupling of the rotor, tower, and power generating system. The aerodynamic loading is derived from blade element theory. Stability is determined by the eigenvalues of a set of linearized constant-coefficient differential equations. All results presented are based on a 3-bladed, 300-ft diameter, 2.0 MW wind turbine. It is shown that unstable or weakly stable behavior can be caused by aerodynamic forces due to motion of the rotor blades and tower in the plane of rotation or by mechanical coupling between the rotor system and the tower.

V.L.


An analytical model for the prediction of fan blade flutter is presented and evaluated using data from NASA tests on an advanced high performance engine. For the cascade conditions appropriate to the test points studied, the aerodynamic theory; cannot predict subcritical flutter. Under the assumptions of a tuned assembly, the imaginary part of the aerodynamic coefficients does indicate flutter for a limited number of interblade phase angles, but these interblade phase angles are close to those at which the acoustic resonance is predicted. Upon using the individual blade frequencies and solving the mistuned system with aerodynamic coupling only, the results show a stable system. Eigenvectors calculated for the mistuned system demonstrate the presence of several harmonics in each mistuned mode. Inclusion of both mechanical and aerodynamic coupling in the solution of the eigenproblem influences not only the frequencies but also damping in the system with a trend toward stability. L.S.


This paper presents an investigation of the effects of blade mistuning on the aerelastic stability and response of a cascade in incompressible flow. The aerodynamic, inertial, and structural coupling between the bending and torsional motions of each blade and the aerodynamic coupling between the blades are included in the formulation. A digital computer program was developed to conduct parametric studies. Results indicate that the mistuning has a beneficial effect on the coupled bending-torsion and uncoupled torsion flutter. The effect of mistuning on forced response, however, may be either beneficial or adverse, depending on the engine order of the forcing function. Additionally, the results illustrate that it may be feasible to utilize mistuning as a passive control to increase flutter speed while maintaining forced response at an acceptable level.

(Author)

A81-17480* National Aeronautics and Space Administration.

AEROELASTIC AND DYNAMIC FINITE ELEMENT ANALY-
SES OF A BLADDER SHROUDED DISK


(NASA-CR-157297: D2536-941001) Avail. NTIS HC AOB/MF A01 CSCL 20K

The delivery and demonstration of a computer program for the analysis of aeroelastic and dynamic finite element analyses of a bladder shrouded disk is described. Approaches to flutter and forced vibration of mistuned discs and transient aerothermoelasticity are described.

R.C.T.

A81-29475* Teetron Bell Aerospace Co. Buffalo, N. Y.

AEROLEASTIC AND DYNAMIC FINITE ELEMENT ANALY-
SES OF A BLADDER SHROUDED DISK


(NASA-CR-157297: D2536-941001) Avail. NTIS HC AOB/MF A01 CSCL 20K

The delivery and demonstration of a computer program for the analysis of aeroelastic and dynamic finite element analyses of a bladder shrouded disk is described. Approaches to flutter and forced vibration of mistuned discs and transient aerothermoelasticity are described.

R.C.T.
A computer program based on state of the art compressor and structural technologies applied to bladed shrouded disc was developed and made operational in NASTRAN Level 16. Aeroelastic analyses, modes and flutter. Theoretical manual updates are included.

The NASTRAN aeroelastic and flutter capability was extended to solve a class of problems associated with axial flow turbomachines. The capabilities of the program are briefly discussed. The aerodynamic data pertaining to the bladed disc sector, the associated aerodynamic modeling, the steady aerothermoelastic 'design/analysis' formulations, and the modal, flutter, and subcritical roots analyses are described. Sample problems and their solutions are included.

A computer program based on state of the art compressor and structural technologies applied to bladed shrouded discs was developed and made operational in NASTRAN Level 16. The problems encompassed include aeroelastic analyses, modes, and flutter. The demonstration manual updates are described.


A new form of elemental surface load on a half space is introduced, presuming a quasi-pyramidal variation of load which is doubly linear in each of four rectangular parts of a surface rectangle. Approximations of arbitrary load distributions by sums of such elements are continuous, piecewise linear in two directions and well adaptable. The loads may be normal or tangential. The explicit solutions obtained for all stress and displacement components due to each elemental load involve only elementary functions, are free of the discontinuities which arise with stepwise elements, and are suitable for computing. Some illustrative stress distributions are presented for elemental loads and for multiple pyramidal loads involving both normal and tangential loads. The value of the load continuity in the more complicated analyses of surface cracks is also illustrated.

(Author)
43 EARTH RESOURCES

Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry, and aerial photography.
For instrumentation see 35 Instrumentation and Photograph.

N81-135817* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

DESIGN DESCRIPTION OF THE SCHUCHULI VILLAGE
PHOTOVOLTAIC POWER SYSTEM Final Report
Anthony F. Ratafca, Richard W. Vasiecz, and Richard DeLaMond.
May 1981 100 p.
(Contract DE-AI01-79ET-20498)
HC AE/MF AO1 CSCL 10B

A stand-alone photovoltaic (PV) power system for the village of Schuchuli (Gunsight, Arizona). On the Pago Pago Indian Reservation is a limited energy, all 120 V (d.c.) system to which loads cannot be arbitrarily added and consists of a 3.5 kW (peak) PV array. 2380 ampere-hours of battery storage, an electrical equipment building, a 120 V (d.c.) electrical distribution network, and equipment and automatic controls to provide control power for pumping water into an existing water system. Operating 15 refrigerators, a clothes washing machine, a sewing machine, and lights for each of the homes and communal buildings. A solar hot water heater supplies hot water for the washing machine and communal laundry. Automatic control systems provide voltage control by limiting the number of PV strings supplying power during system operation and battery charging, and load-management for operating high priority at the expense of low priority loads as the main battery becomes depleted.

N81-13425* Houston Univ., Tex. Dept. of Mathematics.

NUMERICAL TRIALS OF HISSE
Sponsored by NASA, USDA, Dept. of Commerce, Dept. of Interior, and Agency for International Development
ERTS
(Contract NAS9-14689, Proj. AgRISTARS)
HC AO3/MF AO1 CSCL 02C

The mathematical description and implementation of the statistical estimation procedure known as the Houston integrated spatial/spectral estimator (HISSE) is discussed. HISSE is based on a normal mixture model and is designed to take advantage of spectral and spatial information of LANDSAT data pixels, utilizing the initial classification and clustering information provided by the AMOBEA algorithm. The HISSE calculates parametric estimates of class proportions which reduce the error inherent in estimates derived from typical classify and count procedures common to nonparametric clustering algorithms. It also singles out spatial groupings of pixels which are most suitable for labeling classes. These calculations are designed to aid the analyst/interpreter in labeling patches with a crop class label. Finally, HISSE's initial performance on an actual LANDSAT agricultural ground truth data set is reported.

N81-13426* Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

NORMAL CROP CALENDARS. VOLUME 2: THE SPRING
WHEAT STATES OF MINNESOTA, MONTANA. NORTH
Dakota, and South Dakota
Sponsored by NASA, USDA, Dept. of Commerce, Dept. of Interior, and Agency for International Development
ERTS
(Contract NAS9-15800, Proj. AgRISTARS)
(E81-10070, NASA-CR-160867, SR-L0-00485; LEMSCO-15034; JSC-18814) Avail: NTIS
HC AO2/MF AO1 CSCL 02C

The state crop calendars for the principal spring wheat producing states within the United States are presented. These crop calendars are an update of those produced for the large area crop inventory experiment multilabeling task during 1978 and are compiled for the foreign commodity production forecasting (FCPF) project of the agriculture and resources inventory surveys through aerospace remote sensing program.

N81-13427* Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

PRELIMINARY EVALUATION OF THE ENVIRONMENTAL
RESEARCH INSTITUTE OF MICHIGAN CROP CALENDAR
SHIFT ALGORITHM FOR ESTIMATION OF SPRING WHEAT
DEVELOPMENT STAGE
Sponsored by NASA, USDA, Dept. of Commerce, Dept. of Interior, and Agency for International Development
ERTS
(Contract NAS9-15800, Proj. AgRISTARS)
HC AO2/MF AO1 CSCL 02C

An algorithm for estimating spectral crop calendar shifts of spring small grains was applied to 1978 spring wheat fields. The algorithm provides estimates of the date of peak spectral response by maximizing the cross correlation between a reference profile and the observed multitemporal pattern of Keath-Thomas greenness for a field. A methodology was developed for estimation of crop development stage from the date of peak spectral response. Evaluation studies showed that the algorithm provided stable estimates with no geographical bias. Crop development stage estimates had a root mean square error near 10 days. The algorithm was recommended for comparative testing against other models which are candidates for use in AgRISTARS experiments.

N81-13428* Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

LIMITED AREA COVERAGE/HIGH RESOLUTION PICTURE
TRANSMISSION (LAC/HRPT) TAPE I J GRID PIXEL
EXTRACTION PROCESSOR USER'S MANUAL
Sponsored by NASA, USDA, Dept. of Commerce, Dept. of Interior, and Agency for International Development
ERTS
(Contract NAS9-15800, Proj. AgRISTARS)
HC AO2/MF AO1 CSCL 05B

The program, LACREG, extracted all pixels that are contained in a specific L grid section. The pixels, along with a header record are stored in a disk file defined by the user. The program will extract up to 99 L grid sections.

N81-13429* Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

LIMITED AREA COVERAGE/HIGH RESOLUTION PICTURE
TRANSMISSION (LAC/HRPT) DATA VEGETATIVE INDEX
CALCULATION PROCESSOR USER'S MANUAL
Sponsored by NASA, USDA, Dept. of Commerce, Dept. of Interior, and Agency for International Development
ERTS
(Contract NAS9-15800, Proj. AgRISTARS)
(E81-10073, NASA-CR-160870, SR-L0-00703; LEMSCO-15327; JSC-18375) Avail: NTIS
HC AO2/MF AO1 CSCL 08F

The program, LACVIN, calculates vegetation index numbers on limited area coverage/high resolution picture transmission data for selected IJ grid sections. The L grid sections were previously extracted from the full resolution data tapes and stored on disk files.
N81-13430# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

EROS TO UNIVERSAL TAPE CONVERSION PROCESSOR
(Contract NAS9-15800: Proj. AgRISTARS)
LEMSCO-15357: JSC-16382) Avail: NTIS HC AO2/MF AO1
CSCL 058

The function of the EROS processor is to allow a user to select a specific area from a full frame LANDSAT image which is written on tape in the EROS format. The area of interest is read from the EROS formatted tape and converted to the JSC Universal format and written onto another tape. This tape can then be read by the IMDACS processing system and normal analysis can be performed.

N81-13431# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

NORMAL CROP CALENDARS, VOLUME 1: ASSEMBLY AND APPLICATION OF HISTORICAL CROP DATA TO A STANDARD PRODUCT
(Contract NAS9-15800: Proj. AgRISTARS)
(EB1-10075: NASA-CA-160866: SR-LO-00484)
LEMSCO-15033: JSC-16813) Avail: NTIS HC AO2/MF AO1
CSCL 02C

The approach used in the collection, collation, and compilation of normal crop calendar for the foreign commodity production forecasting (FCPF) project of the AgRISTARS program is described.

N81-13432# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

EVALUATION OF RESULTS OF US CORN AND SOYBEANS EXPLORATORY EXPERIMENT: CLASSIFICATION PROCEDURES VERIFICATION TEST
(Contract NAS9-15800: Proj. AgRISTARS)
(EB1-10076: NASA-CA-160873: SR-LO-00423)
LEMSCO-14386: JSC-16339) Avail: NTIS HC AO3/MF AO1
CSCL 02C

The classification procedure utilized in making crop proportion estimates for corn and soybeans using remotely sensed data was evaluated. The procedure was derived during the transition year of the Large Area Crop Inventory Experiment. Analysis of variance techniques were applied to classifications performed by 3 groups of analysts who processed 25 segments selected from 4 agrophysical units (APUs). Group and APU effects were assessed to determine factors which affected the quality of the classifications. The classification results were studied to determine the effectiveness of the procedure in producing corn and soybeans proportion estimates.

N81-13433# Lockheed Engineering and Management Services Co., Inc., Houston, Tex.

LIMITED AREA COVERAGE/HIGH RESOLUTION PICTURE TRANSMISSION, LAC/HRPT TAPE CONVERSION PROCESS USER'S MANUAL
(Contract NAS9-15800: Proj. AgRISTARS)
(EB1-10077: NASA-CA-160871: EW-LO-00701)
LEMSCO-15325: JSC-16373) Avail: NTIS HC AO2/MF AO1
CSCL 058

The program, LACSEG, converts LAC/HRPT data tapes to the CSC defined Universal format. The Universal formatted data tape is then processed the normal way by the FAS IMDACS system.

N81-33539# Environmental Research and Technology, Inc., Concord, Mass.

COMPARATIVE ANALYSIS OF SFA ICE FEATURES USING SIDE-LOOKING AIRBORNE RADAR (SLAR) AND LANDSAT IMAGERY Final Report
James C. Barnes and Clinton J. Bowley, Principal Investigators Cleveland NASA Lewis Research Center Mar. 1981 71 p refs Original contains imagery. Original photography may be purchased from the EROS Data Center, Sioux Falls S.D. 57199.

ERTS
(Contract NAS3-21921)
(EB1-10044: NASA-CA-165335: P-3970-F) Avail: NTIS HC AO4/MF AO1 CSCL 0BL

A comparative analysis of sea ice features was carried out using X-band, real aperture side-looking airborne radar (SLAR) and LANDSAT imagery. The SLAR data were collected by the NASA/Lewis C-131 aircraft on flights over the Mackenzie Delta and Prudhoe-Baron areas of the southern Beaufort Sea and the Norton Sound area of the eastern Bering Sea. The LANDSAT data were for dates near as possible to the dates of the SLAR missions. The analysis of the data sample available for the investigation indicates the SLAR imagery has distinct advantages over LANDSAT for identifying certain features and ice types. It is further indicated that the capability for SLAR observe ice through clouds is essential for an operational ice information system.
PERFORMANCE OF A STEEL SPAR WIND TURBINE BLADE ON THE MOD-0 100 kW EXPERIMENTAL WIND TURBINE

Final Report

The performance and loading of a large wind rotor, 38.4 m in diameter and composed of two low-cost steel spar blades were examined. Two blades were fabricated at Lewis Research Center and successfully operated on the Mod-0 wind turbine at Plum Brook. The blades were operated on a tower on which the natural bending frequency were altered by placing the tower on a leaf-spring apparatus. It was found that neither blade performance nor loading were affected significantly by this tower softening technique. Rotor performance exceeded prediction on a leaf spring apparatus. It was found that neither blade performance nor loading were affected significantly by this tower softening technique. Rotor performance exceeded prediction.

DATA ACQUISITION AND ANALYSIS IN THE DOE/NASA WIND ENERGY PROGRAM

Four categories of data systems, each responding to the task of recording, monitoring, and transmitting a variety of information, are described. These are: (1) a monolithic multijunction solar cell was modified by the addition of a m.dule containing a solar cell power supply. (2) A monolithic multijunction solar cell was modified by the addition of a m.dule containing a solar cell power supply. (3) A monolithic multijunction solar cell was modified by the addition of a m.dule containing a solar cell power supply. (4) A monolithic multijunction solar cell was modified by the addition of a m.dule containing a solar cell power supply.

STATUS OF COMMERCIAL PHOSPHORIC ACID FUEL CELL SYSTEM DEVELOPMENT

In both the electric utility and onsite integrated energy system applications, reducing cost and increasing reliability are the main technology drivers. The longstanding barrier to the attainment of these goals, which manifests itself in a number of ways, was materials. The differences in approach among the three major participants (United Technologies Corporation, Westinghouse Electric Corporation/energy Research Corporation and Engelhard Industries) and their unique technological features, including electrodes, matrices, intercell cooling, bipolar/separators plates, electrolyte management, fuel selection and system design philosophy are discussed.

IGNITION OF LEAN FUEL-AIR MIXTURES IN A PREMIXING PREVAPORIZING DUCT AT TEMPERATURES UP TO 1000 K

Conditions were determined in a premixing prepervaporizing fuel preparation duct at which ignition occurred. An air blast type fuel injector with nineteen fuel injection points was used to provide a uniform spatial fuel air mixture. The range of inlet conditions where ignition occurred were: inlet air temperatures of 600 to 1000 K, air pressures of 180 to 660 kPa, equivalence ratios (fuel air ratio divided by stoichiometric fuel air ratio) of 0.12 to 1.05, and velocities from 3.5 to 30 m/s. The duct was insulated and the diameter was 12 cm. Mixing lengths were varied from 18.5 to 47.6 and residence times ranged from 4.6 to 107 ms. The fuel was no. 2 diesel. Results show a strong effect of equivalence ratio, pressure and temperature on the output. In another embodiment, integrated circuit power conditioning electronics was incorporated in a module containing a solar cell power supply.
conditions where ignition occurred. The data did not fit the
most commonly used model of auto-ignition. A correlation
of the conditions where ignition would occur which apply to this
test apparatus over the conditions tested is (p/V) phi to the
1.3 power - 0.82 e to the 2804/T power where p is the
pressure in kPa, V is the velocity in m/s, phi is the equivalence
ratio, and T is the temperature in K. The data scatter was
considerable, varying by a maximum value of 5 at a given
temperature and equivalence ratio. There was wide spread in
the autoignition data contained in the references. A.R.H.

N81-14396* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
CATALYTIC COMBUSTION OF COAL-DERIVED LIQUIDS
Presented at 26th Ann. Intern. Gas Turbine Conf. Houston, Tex,
8-12 Mar 1981, sponsored by ASME
(Contract DE-A101-77ET-10350)
(NASA-TM-81594: E-661: DOE/NASA/10350-21) Avail:
NTI: HC A02/MF A01: CSCL 10B
A noble metal catalytic reactor was tested with three grades
of SRC 2 coal derived liquids, naphtha, middle distillate, and a
blend of three parts middle distillate to one part heavy distillate.
A petroleum derived number 2 diesel fuel was also tested to
provide a direct comparison. The catalytic reactor was tested at
inlet temperatures from 600 to 800 K, reference velocities from
10 to 20 m/s, lean fuel air ratios, and a pressure of 3 x 10 to
the 5th power Pa. Compared to the diesel, the naphtha gave
slightly better combustion efficiency, the middle distillate was
identical and the middle heavy blend was slightly poorer.
The coal derived liquid fuels contained from 0.5 to
1.0 percent by weight nitrogen and unburned hydrocarbons
emissions were negligible for all test conditions. Nitrogen oxides
emissions were less than 1.9 g NO2/kg fuel for combustion
temperatures below 1560 K. Carbon monoxide emissions were
less than 16 g CO/kg fuel for combustion temperatures greater than
1600 K. Inlet air temperatures higher than 1150 K and residence
times greater than 4.3 microseconds.

N81-14397* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
APPLICABILITY OF ADVANCED AUTOMOTIVE HEAT
ENGINES TO SOLAR THERMAL POWER
Donald G. Beremand, David G. Evans, and Donald L. Alger 1981
25 p refs Presented at SAE Intern. Eng. Congr. and Exposition,
Detroit, 23-27 Feb 1981
(Contract EC-76-A-29-1060)
HC A03/MF A01: CSCL 10B
The requirements of a solar thermal power system are
reviewed and compared with the predicted characteristics of
automobile engines under development. A good match is found
in terms of power level and efficiency when the automobile
engines, designed for maximum powers of 65-100 kW (87 to
133 hp) are operated to the nominal 20-40 kW electric output
requirement of the solar thermal application. At these reduced
power levels it appears that the automobile gas turbine and
Stirling engines have the potential to deliver the 40+ percent
efficiency goal of the solar thermal program. M.G.

N81-14398* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
ULTRA-LEAN COMBUSTION AT HIGH INLET TEMPERATURES
David N. Anderson 1981 20 p refs Presented at 26th Intern.
Gas Turbine Conf. Houston, Tex. 8-21 Mar 1981, sponsored
by ASME
(Contract EC-77-A-31-1101)
HC A02/MF A01: CSCL 10B
Combustion at inlet air temperatures of 1100 to 1250 K
was studied for application to advanced automotive gas turbine
engines. Combustion was initiated by the hot environment and
therefore no external ignition source was used. Combustion was
stabilized without a flameholder. The tests were performed in a
12 cm diameter test section at a pressure of 2.5 x 10 to the
5th power Pa, with reference velocities of 32 to 60 m/sec and
at maximum combustion temperatures of 1350 to 1850 K.
Number 2 diesel fuel was injected by means of a multiple source

N81-14399* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
EFFECT OF FUEL NITROGEN AND HYDROGEN CONTENT ON
EMISSIONS IN HYDROCARBON COMBUSTION
David A. Bittker and Gary Wolfcrandt 1981 24 p refs Presented
1981, sponsored by ASME
(Contract DE-A101-77ET-10350)
HC A02/MF A01: CSCL 10B
How the emissions of nitrogen oxides and carbon monoxide
are affected by (1) the decreased hydrogen content and (2) the
increased organic nitrogen content of coal derived fuels is
investigated. Previous CRT experimental work in a two stage
flame tube has shown the effectiveness of rich lean two stage
combustion in reducing fuel nitrogen conversion to nitrogen oxides.
Previous theoretical work gave preliminary indications that
emissions trends from the flame tube experiment could be
predicted by a two stage, well stirred reactor combustor model
using a detailed chemical mechanism for propane oxidation and
nitrogen oxide formation. Additional computations are reported
and comparisons with experimental results for two additional
fuels and a wide range of operating conditions are given. Fuels
used in the modeling are pure propane, a propane toluene mixture
and pure toluene. These gave hydrogen contents 18, 11 and 9
percent by weight, respectively. Fuel burn and nitrogen contents of
0.5 and 1.0 percent were used. Results are presented for oxides of
nitrogen and also carbon monoxide concentrations as a function
of primary equivalence ratio, hydrogen content and fuel bound
nitrogen content. Author

N81-15446* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
ELECTRONICALLY COMMUTATED dc MOTORS FOR
ELECTRIC VEHICLES
Edward A. Maslowski 1981 18 p refs Prepared for presentation
at Soc. of Automotive Engr. Intern. Congr. and Exposition, Detroit.
23-27 Feb 1981
(Contract DE-A101-77CS-51044)
HC A02/MF A01: CSCL 10B
A motor development program to explore the feasibility of
electronically commutated dc motors (also known as brushless)
for electric cars is described. Two different design concepts and
a number of design variations based on these concepts are
discussed. One design concept is based on a permanent magnet,
medium speed, machine rated at 7000 to 9000 rpm, and powered
via a transistor inverter power conditioner. The other concept is
based on a permanent magnet, high speed, machine rated at
22,000 to 26,000 rpm, and powered via a thyristor inverter
power conditioner. Test results are presented for a medium speed
motor and a high speed motor each of which have been fabricated
using sintered cobalt permanent magnet material. Author

N81-15465* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
CHARACTERIZATION OF THE NEAR-TERA ELECTRIC
VEHICLE (ETV-1) BREADBOARD PROPULSION SYSTEM
OVER THE SAE J227a DRIVING SCHEDULE D
Noel B. Sargent and Miles O. Dustin 1981 15 p refs Prepared
for presentation at Scc. of Automotive Engr. Intern. Congr.
and Exposition, Detroit, 23-27 Feb 1981
(Contract DE-A101-77CS-51044)
HC A02/MF A01: CSCL 10B
The electric test vehicle one (ETV-1) was built from the
ground up with present state of the art technology. Two vehicles
were built and are presently being evaluated by NASA's Jet Propulsion Laboratory (JPL). A duplicate set of propulsion system components was built, mounted on a breadboard, and delivered to NASA's Lewis Research Center for testing on the road load simulator (RLS). Driving cycle tests completed on the system are described.

E. D. K.

**HIGH VOLTAGE PLANAR MULTIJUNCTION**

**DEVICES**


A solar cell which provides high output voltages, comprises a semiconductor wafer in which a number or array of voltage generating regions or unit cells are formed. Each of the unit cells has two regions of opposite conductivity type (e.g., n- and p-) which are separated by a gap region. The unit cells are connected together by metal contacts so that their outputs are additive. Field regions, separated by gaps, overlap the unit cells. Cells are formed in both faces of the wafer. A circular wafer is employed.

**HIGH VOLTAGE PLANAR MULTIJUNCTION**

**DEVICES**


The fabrication of the cell is described. The solar cell features a plurality of discrete voltage generating regions or unit cells which are formed in a single, generally planar semiconductor body. The unit cells comprise doped regions of opposite conductivity type separated by a gap or indiffused regions. 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 gaps overlap the unit cells but the cells may be formed in both faces of the wafer.

**HIGH VOLTAGE PLANAR MULTIJUNCTION**

**DEVICES**


An extensive parametric investigation was performed of the extraction of energy in output gaps of klystron amplifiers using 3-D computer programs. Due to complexity of the program which used a hydrodynamic, axially and radially deformable disk ring model and the resulting long computing time, the investigation was limited to the output gap. By far the most important and difficult part of the klystron interaction. Results show that, for a confined flow focused beam throughout the penultimate cavity, radial velocities remain very small and the beam is highly laminar. It was, therefore, concluded that possible errors resulting from treating only the output cavity in 3-D would remain small.

**HIGH VOLTAGE PLANAR MULTIJUNCTION**

**DEVICES**


Work on heat transport fluids for use with active solar heating and cooling systems is described. Program objectives and how they were accomplished including problems encountered during testing are discussed.

T. M.

**HIGH VOLTAGE V-GROOVE SOLAR CELL**

**DEVICES**


A duplicate set of propulsion system components was built, mounted on a breadboard, and delivered to NASA's Lewis Research Center for testing on the road load simulator (RLS). Driving cycle tests completed on the system are described.

E. D. K.
A multistep diffusion processing schedule is described which allows the attainment of high open circuit voltages in 0.1 ohm/cm silicon cells. The schedule consists of a deep primary diffusion, followed by an anneal. The second diffusion is then followed by a shallow secondary diffusion. A correlation is made between the observed voltage increases and the time of primary diffusion. Results indicate that as the primary diffusion time increases, the voltage rises monotonically.

R.C.T.
THE NASA-LERC WIND TURBINE SOUND PREDICTION CODE
as part of an effort to understand and reduce the noise generated.

 Seventeen performance tests were used to classify spacecraft
batteries in four standard groups established by manufacturers.
Tests included capacity delivered values, and of charge voltage
values, and internal shorts. Variance ratios are listed.

THE NASA-LERC WIND TURBINE SOUND PREDICTION CODE
(Contract DE-A01-76ET-20366)
(NASA-TM-81737; DOE/NASA/20366-1; E-806) Avail. NTIS
HC AO2/ MF AO1 CSCL 10B

Development of the wind turbine sound prediction code began
as part of an effort to understand and reduce the noise generated
by Mod-1. Sound levels predicted with this code are in good
agreement with measured data taken in the vicinity of the Mod-1
wind turbine (less than 2 rotor diameters). Comparison in the
field indicates that propagation effects due to terrain and
atmospheric conditions may amplify the actual sound levels by
6 dB. Parametric analysis using the code shows 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- optimum operation.

ADVANCED INORGANIC SEPARATORS FOR ALKALINE BATTERIES AND METHOD OF MAKING SAME Patent Application
Dean W. Shelbly, inventor (to NASA) Filed 27 Feb. 1981
18 p
NTIS HC AO2/MF AO1 CSCL 10C

A method of forming a flexible, porous battery separator
comprising a coating applied to a porous, flexible substrate is
disclosed. 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 comprises at least
one first filler material, wherein the volume of the mixture of
filler materials is less than 45% of the total volume of the fillers
and the binder, the filler surfact area per gram of binder is
about 20 to 60 sq m/gr, and the amount of plasticizer is sufficient
to coat each filler particle.

COMPARISON OF UPWIND AND DOWNWIND ROTOR OPERATIONS OF THE DOE/NASA 100-kW MOD-D WIND TURBINE
NTIS HC AO2/ MF AO1 CSCL 10B

Three aspects of the test results are compared: rotor blade
bending loads, rotor tower response, and Nacelle yaw moments.
As a result of the tests, a model agreement was obtained that
while mean wind bending moments were unaffected by the placement of the rotor,
cyclic, fastwise 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
flow disturbance for a downwind rotor. Rotor tower response
was not significantly affected by the rotor location relative to
the tower. But appearance of reduced tower stability near
rated wind speed for both configurations. Tower stability appears
to return above wind speed, however. Nacelle yaw moments
are higher for the upwind rotor but do not indicate significant
design problems for either configuration.

PERFORMANCE EVALUATION OF THE DOE/NASA 100-kW MOD-D WIND/TURBINE PROJECTS SPONSORED BY US DOE AND US AID
Philadelphia 26-30 May 1981
(Contract DE-A01-76ET-20485)
(NASA-TM-81738; DOE/NASA/20485-8; E-806) Avail.
NTIS HC AO2/MF AO1 CSCL 10A

Experience with photovoltaic systems (without backup power)
and ranging in output from 23 to 3,500 peak watts, in a wide
range of environmental conditions and with a wide range
of insolation, is described. Cooperation of NASA with other
government agencies results in the installation of an air pollution
monitor in New Jersey, a seismic sensor in Hawaii, power for
lookout towers in national forests in California, an electric power
system for a Papago Indian village in Arizona, and a power
system for a grain mill and water pump in Tangep, Upper
Volta. Significant operational results are discussed and system
reliability is assessed for the 20 experimental systems installed
since 1976. Additional systems to be installed overseas are
highlighted, and economic factors are considered.

AN EXPERIMENTAL INVESTIGATION OF SILICON WAFER SURFACE ROUGHNESS AND ITS EFFECT ON THE FULL STRENGTH OF PLATED METALS
(NASA-TM-81763; E-826) Avail. NTIS HC AO2/MF AO1 CSCL 10A

Plated silicon wafers with surface roughness ranging from
0.4 to 130 micrometers were subjected to tensile pull strength
tests. Electroless Ni/electroless Cu/electroplated Cu and
electrodess Ni/electroplated Cu were the two types of slate contacts tested. It was found that smoother surfaces had higher pull strength than rougher, chemically etched surfaces. The presence of the electrodess Cu layer was found to be important to adhesion. The mode of fracture of the contact as it left the silicon was studied, and it was found that in almost all cases separation was due to fracture of the bulk silicon phase. The correlation between surface roughness and mode of contact failure is presented and interpreted. Author


In the past, propulsion system simulations used in flight simulators have been extremely simple. This resulted in a loss of simulation realism since significant engine and aircraft interactions were neglected and important internal engine parameters were not computed. More detailed propulsion system simulations are needed to permit evaluations of modern aircraft propulsion systems in a simulated flight environment. A real time digital simulation technique has been developed which provides the capabilities needed to evaluate propulsion system performance and aircraft system interaction on manned flight simulations. A parameter correlation technique is used with real and pseudo dynamics in a stable integration convergence loop. The technique has been applied to a multivariable propulsion system for use in a pilot NASA flight simulator program. Cycle time is 2.0 ms on a Univac 1110 computer and 5.7 ms on the simulator computer, a Xerox Sigma 8. The model is stable and accurate with time steps up to 50 ms. The program evaluated the simulation technique and the propulsion system digital control. The simulation technique and model used in that program are described and results from the simulation are presented. Author


Two versions of a Nasvyst multirubber traction drive were tested in liquid oxygen for possible application as cryogenic boost pump speed reduction drives for advanced hydrogen-oxygen rocket engines. One roller drive, with a 10:1 reduction ratio, was successfully run at up to 70,000 rpm input speed and up to 14.9 kW (20 hp) input power level. Three drive assemblies were tested for a total of about three hours of which approximately one hour was nominal full speed and full power conditions. Peak efficiency of 60 percent was determined. There was no evidence of slippage between rollers for any of the conditions tested. The ball drive, a version using balls instead of one row of rollers, and having a 3:2.1 reduction ratio, failed to perform satisfactorily.


Polyvinyl alcohol (PVA) crosslinked chemically with aldehyde reagents produces membranes which demonstrate diffusion resistance, dimensional stability, low ion reactivity, low ionic diffusivity, and low zinc dientrite penetrability 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 C spor. minimal Preparation, property measurements, and cell test results in Ni/Zn and Ag/Zn cells are described and discussed. Author


Degradation of turbine engine hot gas path components by high temperature corrosion can usually be associated with deposits even though other factors may also play a significant role. The origins of the corrosive deposits are traceable to chemical reactions which take place during the combustion process. In the case of hot corrosion/sulphidation, sodium sulfate was established as the deposited corrosive agent even when none of this salt enters the engine directly. The sodium sulfate is formed during the combustion and deposition processes from compounds of sulfur contained in the fuel as low level impurities and sodium, compounds, such as sodium chloride, ingested with intake air. In other turbinr and power generation situations, corrosive and/or fouling deposits can result from such metals as Fe, tellurium, irond, calcium, vanadium, magnesium, and silicon. Author


The fracture surfaces of compact tension specimens from seven nickel-base superalloys fatigue tested at 650 C were studied by scanning electron microscopy and optical metallography to determine the nature and morphology of the crack surface in the region of stable growth. Crack propagation testing was performed as part of an earlier study at 650 C in air using a 0.33 Hz fatigue cycle and a creep-fatigue cycle incorporating a 900 second dwell at maximum load. In fatigue, alloys with a grain size greater than 20 micrometers HIP Astrophy, Waspaloy, MERL 76, and MERL 75 exhibited transgranular fracture. MERL 75 also displayed numerous fracture sites which were associated with boundaries of prior powder particles. The two high strength, fine grain alloys, IN 100 and NAS 9, exhibited intergranular fracture. Rene 95 and HIP plus forged Astroloy displayed a mixed failure mode that was transgranular in the coarse grains and intergranular in the fine grains. Under creep-fatigue conditions, fracture was found to be predominantly intergranular in all seven alloys.


Two Ni-based superalloys were exposed to the high velocity effluent of a pressurized fluidized bed coal combustor. Targets were 15 cm diameter rotors operating at 40,000 rpm and small flat plate specimens. Above an erosion rate threshold, the targets were eroded to bare metal. The presence of accelerated oxidation at lower erosion rates suggests erosion-corrosion synergism. Various mechanisms which may contribute to the observed oxide
growth enhancement include erosive removal of protective oxide layers, oxide and subsurface cracking, and chemical interaction with sulfur in the gas and deposits; damaged surface layers.

N91-23327*/# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
TRIBOLOGICAL PROPERTIES AND THERMAL STABILITY OF VARIOUS TYPES OF POLYIMIDE FILMS

Thermal exposure experiments at 315 and 350°C were conducted on seven different types of polyimide films to determine which was the most thermally stable and adherent. The polyimides were ranked according to the rate at which they lost weight and how well they adhered to the metallic substrate. Friction and wear experiments were conducted at 25°C room temperature on films to 440°C HT stainless steel. Friction, film wear rates, transfer mechanisms, and transfer films of the seven films were investigated and compared. The polyimides were found to fall into two groups as far as friction and wear properties were concerned. Group one had lower friction but an order of magnitude higher film wear rate than group two. The wear mechanism was predominately adhesive, but the size of the wear particles were larger for group two polyimides.

N91-23417*/# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
PROLONGING THERMAL BARRIER COATED SPECIMEN LIFE BY THERMAL CYCLE MANAGEMENT

Measurements were made of the rate of increase in temperature of a ZrO2-BY203 thermal barrier coated (TBC) specimen for various values of fuel/air (F/A) ratios when the specimen is exposed to a 0.3 Mach burner flame. For rod specimens in a carousel, the heating rates increased with (F/A) ratio and were higher at the inside facing surface for a given (F/A). Plate specimens were more sensitive to burner variations. Calculated results are given for the radial stress in the coated rod specimens for variations in (F/A) ratios from 0.04 to 0.085. Over this range, the radial stress varies from 4.3 to 5.3 MPa. The results indicate that controlling the heating rate of a TBC by controlling the (F/A) ratio offers a possible method to prolong TBC cyclic life; uncontrolled (F/A) ratios will produce scatter in experimental results. Geometric arrangement can have an equivalent effect, but is usually fixed by design.

N91-23418*/# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
RELATIONSHIP OF VARIATIONS IN THERMAL CYCLE LIFE DATA OF THERMAL BARRIER COATED RODS

An analysis of thermal cycle life data for 22 thermal barrier coated (TBC) specimens was conducted. The ZrO2-BY203/NicAlY plasma spray coated Rene 41 rods were tested in a Mach 0.3 Jet A/air burner flame. All specimens were subjected to the same coating and subsequent test procedures in an effort to control three parametric groups: material properties, geometry, and heat flux. Statistically, the data sample space had a mean of 1330 cycles with a standard deviation of 520 cycles. The data were described by normal or log-normal distributions, but other models could also apply; the sample size must be increased to clearly delineate a statistical failure model. The statistical methods were also applied to adhesive/cohesive strength data for 20 TBC discs of the same composition, with similar results. The sample space had a mean of 9 MPa with a standard deviation of 4.2 MPa.

N91-23435*/# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
AN INTEGRATED EXHAUST GAS ANALYSIS SYSTEM WITH SELF-CONTAINED DATA PROCESSING AND AUTOMATIC CALIBRATION

An integrated gas analysis system designed to operate in automatic, semiautomatic, and manual modes from a remote control panel is described. The system measures the carbon monoxide, oxygen, water vapor, total hydrocarbons, carbon dioxide, and oxides of nitrogen. A pull through design provides increased reliability and eliminates the need for manual flow rate adjustment and pressure correction. The system contains two microprocessors to range the analyzers, calibrate the system, process the raw data to units of concentration, and provides information to the facility research computer and to the operator through terminal and the control panels. After initial setup, the system operates for several hours without significant operator attention.
A lubricant is any substance that is used to reduce friction and wear and to provide smooth running and a satisfactory life for machine components. Lubrication fundamentals are discussed and the various lubrication mechanisms are defined. These include: hydrodynamic, elastohydrodynamic, mixed, boundary, and extreme pressure. Before the various lubrication mechanisms are presented, it is desirable to define conformal and nonconformal surfaces.

LUBRICATION FUNDAMENTALS

BERNARD J. HENROCK APRIL 1981 8 P. REFS

(NASA-TM-81762 E-825) AVAIL: NTIS HC A02/MF A01 CSCL 11H

A lubricant is any substance that is used to reduce friction and wear, and to provide smooth running and a satisfactory life for machine components. Lubrication fundamentals are discussed and the various lubrication mechanisms are defined. These include: hydrodynamic, elastohydrodynamic, mixed, boundary, and extreme pressure. Before the various lubrication mechanisms are presented, it is desirable to define conformal and nonconformal surfaces.

LUBRICATION FUNDAMENTALS

BERNARD J. HENROCK APRIL 1981 8 P. REFS

(NASA-TM-81762 E-825) AVAIL: NTIS HC A02/MF A01 CSCL 11H

Lubrication fundamentals are discussed and the various lubrication mechanisms are defined. These include: hydrodynamic, elastohydrodynamic, mixed, boundary, and extreme pressure. Before the various lubrication mechanisms are presented, it is desirable to define conformal and nonconformal surfaces.

LUBRICATION FUNDAMENTALS

BERNARD J. HENROCK APRIL 1981 8 P. REFS

(NASA-TM-81762 E-825) AVAIL: NTIS HC A02/MF A01 CSCL 11H
SOLAR CELLS

obtained activation energy is consistent with the presence of annealing temperature from the usual 500 to 300°C. Annealing cm showed short circuit current on annealing at 200°C with I. Weinberg and C. K. Swartz 1961 10 p refs. Presented F181-23927'/ National Aeronautics and Space Administration.

Additional part a result which agrees with the conclusion based on activation energies previously obtained indicate that the presently obtained activation energy is consistent with the presence of either the divacancy or the carbon interstitial carbon substitutional pair, a result which agrees with the conclusion based on defect behavior in boron-doped silicon. S.F.


A heat exchanger of increased effectiveness is disclosed. A porous metal matrix is disposed in a metal chamber or between walls through which a heat transfer fluid is directed. The porous metal matrix is bonded to the chamber in order to remove all thermal contact resistance within the composite structure. Utilization of the invention in a rocket chamber is disclosed as a specific use. Also disclosed is a method of constructing the heat exchanger. Official Gazette of the U.S. Patent and Trademark Office.


A toroidal storage battery designed to handle relatively high amp-hour loads is described. The cell consists of a wound core consisting of a pair of toroidal channel shaped electrodes spaced apart by nylon insulation. The shape of the case electrodes of this toroidal cell allows a first planar doughnut shaped surface and the inner cylindrical case wall to be used as a first electrode and a second planar doughnut-shaped surface and the outer cylindrical case wall to be used as a second electrode. Connectors may be used to stack two or more toroidal cells together by connecting sub-cells of the entire surface area of the first electrode of a fuel cell to substantially the entire surface area of the second electrode of a second cell. The central cavity of each toroidal cell may be used as a conduit for pumping a fluid through the toroidal cell to thereby cool the cell. Official Gazette of the U.S. Patent and Trademark Office.


Contract DE-AI07-77CS-S1040)

A 1 kW preprototype redox storage system underwent characterization tests and was operated as the storage device for a 5 kW (peak) photovoltaic array. The system is described and performance data are presented. Loss mechanisms are discussed and simple design changes leading to significant 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 indicated. Author.


INASA TM 81714 DOE/NASA/20485-7 E-884) A series of tests conducted on a root and section of a laminated wood wind turbine blade are reported. The blade to hub transition of the wood blade uses steel studs cast into the wood D spar with a filled epoxy. Both individual studs and a full scale, short length root section were tested. Results indicate that the bonded stud concept is more than adequate for both the 30 year life fatigue loads and for the high wind or hurricane gust loads. E.A.K.
advantages. (1) temperature sensitivity, (2) rate sensitivity, and (3) state of charge indication. The pilot cell concept is of interest in remote stand alone photovoltaic power systems. The battery can be protected from damaging overcharge by using the proper ratio of pilot cell capacities to main battery capacity.

E.A.K.


The wind turbine safety program identifies the naturally occurring lightning phenomenon as a hazard with the potential to cause loss of program objectives, injure personnel, damage system instrumentation, structure or support equipment, and facilities. Several candidate methods of lightning accommodation for each blade were designed, analyzed, and tested by submitting sample blade sections to simulated lightning. Lightning accommodation systems for composite blades were individually developed. Their effectiveness was evaluated by submitting the systems to simulated lightning strikes. The test data were analyzed and system designs were reviewed on the basis of the analysis.

E.A.K.


An overview on the progress of the automotive gas turbine and automotive Stirling engine technology projects is presented. The following items are reported: (1) formulation and execution of projects in accordance with the Auto Propulsion Research and Development Act of 1978; (2) substantive technology accomplishments; and (3) future path options of the programs.

E.A.K.


A conceptual design study was conducted to assess technical feasibility, environment. characteristics. and economics of coal gasification. The feasibility of a coal gasification combined cycle cogeneration powerplant was examined in response to energy needs and to national policy aimed at decreasing dependence on oil and natural gas. The powerplant provides the steam heating and base load electrical requirements while serving as a prototype for industrial cogeneration and a modular building block for utility applications. The following topics are discussed: (1) screening of candidate gasification, sulfur removal and power conversion components, (2) definition of a reference system, (3) quantification of plant emissions and waste streams, (4) estimates of capital and operating costs, and (5) a procurement and construction schedule. It is concluded that the proposed powerplant is technically feasible and environmentally superior.

E.A.K.


An improved zinc electrode for alkaline cells includes up to about ten percent by weight of Ba(OH)2.8H2O with about five percent being preferred. The zinc electrode may or may not be amalgamated with mercury.

E.A.K.


A heat transparent high intensity solar cell with improved efficiency is described. The surface of each solar cell has a plurality of grooves. Each groove has a vertical face and a slanted face that is covered by a reflecting metal. Light rays are reflected from the slanted face through the vertical face where they traverse a photovoltaic junction. As the light rays travel to the slanted face of an adjacent groove, they again traverse the junction. The underside of the reflecting coating directs the light rays toward the opposite surface of solar cell as they traverse the junction again. When the light rays travel through the solar cell and reach the saw-toothed grooves on the under side, the process of reflection and repeatedly traversing the junction again takes place. The light rays ultimately emerge from the solar cell. These solar cells are particularly useful at very high levels of insolation because the infrared or heat radiation passes through the cells without being appreciably absorbed to heat the cell.


The application of alternative fuels in advanced automotive gas turbine and Stirling engines is discussed on the basis of a literature survey. These alternative engines are briefly described, and the aspects that will influence fuel selection are identified. Fuel properties and combustion properties are discussed, with consideration given to advanced materials and components. Alternative fuels from petroleum, coal, oil shale, alcohol, and hydrogen are discussed, and some background is given about the origin and production of these fuels. Fuel requirements for automotive gas turbine and Stirling engines are developed, and the need for certain research efforts is discussed. Future research efforts planned at Lewis are described.

E.A.K.


The Power Extension Package (PEP) is the prime focus of a development program to produce low cost solar cells. The PEP is a 32 kilowatt flexible substrate, retrievable, solar array system for use on the Space Shuttle Solar Cell cost will be reduced by increasing cell area and simplifying cell and coverglass fabrication processes and specifications. The cost goal is to produce cells below $30 per watt. Two and ten ohm-cm silicon cells
were investigated. This paper describes a unique radiation damage test and side-by-side comparison of candidate cell types under pre-and post-irradiation airplane calibration of outer space short-circuit current.

N81-27808† National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
THE MOD-2 WIND TURBINE DEVELOPMENT PROJECT Final Report
A major part of the Federal Wind Energy Program, the Mod-2 wind turbine, a second-generation machine developed by the Boeing Engineering and Construction Co for the U.S. Department of Energy and the Lewis Research Center of the National Aeronautics and Space Administration, is described. The Mod-2 is a large (2.5-MW power rating) horizontal-axis wind turbine designed for the generation of electrical power on utility networks. Three machines were built and are located in a cluster at Goodnoe Hills, Washington. All technical aspects of the project are described in an engineering approach, with emphasis on innovative features in the mechanical system, the electrical power system, the control system, and the safety system.

N81-27916‡ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
POLYVINYL ALCOHOL BATTERY SEPARATOR CONTAINING INERT FILLER Patent Application
A cross-linked polyvinyl alcohol battery separator is disclosed. A particulate filler, inert to alkaline electrolyte of an alkaline battery, is incorporated in the separator in an amount of 1-20% by weight, based on the weight of the polyvinyl alcohol, and is dispersed throughout the product. Incorporation of the filler enhances performance and increases cycle life of alkaline batteries when compared with batteries containing a similar separator not containing filler. Suitable fillers include titanates, silicates, zirconates, aluminates, wood flour, lignin, and titania. Particle size is not greater than about 50 microns.

N81-28029§ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
COMPARISON OF PHOTOVOLTAIC CELL TEMPERATURES IN MODULES OPERATING WITH EXPOSED AND ENCLOSED BACK SURFACES Final Report
Four different photovoltaic module designs were tested to determine the cell temperature of each design. The cell temperatures were compared to those obtained on identical design, using the same nominal operating cell temperature (NOCT) concept. The results showed that the NOCT procedures do not apply to the enclosed configurations due to continuous transient conditions. The enclosed modules had higher cell temperatures than the open modules, and insulated modules higher than the uninsulated. The severest performance loss was translated from cell temperatures. 17.5% for one enclosed, insulated module as compared to that module mounted open.

N81-28532¶ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
COMPARISON OF INTEGRATED GASIFIER-COMBINED CYCLE AND AFB-STEAM TURBINE SYSTEMS FOR INDUSTRIAL COGENERATION
In the cogeneration technology-alternatives study (CTAS), a number of advanced fuel fired systems were examined and systems using an integrated coal gasifier IGCC or a fluid bed combustor AFB were found to yield attractive cogeneration results. A range of site requirements and cogeneration sizing strategies using ground rules based on CTAS were used in comparing an IGCC and an AFB. The effect of time variations in site requirements and the sensitivity to fuel and electricity price assumptions are examined. The economic alternatives of industrial or utility ownership are also considered. The results indicate that the IGCC system has potentially higher fuel and emission savings and could be an attractive option for utility ownership. The AFB steam turbine system has a potentially higher return on investment and could be attractive assuming industrial ownership.

N81-28833# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
CHARACTERIZATION, PERFORMANCE, AND PREDICTION OF A LEAD-ACID BATTER DATABASE UNDER RELATIVE ELECTRIC VEHICLE DRIVING REQUIREMENTS Final Report
A state-of-the-art 6-V battery module in current use by the electric vehicle industry was tested at the NASA Lewis Re-
search Center to determine its performance characteristics under the SAE J227a driving schedules B, C, and D. The primary objective of the tests was to determine the effects of periods of recuperation and long and short periods of electrical regeneration in improving the performance of the battery module and hence extending the vehicle range. A secondary objective was to formulate a computer program that would predict the performance of the battery module for the above driving schedules. The results show excellent correlation between the laboratory tests and predicted results. The predicted performance compared with laboratory tests was within ±2.4 to ±3.7 percent for the D schedule, ±0.5 to ±7.1 percent for the C schedule, and better than ±11.4 percent for the B schedule.

The status of the Solar Thermal Power Systems Project for FY 1980 is summarized. Included is: a discussion of the project's goals, program structure, and progress in parabolic dish technology. Address and test results of concentrators, receivers, and power converters are discussed. Progress toward the objectives of technology feasibility, technology readiness, system feasibility, and system readiness are covered. E.A.K.

An electricity producing cell of the reduction-oxidation (REDOX) type divided into two compartments by a membrane is disclosed. A ferrous/ferric couple in a chloride solution serves as a cathode fluid to produce a positive electric potential. A chromic/chromous couple in a chloride solution serves as an anode fluid to produce a negative potential. The electrode is an electrically conductive, inert material plated with copper, silver or gold. A thin layer of lead plates onto the copper, silver or gold layer when the cell is being charged, the lead ions being available from lead chloride which has been added to the anode fluid. If the REDOX cell is then discharged, the lead deplates from the negative electrode and the metal coating on the electrode acts as a catalyst to increase current density.

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

An overrunning clutch that slipped freely under reverse torque was tested in the drive train of the Mod-O wind turbine. In low variable wind conditions, the clutch engaged and disengaged smoothly without perturbation or oscillations. The clutch permitted the generator to be connected to the line using a relay instead of an automatic synchronizer. The alternator was connected to the line when the rpm reached 95% of synchronous speed and it motored to synchronous speed in about 0.15 seconds with a momentary power spike of 50 kW. The performance of the clutch was the same with and without the fluid coupling. The ideal power with the clutch was 5 to 7 kW compared to up to 50 kW without the clutch. The overrunning clutch merits consideration in future wind turbine designs as a means of simplifying the control system, increasing energy capture, and increasing the life of blades and electrical switch gear. A.R.H.

A battery separator for an alkaline battery separator comprises a crosslinked copolymer of vinyl alcohol units and unsaturated carboxylic acid units. The crosslinked copolymer is insoluble in water, has excellent xanthate diffusion and oxygen gas barrier properties and a low electrical resistivity. A polyvalent zirconium crosslinking agent is preferred.

NASA

Electrodes for the Redox energy storage system based on iron and chromium chloride reactants is discussed. The physical properties of several lots of felt were determined. Procedures were developed for evaluating electrode performance in lab scale cells. Experimental procedures for evaluating electrodes by cyclic voltmetry are described which minimize the IR losses due to the high internal resistance in the cell (distributed resistance). Methods to prepare electrodes which reduced the coevolution of hydrogen at the chromium electrode and eliminate the drop in voltage on discharge occasionally seen with previous electrodes were discussed. Single cells of 0.3229 ft area with improved membranes and electrodes are operating at over 80% voltage efficiency and coulombic efficiencies of over 98% at current densities of 16 to 20 amp % ft. E.A.K.

The upgraded engine as built to the original design was deficient in power and had excessive specific fuel consumption. A high instrumented version of the engine was tested to identify the sources of the engine problems. Analysis of the data shows the major problems to be low compressor and power turbine efficiency and excessive interstage duct losses. In addition, high HC and CO emission were measured at idle and high NOx emissions at high energy speeds.
GUALIFICATION TESTING OF SECONDARY STERILIZABLE SILVER-ZINC CELLS FOR USE IN THE JUPITER ATMOSPHERIC ENTRY PROBE

Michelle A. Manzo 1
(Contract DE-A101-77CS-51044) (NASA-TM-82638; E-833) NTIS HC A02/MF A01 CSCL 10A

A series of qualification tests were run on the secondary, sterilizable silver oxide-zinc cell developed at the NASA Lewis Research Center to determine if the cell was capable of providing mission power requirements for the Jupiter atmospheric entry probe. The cells were tested for their ability to survive radiation at the levels predicted for the Jovian atmosphere with no loss of performance. Cell performance was evaluated under various temperature and loading conditions, and the cells were tested for their ability to survive radiation deceleration into the Jovian atmosphere. The cell performed acceptably except under the required loading at low temperatures. The cell was redesigned to improve low-temperature performance and energy density. The modified cells improved performance at all temperatures. Results of testing cells of both the original and modified designs are discussed.

Author

APPLICATIONS

STEADY-STATE AND TRANSIENT CONDITIONS

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Author

A REDOX SYSTEM DESIGN FOR SOLAR STORAGE APPLICATIONS


Redox energy storage systems developed for solar power applications and utility load leveling applications are described. The technology readiness of Redox energy storage for transfer of the technology to industry for product development and commercialization by industry is addressed. The design features of Redox systems for application to stand alone or residential storage requirements are described. Redox system designs with 3 to 10 kw power output and storage times of 6 to 250 hours are summarized and performance characteristics presented.

J. M. S

A REDOX ENERGY STORAGE SYSTEM


Are exchanges membranes used in the system serve as a charge transferring medium as well as a reactant separator and are the key enabling component in this storage technology. Each membrane formulation undergoes a series of screening tests for area-resistivity, static (non-flow) diffusion rate determination, and performance in Redox systems. The CDDL series of membranes has, by virtue of its chemical stability and high ion exchange capacity, demonstrated superior properties in the redox environment. Additional resistivity results at several acid and iron solution concentrations, ion diffusion rates, and time dependent iron fouling of the various membrane formulations are presented in comparison to past standard formulations.

T. M.

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T. M.
The radiation resistance and low-temperature annealing properties of lithium-doped N+P silicon solar cells are investigated. Cells fabricated from float zone and Czochralski grown silicon were irradiated with 1 MeV electrons and their performance compared to that of 0.35 ohm cm control cells. The float zone cells demonstrated superior radiation resistance compared to the control cells, while no improvement was noted for the Czochralski grown cells. Annealing kinetics were found to lie between first and second order for relatively short times, and the most likely annealing mechanism found was to be the diffusion of lithium to defects with the subsequent neutralization of defects by combination with lithium. Cells with zero lithium gradients exhibited the best radiation resistance.

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This paper presents an overview of photovoltaic systems applications since the initiation of the U.S. National Photovoltaic Program in 1975. Experiences with these applications are summarized and some conclusions are drawn. Implications for future research, technology development and application experiments are drawn from the experiences to date.


Solar array systems have been studied and compared for earth orbital and orbit transfer missions with the principal objective of quantifying the cost tradeoffs between gallium arsenide and silicon array for specific classes of missions and system characteristics. For the missions considered, it is found that the purchase cost advantage of Si arrays is not overcome by the greater radiation resistance of GaAs arrays. The use of reflectors for concentration may significantly reduce the power system cost. However, GaAs arrays benefit considerably more from solar concentration than Si arrays in terms of mission cost because of their higher allowable temperature. In the case of orbit transfer missions, a cover glass thickness of at least 0.05 cm is recommended to reduce total mission cost.

V.L.
plastic films of FEP or PFA applied with adhesive. Solar cells were exposed to environmental conditions simulating those encountered in outer space. These test conditions include 1 MeV electrons, 0.5 MeV protons, and thermal cycling in vacuum. During testing the solar cells were monitored for variations in electrical characteristics and structural changes.

M.G.


(For primary document see N81-17531 08-44)

(Contract NAS3-21270)

Avail: NTIS HC A17/MF A01 CSCL 10A

Advanced silicon solar cells with both electrical contacts on the back side of the cell are described. These high efficiency wrap around contact solar cells (HEWACS) utilize a screen printed dielectric insulation layer to isolate the 'n' and 'p' contacts from each other. Development of a device exhibiting high AMO conversion efficiencies is addressed along with the processing of such cells to a point where cell fabrication can be carried out by production personnel under operating production line conditions.

J.M.S.

N81-17886# Boeing Aerospace Co., Seattle, Wash. EVALUATION OF SOLAR CELL COVERS AND ENCAPSULANT MATERIALS FOR SPACE APPLICATION Dennis A. Russell In NASA Lewis Research Center Space Photovoltaic Res. and Technol. 1980 p 283-315 ref (For primary document see N81-17531 08-44)

(Contract NAS3-22222)

Avail NTIS HC A17/MF A01 CSCL 10A

The effects of space radiation (electrons and protons), vacuum, and thermal cycling on a variety of solar cell covers are investigated. Cover materials evaluated include glass resins, 2 mil glass applied with adhesives or electrostatically bonded, and tin foil. In vacuum conditions, both foils attained stability in electrical parameters.

T.M.


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T.M.
were studied. The base parameters defined for four near-optimum-performace MHD steam power systems of various types are presented. The finally selected systems consisted of (1) two directly fired cases, one at 1920 K (2996°F) preheat and the other at 1650 K (2876°F) preheat; (2) a separately-fired case where the air is preheated to the same level as the higher temperature directly-fired cases, and (3) an oxygen augmented case with the same generator inlet temperature of 2839 (4650°F) as the high temperature directly-fired and separately-fired cases. Supersonic Mach numbers at the generator inlet, gas inlet swirl, and constant Hall field operation were specified on disk generator orientation. System pressures were based on an optimization of MHD net power. Supernormal reheat stream plants were used in all cases. Open and closed cycle component costs are summarized and compared. A.R.H.

Paul Stonehart, John Baris, John Hochmuth, and Peter Pagliaro
31 Dec. 1980 35 p
(Contracts DEN3-178, DE-AL01-BOET-17088)
NASA CR 158245: DOE/NASA/0176-BO/4, GR-4
Avail: NTIS HC A03/MF A01 C5CL 10A
Alloy electrocatalysts on carbon supports were developed for hydrogen oxidation in the presence of carbon monoxide. These electrocatalysts match the best platinum on carbon catalysts for performance yet cost half as much. The results demonstrate that a significant reduction in anode electrocatalyst material cost can be achieved by replacing the platinum. Since surface characterization of this catalyst is important to explain its performance, several approaches and pitfalls to the elucidation of the surface characterization are presented. T.M.'

`NON-Noble CATALYSTS AND CATALYST SUPPORTS FOR PHOSPHORIC ACID FUEL CELLS Quarterly Report, Aug. - Nov. 1980
A.J. McAlister Nov 1980 13 p refs
NASA Order C 462290 Contract DE ALO1 SOET 17068
Tungsten carbide, which is known to be active for hydrogen oxidation and CO tolerant has a hexagonal structure. Titanium carbide is inactive and has a cubic structure. Four different samples of the cubic alloys W-xTiC were examined to test for active and CO tolerant. These alloys are of interest as possible phosphoric acid fuel cell catalysts. They also are of interest as opportunities to study the activity of W in a different crystalline environment and to correlate the activities of the surface sites with surface composition.

`SYBTEMS IN RESIDENTIAL, COMMERCIAL APPLICATIONS STUDY OF FUEL CELL ON-SITE, INTEGRATED ENERGY SYSTEMS IN RESIDENTIAL/COMMERCIAL APPLICATIONS Final Report
(Contracts DE-N5-169. DE-987-11272)
NASA CR 158144: DOE/NASA/0089-BO/1, EF-FC002
Avail: NTIS HC A14/MF A01 C5CL 10A
Three building applications were selected for a detailed study: a low rise apartment building; a retail store, and a hospital. Building design data were then specified for each application, based on the design and construction of typical, actual buildings. Finally, a computerized building loads analysis program was used to estimate hourly load profiles for each building. Conventional and fuel cell based energy systems were designed and simulated for each building in each location. Based on the results of the computer simulation of each energy system, leveled annual costs and annual energy consumptions were calculated for all systems. T.M.'
The technology development for materials, cells, and reformers for on-site integrated energy systems is described. The carbonization of 25 sq cm, 350 sq cm, and 1200 sq cm cell test hardware was accomplished and the performance of 25 sq cm fuel cells was improved. Electrochemical corrosion rates of graphite/phenolic resin composites in phosphoric acid were determined. Three cells (6 in by 15 in stacks) were operated for longer than 7000 hours. Specified endurance stacks completed a total of 4000 hours. An electrically heated reformer was tested and is to provide hydrogen for 23 cell fuel cell stack.

R.C.T.
oxide is a reduction of surface recombination velocity; the oxide also acts as a moderately efficient AR coating. Boron doped silicon with resistivities from 0.1 to 0.3 ohm-cm has been processed according to this sequence; results show highest open-circuit voltage is attained with 0.1-ohm-cm starting material. The effects of bandgap narrowing, caused by high doping concentrations in the junction, were also investigated by implanting phosphorus over a wide range of dose levels.

(Author)


Efforts to fabricate high efficiency, ultrathin coplanar back contact cells are described. Included is a description of design considerations, cell fabrication, and theoretical and experimental analyses of loss mechanisms. The results of these efforts has been the fabrication of a 11.8% AMO efficient, 50 micron cell when measured at 25 C. Design and process changes required to increase the efficiency are indicated.

(Author)


A cell technology, producing high efficiency wrap-around contact solar cells (HEWACS), with both electrical contacts on the back and AMO conversion efficiencies of almost 15%, is presented. A flow chart indicating the baseline process sequence along with the process changes is given. Tests checking for coating delamination and contact integrity, those measuring contact strength, and thermal cycle tests, successfully demonstrated that this cell technology is ready to be moved to the pilot production stage.

K.S.


A space solar cell concept which combines high cell output with low diffusion length damage coefficients is presented for the purpose of reducing solar cell susceptibility to degradation from the radiation environment. High resistivity n-p silicon solar cells ranging from upward of 82 micron-cm were exposed to AMO ultraviolet illumination. It is shown that high resistivity cells act as extrinsic devices under dark conditions and as intrinsic devices under AMO illumination. Resistive losses in thin n-p cells are found to be comparable to those in low resistivity cells. Present voltage limitations appear to be due to generation and recombination in the diffused regions.

D.K.
ENVIRONMENT POLLUTION
Includes air, noise, thermal and water pollution, environment monitoring, and contamination control.

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VLO015, VLO016, VLO017, VLO018, VLO019, AND VLO020
Leonidas C. Papthikos and Daniel Brehl Jun. 1981 95 p
(refs)
This is the twelfth of a series of reports which describes the data currently available from GASP, including flight routes and dates, instrumentation, data processing procedures, and data tape specifications. In-situ measurements of atmospheric ozone, cabin ozone, carbon monoxide, water vapor, particles, clouds, condensation nuclei, filter samples and related meteorological and flight information obtained during 1732 flights of aircraft N533PA, N4711U, N655PA, and VH-EBE from January 5, 1978 through October 9, 1978 are reported. These data are now available from the National Climatic Center, Asheville, NC 22801. In addition to the GASP data, tropopause pressures obtained from time and space interpolation of National Meteorological Center archived data for the dates of the flights are included.

Author
Includes aeronomy, upper and lower atmosphere studies, ionospheric and magnetospheric physics, and geomagnetism. For space radiation see 93 Space Radiation.

Tabulations are given of GASP ambient ozone mean, standard deviation, median, 84th percentile, and 98th percentile values, by season, flight level, and geographical region. In addition, selected empirical probability variations are highlighted to illustrate the types of curves which might be appropriate in specific analyses of the tabulated data, and an example-case calculation is presented to illustrate how the tables can be used to estimate the frequency of commercial airline flights encountering high cabin ozone levels.

Author
47 METEOROLOGY AND CLIMATOLOGY
Includes weather forecasting and modification

NB1-14565*† National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. ICING INSTRUMENTATION
The types and usage categories of icing instrumentation are discussed. The state-of-the-art for the technology governing the use of icing instrumentation is reported with particular emphasis on ground based facilities for icing tests. R.C.T.

NB1-21668*† National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. ANALYSIS OF ATMOSPHERIC OZONE LEVELS AT COMMERCIAL AIRPLANE CRUISE ALTITUDES IN WINTER AND SPRING, 1976-1977
It was speculated that the ozone sickness experienced by some airline passengers and crew members during the winter and spring of 1976-77 were induced by abnormally high concentrations of ambient atmospheric ozone. To investigate the possibility that 1976-77 was anomalous, ozone measurements from balloons for up to 13 years and from Global Atmospheric Sampling Program (GASP) equipped aircraft for 3 years were studied. The analyses presented show that the winter and spring seasons of 1976-77 were averaged statistically, and no evidence was found to suggest that there was more than a usual variation in the frequency that commercial airplanes encountered high ambient ozone concentrations. Author

Summary statistics and variability studies are presented for cloud encounter and particle number density data as part of the NASA Global Atmospheric Sampling Program (GASP) aboard commercial Boeing 747 airliners. On the average, cloud encounter is shown on about 15% of the 52,164 data samples available; this value varies with season, latitude, synoptic weather situation, and distance from the tropopause. The number density of particles (diameter greater than 3 microns) also varies with time and location, and depends on the horizontal extent of cloudiness. (Author)

An analytical procedure has been developed to predict rime ice growth on unprotected airfoil sections and to evaluate the aerodynamic performance. A time stepping method is used in which (1) water droplet trajectories are calculated, (2) a rime ice shape determined, (3) the flowfield around the iced airfoil is recalculated, and (4) the build-up process iterated upon until the desired icing time is reached. The performance of the iced airfoil shapes are then determined from existing analytic methods. Rime ice shapes determined in the NASA Lewis Icing Research Tunnel on a modified NASA 64 series airfoil agree well with the shapes predicted by the analytical method. Measured and predicted increases in drag due to the rime ice also agree favorably. A simplified scaling analysis is also presented and verified which provides the duplication of full scale results of rime ice accretions in small scale model tests. (Author)
A cerebrospinal fluid shunt in the form of a ventricular catheter for controlling the condition of hydrocephalus by relieving the excessive cerebrospinal fluid pressure is described. A method for fabrication of the catheter and shunting the cerebral fluid from the cerebral ventricles to other areas of the body is also considered. Shunt flow failure occurs if the ventricle collapses due to improper valve function causing overdrainage. The ventricular catheter comprises a multiplicity of inlet microtubules. Each microtubule has both a large openings at its inlet end and a multiplicity of microscopic openings along its lateral surfaces. The microtubules are perforated by an ion beam sputter etch technique. The holes are etched in microtubule by directing an ion beam through an electro-formed metal mesh mask producing perforations.
Color coding techniques used in the processing of remote sensing imagery were adapted and applied to the fluid dynamics problems associated with turbofan mixer nozzles. The computer generated color graphics were found to be useful in reconstructing the measured flow field from low resolution experimental data to give more physical meaning to this information and in scanning and interpreting the large volume of computer generated data from the three dimensional viscous computer code used in the analysis. 

M.G.
COMPUTER PROGRAMMING AND SOFTWARE

Includes computer programs, routines, and algorithms.

NAS1-28898# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

KONFIG AND REKONFIG: TWO INTERACTIVE PREPROCESSING TO THE NAVY/NASA ENGINE PROGRAM (NNEP)
Lawrence H. Fishbach May 1981 59 p

The NNEP is a computer program that is currently being used to simulate the thermodynamic cycle performance of almost all types of turbine engines by many government, industry, and university personnel. The NNEP uses arrays of input data to set up the engine simulation and component matching method as well as to describe the characteristics of the components. A preprocessing program (KONFIG) is described in which the user at a terminal on a time shared computer can interactively prepare the arrays of data required. It is intended to make it easier for the occasional or new user to operate NNEP. Another preprocessing program (REKONFIG) in which the user can modify the component specifications of a previously configured NNEP dataset is also described. It is intended to aid in preparing data for parametric studies and/or studies of similar engines such as mixed flow turbines, turboshifts, etc.

E.D.K.

NAS1-33836# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR PULSED THERMOCOUPLES WITH CORRECTIONS FOR RADIATION EFFECTS
Herbert A. Will Sep 1981 42 p. refs

A pulsed thermocouple was used for measuring gas temperatures above the melting point of common thermocouples. This was done by allowing the thermocouple to heat until it approaches its melting point and then turning on the protective cooling gas. This method required a computer to extrapolate the thermocouple data to the higher gas temperatures. A method that includes the effect of radiation in the extrapolation is described. Correlations of gas temperature are provided, along with the estimate of the final thermocouple wire temperature. Results from tests on high temperature combustor research rigs are presented.

R.C.T.
A preliminary simulator design that uses a parallel computer organization to provide accuracy, portability, and low cost is presented. The hardware and software for this prototype simulator are discussed. A detailed discussion of the inter-computer data transfer mechanism is also presented.

M.G.

Current applications of real-time simulations to the development of complex aircraft propulsion system controls have demonstrated the need for accurate, portable, and low-cost simulators. This paper presents a preliminary simulator design that uses a parallel computer organization to provide these features. The hardware and software for this prototype simulator are discussed. A detailed discussion of the inter-computer data transfer mechanism is also presented.

(Author)
64 NUMERICAL ANALYSIS
Includes iteration, difference equations, and numerical approximation.

NB1-14690* National Aeronautics and Space Administration
Lewis Research Center Cleveland, Ohio
AN ELECTROSTATIC ANALOG FOR GENERATING CASCADE GRIDS
John Jay Adamczyk In NASA Langley Research Center Numerial Grid Generation 1960 p 129-142 (For primary document see NB1-14690 05-64) Avail. NTIS HC A24/MF A01 CSCL 12A
Accurate and efficient numerical simulation of flows through turbomachinery blade rows depends on the topology of the computational grids. These grids must reflect the periodic nature of turbomachinery blade row geometries and conform to the blade shapes. Three types of grids can be generated that meet these minimal requirements: through-flow grids, O-type grids, and C-type grids. A procedure which can be used to generate all three types of grids is presented. The resulting grids are orthogonal and can be stretched to capture the essential physics of the flow. A discussion is also presented detailing the extension of the generation procedure to three dimensional geometries. Author

NB1-14708* National Aeronautics and Space Administration
Lewis Research Center Cleveland, Ohio
FAST GENERATION OF BODY CONFORMING GRIDS FOR 3-D
Ojordje Dukijravich In NASA Langley Research Center Numerical Grid Generation Tech 1980 p 241-252 refs (For primary document see NB1-14690 05-64) Avail. NTIS HC A24/MF A01 CSCL 12A
A fast algorithm was developed for accurately generating boundary conforming, three dimensional, consecutively refined, computational grids applicable to arbitrary axial turbomachinery geometry. The method is based on using a single analytic function to generate two dimensional grids on a number of coaxial axisymmetric surfaces positioned between the hub and the shroud. These grids are of the 'O' type and are characterized by quasi-orthogonality, geometric periodicity, and an adequate resolution throughout the flowfield. Due to the built in additional nonorthogonal coordinate stretching and shearing, the grid lines leaving the trailing of the blade end at downstream infinity, thus simplifying the numerical treatment of the three dimensional trailing vortex sheet. Author

NB1-14721* National Aeronautics and Space Administration
Lewis Research Center Cleveland, Ohio
GENERATION OF C-TYPE CASCADE GRIDS FOR VISCOS FLOW COMPUTATION
Peter M Sockol In NASA Langley Research Center Numerical Grid Generation Tech 1980 p 437-448 refs (For primary document see NB1-14690 05-64) Avail. NTIS HC A24/MF A01 CSCL 12A
A rapid procedure for generating C-type cascade grids suitable for viscous flow computations in turbomachinery blade rows is presented. The resulting mesh is periodic from one blade passage to the next, nearly orthogonal, and continuous across the wake downstream of a blade. The procedure employs a pair of conformal mappings that take the exterior of the cascade into the interior of an infinite strip with curved boundaries. The final transformation to a rectangular computational domain is accomplished numerically. The boundary values are obtained from a panel solution of an integral equation and the interior values by a rapid ADI solution of Laplace's equation. Examples of C-type grids are presented for both compressor and turbine blades and the extension of the procedure to three dimensions is briefly outlined. Author

Population model coefficients are chosen to simulate a saturated 2 to the 4th fixed effects experiment having an unfavorable distribution of relative values. Using random number studies, deletion strategies were compared that were based on the F-distribution, on an order statistics distribution of Cochran's, and on a combination of the two. The strategies were compared under the criterion of minimizing the maximum prediction error, wherever it occurred, among the two-level factorial points. The strategies were evaluated for each of the conditions of 0, 1, 2, 3, 4, 5, or 6 center points. Three classes of strategies were identified as being appropriate, depending on the extent of the experimenter's prior knowledge. In almost every case the best strategy was found to be unique according to the number of center points. Among the three classes of strategies, a security regret class of strategy was demonstrated as being widely useful in that over a range of coefficients of variation from 0 to 65%, the maximum predictive error was never increased by more than 12% over what it would have been if the best strategy had been used for the particular coefficient of variation. The relative efficiency of the experiment, when using the security regret strategy, was examined as a function of the number of center points, and was found to be best when the design used one center point. (Author)
Population model coefficients were chosen to simulate a saturated 2 to the fourth power fixed effects experiment having an unfavorable distribution of relative values. Using random number studies, deletion strategies were compared that were based on the F distribution, on an order statistics distribution of Cochran's, and on a combination of the two. Results of the comparisons and a recommended strategy are given.

For a cell configuration consisting of a thin nematic layer bounded by two parallel plane surfaces, with opposing surfaces suitably treated to produce dissimilar molecular orientations, the elastic continuum theory for nematic liquid crystals was applied to derive an expression relating surface anchoring energies to elastic constants, director orientations at the substrate surfaces, and cell thickness. A numerical comparison with the elastically isotropic result over a range $K_{3} - 1.5 K_{1}$ to $K_{3} = 10 K_{1}$ showed the effect of elastic anisotropy could be quite significant. Surface anchoring energies calculated for anisotropic of $K_{3} = 2 K_{1}$ and $K_{3} = 10 K_{1}$ were approximately 50% and 500%, respectively, than the isotropic values.
**71 ACOUSTICS**

Includes sound generation, transmission and attenuation. For noise pollution see 45 Environment Pollution

NB1-10807* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**NEW INTERPRETATIONS OF SHOCK-ASSOCIATED NOISE WITH AND WITHOUT SCREECH**


Anomalous trends in present convergent nozzle (Mach 1) shock associated noise analyses and predictions, with particular emphasis on the roles of screech and jet temperature, are discussed. Experimentally measured values of shock associated noise are used to reassess data trends, including both frequency and sound pressure level. The data used includes model-scale nozzles, varying in nominal diameter from 5 cm to 13 cm, and full-scale engine nozzles up to 48 cm. All data were obtained at static conditions. From this reassessment of the measured data, new empirical methods for the prediction of shock associated noise are developed. Separate procedures are presented for screech free and for sonic (and supersonic) shock associated noise. In the present approach, shock associated noise spectra are developed from considerations that include the peak sound pressure level and its frequency, the low frequency sound pressure level slope or roll-off, the latter is shown to vary with directivity angle.

**Author**

NB1-11789* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. Fluid Mechanics and Acoustics Div.

**CORE NOISE MEASUREMENTS FROM A SMALL GENERAL AVIATION TURBOFAN ENGINE**


As part of a program to investigate combustor and other core noises, simultaneous measurements of internal fluctuating pressure and far field noise were made with a JT15D turbofan engine. Acoustic waveguide probes, located in the engine at the combustor, the turbine exit and in the core nozzle wall, were used to measure internal fluctuating pressures. Low frequency acoustic pressure determined at the core nozzle exit corresponds in level to the far field acoustic power at engine speeds below 65% of maximum. At approach condition, engine speeds above 65% of maximum, the jet noise dominates in the far field, greatly exceeding that of the core. From coherence measurements, it is shown that the combustor is the dominant source of the low frequency core noise. The results obtained from the JT15D engine were compared with those obtained previously from a YF102 engine, both engines having reverse flow annular combustors and being in the same size class.

**Author**

NB1-11770* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EFFECT OF A SEMI-ANNULAR THERMAL ACOUSTIC SHIELD ON JET EXHAUST NOISE**


Reductions in jet exhaust noise obtained by the use of an annular thermal acoustic shield consisting of a high temperature, low velocity gas stream surrounding a high velocity central jet exhaust appear to be limited by multiple reflections. The effect of a semi-annular shield on jet exhaust noise was investigated with the rationale that such a configuration would eliminate or reduce the multiple reflection mechanism. Noise measurements for a 10 cm conical nozzle with a semi-annular acoustic shield are presented in terms of lossless free field data at various angular locations with respect to the nozzle. Measurements were made on both the shielded and unshielded sides of the nozzle. The results are presented parametrically, showing the effects of various shield and central system velocities and temperatures. Selected results are scaled up to a typical full size engine to determine the perceived noise level reductions.

A.R.H.

NB1-12821* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**ACOUSTIC TRANSMISSION MATRIX OF A VARIABLE AREA DUCT OR NOZZLE CARRYING A COMPRESSIBLE SUBSONIC FLOW**


The differential equations governing the propagation of sound in a variable area duct or nozzle carrying a one dimensional subsonic compressible fluid flow are derived and put in state variable form using acoustic pressure and particle velocity as the state variables. The duct or nozzle is divided into a number of regions. The region size is selected so that in each region the Mach number can be assumed constant and the area variation can be approximated by an exponential area variation. Consequently, the state variable equation in each region has constant coefficients. The transmission matrix for each region is obtained by solving the constant coefficient acoustic state variable differential equation. The transmission matrix for the duct or nozzle is the product of the individual transmission matrices of each region. Solutions are presented for several geometries with and without mean flow.

J.M.S.

NB1-15766* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**ANALYSIS OF PRESSURE SPECTRA MEASUREMENTS IN A DUCTED COMBUSTION SYSTEM**


Combustion noise propagation in an operating ducted liquid fuel combustion system is studied in relation to the development of combustion noise prediction and suppression techniques. The presence of combustor emissions in the duct is proposed as the primary mechanism producing the attenuation and dispersion of combustion noise propagating in an operating liquid fuel combustion system. First, a complex mathematical model for calculating attenuation and dispersion taking into account mass transfer, heat transfer, and viscosity effects due to the presence of liquid fuel droplets or solid soot particles is discussed. Next, a simpler single parameter model for calculating pressure auto-spectra and cross-spectra which takes into account dispersion and attenuation due to heat transfer between solid soot particles and air is developed. Then, auto-spectra and cross-spectra obtained from internal pressure measurements in a combustion system consisting of a J-47 combustor and a slowing piece, and a long duct are presented. Last, analytical results obtained with the single parameter model are compared with the experimental measurements. The single parameter model results are shown to be in excellent agreement with the measurements.

J.M.S.

NB1-19876* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**ON THE PROPAGATION OF LONG WAVES IN ACOUSTICALLY TREATED, CURVED DUCTS**


A two dimensional study is presented on the behavior of long waves in lined, curved ducts. The analysis includes a...
comparison between the propagation in curved and straight lined ducts. A parametric study was conducted over a range of wall admittance and duct wall separation. The complex eigenvalues of the characteristic equation, which in the case of a curved duct are also the angular wavenumbers, were obtained by successive approximations.

Author

N81-20831* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH-FREQUENCY SOUND PROPAGATION IN A SPATIALLY VARYING MEAN FLOW

An equation for acoustic ray paths in a spatially varying mean flow was examined to determine some of the characteristics of the flow gradient effects on sound propagation. In a potential flow, the acoustic rays are deflected in the direction of increasing mean flow, and the gradient of the mean flow speed is the dominant factor causing the ray deflection. In contrast, in a sheared mean flow, the vorticity is the dominant factor in deflection of the acoustic rays.

Author

N81-28844* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NEW TECHNIQUE FOR THE DIRECT MEASUREMENT OF CORE NOISE FROM AIRCRAFT ENGINES

The core noise levels from high-speed aircraft engines were measured using a noise probe which requires that fluctuating pressures be measured in the far field and at two locations within the engine core. The cross spectra of these measurements are used to determine the levels of the far-field noise that propagated from the engine core. The technique makes it possible to measure core noise levels even when other noise sources dominate. The technique was applied to signals measured from an Avco Lycoming YF102 turbofan engine. Core noise levels as a function of frequency and radiation angle were measured and are presented over a range of power settings.

Author

N81-28822* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF PREDICTED ENGINE CORE NOISE WITH CURRENT AND PROPOSED AIRCRAFT NOISE CERTIFICATION REQUIREMENTS

Predicted engine core noise levels are compared with measured total aircraft noise levels and with current and proposed federal noise certification requirements. Comparisons are made at the FAR-36 measuring stations and include consideration of both full- and cutback-power operation at takeoff. In general, core noise provides a barrier to achieving proposed EPA stage 5 noise levels for all types of aircraft. More specifically, core noise levels will limit further reductions in aircraft noise levels for current widebody commercial aircraft.

Author

N81-30080* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF EXIT IMPEDANCE ON FINITE DIFFERENCE SOLUTIONS OF TRANSIENT ACOUSTIC MODE PROPAGATION IN DUCTS

The time-dependent governing acoustic-difference equations and boundary conditions are developed and solved for sound propagation in an asymmetric (cylindrical) hard-wall duct without flow and with spinning acoustic modes. The analysis begins with a harmonic sound source radiating into a quiescent duct. This explicit iteration method then calculates stepwise in real time to obtain the steady solutions of the acoustic field. The transient method did not converge to the steady-state solution for cutoff acoustic duct modes. This has implications as to its use in a variable-area duct, where modes may become cutoff in the small-area portion of the duct. For single cutoff mode propagation the steady-state impedance boundary condition produced acoustic reflections during the initial transient that caused finite instabilities in the numerical calculations. The stability problem is resolved by reformulating the exit boundary condition.

Example calculations show good agreement with exact analytical and numerical results for forcing frequencies above, below, and nearly at the cutoff frequency.

Author

N81-30089* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOTE ON REFLECTION AND TRANSMISSION COEFFICIENTS FOR CONVERGING-DIVERGING DUCTS

Simple formulas for calculating acoustic reflection and transmission coefficients for converging-diverging ducts are derived: they extend the method of Cho and Ingard to arbitrary, slowly varying ducts. These formulas involve two parameters. The first is a function of duct shape and the second is the ratio of the duct radius downstream of the throat to the upstream of the throat. An extension of the method to include mean flow is made for symmetric ducts.

Author

N81-30107* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONDITIONED PRESSURE SPECTRA AND COHERENCE MEASUREMENTS IN THE CORE OF A TURBOFAN ENGINE

Multiple and partial coherence functions and the corresponding conditioned coherent output spectra are computed between fluctuating pressures measured at two locations within the tailpipe of a turbofan engine and far-field acoustic pressure. The results are compared with the ordinary coherent output spectrum as obtained between a single tailpipe pressure measurement and the far-field acoustic pressure. The comparison indicates apparent additional coherent output (i.e., core-noise) beyond that detectable with an ordinary coherent measurement, thus suggesting the tailpipe as a core-noise source region. Further evidence suggests, however, that these differences may be attributed to the presence of transverse acoustic modes in the tailpipe and that the tailpipe is not, in fact, a significant source region.

Author

N81-31966* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF BLADE-VANE RATIO AND ROTOR-STATOR SPACING OF FAN NOISE WITH FORWARD VELOCITY

A research fan stage was acoustically tested in an anechoic wind tunnel with a 41 m/sec tunnel flow. Two stator vane numbers giving cut-on and cutoff conditions were tested at three rotor-stator spacings ranging from about 0.5 to 2.0 rotor chords. These two stators were designed for similar aerodynamic
performance. Hot film anemometer turbulence measurements were made at the leading edge of the stator for each spacing. The cut-off criterion strongly controlled the fundamental tone level at all spacings. The trends made with spacing of the wake defect upstream component at the stator tip showed good agreement with the corresponding cut-on acoustic tone levels.

Author

N81-31987# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
TURBOMACHINERY NOISE STUDIES OF THE AIRSEARCH CCQAT ENGINE WITH INFLOW CONTROL

The Airsearch Quiet Clean General Aviation Turbopan engine was tested on an outdoor test stand to compare the acoustic performance of two inflow control devices (ICD's) of similar design, and three inlet lips of different external shape. Only small performance differences were found. Far-field directivity patterns calculated by applicable existing analyses were compared with the measured tone and broadband patterns. For some of these comparisons, tests were made with an ICD to reduce rotor/inflow disturbance at the nozzle, or with the acoustic suppression panels in the inlet or bypass duct covered with aluminum tape to determine hard wall acoustic performance. The comparisons showed that the analytical expressions used predict many directivity pattern features and trends, but can deviate in shape from the measured patterns under certain engine operating conditions. Some patterns showed lobes from modes attributable to rotor/engine strut interaction sources.

Author

N81-32964# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
AN IMPROVED PREDICTION METHOD FOR NOISE GENERATED BY CONVENTIONAL PROFILE COAXIAL JETS

A semiparametric model for predicting the noise generated by conventional velocity profile jets exhausting from coaxial nozzles is presented and compared with small scale static and simulated flight data. Improvements to the basic circular jet noise prediction are developed which improve the accuracy, especially at high jet velocity and near the jet axis.

Author

N81-33997# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
COMPUTER PROGRAM TO PREDICT AIRCRAFT NOISE LEVELS
Bruce J. Clark. Sep 1981 146 p (NASA-TP-1913; E-733) Avail. NTIS HC A07/MF A01 CSCL 20A

Methods developed at the NASA Lewis Research Center for predicting the noise contributions from various aircraft noise sources were programmed to predict aircraft noise levels either in flight or in ground tests. The noise sources include fan inlet and exhaust, jet/plume (for powered lift), core (combustor), turbine, and airframe Noise propagation corrections are available for atmospheric attenuation, ground reflections, extra ground attenuation, and shielding. Outputs can include spectra, overall sound pressure level, perceived noise level, tone-weighted perceived noise level, and effective perceived noise level at locations specified by the user. Footprint contour coordinates and approximate footprint areas can also be calculated. Inputs and outputs can be in either System International or U.S. customary units. The subroutines for each noise source and propagation correction are described. A complete listing is given.

Author


A review is presented covering both finite difference and finite element analysis of small amplitude linear sound propagation in straight and variable area ducts. As might be found in a typical turbojet engine duct, muffler, or industrial ventilation system. Both 'steady' state and transient theories are discussed. Emphasis is placed on the advantages and limitations associated with the various numerical techniques. Examples of practical problems are given for which the numerical techniques have been applied.

Author

The differential equations governing the propagation of sound in a variable area duct or nozzle carrying a one-dimensional subsonic compressible fluid flow are derived and put in state variable form using acoustic pressure and particle velocity as the state variables. The duct or nozzle is divided into a number of regions. The region size is selected so that in each region the Mach number can be assumed constant and the area variation can be approximated by an exponential area variation. Consequently, the state variable equation in each region has constant coefficients. The transmission matrix for each region is obtained by solving the constant coefficient acoustic state variable differential equation. The transmission matrix for the duct or nozzle is the product of the individual transmission matrices of each region. Solutions are presented for several geometries with and without mean flow. (Author)


A two-dimensional, detailed study is presented on the behavior of long waves in lined, curved ducts. The analysis includes a comparison between the propagation in curved and straight lined ducts. A parametric study was conducted over a range of wall admittance and duct wall separation. The complex eigenvalues of the characteristic equation, which in the case of a curved duct are also the angular wavenumbers, have been obtained by successive approximations. (Author)


The several phenomena involved in theoretical prediction of the far-field sound radiation attenuation from an acoustically lined duct have been studied. These include absorption by the suppressor, termination reflection, and far-field radiation. Extensive parametric studies have shown that the suppressor absorption performance can be correlated with mode cut-off ratio or angle of propagation. The other phenomena can be shown to depend explicitly upon mode cut-off ratio. A complete system can thus be generated which can be used to evaluate aircraft sound suppressors and which can be related to the sound source through the cut-off ratio-acoustic power distribution. Although the method is most fully developed for inlet suppressors, general far-field radiation phenomena will also be discussed. This paper summarized this simplified suppressor design and evaluation method, presents the recent improvements in the technique and discusses areas where further refinement is necessary. Noise suppressor data from engine experiments are compared with the theoretical calculations. (Author)


Calculated engine core noise levels, based on NASA-Lewis prediction procedures, for five representative helicopter engines are compared with measured total helicopter noise levels and proposed FAA helicopter noise certification requirements. Comparisons are made for level flyover and approach procedures. The measured noise levels are generally significantly greater than those predicted for the core noise levels, except for the Sikorsky S-61 and S-64 helicopters. However, the predicted engine core noise levels are generally at or within 3 dB of the proposed FAA noise rule. Consequently, helicopter engine core noise can be a significant contributor to the overall helicopter noise signature and, at this time, will provide a limiting floor to a further decrease in future noise regulations. (Author)

An equation for acoustic ray paths in a spatially varying mean flow has been examined to determine some of the characteristics of the flow gradient effects on sound propagation. In a potential flow the acoustic rays are deflected in the direction of increasing mean flow, and the gradient of the mean flow speed is the dominant factor causing the ray deflection. In contrast, in a sheared mean flow, the vorticity is the dominant factor in deflection of the acoustic rays.

(Author)


An analytical model is developed for the acoustic impedance of a composite made of a fine screen bonded to a perforated plate, the resistance having been modeled using steady flow theory and data, and including both linear and nonlinear components. The model of the screen resistance alone is derived first, and it is then extended to include a plate and plate bonded to the screen. Quantities such as effective open ratio and pressure recovery are evaluated. Conclusions are presented, including: (1) when the screen is bonded to a perforated plate, the linear resistance increases as the inverse of the perforate open area, (2) the nonlinearity in the screen resistance depends on the square of the screen wire diameter, and (3) when the resistance is considered as a function of approach velocity, the screen nonlinear term increases as the inverse of the square of the perforated plate open area ratio. The general theory can be applied to any screen structure, but final results are limited to a twisted square wire screen. Results can be applied to the study of sound absorbing materials used for lining the walls of aircraft engine duct suppressors.

K.S.


A semi-empirical model for predicting the noise generated by conventional-velocity profile jets exhausting from coaxial nozzles is presented and compared with small-scale static and simulated flight data. The present model is an updated version of that part of the original NASA Aircraft Noise Prediction (A3OP) Program (1974) relating to coaxial jet noise. That model has been shown to agree reasonably well with model and full-scale experimental data except at high jet velocities in the region near the jet axis. Improvements to the basic circular jet noise prediction have been developed since this time which improve the accuracy, especially at high jet velocity and near the jet axis, and are incorporated into the coaxial jet procedure in this paper. The new procedure is more theoretically based and has also been improved by some empirical adjustments.

(Author)


When a free jet (or open jet) is used as a wind tunnel to simulate the effects of flight on model noise sources, it is necessary to calibrate out the effects of the free jet shear layer on the transmitted sound, since the shear layer is absent in the real flight case. In this paper, a theoretical calibration procedure for this purpose is first summarized; following this, the results of an experimental program, designed to test the validity of the various components of the calibration procedure, are described. The experiments are conducted by using a point sound source located at various axial positions within the free jet potential core. By using broadband excitation and cross-correlation methods, the angle changes associated with ray paths across the shear layer are first established. Measurements are then made simultaneously inside and outside the free jet along the proper ray paths to determine the amplitude changes across the shear layer. It is shown that both the amplitude and amplitude changes can be predicted accurately by theory. It is also found that internal reflection at the shear layer is significant only for large ray angles in the forward quadrant where total internal reflection occurs. Finally, the effects of sound absorption and scattering by the shear layer turbulence are also examined experimentally.

(Author)
72 ATOMIC AND MOLECULAR PHYSICS
Includes atomic structure and molecular spectra.

N81-22836f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
AN EVALUATION OF A SIMPLIFIED NEAR FIELD NOISE MODEL FOR SUPERSONIC HELICAL TIP SPEED PROPELLERS
(NASA-TM-81727; E-7681) Avail. NTIS HC A02/MF A01 CSCL 20A
Existing propeller noise models are versatile and complex but require large computational times, therefore a simplified noise model that could be used to obtain quick noise estimates for these propellers was evaluated. This simplified noise model compared favorably with a complex model for a straight blade propeller and the assumptions which the propeller sweep was properly considered. The simplified model can thus be used as an approximation to the complex model. Comparisons of either the complex or simplified models with the available noise data are not good for superasonic propeller helical tip speeds. By adjusting various constants in the simplified model, the noise estimates can be brought into the same range as the data at the propeller design point but the variation of the model with helical tip Mach number remains different than the data. A.R.H.

N81-22837f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
A THEORETICAL APPROACH TO SOUND PROPAGATION AND RADIATION FOR DUCTS WITH SUPPRESSORS
(NASA-TM-82612; E-863) Avail. NTIS HC A03/MF A01 CSCL 20A
The several phenomena involved in theoretical prediction of the far-field sound radiation attenuation from an acoustically lined duct were studied. These include absorption by the suppressor, termination reflections, and far-field radiation. Extensive parametric studies show that the suppressor absorption performance can be correlated with mode cut-off ratio or angle of propagation. The other phenomena can be shown to depend explicitly upon mode cut-off ratio. A complete system can thus be generated which can be used to evaluate various results. The authors discuss how results can be related to the sound source through the cut-off ratio-acoustic power distribution. Although the method is based on a simplified suppressor design and evaluation method is summarized, the recent improvements in the technique are presented, and areas where further refinement is necessary are discussed. Noise suppressor data from engine experiments are compared with the theoretical calculations. A.R.H.

N81-22879f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
THE SELF-CONSISTENT CALCULATION OF PSEUDOMOLECULE ENERGY LEVELS, CONSTRUCTION OF ENERGY LEVEL CORRELATION DIAGRAMS AND AN AUTOMATED COMPUTATION SYSTEM FOR SCF-XALPHA-SW CALCULATIONS
Herbert Schlosser (Cleveland State Univ.) Mar. 1981 20 p refs
(NASA-TM-81710; E-740) Avail. NTIS HC A02/MF A01 CSCL 20H
The self consistent calculation of the electronic energy levels of noble gas pseudomolecules formed when a metal surface is bombarded by noble gas ions is discussed along with the construction of energy level correlation diagrams as a function of interatomic spacing. The self consistent field x alpha scattered wave (SCF-Xalpha-SW) method is utilized. Preliminary results on the Ne-Mg system are given. An interactive x alpha programming system, implemented on the LERC IBM 20H.

N81-22878f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
PROPOSED FAA HELICOPTER NOISE CERTIFICATION COMPARISON OF PREDICTED ENGINE CORE NOISE WITH PROPOSED FAA HELICOPTER NOISE CERTIFICATION REQUIREMENTS
(NASA-TM-81739; E-781) Avail. NTIS HC A02/MF A01 CSCL 20A
Calculated engine core noise levels based on NASA-Lewis prediction procedures, for five representative helicopter engines are compared with measured total helicopter noise levels and proposed FAA helicopter noise certification requirements. Comparisons are made for level flyover and approach procedures. The measured noise levels are generally significantly greater than those predicted for the core noise levels except for Sikorsky S-61 and S-54 helicopters. However th, predicted engine core noise levels are generally at or within 3 db of the proposed FAA noise rules. Consequently, helicopter engine core noise can be a significant contributor to the overall helicopter noise signature and, at the time, will provide a limiting floor for a further decrease in future noise regulations. A.R.H.
Thermionic energy converters and metallic-fluid heat pipes are well suited to serve together synergistically. The two operating cycles appear as simple and isolated as their material problems seem forebodingly deceptive and complicated. Simplified equations verify material properties and interactions as primary influences on the operational effectiveness of both. Each experiences flow limitations in thermal emission and vaporization because of temperature restrictions redounding from thermophysicochemical stability considerations. Topics discussed include: (1) successful limitation of alkali-metal corrosion, (2) protection against external hot corrosive gases, (3) coping with external and internal vaporization, (4) controlling interfacial reactions and diffusion, and (5) meeting other thermophysical challenges: expansion matches and creep. A.R.H.
75 PLASMA PHYSICS
Includes magnetohydrodynamics and plasma fusion
For ionospheric plasmas see 46 Geophysics. For space plasmas see 90 Astrophysics.

N81-19920® National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
THERMIONIC ENERGY CONVERSION (TEC) TOPPING THERMOELECTRICS
James F. Morris 1981 16 p refs Proposed for preservation at
Conf. on Plasma Sci., Santa Fe, N. Mex., 18-20 May 1981;
 sponsored by IEEE
(Contract EC-77-A-31-1062)
(NASA-TM-81077; E-702; DOE/NASA/1062-B) Avail. NTIS
HC A02/MF A01 CSCL 201
Performance expectations for thermionic and thermoelectric
energy conversion systems are reviewed. It is noted that internal
radiation effects diminish thermoelectric figures of merit signiﬁcantly
at 1000 K and substantially at 2000 K. The effective thermal conducti
contribution of intrathermoelectric radiative dissipation increases with
the third power of temperature. It is argued that a consideration of thermoelectric power generation
with high temperature sources should include utilization of thermionic energy conversion (TEC) topping thermoelectric systems. However, TEC alone or TEC topping more efﬁcient conversion systems like steam or gas turbines, combined cycles, or Stirling engines would be more desirable generally. M.G.

N81-24628® National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
CONCEPTUAL DESIGN OF THE MHD ENGINEERING TEST FACILITY
(Contract DE-AI01-77ET-10769; EF-77-A-01-2874)
(NASA-TM-82621; DGE/NASA/10769-18; E-872) Avail. NTIS
HC A02/MF A01 CSCL 201
The reference conceptual design of the MHD engineering test facility, a prototype 200 MW e 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 rationale behind their presence is outlined. System and plant facilities are listed and discussed. Construction cost and schedule estimates are included and the engineering issues that should be reexamined are identified.
A.R.H.

N81-24627® National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
A MHD CHANNEL STUDY FOR THE ETF CONCEPTUAL DESIGN
(Contract DE-AI01-77ET-10769)
(NASA TM 81794; DGE/NASA/1769-14; E-827) Avail. NTIS
HC A02/MF A01 CSCL 201
The procedures and computer codes used to identiﬁy a MHD channel for a (400 MW) ETF-scale plant are presented. Under the assumptions of constant maximum (E), E(y), (J), and Beow; results show the best plant performance is obtained for active length, L, approximately 25 M. The initial ETF studies. L is approximately 16 M. As MHD channel length is reduced from 25 M, the channel enthaphy extraction falls off, slowly. This reduces the output of the MHD power output; however, the shorter channels result in lower heat losses to the MHD channel cooling water which allows for the incorporation of more low pressure boiler feedwater heaters into the system and an increase in steam plant efﬁciency. The net result of these changes is a net increase in the overall MHD/steam plant efﬁciency. In addition to the sensitivity of various channel parameters, the trade-offs between the level of oxygen enrichment and the electrical stress on the channel are also discussed. A.R.H.

N81-25608® National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
GOALS OF THERMIONIC PROGRAM FOR SPACE POWER
(NASA-TM-82618; E-898) Avail. NTIS HC A02/MF A01 CSCL 201
The thermionic and Brayton reactor concepts were compared for application to space power. For a turbine inlet temperature of 15000 K the Brayton powerplant weighted 5 to 40% less than the thermionic concept. The out of core concept separates the thermionic converters from their reactor. Technical risks are diminished by: (1) moving the insulator out of the reactor; (2) allowing a higher thermal ﬂux for the thermionic converters than is required of the reactor fuel; and (3) eliminating fuel swelling’s threat against lifetime of the thermionic converters. Overall performance can be improved by including power processing in system optimization for design and technology on more efﬁcient, higher temperature power processors. The thermionic reactors will be larger than the reactors for competing systems with higher conversion efﬁciency and lower reactor operating temperatures. It is concluded that although the effect of reactor size on shield weight will be modest for unmanned spacecraft, the penalty in shield weight will be large for manned or manned-tended spacecraft. E.A.K.

N81-30973® National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
A PROGRAM-MANAGEMENT PLAN WITH CRITICAL-PATH DEFINITION FOR COMBUSTION AUGMENTATION WITH THERMIONIC ENERGY CONVERSION (CATEC)
(Contract EC-77-A-31-1062)
(NASA-TM-82670; E-950; DOE/NASA/1062-01) Avail. NTIS
HC A03/MF A01 CSCL 201
Thermionic energy conversion (TEC) is discussed. In recent TEC-topping analyses, overall plant efﬁciency (OPE) and cost of electricity (COE) improved slightly with current capabilities and substantially with fully matured technologies. Enhanced credibility derives from proven hot-corrosion protection for TEC by silicon-carbide clads in fossil fuel combustion products. Combustion augmentation with TEC (CATEC) affords minimal cost and plant perturbation, but with smaller OPE and COE improvements than more conventional topping applications. Risk minimization as well as comparative simplicity and convenience, favor CATEC for early market penetration. A program-management plan is proposed. Inputs, characteristics, outputs and capabilities are discussed.
S.F.

N81-32028® National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
HIGH B-FIELD, LARGE AREA RATIO MHD DUCT EXPERIMENTS
(Contract DE-AI01-77ET-10769)
(NASA-TM-82672; E-856; DGE/NASA/10769-10) Avail. NTIS
HC A02/MF A01 CSCL 201
Studies of the effect of area ratio variation on the performance of a supersonic Halk MHD duct were extended up to area ratios of 6.25/1.1. It is shown that for a given area ratio there is a combustion pressure above which the power generating region of the duct is shock free and the power output increases linearly.

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with the square of the magnetic field. Below this pressure a shock forms in the duct which moves upstream with increasing magnetic field strength and results in a 'less rapid rise in power output.'

AUTHOR


The considered investigation has the two objectives to assess the feasibility of operating a Brayton power-generating system at 1500 K and to explore the manner in which changing goals for the thermionic program may have resulted in the rise in specific mass that has been observed. Concerning the first objective, it is pointed out that to date no components have been built and evaluated for use in a Brayton space-power system at 1500 K. On the other hand, the principles in design were successfully demonstrated at 1150 K with materials appropriate to that temperature. Long time creep data for both the tantalum alloy ASTM-811 C and the molybdenum alloy TZM support the performance predictions made by Harper (1979) with respect to a Brayton system providing a specific mass value of 21 kg/kW at 1500 K. For the thermionic program, it is recommended to conduct an investigation of the original goals of high emitter temperature (1800-2000 K) and high power density.

G.R.


A method, based on full viscous calculations, is presented to predict performance of straight two dimensional diffusers. The method predicts adequately the experimental pressure recovery data, up to the point of maximum pressure recovery, for small and large inlet boundary layer thicknesses. It is shown that at the point of maximum pressure recovery the streamwise velocity in the very near wall region varies as z to the 0.22 power, where z is the distance from the diffuser wall.

AUTHOR


A computer code for performing parametric design point calculations and evaluating the rift design performance of magnetohydrodynamic generators was developed. Details of the computer code are presented. An assessment of the effect of preheat, stoichiometry, and oxygen enrichment on the design point electrical performance of the generator, and the NOs concentration at the exit of the radiative boiler are included. The off design study included variations in mass flow rate and oxygen enrichment. Maximum design point performance was achieved with a combination of high preheat, high stoichiometry, and no oxygen enrichment. The reduction in generator power was found to scale almost quadratically with the mass flow rate reduction. The power increased to a maximum level for off design operation at an oxygen enrichment value of 80 percent, then decreased with further increases in oxygen enrichment. The off design generator would not run at oxygen enrichment levels less than the 50 percent design level and simultaneously match the imposed thermal power input and downstream pressure constraints. S.F.


The important user experiments conducted during the four year period from 1986 to 1988 are summarized. A description of each of the satellites and a brief summary of each user experiment is presented. A cross index of user experiments sorted by various parameters and a listing of keywords versus experiment number is included. The experiments are grouped by type of service offered: for example, education, health services, and data transmission. A bibliography of reports by accession number and by author is also presented. User viewpoints of in-sat systems are presented.

AUTHOR


Data from sufficiently well-instrumented, short-duration experiments at AEDC/HPDE, Reynolds Metal Co., and Hercules, Inc., are compared to analyses with multidimensional and time-dependent simulations with the STD/MHD computer codes. These analyses reveal detail features of major transient events, severe loss mechanisms, and anomalous MHD behavior. In particular, these analyses predicted higher-than-design voltage drops, Hall voltage overshoots, and asymmetric voltage drops before the experimental data were available. The predictions obtained with these analyses are in excellent agreement with the experimental data and the failure predictions are consistent with the experiments. The design of large, high-interaction or advanced MHD experiments will require application of sophisticated, detailed and comprehensive computational procedures in order to account for the critical mechanisms which led to the observed behavior in these experiments.

(Author)


A fundamental instability in MHD channel flow, hitherto unknown or unappreciated, is described. Lorentz force-driven secondary flow cells preferentially couple core temperature gradient modes into the near field of the anode wall leading to a locally growing Lorentz force which eventually separates the anode boundary layer. The instability is described with both heuristic order-of-magnitude analyses and detailed three-dimensional, turbulent, MHD flow computations. This magnetoathermal instability will be manifested in commercial MHD generators of moderate MHD interaction parameter. Methods of control and prevention of the magnetoathermal instability exist.

(Author)

The present study analyzes the capability of a fluid model of electron transport to explain observed properties of the external plasma of a hollow cathode neutralizer used to neutralize beams emerging from ion thrusters. Calculations reported here show that when the effective collision frequency in such a model is near the plasma frequency, the resulting electric potential and electron temperature variations are in qualitative agreement with values measured in the plume mode of the hollow cathode. Both theory and experiment show strong variations of temperature and potential within a few centimeters of the cathode orifice. (Author)
SOLID-STATE PHYSICS
includes superconductivity
For related information, see also 33 Electronics and
Electrical Engineering and 36 Lasers and Masers.

A81-43004* 1-s diagram for gadolinium near the Curie
temperature. S. M. Benford and G. V. Brown (NASA, Lewis
Research Center, Cleveland, OH) (American Institute of Physics and
Institute of Electrical and Electronics Engineers, Annual Conference
on Magnets and Magnetic Materials, 26th, Dallas, TX, Nov. 11-14,
2110-2112. 9 refs.
The algebraic theory of thermodynamics developed in a previous paper is extended to include the algebraic structure that arises from the introduction of a physical body into the theory. The extension is based on very general definitions of both the thermodynamic states of a body and subsystems of that body. The algebraic analysis, which includes bodies in nonuniform states, shows that the set of all thermodynamic states of a body has the same algebraic structure as the set of thermodynamic states and that composite systems are induced by the algebraic structure of thermodynamic states. The analysis also justifies a variational treatment of thermodynamic bodies in uniform as well as nonuniform states. The variational calculation includes all conventional methods of calculation as special cases and helps to illuminate the origin and interpretation of the electrochemical potential. (Author)
DOCUMENTATION AND INFORMATION SCIENCE

Includes information storage and retrieval technology, micrography, and library science.

For computer documentation see 61 Computer Programming and Software.

BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1979
May 1980 378 p
(NASA-TM-81525; E-9449-4) Available NTIS HC A17/MF A01
CSCL 058

This compilation of over 1100 abstracts describes and indexes the technical reporting that resulted from the scientific and engineering work performed and managed by the Lewis Research Center in 1979. All the publications were announced in the 1979 issues of STAR (Scientific and Technical Aerospace Reports) and/or IAA (International Aerospace Abstracts). Research reports, journal articles, conference presentations, patents and patent applications, and theses are included. Subject, author, corporate source, contract number, and report number indexes are provided.

A.R.H.

BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1978
May 1979 367 p
(NASA-TM-79162; E-9449-3) Available NTIS HC A16/MF A01
CSCL 058

All the publications were announced in the 1978 issues of STAR (Scientific and Technical Aerospace Reports) and/or IAA (International Aerospace Abstracts). Included are research reports, journal articles, conference presentations, patents and patent applications, and theses.

T.M.

BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1980
May 1981 373 p
(NASA-TM-82661; E-9449-5) Available NTIS HC A16/MF A01
CSCL 058

This compilation of abstracts describes and indexes over 780 research reports, journal articles, conference presentations, patents and patent applications, and theses resulting from the scientific and engineering work performed and managed by the Lewis Research Center in 1980. All the publications were announced in Scientific and Technical Aerospace Reports and/or International Aerospace Abstracts.

A.R.H.

CONCEPTUAL DESIGN OF AN IN-SPACE CRYOGENIC FLUID MANAGEMENT FACILITY, EXECUTIVE SUMMARY
Final Report
36 p refs
(Contract NAS3-22280)
(NASA CR-165279; Exec-Summ, BAB ER 14967-Exec-Summ) Available NTIS HC A03/MF A01 CSCL 21H

The conceptual design of a Spacelab experiment to develop the technology associated with low gravity propellant management is summarized. The preliminary facility definition, conceptual design and design analysis, and facility development plan, including schedule and cost estimates for the facility, are presented J.D.H.
A broad range of agricultural, rural development, and other power applications in various regions of Morocco were examined to determine the potential market for photovoltaic products in Moroccan development. The primary focus of the study was the agriculture sector which accounts for approximately 17% of the country's GNP. The country has a clear need for reliable remote power systems, but does not have the financial resources to invest in the relatively high capital cost PV equipment. A modest potential for PV use was identified in nonagricultural rural services, such as refrigerators for rural clinics and rural radio-telephones. The main potential for PV in Morocco in the next five years lies mainly in the telecommunications sector. Applications include rural TV sets, TV repeater stations, microwave relay stations, and railroad, marine, and airline signaling. Market size estimates were derived from development and expansion plans. At an average customer cost for complete installed systems from $18/Wp to $30/Wp the total potential market value is estimated in the range of $6.5 to $11 million over the 1981-1986 period.

A R H
HIGH-POWER BASELINE AND MOTORING TEST RESULTS FOR THE GPU-3 STIRLING ENGINE Final Report
Test results are given for the full power range of the engine with both helium and hydrogen working fluids. Comparisons are made to previous testing using an alternator and resistance load bank to absorb the engine output. Indicated power results are presented as determined by several methods. Motoring tests were run to aid in determining engine mechanical losses. Comparisons are made between the results of motoring and energy-balance methods for finding mechanical losses.

Progress is reported in the following: Stirling reference engine system design, components and subsystems, F-40 baseline Stirling engine installation and test, the first automotive engine to be built on the program: computer development activities, and technical assistance to the Government. The overall program philosophy is outlined, and data and results are given.

COST/BENEFIT ANALYSIS OF ADVANCED MATERIALS TECHNOLOGY CANDIDATES FOR THE 1980'S, PART 2 Final Report
R E. Dennis and H F Maertins Aug. 1980 106 p refs (Contract NAS3-20073) (NASA CR-165176; AIRRESEARCH-21-3663-PT-2) Avail NTIS HC A06/MF A01 CSCL 05A
Cost/benefit analyses to evaluate advanced material technologies projects considered for general aviation and turboprop commuter aircraft through estimated life-cycle costs, direct operating costs, and development costs are discussed. Specifically addressed is the selection of technologies to be evaluated, development of property goals, assessment of candidate technologies on typical engines and aircraft, sensitivity analysis of the changes in property goals on performance and economics, cost, and risk analysis for each technology, and ranking of each technology by relative value. The cost/benefit analysis was applied to a domestic, nonrevenue producing, business-type jet aircraft configured with two TFE731-3 turbofan engines, and to a domestic, nonrevenue producing, business type turboprop aircraft configured with two TPE331-10 turboprop engines. In addition, a cost/benefit analysis was applied to a commercial turboprop aircraft configured with a growth version of the TPE331-10.
A METHODOLOGY FOR FOSTERING COMMERCIALIZATION OF ELECTRIC AND HYBRID VEHICLE PROPULSION SYSTEMS


The rationale behind, and a proposed approach for, application of government assistance to accelerate the process of moving a new electric vehicle propulsion system product from technologically readiness to profitable marketplace acceptance and utilization are described. Emphasis is on strategy, applicable incentives, and an implementation process.

SYSTEM SAFETY IN STIRLING ENGINE DEVELOPMENT

The DOE/NASA Stirling Engine Project Office has required that contractors make safety considerations an integral part of all phases of the Stirling engine development program. As an integral part of each engine design subtask, analyses are evolved to determine possible modes of failure. The accepted system safety analysis techniques (Fault Tree, FMEA, Hazards Analysis, etc.) are applied in various degrees of extent at the system, subsystem and component levels. The primary objectives are to identify critical failure areas, to enable removal of susceptibility to those failures or their effects from the system and to minimize risk.

EFFECT OF VOLTAGE ON THE COST OF AN ELECTRIC VEHICLE PROPULSION SYSTEM

The life cycle cost and the purchase price of simple dc and ac propulsion systems are estimated as a function of battery voltage from 50 to 500 V. The results show a slight preference for a battery pack voltage of approximately 100 V. Three propulsion systems are examined: one has a series motor with a chopper controller, another an induction motor with an inverter controller, and the third a shunt motor using stepped-voltage control below base speed and field control above base speed. Motor power rating is assumed to be 20 kW continuous duty. The cost and the specific energy of a 24 kW-hr battery pack are estimated from 50 to 800 V by a battery manufacturer. The impact of system voltage variation on the efficiency, weight, and cost of the other electrical components is estimated from basic electrical considerations and informal discussions with manufacturers.

VEHICLE TESTING OF CUMMINS TURBOCOMPOUND DIESEL ENGINE Final Report

Two turbocompound diesel engines were installed in Class VII heavy-duty vehicles to determine the fuel consumption potential and performance characteristics. One turbocompound powered vehicle was evaluated at the Cummins Pilot Center where driveability, fuel consumption, and emission studies for each were evaluated. Fuel consumption testing showed a 14.8% benefit for the turbocompound engine in comparison to a production NTC-400 used as a baseline. The turbocompound engines also achieved lower noise levels, improved driveability, improved gradeability, and marginally superior engine retardation. The second turbocompound engine was placed in commercial service and accumulated 50,000 miles on a cross-country route without malfunction. Tank mileage showed a 15.92% improvement over a production NTCC-400 which was operating on the same route.

ADVANCED PROPULSION SYSTEM CONCEPT FOR HYBRID VEHICLES

A series hybrid system utilizing a free piston Stirling engine with a linear alternator, and a parallel hybrid system, incorporating a kinematic Stirling engine, are analyzed for various specified reference missions/vehicles ranging from a small two passenger commuter vehicle to a van. Parametric studies for each configuration, detail tradeoff studies to determine engine, battery and system definition, short term energy storage evaluation, and detail life cycle cost studies were performed. Results indicate that the selection of a parallel Stirling engine/electric, hybrid propulsion system can significantly reduce petroleum consumption by 70 percent over present conventional vehicles.

ANALYTICAL DESIGN OF AN ADVANCED RADIAL TURBINE Final Report, 1 Feb. 1979 - 1 Aug. 1980

The aerodynamic and mechanical potential of a single stage ceramic radial inflow turbine was evaluated for a high temperature single stage automotive engine. The aerodynamic analysis utilizes a turbine system optimization technique to evaluate both radial and nonradial rotor blading. Selected turbine rotor configurations were evaluated mechanically with three dimensional finite element techniques. Results indicate that exceptionally high rotor tip speeds (2300 ft/sec) and performance potential are feasible with radial bladed rotors if the projected ceramic material properties are realized. Nonradial rotors reduced tip speed requirements (at constant turbine efficiency) but resulted in a lower cumulative probability of success due to higher blade and disk stresses.

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The DOE/NASA Ceramic Regenerator Design and Reliability Program aims to develop ceramic regenerator cores that can be used in passenger car and industrial/truck gas turbine engines. The major cause of failure of early gas turbine regenerators was found to be chemical attack of the ceramic material. Improved materials and design concepts aimed at reducing or eliminating chemical attack were placed on durability test in Ford 707 industrial gas turbine engines late in 1974. Results of 53,085 hours of turbine engine durability testing are described. Two materials, aluminum silicate and magnesium aluminum silicate, show promise. Five aluminum silicate cores attained the durability objective of 10,000 hours at 800°C (1472°F). Another aluminum silicate core shows minimal evidence of chemical attack after 8071 hours at 982°C (1800°F). Results obtained in ceramic material screening tests, aerothermodynamic performance tests, stress analysis, cost studies, and material specifications are included.
National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

IMPACT FOR THE 80'S: PROCEEDINGS OF A CONFERENCE ON SELECTED TECHNOLOGY FOR BUSINESS AND INDUSTRY
Nov. 1980 238 p. Conf. held in Cleveland, 14-15 May 1980
NACA-CP-2149. E-489. Avis. NTIS HC A11/MF A01 CSCL 05A

Various aspects of advanced energy technology are discussed. Specific emphasis is given to aircraft propulsion, wind power commercialization, materials and structures, lubrication and bearings, Stirling and gas turbine engines, and electric and hybrid vehicles. For individual titles, see N81-12979 through N81-12991.

N81-12979# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ENERGY OVERVIEW
Henry O. Stone In its Impact for the 80's. Proc. of a Conf. on Selected Technol. for Business and Ind. Nov. 1980 p 1-9
(For primary document see N81-12978 03-99)
Avis. NTIS HC A11/MF A01 CSCL 10A

The experience, capabilities, and facilities being utilized at NASA Lewis in support of energy programs conducted by the Department of Energy and other agencies are discussed. Background information is given regarding NASA's involvement in solving energy problems. R.C.T.

N81-12980# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

NASA RESEARCH IN AEROPROPULSION
Warner L Stewart In its Impact for the 80's. Proc. of a Conf. on Selected Technol. for Business and Ind. Nov. 1980 p 11-26
(For primary document see N81-12978 03-99)
Avis. NTIS HC A11/MF A01 CSCL 21E

The role of Lewis Research Center in aeronautical propulsion is described. The state of the art in engine systems and components are discussed and some of the problems that confront the civil and military aeronautical sectors are addressed. Some of the programs that are under way are summarized with emphasis on the future needs and opportunities in aeronautics. R.C.T.

N81-12981# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

LARGE WIND TURBINES: A UTILITY OPTION FOR THE GENERATION OF ELECTRICITY
Avis. NTIS HC A11/MF A01 CSCL 10B

The economic and technical potential of wind energy in the United States is discussed. Particular attention is given to the status of wind turbine operational experience as well as the environmental posture of the technology. R.C.T.

N81-12982# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PROGRESS IN MATERIALS AND STRUCTURES AT LEWIS RESEARCH CENTER
Thomas K. Glasgow, Richard W. Lauver, Gary R. Halford, and Robert L. Davies In its Impact for the 80's. Proc. of a Conf on Selected Technol. for Business and Ind. Nov. 1980 p 43-64 refs (For primary document see N81-12978 03-99)
Avis. NTIS HC A11/MF A01 CSCL 11G

The development of power and propulsion system technology is discussed. Specific emphasis is placed on the following: high temperature materials; composite materials; advanced design and life prediction; and nondestructive evaluation. Future areas of research are also discussed. R.C.T.

N81-12983# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

THIN-FILM COATINGS
Donald H. Buckley In its Impact for the 80's. Proc. of a Conf. on Selected Technol. for Business and Ind. Nov. 1980 p 65-74
(For primary document see N81-12978 03-99)
Avis. NTIS HC A11/MF A01 CSCL 11F

Thin-adherent, high density films are discussed with respect to their application in two plasma physics techniques (ion plating and sputtering). The operation of each technique is described as well as what surfaces can be coated, and what kind of materials can be applied. The effects of these films on the mechanical properties of solid surfaces are also discussed. R.C.T.

N81-12984# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

SELF-LUBRICATING COMPOSITE MATERIALS
Harold E. Sliney In its Impact for the 80's. Proc. of a Conf. on Selected Technol. for Business and Ind. Nov. 1980 p 75-95
(For primary document see N81-12978 03-99)
Avis. NTIS HC A11/MF A01 CSCL 11D

The mechanical properties of two types of self lubricating composites (polymer matrix composites and inorganic composites) are discussed. Specific emphasis is given to the applicability of these composites in the aerospace industry. R.C.T.

N81-12985# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PROPULSION SYSTEM RESEARCH AND DEVELOPMENT FOR ELECTRIC AND HYBRID VEHICLES
Harvey J. Schwartz In its Impact for the 80's. Proc. of a Conf on Selected Technol. for Business and Ind. Nov. 1980 p 97-103 (For primary document see N81-12978 03-99)
Avis. NTIS HC A11/MF A01 CSCL 13F

An approach to propulsion subsystem technology is presented. Various tests of component reliability are described to aid in the production of better quality vehicles. Component characterization work is described to provide engineering data to manufacturers on component performance and on important component propulsion system interactions. R.C.T.

N81-12986# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

THE FEDERAL ELECTRIC AND HYBRID VEHICLE PROGRAM
Harvey J. Schwartz In its Impact for the 80's. Proc. of a Conf on Selected Technol. for Business and Ind. Nov. 1980 p 105-109 (For primary document see N81-12978 03-99)
Avis. NTIS HC A11/MF A01 CSCL 13F

The commercial development and use of electric and hybrid vehicles is discussed with respect to its propagation as a possible alternative transportation system. A market demonstration is described that seeks to place 10,000 electric hybrid vehicles into public and private sector demonstrations. R.C.T.
Avail NTIS HC A11/MF A01 CSCL 13F

Efforts to achieve a 100 mile urban range, to reduce petroleum usage 40% to 70%, and to commercialize battery technology are discussed with emphasis on an all plastic body, four passenger car that is flywheel assisted and battery powered, and on an all metal body, four passenger car with front wheel drive and front motor. For the near term case, a parallel hybrid in which the electric motor and the internal combustion engine may directly power the drive wheels, is preferred to a series design. A five passenger car in which the electric motor and the gasoline engine both feed into the same transmission is discussed. Upgraded demonstration vehicles were tested using advanced lead acid, nickel zinc, nickel iron, and zinc chloride batteries to determine maximum acceleration, constant speed, and battery behavior. The near term batteries demonstrated significant improvement relative to current lead acid batteries. The increase in range was due to improved energy density, and amperage hour capacity, with relatively small weight and volume differences. A.R.H.

Avail NTIS HC A11/MF A01 CSCL 10A

As part of the National Solar Energy program, the U.S. Department of Energy is now engaged in the development of technically feasible, low cost candidate component and system technologies to the point where technical readiness can be demonstrated by 1982. The overall strategy is to pursue parallel options that continue to show promise of meeting the program goals, thus increasing the probability that at least one technology will be successful. Included in technology development are both flat plate solar collectors and concentrator solar collectors, as well as the balance of system components such as structures, power conditioning, power controls, protection, and storage. Generally, these last items are common to both flat plate and concentrator systems, but otherwise there is considerable disparity in design philosophy, photovoltaic cell requirements, and possible applications between the two systems. Objectives for research activities at NASA Lewis for stand alone applications, and at Sandia Laboratories where intermediate load center applications are addressed, are highlighted as well as college projects directed by Oak Ridge National Laboratory, and international applications managed by the Solar Energy Research Institute Joint DOD/DOE effects for military applications are also summarized. A.R.H.
AIRCRAFT CONSTRUCTION MATERIALS
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