NOTICE

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BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1978

Lewis Research Center
Cleveland, Ohio 44135
May 1979
PREFACE

In 1978, the Lewis publications output was 213 research reports and 243 journal articles and conference presentations. The number of conference presentations (199) that were given at seminars and society symposiums was the highest in the Center's history. The production of 267 contractor reports increased 16 percent over that of 1977. In addition, 50 patent applications were filed and 35 patents issued.

In 1977, the Lewis Director initiated the Annual Award for Best Lewis Publication. The purpose of the award is to encourage and reward outstanding research and technology contributions by Lewis staff members. The criteria for selection are quality and innovativeness, potential impact on the research and technology field, and the excellence of the presentation. The publication date must be between July 1 of the preceding year and June 30 of the award year. The winning publication is selected by the Lewis Research Advisory Board. The award is a framed certificate and $1000.

In 1977, the first year of the award, the Best Lewis Publication was "Isothermal Elastohydrodynamic Lubrication Point Contacts, Parts III and IV" by Bernard J. Hamrock and Duncan Dowson (TN's D-8317 and D-8318). They are described in Abstracts N77-11400 (p. 111) and N76-35509 (p. 89) of the "Bibliography of Lewis Research Center Publications Announced in 1977" and the "Bibliography of Lewis Research Center Publications Announced in 1976," respectively.

In 1978, the Annual Award for Best Lewis Publication was presented for the following two papers: "Unsteady Flow in a Supersonic Cascade with Strong In-Passage Shocks" by Marvin E. Goldstein, Willis Braun, and J. J. Adamczyk, which is described in Abstract A78-17270 (p. 6) and "Models for Some Aspects of Atmospheric Vortices" by Robert G. Deissler, which is described in Abstract A78-14581 (p. 150).

All the publications in this collection were announced in the 1978 issues of STAR (Scientific and Technical Aerospace Reports) and/or 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.
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01 AERONAUTICS (GENERAL)

N78-28049# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

INTERACTION OF A TURBULENT-JET NOISE SOURCE WITH TRANSVERSE MODES IN A RECTANGULAR DUCT
refs. (NASA TP-1248, E 9462) Aval NTIS HC A03/ MF A01 CSLC 20A

A turbulent jet was used to excite transverse acoustic modes in a rectangular duct. The pressure spectrum showed asymmetric singularities (pressure spikes) at the resonant frequencies of the duct modes. This validates previously published theoretical results. These pressure spikes occurred over a range of jet operation conditions and at the frequency of the spike. The measured transverse pressure shape matched the resonant mode shape. Author

N78-27048# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

ACE PROPULSION OVERVIEW
c07
Donald L. Birell in NASA. Langley Res Center CTOL Transport Technol. 1978 Jun 1978 p 9-23 refs (For primary document see N78-27048 18-01) Aval NTIS HC A22/ MF A01 CSLC 21E

Technology for fuel efficient subsonic CTOL transport aircraft is discussed in the energy efficient engine project. The advanced turboprop projects are included. The overall goals and objectives of each project are reviewed and the approach and schedule for accomplishing these projects are given. J.M.S.

N78-27056# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

STATUS OF ADVANCED TURBOPROP TECHNOLOGY
c07
J F Dugan, B A Miller and D A Sagerseer In NASA. Langley Res Center CTOL Transport Technol. 1978 Jun 1978 p 139-186 refs (For primary document see N78-27046 18-01) Aval NTIS HC A22/ MF A01 CSLC 21E

Research is reviewed in the following areas: turboprop powered transport aircraft, wind tunnel aerodynamic and acoustic tests of subsonic transports, turboprop maintenance, and wind tunnel tests on airframe turboprop-aircraft interactions. Continued development of the technology for advanced turboprop transport was emphasized. J.M.S.

N78-27056# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

PROPULSION SYSTEMS NOISE TECHNOLOGY
c07
C E Feler In NASA. Langley Res Center CTOL Transport Technol. 1978 Jun 1978 p 167-185. refs (For primary document see N78-27046 18-01) Aval NTIS HC A22/ MF A01 CSLC 21F

Turborfan engine noise research relevant to conventional aircraft is discussed. Criteria for Fan noise were presented for two different ways of simulating flight behavior. Experimental results from a swept rotor fan design are presented which show that the concept has potential for reducing the jet noise. The results are also compared to shock waves in a fan operating at supersonic tip speeds. Acoustic suppressor research objectives centered around the effect of noise systems generated by the fan stage that is the input to the treatment. A simplifying and unifying parameter, cyle cutoff ratio was described. Results are presented which show that suppressor performance may be improved if the input waves are more precisely described. J.M.S.

N78-27067# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

ADVANCED MATERIALS RESEARCH FOR LONG-HAUL AIRCRAFT TURBINE ENGINES
c07

The status of research efforts to apply low to intermediate temperature composite materials and advanced high temperature materials to engine components is reviewed. Existing materials technologies and potential benefits to aircraft gas turbines were emphasized. The problems were identified, and the general state of the technology for near-term use was assessed. J.M.S.

N78-27068# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

GAS TURBINE ENGINE EMISSION REDUCTION TECHNOLOGY PROGRAM
c07
Donald A Petrasch and Larry A Dahl In NASA. Langley Res Center CTOL Transport Technol. 1978 Jun 1978 p 205-216 (For primary document see N78-27046 18-01) Aval NTIS HC A22/ MF A01 CSLC 21E

Progress in the development of combustor technology to meet the standards for allowable pollutant emission levels of aircraft gas turbine engines is reported. The high-bypass ratio turbofan engines which power the large commercial aircraft were emphasized along with efforts to reduce emission for near-term application. Recommendations for continuing research to reduce emissions to meet short-term needs are given. J.M.S.

N78-15987# Nielsen Engineering and Research, Inc., Mountain View, Calif

PERTURBATION SOLUTIONS FOR TRANSONIC FLOW ON THE BLADE-TO-BLADE SURFACE OF A COMBUSTOR BLADE ROWS Final Report
Stephen S Stahara, Denny S Chaussee and John R Spritere Jan 1978 71 p refs (Contract NAS3-19738)
NASA CR-2941 Aval NTIS HC A04/ MF A01 CSLC 21E

A preliminary investigation was conducted to establish the theoretical basis of perturbation techniques with the objective of minimizing computational requirements associated with parametric studies of transonic flows in turbomachinery. The theoretical analysis involved the development of perturbation methods for determining first order changes in the flow solution due to variations of one or more geometrical or flow parameters. The formulation is primarily directed toward transonic flows on the blade to blade surface of a single blade row compressor. Two different perturbation approachs were identified and studied. Applications and results of these methods for various perturbations are presented for selected two dimensional transonic cascades flows to illustrate the advantages and disadvantages of each technique. Additionally, it was found that for flows with shock waves over account of shock displacement was crucial. Author.

J.M.S.
A compilation of all the detailed acoustic and aerodynamic data covering static aero-acoustic tests of duct-burning turbofan exhaust nozzle configurations is presented. The basic model scale acoustic and aerodynamic data are presented and discussed. The detailed test data are shown for various sideline distances.

Author
02 AERODYNAMICS

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

For related information see also J4 Fluid Mechanics and Heat Transfer.

N78-10003**/ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ATMOSPHERIC EFFECTS ON INLETS FOR SUPERSONIC CRUISE AIRCRAFT

Mixed-compression inlet dynamic behavior in the vicinity of unstalled was simulated and analyzed to investigate the time response of an inlet's normal shock to independent disturbances—ambient temperature and pressure and relative velocity (longitudinal gust). with and without inlet controls active. The results indicate that atmospheric disturbances may be more important than internal disturbances in setting inlet control requirements because they are usually not anticipated and because normal shock response to rapid atmospheric disturbances is not attenuated by the inlet, as it is for engine induced disturbances. However, before inlet control requirements can be fully assessed, more statistics on extreme atmospheric disturbances are needed. Author

N78-10002**/ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EXPERIMENTAL PERFORMANCE OF A 13 DS-
CENTIMETER-TIP-DIAMETER TANDEM-BLADED SWEEP-
BACK CENTRIFUGAL COMPRESSOR DESIGNED FOR A
PRESSURE RATIO OF 6
Hugh A. Klassen, Jerry R. Wood (Army Air Mobility Res. and Develop. Lab., Cleveland), and Lawrence F. Schuman (Army Air Mobility Res. and Develop. Lab., Cleveland) Nov 77 27 p. refs. (NASA-TP-1091) Avail. NTIS: HC A05/MF A01 C5CL 01A

A 13.65 cm tip diameter backswept centrifugal impeller having a tandem inducer and a design mass flow rate of 0.907 kg/sec was experimentally investigated to establish stage and impeller characteristics. Tests were conducted with both a cascade diffuser and a vaneless diffuser. A pressure ratio of 5.9 was obtained near surge for the smallest clearance tested. Flow range at design speed was 6.3 percent for the smallest clearance test. Impeller exit to shroud axial clearance at design speed was varied to determine the effect on stage and impeller performance. Author

N78-11006**/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECT OF COOLANT FLOW EJECTION ON AERODYNAMIC PERFORMANCE OF LOW-ASPECT-RATIO VANES 2: PERFORMANCE WITH COOLANT FLOW EJECTION AT TEMPERATURE RATIOS UP TO 2.5

The aerodynamic performance of a 0.5 aspect ratio turbine vane configuration with coolant flow ejection was experimentally determined in a full annular cascade. The vanes were tested at nominal mass flow a critical velocity ratio of 0.850 over a range of primary to coolant total temperature ratio from 1.0 to 2.0 and a range of coolant to primary total pressure ratio from 1.0 to 1.4 which corresponded to coolant flows from 3.0 to 10.7 percent of the primary flow. The variations in primary and thermodynamic efficiency and exit flow conditions with circumferential and radial position were obtained. Author

N78-14990**/ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

COLD-AIR PERFORMANCE OF A TIP TURBINE DESIGNED TO DRIVE A LIFT FAN

Performance was obtained over a range of speeds and pressure ratios for a 0.4 linear scale version of the LF460 lift fan turbine with the rotor radial tip clearance reduced to about 2.5 percent of the rotor blade height. These tests covered a range of speeds from 80 to 140 percent of design equivalent speed and a range of scroll inlet total to diffuser exit static pressure ratios from 2.6 to 4.2. Results are presented in terms of equivalent mass flow, equivalent torque, equivalent specific work, and efficiency. Author

N78-18001**/ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

COLD-AIR PERFORMANCE OF A TIP TURBINE DESIGNED TO DRIVE A LIFT FAN 3: EFFECT OF SIMULATED FAN LEAKAGE ON TURBINE PERFORMANCE

Performance data were obtained experimentally for a 0.4 linear scale version of the LF460 lift fan turbine for a range of scroll inlet total to diffuser exit static pressure ratios at design equivalent speed with simulated fan leakage air. Tests were conducted for full and partial admission operation with three separate combinations of rotor inlet and rotor exit leakage air. Data were compared to the results obtained from previous investigations in which no leakage air was present. Results are presented in terms of mass flow, torque, and efficiency. Author

N78-17001**/ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SYNTHESIS OF BLADE FLUTTER VIBRATORY PATTERNS USING STATIONARY TRANSUDERS

Flutter frequency was determined and rotor vibratory amplitude and phase distributions during flutter were reconstructed from stationary aerodynamic type measurements. A previously reported optical method for measuring blade-tip displacement during flutter was extended by means of digital analysis. Displacement amplitudes and phase angles were determined based on this method. For selected blades, spectral results were also obtained from strain gage measurements. The results from these three types of measurement were compared and critically evaluated. Author

N78-17990**/ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF DESIGN CHANGES ON AERODYNAMIC AND ACOUSTIC PERFORMANCE OF TRANSLATING- CENTERBODY SONIC INLETS
Brent A. Muller Feb 1978 49 p. refs. (NASA-TP-1132; E-9283) Avail. NTIS: HC A03/MF A01 C5CL 01A

An experimental investigation was conducted to determine the effect of design changes on the aerodynamic and acoustic performance of translating centerbody sonic inlets. Scale model inlets were tested in the Lewis Research Center’s V/STOL wind tunnel. The effects of centerbody position, entry lip contraction ratio, diffuser length, and diffuser area on inlet total pressure recovery, distortion, and noise investigation at static conditions and at forward velocity and angle of attack. With the centerbody in the takeoff position (retracted), good aerodynamic and acoustic performance was attained at static
and four engine configurations were investigated. Powered engine simulators were used to properly represent nozzle flow. Large differences in cruise drag penalties associated with the various nozzle designs were seen. Some geometric parameters influencing nozzle cruise drag are identified.

Author

N78-24063* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ANALYTICAL MODELING OF UNDER-THE-WING EXTERNALLY BLOWN FLAP POWERED-LIFT NOISE
Daniel J. McKenzie, Jr. In NASA: Langley Res Center:
Powered-Lift Aerodynamics 1976 p 263-282 refs
(for availability see N78-24046 15-02)
Avail NTIS HC A22/MF A01 CScL 01A

The sound field produced by the interaction of a subsonic jet with a large scale model of the under the wing externally blown flap in an approach attitude was analyzed. The analysis was performed to obtain a better understanding of the dominant noise sources and the mechanisms associated with pressure level frequency of the broad-band spectra. An analytical expression is derived which incorporates two available theories and experimental data: the expression predicts the sound field along a circular arc of approximately 120 degree measured from the upstream jet axis in the fly-over plane. The analysis compares favorably with test results obtained from two large-scale models, one using cold air from a conical nozzle and the other using hot gas from a TF-34 turbine engine having a conical exhaust nozzle with a 12 lobe internal forced mixer. The frequency at which the peak sound pressure level occurs appears to be governed by a phenomenon which produces periodic formation and shedding of large-scale turbulence structures from the nozzle lip.

Author

N78-24068* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

OVERVIEW OF THE OCSEE PROGRAM
Carl C. Ciepluch In NASA: Langley res Center: Powered Lift
Aerodynamics and Acoustics 1976 p 325-333 refs
(for availability see N78 24046 15-02)
Avail NTIS HC A22/MF A01 CScL 01A

Externally blown flap and upper surface blown flap powered lift concepts were investigated in the Quiet Clean Short-Haul Experimental Engine Program and briefly discussed along with propulsion system requirements. Noise limits, emission standards, thrust requirements, and thrust-to-weight ratios are among the factors considered.

J.M.S.

N78-24057* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ACOUSTIC DESIGN OF THE OCSEE PROPULSION SYSTEMS
Irvin J. Loeffler, Edward B. Smith (GE Co., Fairfield, Conn.)
(for availability see N78 24046 15-02)
Avail NTIS HC A22/MF A01 CScL 01A

Acoustic design features and technologies employed in the Quiet Clean Short-Haul Experimental Engine (OCSEE) Program are described. The role of jet/flare noise in selecting the engine fan pressure ratio for powered lift propulsion systems is discussed. The OCSEE acoustic design features include a hybrid inlet (near-sonic throat velocity with acoustic treatment); low fan and core pressure ratios; low fan tip speeds; gear-driven fans, high and low frequency stacked core noise treatment; multiple-thickness treatment, bulk absorber treatment, and treatment on the static vanes. The OCSEE designs represent and anticipated acoustic technology improvement of 12 to 16 PNdB relative to the noise levels of the low-noise engines used on current wide-body commercial jet transport aircraft.

Author

N78-19907* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PERFORMANCE CHARACTERISTICS OF TWO ANNUULAR DUMP DIFFUSERS USING STABILIZED VORTICE FLOW CONTROL
A. J. Juhaz and J. M. Smith 1978 14 p refs
In ENGLISH:
A. J. Juhaz and J. M. Smith 1978 14 p refs
Proposed for Presentation at the Joint Symp.
A. J. Juhaz and J. M. Smith 1978 14 p refs
Design and Operation of Fluid Machinery. Fort Collins, Colo.
A. J. Juhaz and J. M. Smith 1978 14 p refs
(NASA-TM-73857) Avail: NTIS HC A02/MF A01 CScL 01A
A. J. Juhaz and J. M. Smith 1978 14 p refs

Test results are described for two annular area change annular diffusers with provisions for maintaining suction stabilized toroidal vortices at the area discontinuity. Both diffusers had an overall area ratio of 4.0 with the diffusor area ratio being 1.18 for diffuser A and 1.4 for diffuser B. Performance was evaluated at near atmospheric pressure and temperature for a range of inlet Mach numbers from 0.18 to 0.41 and suction rates from 0 to 18%. Static pressure recovery improved significantly as the suction rate was increased to approximately 11%. Results obtained with diffuser A were superior to that obtained with diffuser B. Flat radial profiles of exit velocity were not obtained since the flow showed preferential hub or lip attachment at moderate suction rates. At high suction rates the diffuser exit flow became circumferentially nonuniform and unstable.

Author

N78-20080* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF COOLING-HOLE GEOMETRY ON AERODYNAMIC PERFORMANCE OF A FILM-COOLED TURBINE VANE TESTED WITH COLD AIR IN A TWO-DIMENSIONAL CASCADE
49 p refs
NASA-TP-1136: E-9174 Avail: NTIS HC A03/MF A01 CScL 01A

The effect of the orientation and cooling-hole size on turbine-vane aerodynamic losses was evaluated. The contribution of individual vane regions to the overall effect was also investigated. Test configurations were based upon a representative configuration having 45 spanwise rows of holes spaced about the entire vane profile. Nominal hole diameters of 0.0254 and 0.0356 cm and nominal hole orientations of 35 deg, 45 deg, and 55 deg from the local vane surface and 0 deg, 45 deg, and 90 deg from the mainstream flow direction were investigated. Flow conditions and aerodynamic losses were determined by vane exit surveys of total pressure, static pressure, and flow angle.

Author

N78-24058* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF NOZZLE DESIGN AND POWER ON CRUISE DRAG FOR UPPER SURFACE BLOWING AIRCRAFT
(for availability see N78 24046 15-02)
Avail NTIS HC A22/MF A01 CScL 01A

A high speed wind tunnel investigation was conducted on a series of upper surface blowing nozzles with 0-shaped exits installed on a representative short haul aircraft model. Both two
INLET TECHNOLOGY FOR POWERED-LIFT AIRCRAFT
Roger W. Coles, Jr. NASA Lewis Research Center, Cleveland, Ohio
A concept of powering a lift fan using the air entering the fan and core compressor from the rear of the engine. The direction of fan blade pitch rotation for best reverse-thrust aerodynamic performance, and engine response and operating characteristics during forward-to-reverse thrust transitions are among the factors studied. The test results of several scale fan models as well as a full-size variable pitch fan engine are summarized. Results show that the following three bladed reverse-thrust nozzle makes a good reverse-thrust inlet acceptable core inlet duct recovery and distortion levels in reverse flow were demonstrated. Adequate thrust levels were achieved, forward to reverse-thrust response time achieved was better than the goal. Thrust and noise levels strongly favor reverse through feather pitch, and finally, light-type inlets make the establishment of reverse flow more difficult.

COLD-AIR PERFORMANCE OF THE COMPRESSOR-DRIVE TURBINE OF THE DEPARTMENT OF ENERGY BASELINE AUTOMOBILE GAS TURBINE ENGINE
Richard J. Rooske and Kerry L. McAllin
The aerodynamic performance of the compressor-drive turbine of the DOE baseline gas-turbine engine was determined over a range of pressure ratios and speeds. In addition, static pressures were measured in the diffusing transition duct located immediately downstream of the turbine. Results are presented in terms of mass flow, torque, specific work, and efficiency for the turbine and in terms of pressure recovery and effectiveness for the transition duct.
additional operating range, analysis of the data indicates that the flow around the
hub appears to be critical and limits the stable operating range of this stage. For all levels of tip and
hub radial distortion, there was a large reduction in the rotor
stall margin. &

A78-12289 * Calculation of 3-dimensional choking mass
flow in turbomachinery with 2-dimensional flow models. T. Katsumi
NASA, Lewis Research Center, Cleveland, Ohio: Transonic flow
problems in turbomachinery. Proceedings of the Workshop, Montery, Calif., February 11-12, 1976. (A78-12286 02-02) Wash-
ington, D.C., Hemisphere Publishing Corp., 1977, p. 60-67. Dis-
cussion, p. 67-69.

An approach is considered for obtaining an approximate flow
solution in a case of a cross-sectional flow surface within a guided
channel, taking into account a part of turbulent boundary layer
with three-dimensional orthogonal surfaces across the flow passage.
In the calculation of the mass flow across the throat in the case of a 2-D
passage with circular walls, and the determination of the choking
mass flow. It is pointed out that the choking solution for a three-
dimensional guided passage in a blade row can be obtained in a very
similar manner by satisfying momentum equations for the blade-to-
blade and the hub-to-hub direction. A modified example involves
the calculation of the choking mass flow for a centrifugal compressor
impeller in an automotive application.

A78-12312 * Review of experimental work on transonic
flow in turbomachinery. W. D. McCaffery, NASA, Lewis Research
Center, Cleveland, Ohio: Transonic flow problems in turbomach-
inery. Proceedings of the Workshop, Montery, Calif., February 11-12, 1976. (A78-12286 02-02) Washing-

The review is primarily concerned with modern experimental
techniques of high pressure and laser-supported instrumentation.
The presented techniques make it possible to obtain detailed data of
shear layer and stagnation pressure occurring inside transonic blade rows,
and in the vicinity of the rows. Such data are essential for the verifica-
tion of theories to be used for the study of the operational
dependence of the compressor, Attention is given to U-shaped
scheme transducers, pitot probes, but there are also laser Doppler
velocimeter systems, laser fluorescence, and laser holography.

A78-17270 * Unsteady flow in a supersonic cascade with
strong leading-edge shocks. M. E. Goldstein, W. Braun, and J. J.
Adamszky (NASA, Lewis Research Center, Cleveland, Ohio). Journal

Linearized theory is used to study the unsteady flow in a supersonic cascade with
leading-edge shock waves. We use the Wiener-Hopf technique to obtain a closed-form analytical solution for the
supersonic region. To obtain a solution for the rotational flow in the
subsonic region we must solve an infinite set of linear algebraic
equations. The analysis shows that it is possible to correlate quantitatively the oscillatory shock motion with the Kutta condition
at the trailing edges of the blades. This feature allows us to account
for the effect of shock motion on the stability of the cascade. Unlike
the theory for a completely supersonic flow, the present study
predicts the occurrence of supersonic leading-edge flutter. It therefore
provides a possible explanation for the bending flutter that has
recently been detected in aircraft-engine compressors at higher blade
loadings.

A78-20701 * Development and test of an inlet and duct to
provide airflow for a wing boundary-layer control system. D. W.
Gunnerson (Boeing Commercial Airplane Co., Seattle, Wash.) and J.
C. McAdie (NASA, Lewis Research Center, Cleveland, Ohio). American Institute of Aeronautics and Astronautics, Aeronautical
Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper
78-147, 9 p., NASA-sponsored research.

The boundary layer control system (BLCS) of the quiet short-
haul research aircraft (QSRRA) requires significant amounts of
pressurized airflow for successful operation. An inlet and duct were
successfully designed which removed airflow from the engine fan
duct for the BLCS system at or above the required total pressure
of 99% of the average fan duct total pressure. The design was
constrained by the tight space limitations of the QSRRA nacelle. Potential flow with boundary layer analysis techniques were
used in an effort to select the inlet and duct geometries. Airflow and total
pressure profile data were obtained during development tests.

A78-20702 * A combined potential and viscous flow solu-
tion for V/STOL engine inlets. A. H. Ybarra, W. H. Rhoads (Wright
Corp., Dallas, Tex.), and N. D. Stackmon (NASA, Lewis Research
Center, Cleveland, Ohio). American Institute of Aeronautics and
Astronautics, Aeronautical Sciences Meeting, 16th, Huntsville, Ala.,

A potential flow routine and a viscous boundary layer routine have been combined into a single routine for simulating the flow in
and around supersonic inlets. In this combined routine, the viscous
flow solution about the inlet body is obtained by adding the viscous
displacement thickness to the inlet geometry. Combination of the
two flow solutions has resulted in cost savings, both in precalcula-
tion time and in computer time. This routine is especially useful in
comparing inlet shapes for V/STOL inlets. The method of combining the routines,
comparing with NASA test data and utilization of the routine for
V/STOL inlet design are presented.

A78-41843 * A viscous-inviscid interactive compressive
solution. D. A. Johnston (Cornell Aeronautical Laboratory, Cleveland, Gland) and P. M. Soder (NASA, Lewis Research Center,
Cleveland, Ohio). Annual Report of Institute of Aeronautics and
Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle,
Wash., July 11-12, 1978, Paper 78-1140. 10 p., 24 refs. NASA
sponsored research.

A viscous-inviscid interactive procedure for simulating flow is
developed and applied in an axial compressor. Calculations were
performed on a 2-dimensional blade-to-blade section of constant
pitch leaned to a mean blade. High and low pressure side effects
are included. The inviscid part of the program used a shock
enhancement method: a transonic marching technique is used to define the pressure, temperature, density, and Mach
number, and an iterative interaction scheme is constructed that

matches them in way that incorporates information related to momentum and enthalpy thicknesses as well as the displacement thickness. The calculations are quasi-three-dimensional in the sense that the boundary layer and wake solutions allow for the presence of spanwise (radial) velocities. (Author)


A semi-empirical scheme for the prediction of transonic pressure distribution on the surface of V/STOL inlet at high incidence angles has been developed. The investigation is intended to improve the boundary layer calculation and separation prediction by including the effects of shock wave-boundary layer interaction into the Lewis Inlet Viscous Computer Program. Wind-tunnel results and theoretical pressure calculation for critical cases are used in constructing the transonic pressure distribution. The program, which describes the development of the boundary layer and predicts the possible flow separation, can handle the cases of inlet at high incidence angles where local supersonic region may occur in the flow. (Author)


Airflow characteristics of variable cycle engines (VCE) designed for Mach 2.2 can have transonic airflow requirements as high as 1.6 times the cruise airflow. This is a formidable requirement for conventional, high performance axisymmetric, translating centerbody mixed compression inlets. An alternate inlet is defined where the second cone of a two cone centerbody collapse to the initial cone angle to provide a large off-design airflow capability, and incorporates modest centerbody translation to minimize spillage drag. Estimates of transonic spillage drag are competitive with those of conventional translating centerbody inlets. The inlet's cruise performance exhibits very low bleed requirements with good recovery and high angle of attack capability. (Author)


An integral boundary layer procedure has been developed for the computation of viscous and secondary flows along the annulus walls of an axial compressor. The procedure is an outgrowth and extension of the pitch-averaged method of Meller and Huntlock. In the present work, secondary flow theory is used to develop approximations for the velocity profiles inside a rotating blade row and for the blade force deficit terms in the momentum integral equations. The computer code based on this procedure has been extensively coupled to a quasi-three-dimensional model for the external inviscid flow. Computed results are compared with measurements in a compressor cascade. (Author)

A78-12034 ** Advanced Technology Labs., Inc., Westbury, N.Y.


Documentation for the FORTRAN program B2DATL is provided. The program input, output, and operational procedures are described; a dictionary of the principal FORTRAN variables is provided, the function of all subroutines is outlined and flow charts of the principal subroutines and the main program are presented. (Author)

A78-12038 ** Advanced Technology Labs., Inc., Westbury, N.Y.


A small perturbation type analysis has been developed for the acoustic far field in an infinite duct extending upstream and downstream of an axial turbomachinery stage. The analysis is designed to interface with a numerical solution of the near field of the blade rows and, by providing the necessary body closure condition to complete the statement of infinite duct boundary conditions for the subject problem. The present analysis differs from conventional inlet duct analyses in that a simple harmonic time dependence was not assumed, since a transient signal is generated by the numerical near-field solution and periodicity is attained only asymptotically. A description of the computer code developed to carry out the necessary convolutions numerically is included, as well as the results of a sample application using an impulsively initiated harmonic signal. (Author)

A78-17991 ** Pratt and Whitney Aircraft, East Hartford, Conn.

MEAN VELOCITY, TURBULENCE INTENSITY AND TURBULENCE CONVECTION VELOCITY MEASUREMENTS FOR A CONVERGENT NOZZLE IN A FREE JET WIND TUNNEL. COMPREHENSIVE DATA REPORT. C. J. McColgan and R. S. Larson, Apr. 1977 262 p. (Contract NAS3-17866) (NASA CR 135738. PWA 5516) Avid: NTIS HC A12/MF A01. CSSL 01A
The effect of flight on the mean flow and turbulence properties of a 0.065 m circular jet determined in a free jet wind tunnel. The nozzle exit velocity was 122 m/sec, and the wind tunnel velocity was set at 0.12, 37, and 61 m/sec. Measurements of flow properties including mean velocity, turbulence intensity and spectra, and eddy convection velocity were carried out using two linearized hot wire anemometers. This report contains the raw data and graphical presentations. The final technical report includes a description of the test facilities, test hardware, along with significant test results and conclusions. Author

NT8-20067** Advanced Technology Labs., Inc., Westbury, N.Y.
COMPUTATION OF UNSTEADY TRANSIENT FLOWS THROUGH ROTATING AND STATIONARY CASCADES. 1.
METHOD OF ANALYSIS. Final Report
A numerical method of solution of the inviscid, compressible, twodimensional unsteady flow on a blade-to-blade stream surface through a stage (rotor and stator) or a single blade row of an axial flow compressor or fan is described. A cyclic procedure has been developed for representation of adjacent blade-to-blade passages which asymptotically achieves the correct phase between all passages of a stage. A shock-capturing finite difference method is employed in the interior of the passage, and a method of characteristics technique is used at the boundaries. The blade slits form two of the passage boundaries and are treated as moving contact surfaces capable of supporting jumps in entropy and tangential velocity. The Kutta condition is imposed by requiring the slits to emanate at the trailing edges, which are assumed to be sharp. Results are presented for several transonic fan rotors and compared with available experimental data, consisting of holographic observations of shock structure and pressure contour maps. A subcritical stator solution is also compared with results from a relaxation method. Finally, a periodic solution for a stage consisting of 44 rotor blades and 46 stator blades is discussed.

Author

NT8-21068** Pratt and Whitney Aircraft Group, East Hartford, Conn.
MEAN VELOCITY, TURBULENCE INTENSITY AND TURBULENCE CONVECTION VELOCITY MEASUREMENTS FOR A CONVERGENT NOZZLE IN A FREE JET WIND TUNNEL Final Report
(Contract NAS3-17866) (NASA-CR-2949: PWA 5506) Avail: NTIS HC A03/MF A01 CSCL 01A
The effect of light on the mean flow and turbulence properties of a 0.056 m circular jet were determined in a free jet wind tunnel. The nozzle exit velocity was 122 m/sec, and the wind tunnel velocity was set at 0, 12, 37, and 61 m/sec. Measurements of flow properties including mean velocity, turbulence intensity and spectra, and eddy convection velocity were carried out using two linearized hot wire anemometers. Normalization factors were determined for the mean velocity and turbulence convection velocity.

Author

NT8-31544** United Technologies Research Center, East Hartford, Conn.
DERIVATION AND EVALUATION OF AN APPROXIMATE ANALYSIS FOR THE THREE-DIMENSIONAL VISCOS SUBSONIC FLOW WITH LARGE SECONDARY VELOCITIES Final Report
(Contract NAS3-19752) (NASA-CR-159430: UTRC-106) Avail: NTIS HC A05/MF A01: CSCL 01A
An approximate analysis is presented for calculating three-dimensional, low Mach number, laminar viscous flows in curved passages with large secondary flows and corner boundary layers. The analysis is based on the decomposition of the overall velocity field into inviscid and viscous components with the overall velocity being determined from superposition. An incompressible vorticity transport equation is used to estimate inviscid secondary flow velocities to be used as corrections to the potential flow velocity field. A parabolized streamwise momentum equation coupled to an adiabatic energy equation and global continuity equation is used to obtain an approximate viscous correction to the pressure and longitudinal velocity fields. A collateral flow assumption is invoked to estimate the viscous correction to the transverse velocity fields. The approximate analysis is solved numerically using an implicit ADI solution for the viscous pressure and velocity fields. An iterative ADI procedure is used to solve for the inviscid secondary vorticity and velocity fields. This method was applied to computing the flow within a turbine vane passage with inlet flow conditions of M = 0.1, Re = 1000 and adiabatic walls, and for a constant radius curved rectangular duct with R/D = 12 and 14 and with inlet flow conditions of M = 0.1, Re = 1000, and adiabatic walls. A.R.H.

The paper describes a perturbation method for turbomachinery calculations, particularly where it is necessary to carry out a number of calculations for closely related flows such as are needed in a parametric study. The method is applied for solving a model problem involving blade-to-blade surfaces of a transonic compressor. Basically, the method makes use of a previously calculated basic solution to determine first-order changes in the flow field due to variations in one or more of a variety of geometrical or flow field parameters. The fundamental assumption associated with the perturbation solutions is that the magnitude of the deviations from the base solution lies within the range of a linear perturbation analysis. Comparisons are made for results obtained, by varying the thickness ratio of an unstaggered lifting cascade composed of linearized sections in a flow with an incoming freestream Mach number of 0.60. S.D.
03  AIR TRANSPORTATION
AND SAFETY

Includes passenger and cargo air transport operations; and
aircraft accidents. For related information see also 16 Space Transportation
and 85 Urban Technology and Transportation.

N78-31081* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

SIMULTANEOUS MEASUREMENTS OF OZONE OUTSIDE
AND INSIDE CABINS OF TWO B-747 AIRLINERS AND A
GATES LEARJET BUSINESS JET
for presentation at the Conf. on Atmospheric Envirion of Aerospace
sponsored by the Am. Meteorol Soc and the AIAA
(NASA-TM 78983; E-9760) Avail. NTIS HC A02/MT A01
CSCI 06T

The average amount of ozone measured in the cabins of
two B-747 airliners varied from 40 percent to 80 percent
of the atmospheric concentrations without special ozone destruction
systems. A charcoal filter in the cabin air inlet system of one
B-747 reduced the ozone to about 5 percent of the atmospheric
concentration. A Learjet 23 was also instrumented with
monitors to measure simultaneously the atmospheric and ozone
concentrations. Results indicate that a significant portion of the
atmospheric ozone is not destroyed in the pressurization system
and remains in the aircraft cabin of the Learjet. For the two
cabin configurations tested the ozone retentions were 63 and
41 percent of the atmospheric ozone concentrations. Ozone
concentrations measured in the cabin near the conditioned-air
outlets were reduced only slightly from atmospheric ozone
concentrations. It is concluded that a constant difference
between ozone concentrations inside and outside the cabin does
not exist.

N78-11024* General Electric Co, Pittsfield, Mass
LIGHTNING PROTECTION OF AIRCRAFT
refs (Contract NAS3 19080)
(NASA RP 1008) Avail. NTIS HC A23/MT A01 CSCI 01C

The current knowledge concerning potential lightning effects
on aircraft and the means that are available to designers and
operators to protect against these effects are summarized. The
increased use of nonmetallic materials in the structure of aircraft
and the constant trend toward using electronic equipment to
handle flight critical control and navigation functions have caused
an interest for this study. For individual titles see N78-11025
through N78-11041.
05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

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

N75-17041‡ National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

PRELIMINARY STUDY OF PROPULSION SYSTEMS AND AIRPLANE WEIGHT PARAMETERS FOR A US NAVY SUBSONIC V/STOL AIRCRAFT
NASA-TM-73652; E-9519. Avail. NTIS HC 003/MF A01 CSCL 01C

Two V/STOL propulsion concepts were evaluated in a common aircraft configuration. One propulsion system consists of cross-coupled turboshaft engines driving variable pitch fans. The other system is a gas coupled combination of turbojet gas generators and tip turbine fixed pitch fans. Evaluations were made of endurance at low altitude, low speed, storm with equal takeoff fuel loads. Effects of propulsion system sizing bypass ratio, and aircraft wing planform parameters were investigated and compared. Shaft driven propulsion systems appear to result in better overall performance, although at higher installed weight, than gas systems.

N78-25080‡ Sikorsky Aircraft, Stratford, Conn.

OIL-AIR MIST LUBRICATION FOR HELICOPTER GEARING
Final Report
F. McGroohan Dec. 1976. 52 p refs
(Contract: NASA 18538)
N78-CR-135031. SER 509599. Avail. NTIS HC 004/MF A01 CSCL 01C

The applicability of a once-through oil mist system to the lubrication of helicopter spur gears was investigated and compared to conventional jet spray lubrication. In the mist lubrication mode, cooling air was supplied at 366K (200°F) to the out of mesh location of the gear sets. The mist air was also supplied at 366K (200°F) to the radial position mist nozzle at a constant rate of 0.0632 mol/s (3 SCFM) per nozzle. The lubricant contained in the mist air varied between 32 - 44 cc/hour. In the recirculating jet spray mode, the flow rate was varied between 1893 - 2650 cc/hour. Visual inspection revealed the jet spray mode produced a superior surface finish on the gear teeth but a thermal energy survey showed a 15 - 20% increase in heat generated. The gear tooth condition in the mist lubrication mode system could be improved if the cooling air and lubricant/air flow ratio were increased. The test gearbox and the procedure used are described.

Author
06 AIRCRAFT INSTRUMENTATION

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

N78-17035 [1] National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. INSTRUMENTATION FOR PROPULSION SYSTEMS DEVELOPMENT.

Apparatus and techniques developed or used by NASA-Lewis to make steady state or dynamic measurements of gas temperature, pressure, and velocity and of the temperature, tip clearance, and vibration of the blades of high-speed fans or turbines are described. The advantages and limitations of each instrument and technique are discussed and the possibility of modifying them for use in developing various propulsion systems is suggested.

Author

N78-36130 [1] National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. ON THE USE OF RELATIVE VELOCITY EXPONENTS FOR JET ENGINE EXHAUST NOISE.

The effect of flight on jet engine exhaust noise has often been presented in terms of a relative velocity exponent, n, as a function of location angle. The value of n is given by the ASPL reduction due to relative velocity divided by 10 times the logarithm of the ratio of relative jet velocity to absolute jet velocity. In such terms, classical subsonic jet noise theory would result in a value of n being approximately 7 at 90 degree angle to the jet axis with n decreasing, but remaining positive, as the jet axis is approached and increasing as the jet axis is approached. However, flight tests have shown a wide range of results, including negative values of n in some cases. In this paper it is shown that the exponent n is positive for pure subsonic jet noise and varies in a systematic manner as a function of flight conditions and jet velocity.

Author

N78-24130 [1] National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. DESIGN AND PRELIMINARY RESULTS OF A SEMI-THERMAL COOLED (LAMINOLY) LINER FOR A HIGH-PRESSURE HIGH-TEMPERATURE COMBUSTOR.

A Laminoloy combustor liner was designed, fabricated and tested in a combustor at pressures up to 8 atmospheres. The liner was fabricated of a three layer Laminoloy structure and designed to replace conventional metal louver liner. The liner is to be used in a combustor that provides hot gases to a turbine cooling test facility at pressures up to 40 atmospheres. The Laminoloy liner was tested extensively at lower pressures and demonstrated lower metal temperatures than the conventional liner, while the same time requiring about 40 percent less cooling air flow. Tests conducted on combustor exit temperatures in excess of 2200 K have not indicated any cooling or durability problems with the Laminoloy liner.

Author

N78-36130 [1] National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. GENERAL AVIATION INTERNAL-COMBUSTION ENGINE RESEARCH PROGRAMS AT NASA LEWIS RESEARCH CENTER.

An update is presented of non-turbine general aviation engine programs. The program encompasses conventional, lightweight diesel and rotary engines. It's three major thrusts are: (1) reduced SFC's; (2) improved fuel tolerance, and (3) reduced emissions. Current and planned future programs in such areas as lean operation, improved fuel management, advanced cooling techniques and advanced engine concepts, are described. These are expected to lay the technology base by the mid to latter 1980's, for engines whose life cycle fuel costs are 30 to 50% lower than today's conventional engines.

Author
- 07 AIRCRAFT PROPULSION AND POWER

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

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

N78-100828* Symbol National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CONCEPTS FOR THE DEVELOPMENT OF LIGHT-WEIGHT COMPOSITE STRUCTURES FOR ROTOR BLADE CONTAINMENT

Arthur G. Holme

Avitl NTIS HC A18/MF AO1 CSCL 21E

The current status of the first generation eutectics, gamma/gamma transition - delta and Ni-TaC-13, is described in detail. Several second generation systems, such as gamma/gamma transition - alpha and Ni-TaC-3116A, gamma beta, and COTAC 74 are also reviewed with particular emphasis on their critical physical and mechanical properties, future research directions, and potential applications. Results of recent cost/benefit analyses of eutectic turbine blades are discussed. Author

N78-100829* Symbol National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

APPLICATION OF A FLIGHT-LINE DISK CRACK DETECTOR TO A SMALL ENGINE

John R Barranger

Avai! NTIS HC A18/MF AO1 CSCL 21E

A conference on an aircraft engine emissions was held to present the results of recent and current work. Such diverse areas as components controls, engine efficient design, and noise and pollution reduction were discussed. For individual titles, see N78-11066 through N78-11080.
R78-11087* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

POSSIBILITY OF REDUCING TECHNOLOGY PROGRAM FOR
CLAIMS AND EMISSIONS REDUCTION ENGINEERS

Avail NTIS HC A20/MF A01 CSCL 21E

The technology required to develop commercial gas turbine engines with reduced exhaust emissions was demonstrated. Cowl-combustor systems for the JTBD engine family (EPA class T4) were investigated. The JTBD turbofan engine is an axial-flow, dual-spool, moderate-bypass-ratio design. It has a two-stage fan, a four-stage low-pressure compressor driven by a three-stage low-pressure turbine, and a seven-stage high-pressure compressor driven by a single-stage high-pressure turbine. A cross section of the JTBD-17 showing the mechanical configuration is given Key specifications for this engine are listed Author

R78-11071* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SUMMARY OF EMISSIONS REDUCTION TECHNOLOGY PROGRAMS
Richard W. Niedzwiecki In its Aircraft Eng. Emissions Oct 1977, p 181-202 (For availability see N78-11063 02-07)

Avail NTIS HC A20/MF A01 CSCL 21E

The NASA emissions reduction programs for EPA aircraft engine classes P2 (turboshaft engines), T1 (jet engines with thrust under 8000 Ib), T4 (JTBD engines), and T2 (jet engines with thrust over 8000 lb) are discussed. The most important aspects of these programs, the commonality of approaches used, the test results, and assessments regarding applications of the derived technology are summarized Author

R78-11072* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EMISSIONS CONTROL FOR GROUND POWER GAS TURBINES

Avail NTIS HC A20/MF A01 CSCL 21E

The similarities and differences of emissions reduction technology for aircraft and ground power gas turbines is described. The capability of this technology to reduce ground power emissions is evaluated and proposed emissions standards are presented and discussed. These areas where the developing aircraft gas turbine technology may have direct application to ground power and those areas where the needed technology may be unique to the ground power mission are pointed out. Emissions reduction technology varying from simple combustor modifications to the use of advanced combustor concepts, such as catalysis is described and discussed Author

R78-11073* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

GENERAL AVIATION PISTON ENGINE EXHAUST EMISSION REDUCTION

Avail NTIS HC A20 MF A01 CSCL 21E

To support the proliferation of aircraft regulations two airports were examined Van Nuys and Tammam. It was determined that the carbon monoxide (CO) emissions from piston engines aircraft have a significant influence on the CO levels in the ambient air and around airports where workers and travelers would be exposed. Emissions standards were set up for control of emissions from aircraft piston engines manufactured after December 31, 1979. The standards selected were based on a technologically feasible and economically reasonable control of carbon monoxide It was concluded that substantial CO reductions could be realized if the range of typical fuel-air ratios could be narrowed. Thus, improvements in fuel management were determined as reasonable controls. Author

R78-11094* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ALTERNATIVE FUELS
Jack S. Grabman, Halmot F. Butre, Robert Friedman, Albert C. Antoine, and Thomas W. Reynolds. In its Aircraft Eng. Emissions Oct 1977, p 277-308 (For availability see N78-11063 02-07)

Avail NTIS HC A20/MF A01 CSCL 21E

Potential problems related to the use of alternative aviation turbine fuels are discussed and both ongoing and required research into these fuels is described. The discussion is limited to aviation turbine fuels composed of liquid hydrocarbons. The advantages and disadvantages of the various solutions to the problems are summarized. The present solution is to continue to develop the necessary technology at the refinery to produce specification jet fuels regardless of the crude source. The second solution is to minimize energy consumption at the refinery and keep fuel costs down by relaxing specifications Author

R78-11076* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

GLOBAL ATMOSPHERIC SAMPLING PROGRAM

Avail NTIS HC A20/MF A01 CSCL 21E

Automated instruments were installed on a commercial B-747 aircraft, during the program, to obtain baseline data and to monitor key atmospheric constituents associated with emissions of aircraft engines in order to determine if aircraft are contributing to pollution of the upper atmosphere. Data thus acquired, on a global basis over the commercial air routes for 5 to 10 years will be analyzed. Ozone measurements in the 25,000 to 45,000 foot altitude range have been collected for comparison. The data show low levels of sulfates and nitrates in the upper troposphere. Recently installed instruments for measurement of carbon monoxide and condensation nucleus are beginning to yield results Author

R78-11077* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STRATOSPHERIC CRUISE EMISSION REDUCTION PROGRAM
Larry A. Dall Gregority M. Reck, Cecil J. Marks, and Andrew J. Staniasi. In its Aircraft Eng Emisions Oct 1977, p 357-391 (For availability see N78-11063 02-07)

Avail NTIS HC A20/MF A01 CSCL 21E

A recently implemented NASA effort specifically aimed at reducing cruise oxides of nitrogen from high-altitude aircraft is discussed. The desired emissions levels and the combustor technology required to achieve them are discussed. A brief overview of the SCERP operating plan is given. Lean premixed, premixed combustion and some of the potential difficulties that are associated with applying this technique to gas turbine combustors are examined. Base technology was developed in several key areas. These fundamental studies are viewed as a requirement for successful implementation of the lean premixed combustion technique Author
N78-11078** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
HIGH ALTITUDE GAS TURBINE RESEARCH
Peter B. Roberts (International Harvester, Chicago) In Its Aircraft Eng. Emissions Oct. 1977 p 779-815 ref (For availability see N78-11083 02-07)
Avail NTIS HC A2/0 MF A01 CSCL 21E
The impact of gas-turbine-engine-powered aircraft on worldwide pollution was defined within two major areas of effort: the contribution of aircraft to the local air pollution of metropolitan areas and, second, the long-term effects on the chemical balance of the stratosphere of pollutants emitted from future generations of high-altitude, supersonic commercial and military aircraft. Preliminary findings indicate that stratospheric ozone of nitrogen (NOx) emissions may have to be limited to very low levels if, for example, ozone depletion with concomitant increases in sea-level radiation, are to be avoided. Theoretical considerations suggest that NOx levels as low as 1.0 gram per kilogram of fuel and less should be attainable from an idealized premixed type of combustor. Experimental SS studies were intended to explore new combustor concepts designed to minimize the formation of NOx in aircraft gas turbines and to define their major operational problems and limitations. Author

N78-11086** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
EFFECT OF ENDWALL COOLING ON SECONDARY FLOWS IN TURBINE BLADE PASSAGE
Louis J. Goldman and Jerry L. McAllum In AGARD Secondary Flows in Turbomachines Sep 1977 p 29 p refs (For availability see N78-11083 02-07)
Avail NTIS HC A14/ MF A01 CSCL 21E
An experimental investigation was performed to determine the effect of endwall cooling on the secondary flow behavior and the aerodynamic performance of a core turbine stator vane. The investigation was conducted in a cold-air, full annular cascade, where three-dimensional effects could be obtained Two endwall cooling configurations were tested. In the first configuration, the cooling holes were oriented so that the coolant was injected in line with the inviscid streamline direction. In the second configuration, the coolant was injected at an angle of 15 deg to the inviscid streamline direction and oriented toward the outer vane surface. In both cases the stator vane was solid and uncooled so that the effect of endwall cooling could be obtained directly. Total pressure surveys were taken downstream of the stator vanes over a range of cooling flows at the design mean-radius critical velocity ratio of 0.778. Changes in the total-pressure contours downstream of the vanes were used to obtain the effect of endwall cooling on the secondary flows in the stator Comparisons were made between the two cooled-endwall configurations and with the results obtained previously for solid endwall. Author

N78-11088** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
ALTITUDE TEST OF SEVERAL AFTERBURNER CONFIGURATIONS ON A TURBOFAN ENGINE WITH A HYDROGEN HEATER TO SIMULATE AN ELEVATED TURBINE DISCHARGE TEMPERATURE
P M Johnson and D L Calhoon Nov 1977 57 p refs (NASA TP 1068 E 9027) Avail NTIS HC A04/ MF A01 CSCL 21E
A performance test of several experimental afterburner configurations was conducted with a mixed-flow turbomachinery engine in an altitude facility. The simulated flight conditions were for Mach 1.4 at two altitudes 12 190 and 14 630 meters Turbine discharge temperatures of 889 and 1056 K were used A production afterburner was used as a reference configuration. The research afterburners included partial forced mixers with V-gutter flameholders, a carbureted V-gutter flameholder, and a triple V-gutter flameholder with four swirl-can fuel mixers Fuel injection variations were included. Performance data shown include augmented thrust ratio, thrust specific fuel consumption, combustion efficiency, and total pressure drop across the afterburner. Author

N78-13065** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
EFFECT OF FUEL PROPERTIES ON PERFORMANCE OF SINGLE AIRCRAFT TURBOShaft COMBUSTOR AT SIMULATED MARINE, CRUISE, AND TAKEOFF CONDITIONS
Helmut F. Butz and Arthur L Smith Sep 1977 21 p refs (NASA TM 73780) E 8338 Avail NTIS HC A02/ MF A01 CSCL 21E
The performance of a single-can JT8D combustor was investigated with a number of fuels exhibiting wide variations in chemical composition and volatility. Performance parameters investigated were combustion efficiency, emissions of CO, unburned hydrocarbons and nitrogen oxides, as well as linear temperatures and smoke. The most pronounced effects of changes in fuel composition were observed at simulated cruise and takeoff conditions where smoke and emissions were found to be significantly higher than the hydrogen content of the fuel decreased. At the simulated idle condition, emissions of CO and unburned hydrocarbons increased slightly and, accordingly, combustion efficiencies decreased slightly as the hydrogen content of the fuels decreased. Author

N78-13080** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
FLIGHT EFFECTS ON PREDICTED FAN FLY BY NOISE
Marcus F. Haidmann and Bruce J. Clark 1977 24 p refs Presented at 94th Meeting of the Acoustical Soc. of Am., Miami, Fla. 13 16 Dec 1977 (NASA TM 73798) Avail NTIS HC A02/ MF A01 CSCL 20A
The impact on PNL (Perceived Noise Level, Tone corrected) and Fly by EPNL (Effective Perceived Noise Level) when forward motion reduces the noise generated by the bypass fan of an aircraft engine was studied Calculated noise spectra for a typical subsonic tip speed fan designed for blade passage frequency (BPF) tone cutoff were translated in frequency by systematically varying the BPF from 15 to 8 kHz Two cases of predicted flight effects on fan source noises were considered reduced BPF tone level of 8 dB and reduced broadband noise level of about 2 dB in addition to reduced tone level. The maximum reduction in PNL of the noise as emitted from the fan occurs when the BPF was at 4 kHz where the reductions were 7.4 and 10.0 dB. The maximum reduction in EPNL of the noise as received during a 500-foot altitude fly by occurred when the BPF was at 2.5 kHz where the reductions were 5.0 and 7.8 db. Author

N78-13081** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
AN EMPIRICAL MODEL FOR INVERTED VELOCITY PROFILE JET NOISE PREDICTION
An empirical model for predicting the noise from inverted-velocity-profile coaxial or coannular jets is presented and compared with small-scale static and simulated flight data. The model considered the combined contributions of as many as four uncorrelated constituent sources the premerged jet ambient mixed region the merged jet/ambient mixing region, outer stream shock/turbulence interaction, and inner stream shock/turbulence interaction. The noise from the merged region occurs at relatively low frequency and is modeled as the contribution of a circular jet at merged conditions and total exhaust area with the high frequencies attenuated. The noise from the prmerged region occurs at high frequency and is modeled as the contribution of an equivalent plug nozzle at outer stream conditions, with the low frequencies attenuated. Author

N78-13082** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio
AN OVERVIEW OF AEROSPACE GAS TURBINE TECHNOLOGY OF RELEVANCE TO TRL DEVELOPMENT OF THE AUTOMOTIVE GAS TURBINE ENGINE
N78-13063* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

MECHANICAL CHARACTERISTICS OF STABILITY-BLEED VALVES FOR A SUPERSONIC INLET

George H. Naun, Mike O. Dustin, and Gary L. Cole Washington, D.C.


Mechanical characteristics of a set of direct-operated relief valves used in a thrust-by-pass stability-bleed system designed for the YF-12 aircraft inlet are described. A comparison of data taken before and after the conducted tests (at room temperature) showed that both the effective spring rate and the piston friction had decreased during the wind tunnel tests. In neither the effective spring rate nor the piston friction was the magnitude of change great enough to cause significant impairment of overall system effectiveness. No major valve mechanical problems were encountered in any of the tests. During high temperature banch tests, piston frictional drag increased. The friction returned to its initial room temperature value when the stability-bleed valve was disassembled and reassembled. The problem might be solved by using a different material for the piston sleeve bearing and the piston rings.

Author

N78-13064* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

INFLUENCE OF OIL SQUEEZE FILM DAMPING ON STEADY STATE RESPONSE OF FLEXIBLE ROTOR OPERATING TO SUBCRITICAL SPEEDS

Robert E. Cunningham Dec 1977 44 p ref.

(NASA-TP-1094) E-9081) Avail. NTIS HC AO3/MF AO1 CSCL 21E

Experimental data were obtained for the unbalance response of a flexible rotor to speeds above the third lteral bending critical Squeeze-film damping coefficients calculated from measured data showed good agreement with short journal-bearing approximations over a frequency range from 5000 to 31 000 rpm. Response of a rotor to varying amounts of unbalance was investigated. A very light damper was compared with one where oil-squeeze dampers were applied.

Author

N78-18042* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PRELIMINARY DICEE PROGRAM TEST RESULTS


(NASA-TM-73732) Avail. NTIS HC AO2/MF AO1 CSCL 21E

The OICEE (Quiet, Clean, Short-Haul Experimental Engine) program has entered the engine test phase. Overall design and advanced technology incorporated into the two engines in the program. Test results, preliminary tests are presented and compared to the technological requirements of the engines are designed to meet.

Author

N78-18043* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR CALCULATION OF A GAS TEMPERATURE PROFILE BY INFRARED EMISSION ABSORPTION SPECTROSCOPY


A computer program to calculate the temperature profile of a flame or hot gas was presented in detail. Emphasis was on profiles found in jet engine or combustor streams containing H2O or CO2 radiating gases. The temperature profile was assumed symmetric with an assumed functional form controlled by two variable parameters. The parameters were calculated using measurements of gas radiation at two wavelengths in the infrared. The program also gave some information on the pressure profile. A method of selection of wavelengths was given that is likely to lead to an accurate determination of the parameters. The program is written in FORTRAN 4 language and runs in less than 60 seconds on a Univac 1100 computer.

Author

N78-18046* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

TEMPERATURE DISTRIBUTIONS AND INTRAMAL STRESSES IN A GRADED ZIRCONIA/METAL GAS PATH SEAL SYSTEM FOR AIRCRAFT GAS TURBINE ENGINES


(NASA-TM-73818) Avail. NTIS HC AO2/MF AO1 CSCL 21E

A ceramic/metallic aircraft gas turbine outer gas path seal designed for improved engine performance was studied. Transient temperature and stress profiles in a test seal geometry were determined by numerical analysis. During a simulated engine deceleration cycle from sea-level takeoff to idle conditions, the maximum seal temperature occurred below the seal surface, therefore the top layer of the seal was probably subjected to tensile stresses exceeding the modulus of rupture. In the stress analysis both two- and three-dimensional finite element computer programs were used. Predicted trends of the simpler and more easily usable two-dimensional element programs were borne out by the three-dimensional finite element program results.

Author

N78-18045* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

A COMPUTER PROGRAM FOR THE TRANSIENT THERMAL ANALYSIS OF AN IMPINGEMENT COOLED TURBINE FLADE


(NASA-TM-73819) Avail. NTIS HC AO2/MF AO1 CSCL 21E

A computer program to calculate transient and steady state temperatures, pressures, and coolant flows in a cooled turbine blade or vane with an impingement insert is described. Input to the program includes a description of the blade geometry, coolant supply conditions, edges thermal boundary conditions and wheel speed Coolant-air heat transfer coefficients are calculated internally in the program, with the user specifying the mode of heat transfer at each internal flow station. Program output includes the temperature at each node, the coolant pressures and flow rates, and the inside heat transfer coefficients. A sample problem is discussed.

Author

N78-18063* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COLD-AIR PERFORMANCE OF FREE-POWER TURBINE DESIGNED FOR 112 KILOWATT AUTOMOTIVE GAS TURBINE ENGINE 1: DESIGN STATOR-VANE-CHORD SETTING ANGLE OF 35 DEG


A cold air experimental investigation of a free power turbine designed for a 112-kW automotive gas turbine was made over a range of speeds from 0 to 130 percent of design equivalent speeds and over a range of pressure ratio from 1 to 2.45. Results are presented in terms of equivalent power, torque, mass flow and efficiency for the design power point setting of the variable stator.

Author
in sintering, reaction sintering, and hot pressing processes are discussed including the factors responsible for strength limitations in ceramic bodies. Significant improvements in material properties can be achieved by reducing or eliminating the strength limiting factors with consistent powder and process characterization along with process control.

Author

N78-19085 © National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

INTEGRATED GAS TURBINE ENGINE-NACELLE Patent

A nacelle was defined for use with a gas turbine engine. An integral webbed structure resembling a spoked wheel for rigidity interconnecting the nacelle and engine, provides lightweight support. The inner surface of the nacelle defines the outer limits of the engine system fluid flow annulus while the outer surface of the nacelle defines a streamlined envelope for the engine.

Official Gazette of the U.S. Patent Office

N78-19087 © National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

VARIABLE MIXER PROPULSION CYCLE Patent

A design technique, method, and apparatus are delineated for controlling the bypass gas stream pressure and varying the bypass ratio of a mixed flow gas turbine engine in order to achieve improved performance. The disclosed embodiments each include a mixing device for combining the core and bypass gas streams. The variable area mixing device permits the static pressures of the core and bypass streams to be balanced prior to mixing at widely varying bypass stream pressure levels. The mixed flow gas turbine engine therefore operates efficiently over a wide range of bypass ratios and the dynamic pressure of the bypass stream is maintained at a level which keeps the engine inlet airflow matched to an optimum design level throughout a wide range of engine thrust settings.

Official Gazette of the U.S. Patent Office
ND7-19189# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. REDUCED INLET GAS TEMPERATURES FOR TUNGSTEN FIBER REINFORCED SUPERALLOY TUBE BLADES. Edward A. Wines, Leonard J. Westfall, and Donald W. Petraske. 1978 23 p refs. Presented at 26 Intern. Conf. on Composite Materials, Toronto, Canada, 16-20 Apr. 1978; sponsored by Am. Inst. of Mining, Metallurgical, and Petroleum Engineers (NASA-TM-73642) Avail. NTIS HC AO3/MF AO1 CSCL 21E. Tungsten fiber-reinforced superalloy composites (TFRS) impingement cooled turbine blade inlet gas temperatures were calculated taking into account material spanwise strength, thermal conductivity, material oxidation resistance, fiber-matrix interaction, and coolant flow. Measured values of TFRS in-mat conductivities are presented. Calculations indicate that blades made of 30% volume percent fiber content TFRS have a 12.0 J/°K-m/sec stress-to-density ratio while operating at 40 atmospheres and a 0.06 coolant flow ratio could permit a turbine blade inlet gas temperature of over 1900K. This is more than 150K greater than similar superalloy blades. Author

ND7-19189# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. HIGH TEMPERATURE ENVIRONMENTAL EFFECTS ON METALS. S. J. Grisaffa, C. E. Lovell, and C. A. Steams. 1977 18 p refs. Presented at 24th Sagedon Army Materials Res. Conf. Risk and Failure Analysis for Reliability, Bolton Landing, N.Y. 22-26 Aug. 1977 (NASA-TM-73678) Avail. NTIS HC AO2/MF AO1 CSCL 21E. The gas turbine engine was used as an example to predict high temperature environmental attack on metals. Environmental attack in a gas turbine engine derives from high temperature, combustion products of the air and fuel burned, and impurities. Of all the modes of attack associated with impurity effects, hot corrosion was the most complicated mechanistically. Solutions to the hot corrosion problem were sought semi-empirically in: (1) improved alloy cermets; (2) protective surface coating; (3) use of additives to the engine environment; and (4) air/fuel cleanup to eliminate harmful impurities. J.C.S.

ND7-19189# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. EXPERIMENTAL DETERMINATION OF TRANSIENT STRAIN IN A THERMALLY-CYCLED SIMULATED TURBINE BLADE UTILIZING A NON-CONTACT TECHNIQUE. Frederick D. Callo and Peter T. Baron. Jan. 1978 31 p refs (NASA-TM-73886; E-9501) Avail. NTIS HC AO3/MF AO1 CSCL 21E. A type of noncontacting electro-optical extensometer was used to measure the displacement between parallel targets mounted on the blade edge of a simulated turbine blade throughout a complete heating and cooling cycle. The blade was cyclically heated and cooled by moving it into and out of a Mach 1 hot gas stream. The principle of operation and measurement procedure of the electro-optics extensometer are described. Author

ND7-20130# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. TWO-DIMENSIONAL COLD-AIR CASCADE STUDY OF A FILM-COOLED TURBINE STATOR BLADE. 4: COMPARISON OF EXPERIMENTAL AND ANALYTICAL AERODYNAMIC RESULTS FOR BLADE WITH 9 ROEWS OF 0.076-CENTIMETER (0.030-INCH) DIAMETER HOLES HAVING STREAMWISE EJECTION ANGLES. Herman W. Prust, Jr. Mar. 1978 30 p refs (NASA-TP-1151; E-8187) Avail. NTIS HC AC3/MF AO1 CSCL 21E. Previously published experimental aerodynamic efficiency results for a film cooled turbine stator blade are compared with analytical results computed from two published analytical methods. One method was used as published; the other was modified for certain cases of coolant discharge from the blade suction surface. For coolant ejection from blade surface regions where the surface static pressures are higher than the blade exit pressure, both methods predict the experimental results quite well. However, for ejection from regions with surface static pressures lower than the blade exit pressure, both methods predict too small a change in efficiency. The modified method gives the better prediction. Author

ND7-20130# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. PERFORMANCE OF A SHORT ANNUAL DUMP DIFFUSER USING SUCTION-STABILIZED VORTICES AT INLET MACH NUMBERS TO 0.61. John M. Smith and Albert J. Juhasz. Apr. 1978 40 p refs (NASA-TP-1194; E-9332) Avail. NTIS HC AO3/MF AO1 CSCL 21E. A short, annular dump diffuser was designed to use suction to establish stabilized vortices on both walls for improved flow expansion in the region of an abrupt area change. The diffuser was tested at near ambient inlet pressure and temperature. The overall diffuser area ratio was 4.0. The inlet height was 2.64 cm and the exit pilot-static ratios were located at a distance from the vortex leading edge to two or six times the inlet height. Performance data were taken at near ambient temperature and pressure for nominal inlet Mach numbers of 0.18 to 0.41 with suction rates of 0 to 18% of the total inlet airflow. The exit velocity profile could be shifted toward either wall by adjusting the inner or outer-wall suction. The exit velocity profiles were unstable, with a tendency to shift back to hub- or tip-weighted profile. Diffuser effectiveness was increased from about 47 percent without suction to over 85 percent at a total suction rate of about 14 percent. The diffuser total pressure losses at inlet; Mach numbers of 0.18 and 0.41 decreased from 1.1 and 5.6 percent without suction to 0.48 and 5.2 percent at total suction rates of 14.4 and 5.8 percent, respectively. Author

ND7-20130# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. SIMULATED FLIGHT EFFECTS ON NOISE CHARACTERISTICS OF A FAN INLET WITH HIGH THROAT MACH NUMBER. Howard L. Wesoky, Donald A. Dietrich, and John M. Abbott. Apr. 1978 45 p refs (NASA-TP-1199; E-9253) Avail. NTIS HC AO3/MF AO1 CSCL 21E. An anechoic wind tunnel experiment was conducted to determine the effects of simulated flight on the noise characteristics of a high throat Mach number fan inlet. Comparisons were made with the performance of a conventional Mach number inlet with the same 50.8 cm fan noise source. Simulated forward velocity of 41 m/sec reduced perceived noise levels for both inlets, the largest effect being more than 3 db for the high throat Mach number inlet. The high throat Mach number inlet was as much as 7.5 db quieter than the low throat Mach number inlet with tunnel airflow and about 8 db quieter without tunnel airflow. Effects of inlet flow angles up to 30 deg were seemingly irregular and difficult to characterize because of the complex flow fields and generally small noise variations. Some modifications of tones and directivity at blade passage harmonics resulting from inlet flow angle variation were noted. Author

ND7-20130# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. TWO-DIMENSIONAL COLD-AIR CASCADE STUDY OF A FILM-COOLED TURBINE STATOR BLADE. 5: COMPARISON OF EXPERIMENTAL AND ANALYTICAL AERODYNAMIC RESULTS FOR BLADE WITH 12 ROEWS OF 0.038-CENTIMETER (0.015-INCH) DIAMETER COOLANT HOLES HAVING STREAMWISE EJECTION ANGLES. Herman W. Prust, Jr. Apr. 1978 23 p refs (NASA-TP-1204; E-9342) Avail. NTIS HC AC3/MF AO1 CSCL 21E. Published experimental aerodynamic efficiency results were compared with results predicted from two published analytical methods. This is the second of two such comparisons. One of the analytical methods was used as published; the other was
modified for certain cases of coolant discharge from the blade suction surface. The results show that for 23 cases of single row and multrow discharges covering coolant fractions from 0 to about 9 percent, the difference between the experimental and predicted results was no greater than about 1 percent in any case and less than 1/2 percent in most cases. Author

N78-21105* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF THE NOISE CHARACTERISTICS OF TWO LOW PRESSURE RATIO FANS WITH A HIGH THROAT MACH NUMBER INLET

Howard L. Wesley, John M. Abbott, and Donald A. Dietrich
Jan 1978 31 p refs
NASA-TM-73890; E-9489 Avail. NTIS HC A03/MF AU1 CSCL 21E

Acoustics data obtained in experiments with two low pressure ratio 50.8 cm (20 in) diameter model fans differing in design tip speed were compared. Determination of the average throat Mach number used to compare high Mach inlet noise reduction characteristics was based on a correlation of inlet wall static pressure measurements with a flow field calculation. The largest noise reductions were generally obtained with the higher tip speed fan. At a throat Mach number of 0.79, the difference in noise reduction was about 2.5 db with static test conditions. Although the noise reduction increased for the lower tip speed fan with a simulated flight velocity of 41 m/sec (80 knots), it was still about 2 db less than that of the high tip speed fan which was only tested at the static condition. However, variations in acoustic performance could not be absolutely attributed to the different fan designs because of differences in inlet lip contours which resulted in small variations of peak wall Mach number and axial extent of supersonic and near-sonic flow. Author

N78-21106* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GAS PATH SEALING IN TURBINE ENGINES

NASA-TM-73890; E-9506 Avail. NTIS HC A03/MF AU1 CSCL 21E

A survey of gas path seals is presented with particular attention given to sealing clearance effects on engine component efficiency. The effects on compressor pressure ratio and stall margin are pointed out. Various case-rotor relative displacements, which affect gas path seal clearances, are identified. Forces produced by nonuniform seal clearances and their effect on rotor stability are discussed quantitatively, and recent work on turbine-blade-tip sealing for high temperature is described. The need for active clearance control and for engine structural analysis is discussed. The functions of the internal-flow system and its seals are reviewed. Author

N78-21110* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PHOTOGRAPHIC CHARACTERIZATION OF SPARK-IGNITION ENGINE FUEL INJECTORS

Peggy L. Evans Feb 1978 27 p refs
NASA-TM-78830; E-9535 Avail. NTIS HC A03/MF AU1 CSCL 21E

Manifold port fuel injectors suitable for use in general aviation spark-ignition engines were evaluated qualitatively on the basis of fuel spray characteristics. Photographs were taken at various fuel flow rates or pressure levels. Mechanically and electronically operated pintle injectors generally produced the most atomization. The plain-orifice injectors used on most fuel-injected general aviation engines did not atomize the fuel when sprayed into quiescent air. Author

N78-21112* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AIRFLOW AND THRUST CALIBRATION OF AN F100 ENGINE, S/N P880059, AT SELECTED FLIGHT CONDITIONS

Thomas J. Biesiadecki, Douglass Lee, and Jose R. Rodriguez Apr 1978 27 p refs
NASA-TP-1008; E-92571 Avail. NTIS HC A03/MF AU1 CSCL 21E

An airflow and thrust calibration of an F100 engine, S/N P880059, was conducted to study airflow propulsion system integration losses in turbfan-power high-performance aircraft. The tests were conducted with and without thrust augmentation for a variety of simulated takeoff conditions with enhanced performance on the transonic regime. The resulting corrected airflow data generalized into one curve with corrected fan speed while corrected gross thrust increased as simulated flight conditions increased. Overall agreement between measured data and computed results was 1 percent for corrected airflow and -1 1/2 percent for gross thrust. The results of an uncertainty analysis are presented for both parameters at each simulated flight condition. Author

N78-21114* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THEORETICAL FLOW CHARACTERISTICS OF INLETS FOR TILTING-NASCEL VTOL AIRCRAFT

Michael A. Boles, Rogers W. Ludens, and Norbert O. Stockman Apr 1978 31 p refs
NASA-TP-1205; E-9387 Avail. NTIS HC A03/MF AU1 CSCL 21E

The results of a theoretical investigation of geometric variables for lift-cruise-fan, tilting nascel inlets operating at high incidence angles are presented. These geometric variables are investigated for their effects on surface static to freestream pressure ratio, and the separation parameters of maximum to diffuser exit "surface velocity ratio and maximum surface Mach number for low speed operating conditions. The geometric parameters varied were the internal lip contraction ratio, external fbody diffuser exit diameter ratio external forebody length to diameter ratio and internal lip major to minor axis ratio. Author

N78-21122* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROGRESS IN ADVANCED HIGH TEMPERATURE TURBINE MATERIALS, COATINGS, AND TECHNOLOGY

John C. Freche and G. Marvin Ault In AGARD High Temp. Prob. in Gas Turbine Eng. Feb 1978 31 p refs (For availability see N78 21118 12-07)
Avail. NTIS HC A25/MF AU1 CSCL 21E

Advanced materials, coatings, and cooling technology is assessed in terms of improved aircraft turbine engine performance. High cycle operating temperatures, lighter structural components, and adequate resistance to the various environmental factors associated with aircraft gas turbine engines are among the factors considered. Emphasis is placed on progress in development of high temperature materials for cooling protection against oxidation, hot corrosion and erosion, and in turbine cooling technology. Specific topics discussed include metal matrix composites, superalloys, directionally solidified eutectics, and ceramics J.M.S

N78-22057* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IMPACT BEHAVIOR OF FILAMENT WOUND GRAPHITE/EPoxy FAN BLADES

Kenneth J. Bowles 1978 18 p refs Presented at the 3rd Natl. SAMPE Symp. and Exhibition, Anaheim, Calif. 2-4 May 1978
NASA-TM-78845; E-9562 Avail. NTIS HC A02/MF AU1 CSCL 21E

The fabrication and impact tests of graphite/epoxy filament wound fan blades are discussed. Blades which were spun tested at tip speeds up to 305 meters per second retained their structural integrity. Two blades were each impacted with a 454 gram slice of a 908 gram simulated bird at a tip speed of 263 meters
per second and impact angles of 22 and 32 deg. The impact tests were recorded with high-speed movie film. The blades which was impacted at 22 deg sustained some root delamination but remained intact. The 32 deg impact separated the blade from the root. No local damage other than leading edge debonding was observed for either blade. Results of a fatigue mode analysis are also discussed. Author


To accomplish simultaneous reduction of unburned hydrocarbons, carbon monoxide, and oxides of nitrogen, required major modifications to the combustion. The modification most commonly used was a staged combustion technique. While these designs are more complicated than production combustors, no insurmountable operational difficulties were encountered in either high-pressure or engine tests which could not be resolved with additional development. The emission reduction results indicate that reductions in unburned hydrocarbons were sufficient to satisfy both near and far-term EPA requirements. Although substantial reductions were observed, the success in achieving the CO and NOx standards was mixed and depended heavily on the engine/engine cycle on which it was employed. Technology for near-term CO reduction was satisfactory or marginally satisfactory. Considerable doubt exists if this technology will satisfy all far-term requirements. Author


Lean blowout limits were reported for a premixed, pre vaporized propane jet issuing into a cylindrical combustor. A single hole in a flat plate was used as a flameholder. Flameholders with various hole diameters were used. Jet velocities were varied from 3 to 280 meters per second. The combustor cross-sectional area was changed by using different quartz liners of 12.7 and 22.2 millimeters diameters. As a result the combustor Reynolds number varied from 1000 to 9000. Stability was achieved at laminar and turbulent conditions. Three zones of the stability were observed. The blowout equivalence ratio varied with step size and the combustor and jet Reynolds numbers. The combustor inlet mixture temperature was 385 K, and the combustor pressure was 1 atmosphere. Author

NT8-22011* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. IN-PLACE RECALIBRATION TECHNIQUE APPLIED TO A CAPACITANCE-TYPE SYSTEM FOR MEASURING ROTOR BLADE TIP CLEARANCE. John P. Barranger Apr. 1978-35 p ref (NASA-TP-1110; E:9395) Avail: NTIS HC AO3/MF AO1 CSC 20E

The rotor blade tip clearance measurement system consists of a capacitance sensing probe with self contained tuning elements, a connecting coaxial cable, and remotely located electronics. A new capacitance measurement technique was presented which partly overcomes this problem through a simple modification of the electronics that permits a scale factor correction. This technique, when applied to a commercial system significantly reduced errors under varying conditions of humidity and temperature. Equations were also found that characterize the important cable and probe design quantities. Author


Engine performance, weight and mission studies were carried out for supersonic through flow fan engine concepts. The mission used was a Mach 2.32 cruise mission. The advantages of supersonic through flow fan engines were evaluated in terms of mission range comparisons between the supersonic through flow fan engines and a more conventional turbofan engine. The specific fuel consumption of the supersonic through flow fan engines was 12 percent lower than the more conventional turbofan. The aircraft mission range was increased by 20 percent with the supersonic fan engines compared to the conventional turbofan. Author


Engine performance, weight and mission studies were carried out for supersonic through flow fan engine concepts. The mission used was a Mach 2.32 cruise mission. The advantages of supersonic through flow fan engines were evaluated in terms of mission range comparisons between the supersonic through flow fan engines and a more conventional turbofan engine. The specific fuel consumption of the supersonic through flow fan engines was 12 percent lower than the more conventional turbofan. The aircraft mission range was increased by 20 percent with the supersonic fan engines compared to the conventional turbofan. Author

NT8-23036* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ALTITUDE CALIBRATION OF AN F100, S/N P590063, TURBOPROP ENGINE. Thomas J. Bissellady, Douglas Lee, and Jose R. Rodrigues May 1978-23 p ref (NASA-TP-1228; E:9356) Avail: NTIS HC AO2/MF AO1 CSC 21E

An airflow and thrust calibration of an F100 engine was conducted in cooperation with a flight test program to study airflow-propulsion system integration characteristics of turboprop-powered high-performance aircraft. The tests were conducted with and without augmentation for a variety of simulated flight conditions with emphasis on the transonic regime. Test results for all conditions are presented in terms of corrected airflow and corrected gross thrust as functions of corrected fan speed for nonaugmented power and an augmented thrust as a function of fuel-air ratio for augmented power. Comparisons of measured and predicted data are presented along with the results of an uncertainty analysis for both corrected airflow and gross thrust. Author


Carbon monoxide and unburned hydrocarbon emissions in a gas turbine engine are reduced by bleeding hot air from the
engine cycle and introducing it back into the engine upstream of the bleed valve and upstream of the combustor inlet. As this hot inlet air is recycled, the combustor inlet temperature rises rapidly at a constant engine thrust level. In most combustors, this will reduce carbon monoxide and unburned hydrocarbon emissions significantly. The preferred locations for hot air extraction are at the compressor discharge or from within the turbine, whereas the preferred reentry location is at the compressor inlet.

Official Gazette of the U.S. Patent Office

N78-25080† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COUNTER PUMPING DEBNS EXCLUDER AND SEPARA-
TOR Patent

Lawrence P. Ludwig, inventor (to NASA) Issued 18 Apr. 1978

A dirt separator and excluder for removing entrained debris from gas turbine shaft seals is described. A helical groove pattern is constructed on the rotating shaft with the pumping pattern such that it tends to pump seal pressurizing gas toward the gas turbine seal. A second helical groove pattern is provided on the stationary housing or counter rotating member coaxial with the shaft, and this pattern is designed to provide pumping in the direction opposite from that of the groove pattern on the shaft. Gas with entrained debris entering this grooved area will be subjected to high centrifugal forces due to the swirl motion induced by the groove pattern and the rotation of the shaft. This debris is centrifuged outwardly into the outer groove pattern on the housing or counter rotating member. Because the outer groove pattern has a pumping direction opposite from that of the seal, dirt is pumped away from the seal and can be collected in a suitable debris trap remote from the seal location.

Official Gazette of the U.S. Patent Office

N78-26143† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMBUSTION CONCEPTS FOR AIRCRAFT GAS TURBINE LOW-POWER EMISSIONS REDUCTION


Several combustor concepts were designed and tested to demonstrate significant reductions in aircraft engine idle pollutant emissions. Each concept used a different approach for pollutant reductions, the hot wall combustor employs a thermal barrier coating and impingement cooled liners, the recuperative cooling combustor preheats the air before entering the combustion chamber, and the catalytic converter combustor is composed of a conventional primary zone followed by a catalytic bed for pollutant cleanup. The designs are discussed in detail and test results are presented for a range of aircraft engine idle conditions. The results indicate that ultralow levels of unburned hydrocarbons and carbon monoxide emissions can be achieved.

N78-26144† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

END-WALL BOUNDARY LAYER PREDICTION FOR AXIAL-
COMPRESSORS Patent


An integral boundary layer procedure was developed for the computation of viscous and secondary flows along the annulus walls of an axial compressor. The procedure is an outgrowth and extension of the pitch-averaged methods of Moller and Hotrock. In the present work secondary flow theory is used to develop approximations for the velocity profiles inside a rotating blade row and for the blade force deficit term in the momentum integral equations. The computer code based on this procedure was iteratively coupled to a quasi-one-dimensional model for the external inviscid flow. Computed results are compared with measurements in a compressor cascade.

Author

N78-26145† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LIQUID-COOLING TECHNOLOGY FOR GAS TURBINES REVIEW AND STATUS


A review of research related to liquid cooling of gas turbines was conducted and an assessment of the state of the art was made. Various methods of liquid cooling turbines were reviewed. Examples of results with test and demonstrator turbines utilizing these methods along with the advantages and disadvantages of the various methods are discussed.

Author

N78-26146† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EMISSION AND ABSORPTION OF NASA CERAMIC THERMAL BARRIER COATING SYSTEM


Spectral emissivity measurements were made on a two-layer ceramic thermal barrier coating system consisting of a metal substrate, a NiCrAlY bond coating and a yttria-stabilized zirconia ceramic coating. Spectral emissivity data were obtained for the coating system at temperatures of 300 to 1500 K, ceramic thickness of zero to 0.076 centimeter, and wavelengths of 0.4 to 14.6 micrometers. The data were transformed into total hemispherical emissivity data correlated with respect to ceramic coating thickness and temperature using multiple regression curve fitting techniques. The results show that the ceramic thermal barrier coating system is highly reflective and significantly reduces radiation heat loads on cooled gas turbine engine components. Calculation of the radiant heat transfer within the nonisothermal, transient ceramic coating material shows that the gas-side ceramic coating surface temperature can be used in heat transfer analysis of radiation heat loads on the coating system.

Author

N78-27122† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SUPERCRITICAL FUEL INJECTION SYSTEM Patent Application


A fuel injection system for gas turbines or the like which includes a pair of high pressure pumps which provide fuel and a carrier fluid such as air at pressures above the critical pressure of the fuel was developed. A supercritical mixing chamber mixes the fuel and carrier fluid and the mixture is sprayed into a combustion chamber for burning therein. The use of fuel and a carrier fluid at supercritical pressures promotes rapid mixing of the fuel in the combustion chamber so as to reduce the formation of pollutants and promote cleaner burning.

NASA
I

Jun 1978

A COMPUTER PROGRAM FOR FULL-COVERAGE FILM-COOLDED BLADING ANALYSIS INCLUDING THE EFFECTS OF A THERMAL BARRIER COATING


The program input, coolant flow and heat transfer model, and the program output are discussed. As an example, sections of the suction and pressure sides of high temperature, high pressure turbine vanes are analyzed to show the effects of a thermal barrier coating. Compared to the uncoated design, the coating halves the required coolant flow, while simultaneously reducing metal outer temperatures by over 11 K.

Author

N78-27128$‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


Technology developments for more fuel efficiency subsonic transport aircraft are reported. Three major propulsion projects were considered: (1) engine component improvement - directed at current engines; (2) energy efficient engine - directed at new turboshaft engines, and (3) advanced turboprops - directed at technology for advanced turboprop powered aircraft. Each project is reviewed and some of the technologies and recent accomplishments are described.

G.G.

N78-27126$‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


A computer program for full-coverage film-cooled blading analysis including the effects of a thermal barrier coating

N78-28100$‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


A carbureted four cylinder aircraft engine was tested to establish the effects of air temperature and humidity at various fuel-air ratios on the exhaust emissions on a per-mode basis. The test conditions include carburetor lean-out at air temperatures of 50, 58, 80, and 100 F at relative humidity of 0, 30, 60, and 90 percent. Temperature humidity effects at the higher values of air temperature and relative humidity tested indicated that the HC and CO emissions increased significantly, while the NOx emissions decreased. As a result, fuel air ratio, the HC emissions increase and the NOx emissions decrease at the higher values of air temperature and humidity.

B.B.

N78-31103$‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

REVERSE FLOW COMBUSTOR FOR SMALL GAS TURBINES WITH PRESSURE-ATOMIZING FUEL INJECTORS Carl T. Nory, Jr., Edward J. Mulari (AVRADCOM Res and Technol Labs), and Stephen M. Riddlebaugh Aug. 1978 30 p refs (NASA TP 1260; AVRADCOM TR 78 22FLU; E-9458) Avail: NTIS HC AO3/MF AO1 CSCL 21E

A reverse flow combustor suitable for small gas turbine (2 to 3 ksl/s mass flow) was used to evaluate the effect of pressure-atomizing fuel injectors on combustor performance. In these tests an experimental combustor was designed to operate with 18 simplex pressure atomizing fuel injectors at sea level takeoff conditions. To improve performance at low power conditions, fuel was redistributed so that only every other injector was operational. Combustor performance, emissions, and liner temperature were compared over a range of pressure and inlet air temperatures corresponding to simulated idle, cruise, and takeoff conditions typical of a 10 to 1 pressure ratio turbine engine.

B.B.

N78-28099$‡ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


A gas path seal for a turbine engine or compressor is provided. The gas path seal comprises a seal of material wearable or abrasible relative to the material of the turbine or compressor blades and closely spaced from the blade tips. A compliant backing, preferably of several layers of corrugated metal or a compliant in-material covered with a layer of ductile material, is provided about the shroud, and a rigid mounting surrounds the compliant backing. The novel feature is a compliant backing between the shroud and mounting. As a result normal forces during a blade rub are limited and wear is reduced and the life of the shroud is lengthened for a design of comparable clearance of blade to shroud.
A thermal barrier coating on a full-covering film-cooled turbine vane


The potential benefits of combining full-covering film cooling with a thermal-barrier coating were investigated analytically for sections on the suction and pressure sides of a high-temperature, high-pressure turbine vane. Metal and ceramic coating temperatures were calculated as a function of coating thickness and coolant flow. With a thermal-barrier coating, the coolant flows required for the chosen sections were half those of an uncoated design, and the metal outer temperatures were simultaneously reduced by over 111 K (200 °F). For comparison, transpiration cooling was also investigated. Full-covering film cooling of a coated vane required more coolant flow than did transpiration cooling. Author

N78-23101* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

REDUNDANT DISC Patent


A rotatable disc is described that consists of parallel plates tightly joined together for rotation about a hub. Each plate is provided with several angularly projecting spaced lands. The lands of each plate are interposed in alternating relationship between the lands of the next adjacent plate. In this manner, circumferential displacement of adjacent sectors in any one plate is prevented in the event that a crack develops. Each plate is redundantly sized so that, in event of structural failure of one plate, the remaining plates support a proportionate share of the load of the failed plate. The plates are prevented from separating laterally through the inclusion of generally radially extending splines which are inserted to interlock cooperating, circumferentially adjacent lands. Official Gazette of the U.S. Patent Office

N78-23102* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RESULTS AND STATUS OF THE NASA AIRCRAFT ENGINE EMISSION REDUCTION TECHNOLOGY PROGRAMS


The results of an aircraft engine emission reduction study are reviewed in detail. The capability of combustor concepts to produce significantly lower levels of exhaust emissions than present production combustors was evaluated. The development status of each combustor concept is discussed relative to its potential for implementation in aircraft engines. Also, the ability of these combustor concepts to achieve proposed NME and NCE EPA standards is discussed. B.B.

N78-31107* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A TRANSSONIC FAN STAGE DESIGNED FOR A LOW MERIDIONAL VELOCITY RATIO


The aerodynamic performance and design parameters of a transonic fan stage are presented. The fan stage was designed for a meridional velocity ratio of 0.8 across the tip of the stage, a pressure ratio of 1.57, a flow of 28.5 kilograms per second, and a tip speed of 426 meters per second. Radial surveys were obtained over the stable operating range from 0 to 100 percent of design speed. The measured, peak efficiency (0.81) of the stage occurred at a pressure ratio of 1.58 and a flow of 28.7 kilograms per second. L.S.
A78-20861 * A review of NASA's propulsion programs for
civil aviation. W. L. Stewart (NASA, Lewis Research Center,
Cleveland, Ohio), H. W. Johnson (NASA, Aeronautical Propulsion
Div., Washington, D.C.), and R. J. Weber (NASA, Lewis Research
Center, Mission Analysis Branch, Cleveland, Ohio). American
Institute of Aeronautics and Astronautics, Aerospace Sciences
18 refs.
Two NASA engine-oriented propulsion programs of major
importance to civil aviation are presented and discussed. Included
are programs directed at exploring propulsion-system concepts for (1)
energy-conservative subsonic aircraft (improved current turbofj
advanced turbofans, and advanced turboprops), (2) supersonic cruise
aircraft (variable-cycle engines), (3) general aviation aircraft (im
proved reciprocating engines and small gas turbines), (4) powered-lift
aircraft (advanced turbofans), and (5) advanced rotorcraft. These
programs reflect the opportunities still existing for significant
improvements in civil aviation through the application of advanced
propulsion concepts.
(Author)

A78-23840 * Preliminary QCSEE program - Test results. C.
C. Ciepluch (NASA, Lewis Research Center, Cleveland, Ohio).
Society of Automotive Engineers, Aerospace Meeting, Los Angeles,
Preliminary results are reported for the Quiet Clean Short-haul
Experimental Engine (QCSEE) program initiated by NASA in 1974
to develop propulsion system technology suitable for powered-lift
short-range commercial aircraft. The QCSEE technology also has
applications to the proposed U.S. Navy V/STOL aircraft. Emphasis
in the QCSEE program is placed on developing engines with low
noise characteristics; in addition, the power plants are required to
conform to EPA 1979 pollutant emission standards. Thrust
performance, fan design, and thrust-to-weight ratio are discussed for
both the over-the-wing and under-the-wing engine configurations under study.
J.M.B.

A78-23891 * The application of the Routh approximation
method to turbofan engine models. W. C. Merrill (NASA, Lewis
Research Center, Cleveland, Ohio). In: Joint Automatic Control
Volume 2 (A78-23891 08-63) New York, Institute of Electrical
The Routh approximation technique is applied in the frequency
domain to a 18th order state variable turbofan engine model. The
results obtained motivate the extension of the frequency domain
formulation of the Routh method to the time domain to handle the
state variable formulation directly. The time domain formulation is
defined and a new characterization, which specifies all possible
Routh similarity transformations, is given. This characterization is
computed by the solution of two eigenvalue-eigenvector problems.
The application of the time domain Routh technique to the state
variable engine model is described and some results are given.
Additional computational problems are discussed including an
optimization procedure which can improve the approximation
accuracy by taking advantage of the transformation characterization.
(Author)

A78-23892 * Minimum-time acceleration of aircraft turbofan
engines. F. Teran (NASA, Lewis Research Center, Cleveland,
Ohio). In: Joint Automatic Control Conference, San Francisco,
New York, Institute of Electrical and Electronics Engineers, Inc.,
1977, p. 1026-1037. 12 refs.
Minimum-time accelerations of the F100 turbofan engine are
presented. A piecewise-linear engine model, having three state
variables and four control variables, is used to obtain the minimum-
time solutions. This linear model, which yields a given time in
the trajectory is determined by calculating a normalized 'distance' from
the current state to the equilibrium state associated with each linear
model. The linear model associated with the closest equilibrium
point is then used. The control histories for the minimum-time
solutions are used as input to a nonlinear simulation of the F100
engine to verify the accuracy of the piecewise-linear solutions.
(Author)

A78-23807 * Design of turbofan engine controls using output-
feedback regulator theory. W. C. Merrill (NASA, Lewis Research
Center, Cleveland, Ohio). In: Joint Automatic Control Conference,
(A78-23891 08-63) New York, Institute of Electrical and Electronics
A multivariable control design procedure based on output
feedback regulator (OFR) theory is applied to the F100 turbofan
engine. Results for the OFR design are compared to a design based
on linear quadratic regulator (LQR) theory. The OFR design
was obtained as part of the F100 Multivariable Control Synthesis
(MVCS) program. In the MVCS program the LQR feedback
control was designed to reduce the uncontrolled and, then applied to
the original system. However, the OFR feedback control is designed
in the full order state space and thus eliminates any need for model
reduction techniques. Using the performance measure and control
structure of the MVCS program LQR design, an equivalent OFR
feedback control is obtained. The flexibility of the OFR as a control
design procedure is demonstrated and differing feedback control
structures are evaluated.
(Author)

A78-24877 * Noise of deflectors used for flow attachment
with STOL-OTW configurations. U. von Giezen and D. Grosebeck
(NASA, Lewis Research Center, Cleveland, Ohio). Acoustical
Society of America, Meeting, 94th, Miami Beach, Fla., Dec. 13-16,
Future STOL aircraft may utilize engine-over-the-wing (OTW)
installations in which the exhaust nozzles are located above and
separated from the upper surface of the wing. An external jet-
deflector can be used with such installations to provide flow
attachment to the wing/planform surfaces for lift augmentation. In
the present work, the deflector noise in the flow mixer plane measured
with several model-scale nozzle-deflector-lng configurations is examined.
The deflector-attached noise is correlated in terms of velocity and
geometry parameters. The data also indicate that the effective overall
sound pressure level of the deflector associated noise peaks in
the forward quadrant near 40 deg from the inlet axis.
(Author)

A78-24878 * Combustor fluctuating pressure measurements:
in-engine and in a component test facility - A preliminary
comparison. M. Replu, W. A. Karchmar (NASA, Lewis Research
Center, Cleveland, Ohio). Acoustical Society of America, Meeting,
Combustor internal fluctuating pressure and far-field noise
generated in a YF-102 turbofan engine are investigated; combustor
internal measurements are also made in a duct-component test
facility operating over a range of conditions encompassing those
characteristic of the aircraft engine. Although directly measured
spectra for the engine and test facility show considerable
discrepancies, the results of coherence function, transfer function
and phase relationship comparisons suggest that the internal
dynamics of the combustor at sonic source may be preserved in
a component test facility.
J.M.B.

A78-24479 * An empirical model for inverted-velocity-
profile jet noise prediction. J. R. Stone (NASA, Lewis Research
Center, Cleveland, Ohio). Acoustical Society of America, Meeting,
It is known that the noise generated by inverted velocity-profile
nozzles (without center plug) and co-rotating (with center plug)
nozzles should be modeled as the combined contributions of various
source regions and noise generation mechanisms. In this paper, an empirical noise-prediction model is described which considers the noise generated by two jet-mixing regions and two potential regions of shock/turbulence interaction. Results calculated from the empirical model are compared with model-scale experimental data for static and simulated flight conditions. These comparisons are made for cases where both streams are subsonic, where the outer stream is supersonic with the inner stream subsonic, and where both streams are supersonic. The case considered covers a range of inner-to-outer-stream area ratios and includes both coaxial and conical nozzle geometries. It is shown that the model gives reasonable predictions of absolute noise spectra and even better predictions of incremental changes.

S.D.


A hot-wire inlet flow control device was tested on a 50.8 cm. (20-inch) diameter fan stage in the NASA-Lewis Anechoic Chamber. The control device used honeycomb and wire mesh to reduce turbulence intensities entering the fan. Fan field acoustic power level results showed about a 5 dB reduction in blade passing tone and about 10 dB reduction in multiple tone sound power at 90% design fan speed with the inlet device in place. Hot film cross probes were inserted in the inlet to obtain data for two components of the turbulence at 65 and 50% design fan speed. Without the flow control device the axial intensities were below 1.0%, while the circumferential intensities were almost twice this value. The inflow control device significantly reduced the circumferential turbulence intensities and also reduced the axial length scale. (Author)


A multivariable control design procedure based on the output feedback regulator formulation is described and applied to an F106 turbofan engine model. Full order model dynamics, are incorporated in the example design. The effect of actuator dynamics on closed loop performance is investigated. Also, the importance of turbine inlet temperature as an element of the dynamic feedback is studied. Step responses are given to indicate the improvement in system performance this control. Calculation times for all experiments are given in CPU seconds for comparison purposes. (Author)


A review is presented of non-turbine general aviation engine programs underway at the NASA-Lewis Research Center in Cleveland, Ohio. The program encomposses conventional, lightweight diesel and rotary engines. Its three major thrusts, are in order of priority: (1) reduced SFCs; (2) improved fuels tolerance; and (3) reducing emissions. Current and planned future programs in such areas as lean operation, improved fuel management, advanced cooling techniques, and advanced engine concepts, are discussed. These are expected to lay the technology base, by the mid to later 1980s for engines whose total fuel costs are as much as 30% lower than today's conventional engines. (Author)


A scanning radiometer was used to determine the effect of airstream velocity on the mean drop diameter of water sprays produced by pressure atomizing and air atomizing fuel nozzles used in previous combustion studies. Increasing airstream velocity from 23 to 53.4 meters per second reduced the Sauter mean diameter by approximately 50 percent. Test conditions included airstream velocities of 23 to 53.4 meters per second at 293 K and atmospheric pressure. (Author)


Survey of gas path seals is presented with particular attention given to sealing clearance effects on engine component efficiency. The effects on compressor pressure ratio and stall margin are pointed out. Various case-rotor relative displacements, which affect gas path seal clearances, are identified. Forces produced by nonuniform sealing clearances and their effect on rotor stability are discussed qualitatively, and recent work on turbine-blade sealing for high temperatures is described. The need for active clearance control and for engine structural analysis is discussed. The functions of the internal-flow system and its seals are reviewed. (Author)


A description is presented of some of the recent advances in the technology of turbofan engine noise reduction, taking into account turbomachinery noise sources, new fans for low noise, fan and core noise suppression, and a new program for improving static noise testing of fans and engine. The problem of jet noise has been substantially reduced in connection with the lower jet velocities employed in the case of the high bypass turbofan engines. The dominant noise sources are now related to the turbomachinery with the fan stage, the compressor, and the turbine. Since the fan stage is the primary source of turbomachinery noise, it has been considered in a major part of the investigations designed to reduce turbofan engine noise. G.R.


The effect of flight on jet engine exhaust noise has often been presented in terms of a relative velocity exponent, n, as a function of radiation angle. The value of n is given by the OASPL reduction due to relative velocity divided by 10 times the logarithm of the ratio of relative jet velocity to absolute jet velocity. It is shown in this paper that the exponent n is positive for pure subsonic jet mixing noise and varies, in a systematic manner, as a function of flight conditions and jet velocity. On the basis of calculations, empirical models for jet mixing noise, shock noise and internally-generated noise, it is shown that when other sources are present, the resulting range of n is increased over the range for jet mixing noise; and in some cases negative values of n are obtained. (Author)

NASA aims at developing propulsion technology to reduce fuel consumption of existing engines by 9%, that of new engines of the late 1980s by at least 12%, and that of an advanced early 1990s turbojet by an additional 15%. This paper reviews three separate NASA programs which take up these aims: They are, respectively, Engine Component Improvement, Energy Efficient Engine, and Advanced Turbojet.


In 1976 NASA initiated the Aircraft Energy Efficiency (ACEE) Program to assist in the development of new fuels for aircraft for commercial airline use. The Energy Efficient Engine (EEE) Project of the ACEE program is intended to carry the advanced technology foundation for a new generation of turbofan engine. This project, planned as a seven-year cooperative government-industry effort, is aimed at developing and demonstrating advanced component and systems technologies for engines that could be introduced into airline service by the late 1980s or early 1990s. In addition to fuel savings, new engines must offer potential for being economically attractive to the airline users and environmentally acceptable. A description is presented of conceptual energy-efficient engine designs which offer potential for achieving all of the goals established for the EEE project. G.R.


An update of non-turbine general aviation engine programs underway at the NASA Lewis Research Center in Cleveland, Ohio. The program encompasses conventional, lightweight diesel and rotary engines. Its three major thrusts are: (a) reduced SFC's, (b) improved fuels tolerance, and (c) reducing emissions. Current and planned future programs in such areas as lean operation, improved fuel management, advanced cooling techniques and advanced engine concepts, are described. These are expected to lower the technology base, by the mid to late 1980's, for engines whose life cycle fuel costs are 30 to 50% lower than today's conventional.


A Lamblly combustor liner has been designed, fabricated and tested in a combustor at pressures up to 8 atmospheres. The liner was fabricated of three layers Lamblly structure and configured to replace a conventional step-lower liner. The liner will be used in a combustor that provides hot gases to a turbine cooling test facility at pressures up to 40 atmospheres. The Lamblly liner was tested extensively at lower pressures and demonstrated lower metal temperatures than the conventional liner, while at the same time requiring about 40 percent less cooling air flow. Tests conducted at combustion exit conditions in excess of 2200 K have not indicated any cooling or durability problems with the Lamblly liner. (Author)


Three combustor concepts have been designed and tested to demonstrate significant reductions in aircraft engine idle pollutant emissions. Each concept used a different method for pollutant reduction: the Hot Wall Combustor employs a thermal barrier coating and improved cooled liners, the Recuperative Cooling Combustor preheats the air before entering the combustion chamber, and the Catalytic Combustor Concept includes a conventional primary zone followed by a catalytic bed for pollutant cleanup. The designs are discussed in detail and test results are presented for a range of aircraft engine idle conditions. The results indicate that ultra-low levels of unburned hydrocarbons and carbon monoxide emissions can be achieved with this technology. (Author)


The Engine Component Improvement (ECI) Program in initiated in connection with projects designed to reduce the impact of the world-wide energy crisis in the area of aviation. The two parts of the ECI program have the overall objective to identify and quantify the sources and causes of CF6 engine performance deterioration, and to reduce the fuel consumption of CF6 engines through the development and the incorporation of various performance improvement concepts. The CF6 high-bypass turbofan engine was selected as a basis for this effort, since it is expected to be a significant fuel use in commercial service for the next 15 to 20 years. The first part of the ECI program represents the initial step in an effort to achieve a goal of five percent reduction in fuel use for CF6 engines in the 1979-82 time period. The first performance improvement concept selected is an improved efficiency fan blade. Other improvements are related to a short core exhaust system and an improved high pressure turbine. G.R.

A76-44652 # NASA engine system technology programs - An overview. H. W. Johnson (NASA, Ames Research Laboratory, Washington, D.C.) and K. E. Conrad (NASA, Lewis Research Center, Energy Conservation Engine Office, Cleveland, Ohio). American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978. AIAA Paper 78-929. 5 p. The various propulsion system technology programs are examined. The Stratophysic Cruise Emission Reduction program has the objective to explore and demonstrate advanced technology fuel preparation and combustion systems which produce very low emission levels, particularly with respect to the oxides of nitrogen, during high altitude cruising flight. Other programs considered include the Quiet, Clean, General Aviation Turboprop program, the Variable Cycle Engine Technology program, the Helicopter Transmission Technology program, the Broad Specification Fuels Technology program, the Engine Component Improvement program, the Advanced Turboprop Technology program, the Supersonic Cruise Propulsion Technology program, the Materials for Advanced Turboprop engines program, and the Aerodynamic of Supersonic Engines program. G.R.
R78-108082/2 TRW, Inc., Cleveland, Ohio
(NASA CR-135203, TRW IER-7330) Avas NTIS
HC A08/MF A01 CSCL 21E
A rigorous analysis was conducted to estimate relative manufacturing costs for high technology gas turbine blades processed by three computer-aided processes systems. The manufacturing costs for the same turbine blade configuration of directionally solidified castin toolkit, an oxide dispersion strengthened alloy, and a fiber reinforced superalloy were computed on a relative basis to the costs of the same blade currently in production utilizing the directionally solidification process. An analytical process cost model was developed to quantitatively perform the cost comparisons. The impact of individual process yield factors costs were also assessed as well as effects of process parameters, raw materials, labor rates and consumable items. Author

R78-108083/2 Douglas Aircraft Co. Inc., Long Beach Calif EFFECT OF FORWARD MOTION ON ENGINE NOISE
(NASA CR 134054 A MIDC-J70B) Avas NTIS
HC A08/MF A01 CSCL 20A
Methods used to determine a procedure for correcting static engine data for the effects of forward motion are described. Data were analyzed from airplane flyover and static engine tests with a JT8D-109 low-bypass-ratio turbofan engine installed on a DC-9-30, with a CF6-6D high-bypass-ratio turbofan engine installed on a DC-10-10, and with a JT8D-5A high-bypass-ratio turbofan engine installed on a DC-10-40. The observed differences between the static and the flyover data bases are discussed in terms of noise generation, convective amplification, atmospheric propagation, and engine installation. The results indicate that each noise source must be analyzed separately for forward motion and installation effects and then projected to flight conditions as a function of source-path angle, directivity angle, and acoustic range relative to the microphones on the ground. Author

R78-11002/2 Pratt and Whitney Aircraft Group, West Hartford Conn Commercial Products Div
ADVANCED SUPERSONIC PROPULSION STUDY: PHASE 1 Final Report, R. A. Howlett Sep 1977 109 p
(Contract NAS3 19540)
(NASA CR 135273 PWA 5547 4) Avas NTIS
HC A06 MF A01 CSCL 21E
Installation characteristics for a Variable Stream Control Engine (VSCME) were studied for three advanced supersonic airplane designs. Sensitivity of the VSCM concept to change in technology projections was evaluated in terms of impact on overall installed performance. Based on these sensitivity results critical technology requirements were reviewed in light of the reaffirmation of the following requirements: low noise nose cone system; high performance low emissions duct burner and main burner; hot section technology; variable geometry components and propulsion integration features including an integrated electronic control system. Author

R78-11001/2 General Electric Co., Cincinnati, Ohio
COST BENEFIT STUDY OF ADVANCED MATERIALS TECHNOLOGY FOR AIRCRAFT TURBINE ENGINES
R. V. Helfray and R. P. Johnston Sep 1977 89 p refs (Contract NAS3 20074)
(NASA CR 135235) Avas NTIS HC A05 MF A01 CSCL 21E
The cost benefits of eight advanced materials technologies were evaluated for two aircraft missions. The overall study was based on a time frame of commercial engine use of the advanced material technologies by 1985. The material technologies evaluated were as follows: turbine blades, transient steam-shielded components, ceramic vanes, shrouds and combustor liners, tungsten composite FeCrAlAl yx, gamma prime oxide dispersion strengthened (ODS) alloy blades, and no cost (ODS) alloy combustor liners. They were evaluated in two conventional takeoff and landing missions, one transcontinental and one intracontinental. Author

R78-11002/2 Rocketdyne, Canoga Park, Calif
H. C. Deen and F. F. Kiley Nov 1977 236 p refs (Contract NAS3 20114)
(NASA CR 135231 PWA R1/DO77 170) Avas NTIS
HC A11/MF A01 CSCL 21A
Parametric data on split-combustor linear engine propulsion systems are presented for use in mixed mode single stage-to-orbit (SSTO) vehicle studies. Preliminary design data for two selected engine systems are included. The split combustor was investigated for mixed mode operation with two propellants used in the inner combustor in Module 2 and in conjunction with either oxygen/RF 1, oxygen/RU 5, O2/CH4 or O2/H2 propellants in the outer combustor for Module 1. Both gas-generator and staged combustion power cycles were analyzed for providing power to the turbopumps of the inner and outer combustors. Numerous cooling circuits and cooling fluid propellants were analyzed and hydrogen was selected as the preferred coolant for both combustors and the linear aerospace nozzle. The maximum operating chamber pressure was determined to be limited by the availability of hydrogen coolant pressure drop in the coolant circuit. Author

R78-12001/2 Pratt and Whitney Aircraft Group, West Palm Beach, Fla Government Products Div
EVALUATION OF A LOW ASPECT RATIO SMALL AXIAL COMPRESSOR STAGE, VOLUME 1 Final Report
C. W. Sawyer, Ill Nov 1977 148 p refs (Contract NAS3 19424)
(NASA CR 135240 PWA FR 8499 Vol 1) Avas NTIS
HC A07 MF A01 CSCL 21E
A program was conducted to evaluate the effects of scaling-tip clearance and IGV reset on the performance of a low aspect ratio compressor stage. Stage design was obtained by scaling an existing single stage compressor with a linear factor of 3.04. The design objective was to maintain the minimum engine fan performance of the base machine in the smaller size. Adjustments were made to account for predicted blockage differences and to chord lengths and airflow ratio to obtain reasonable blade geometries. Measurements velocity diagrams of the base stage were not maintained at the scaled size. At design speed and flowrate the scaled stage achieved a pressure ratio of 1.423 with an adiabatic efficiency of 0.822 and surge margin of 18.5%. The corresponding performance parameters for the base stage were 1.480, 0.872 and 22.2% respectively. The base stage demonstrated a peak efficiency at design speed of 0.872 the scaled stage achieved a level of 0.838. When the scaled stage rotor and stator tip clearances were doubled the stage achieved a pressure ratio of 1.413 efficiency of 0.799 and surge margin of 16.0% at the design flowrate. The peak stage efficiency at design speed was 0.825 with the increased clearance increased peakwidth lowered the stage pressure ratio as expected. Stage efficiency was maintained with ten degrees of increased peakwidth and decreased substantially with ten additional degrees of reset. Author
A digital computer simulation of a mixed flow, two spool, turbofan engine was assembled to evaluate and improve the dynamic characteristics of the engine simulation to disturbance frequencies of at least 100 Hz. One dimensional forms of the dynamic mass, momentum and energy equations were used to model the engine. A TF30 engine was simulated so that dynamic characteristics could be evaluated against results obtained from testing of the TF30 engine at the NASA Lewis Research Center. Dynamic characteristics of the engine simulation were improved by modifying the compression system model. Modifications to the compression system model were established by investigating the influence of size and number of finite dynamic elements. Based on the results of this program, high frequency engine simulations using finite dynamic elements can be assembled so that the engine dynamic configuration is optimum with respect to dynamic characteristics and computer execution time. Resizing of the compression system finite elements improved the dynamic characteristics of the engine simulation but showed that additional refinements are required to obtain close agreement simulation and actual engine dynamic characteristics.

Author

**877-13088**

General Electric Co., Cincinnati, Ohio Aircraft Engine Group

**ADVANCED SUPERSONIC PROPULSION STUDY. PHASES 3 AND 4**


Advanced propulsion concepts for supersonic cruise aircraft are identified in the identification of the double bypass variable cycle engine as a promising concept. Conceptual design studies were conducted and an annual exhaust nozzle to provide high takeoff thrust and low jet noise. The engine also provides good performance at both supersonic cruise and subsonic cruise speeds. Conceptual design studies are presented. The advanced technology double bypass variable cycle engine was evaluated for an improvement in aircraft range performance relative to earlier supersonic jet engine designs and yet at a lesser level of engine noise. Research and development programs required in certain design areas for this engine concept to realize its potential benefits include refined parametric analysis of selected variable cycle engine concepts, screening of advanced unconventional concepts and engine preliminary design studies. Required critical technology programs are summarized.

Author

**877-14847**


**WIDE RANGE OPERATION OF ADVANCED LOW NOx COMBUSTORS FOR SUPERSONIC HIGH-ALTITUDE AIRCRAFT GAS TURBINES**


P. B. Roberts and R J Froeha Oct 1977 44 p

An initial rig program tested the jet induced Circulation LIFCI and Vortex Air Blist (VAB) systems in small can combustor configurations for NOx reductions at a simulated high altitude supersonic cruise condition. The VAB combustor demonstrated the capability of meeting the NOx goal of 1.0 g NOx/kg fuel at the cruise condition. In addition, the program served to demonstrate the limited low-emissions range available from the lean premixed combustor. A follow-on effort was concerned with the problem of operating these lean premixed combustors with acceptable emissions at simulated engine idle conditions. Various techniques have been demonstrated that allow satisfactory operation on both the JIC and VAB combustors at idle with NOx emissions below 20 g NOx/kg fuel. The VAB combustor was limited by flashback due to droplet sizes that cause NOx emissions at the cruise conditions to a pressure of 8 atmospheres. The JIC combustor was operated up to the full design cruise pressure of 14 atmospheres without encountering an autoignition limitation, although the NOx levels in the 2.5 g NOx/kg fuel range exceeded the program goal.

Author

**877-15041**

Pitts and Whitney Aircraft Group, East Hartford, Conn.

**EXPERIMENTAL CLEAN COMBUSTOR PROGRAM: TURBULENCE CHARACTERISTICS OF COMPRESSOR DISCHARGE FLOWS**


The results of turbulence measurements at the entrance to the small duct of the large gas turbine are presented. The measurements were conducted over a compressor discharge temperature range of 450K to 608K. It was found that the turbulent intensity at the I/D location increases from 8.1 to 1.7 percent at 10 percent at approach. The turbulent intensities at the OD location increases from 7.5 to 0.5 percent at 15.0 percent at approach. The energy in the velocity waves is...
ANALYTICAL STUDY OF THERMAL BARREL COATED FIRST-STAGE BLADES IN AN F100 ENGINE Progress Report, 1 Sep. 1977 - 31 Jan. 1978
D E Andresen Feb 1978 27 p
(Contract NAS6-21033)
(NASA-CR-135360; PWA 5590) Avail NTIS HC A03/MF A01 CSCL 21E

Heat transfer and stress analyses were performed on two sections of a thermal barrier coated (TBC) F100 1st stage turbine blade. Results of the analyses indicate that the TBC on the leading edges of both sections experience the highest elastic strain ranges and these occur during transient engine operations. Further study is recommended to determine the effects of plastic deformation (creep) and creep-fatigue interaction on coating life.

Author

978-170987* Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
H L Stevens Feb 1978 171 p ref.
(Contract NAS6-20808)
(NASA-CR-135292; PWA 5554 3) Avail NTIS HC A08/MF A01 CSCL 21E

Nozzle and cooling methods were defined and analyzed to provide a viable system for demonstration of 2-D nozzle technology on the F-15 aircraft. Two candidate cooling systems applied to each nozzle were evaluated. The F-100 engine model and case modifications were analyzed and the actuators and control system requirements for two-dimensional nozzles were defined. Nozzle performance changes relative to the asymmetric baseline nozzle were evaluated and performance and weight characteristics for axisymmetric reference configurations were estimated. The infrared radiation characteristics of these nozzles installed in the F-100 engine were predicted. A full scale development plan with associated costs to carry the F-100 engine/two-dimensional (2-D) nozzle through flight tests was defined.

Author
R78-19163\textsuperscript{2} Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.

**ABSTRACT**

CROSS FLOW IN A RADIAL INFLOW TURBINE SCROLL

A. Hamad, S. Abdallah, and W. Tabakoff Nov. 1977 61 p

(Grant No. 30464)


Equation of motion were derived, and a computational procedure was presented for determining the nonviscous flow characteristics in the cross-sectional planes of a curved channel due to continuous mass discharge or mass addition. An analysis was applied to the radial inflow turbine scroll to study the effects of scroll geometry and the flow of flow velocity profile on the flow behavior. The computed flow velocity component in the scroll cross-sectional plane, together with the through flow velocity profile which could be determined in a separate analysis, provided a complete description of the three-dimensional flow in the scroll.

Author

R78-19164\textsuperscript{2} Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.

**COMPUTER PROGRAM FOR THE ANALYSIS OF THE CROSS FLOW IN A RADIAL INFLOW TURBINE SCROLL**

A. Hamad, S. Abdallah, and W. Tabakoff Nov. 1977 56 p

(Grant No. 30856)


A computer program was used to solve the governing of the potential flow in the cross sectional planes of a radial inflow turbine scroll. A list of the main program: the subroutine and typical output example are included.

Author

R78-19160\textsuperscript{2} Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.

**VCE TESTED PROGRAM PLANNING AND DEFINITION STUDY**

J. S. Westmoreland and J. Godston Jan 1978 82 p

(Contract NAS3-201-28)

(NASA CR-135582: PWA 5548-7) Avail NTIS HC AO5/MF AO1 CSCL 21E

The flight definition of the Variable Stream Control Engine (VSC) was updated to reflect design improvements in the two key components: (1) the low emissions duct burner, and (2) the coaxial exhaust nozzle. The testbed design was defined and plans for the overall program were formulated. The effect of these improvements was evaluated for performance, emissions, noise, weight, and length. For experimental large scale testing of the duct burner and coaxial nozzle, a design definition of the VCE testbed configuration was made. The selected design core engine, instrumentation requirements, and selecting the test facilities in addition to defining control system and assembly requirements. Plans for a comprehensive test program to demonstrate the duct burner and nozzle technologies were formulated. The plans include both aeroacoustic and emissions testing.

Author

R78-21111\textsuperscript{2} Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.

**EVALUATION OF FEDERAL AVIATION ADMINISTRATION AIGN ENGINE ENVIRONMENT SAMPLING RACE Final Report**


(Contract NAS3-19447: DOT-FAG01-708)


A FAA exhaust emissions rate was tested in the Experimental Clean Combustor Program, Phase 3 to permit comparison of the values of gaseous emissions and smoke measured by the FAA rate with those measured with the NASA Pratt and Whitney Aircraft (P&WA) rate used in the Phase 3 Experimental Clean Combustor Program and with nitrogen oxides. The results showed that the levels of NOx and NO are lower than those measured by the FAA rate at high power and that NOx emissions measured by the FAA rate are significantly higher than those measured by the NASA/P&WA rate at low power.

Author


**EFFECTS OF FUEL INJECTION ON PERFORMANCE OF A COOLED TURBINE**

J. H. McDonald and James E. Eisewirth In AIAA/ASD High Temp. Protol in Gas Turbine Eng. Feb. 1978 11 p refs (For availability see R78-21118 12-07)

(Contract NAS3-10732) Avail NTIS HC ACA/AC AO1

Tests were conducted in a 20 inch diameter single stage air cooled turbine designed to evaluate the effects of film cooling on turbine performance. The results are used to determine the effects of film cooling on overall engine performance for selected cycle conditions. The engine performance studies are used to show the cycle benefits of increased gas temperature at various coolant flow rates.

Author

R78-22080\textsuperscript{2} Pratt and Whitney Aircraft Group, East Hartford, Conn.

**F100C3 PARALLEL COMPRESSOR COMPUTER CODE AND USER'S MANUAL**

Contractor Report, Mar. 1977 - Feb. 1978


(Contract NAS3-20810)

(NASA CR-135588: PWA 5548-9) Avail NTIS HC AO4/MF AO1 CSCL 21E

The Pratt & Whitney Aircraft multiple segment parallel compressor model has been modified to include the influence of variable compressor vane geometry, on the sensitivity to circumferential flow distortion. Further, performance characteristics of the F100 (3) compressor stage have been incorporated into the model on a blade row basis. In this modified form, the distortion at the upstream location is calculated using empirical relations relative to the variable vane controlling sensors of the F100 (3) engine so that the proper solution can be obtained regardless of distortion orientation. This feature is particularly important for the analysis of inlet temperature distortion. Compatibility with fixed geometry compressor applications has been maintained in the model.

Author
High-bypass turbofan engines with features required for commercial short haul powered lift transports were designed. Two engines were configured for each of the externally blown flap installations, under-the-wing and over-the-wing. Estimates of installed and uninstalled performance, noise, and weight were defined for each propulsion system.

Author


The development of the plasma sprayed graded, layered ZrO2/CoCrAlY seal system for gas turbine engine blade tip seal applications up to 1589 K (2400 °F) surface temperature was continued. The effect of changing ZrO2/CoCrAlY ratios in the intermediate layers on thermal stresses was evaluated analytically with the goal of identifying the materials combinations which would minimize thermal stresses in the seal system. Three methods of inducing compressive residual stresses in the sprayed seal materials to offset tensile thermal stresses were analyzed. The most promising method, thermal prestraining, was selected based upon potential feasibility and complexity considerations. The plasma spray equipment was modified to heat control and monitor the substrate temperature during spraying. Specimens were fabricated and experimentally evaluated to (1) substantiate the capability of the thermal prestrain method to develop compressive residual stresses in the sprayed structure and (2) define the effect of spraying on a heated substrate on abradability, erosion and thermal shock characteristics of the seal system. Thermal stress analysis including residual stresses and material properties variations, was performed and correlated with thermal shock test results. Seal system performance was assessed and recommendations for further development were made.

Author


Emissions of NOx, CO, and unburned hydrocarbons (UHC) are reported for a lean premixed propane air system at inlet conditions of 0.005 and 1.0MPa using twelve flameholder designs. The flameholders tested represent six design concepts with two values of blockage for each concept. Data were obtained at reference velocities of 35 m/s, 25 m/s and 20 m/s at combustor stations 10 cm and 30 cm downstream of the flameholders. Flameholder pressure drop was found to be a principal determinant of emissions. Designs producing larger pressure drops also produced less NOx, CO, and UHC emissions. The lean stability limit equivalence ratio was found to be approximately 0.35 for all designs. Flashback velocities (loss components in the flameholders) were varied between 30 m/s and 40 m/s. A perforated plate flameholder was operated with a velocity as low as 23 m/s through the perforations at equivalence ratio 0.7 without production flashback.

Author


The feasibility of measuring JTBD propulsion system flight inertia loads on a 747 airplane is studied. Flight loads background is discussed including the current status of JETBD loads knowledge. An instrumentation and test plan is formulated for an airline-owned in-service airplane and the Boeing-owned RA001 test airplane. Technical and cost comparisons are made between these two options. An overall technical feasibility evaluation is made and a cost summary presented. Conclusions and recommendations are presented in regard to using existing inertia loads data versus conducting a flight test to measure inertia loads.

Author


A program was conducted to develop an innovative digital output interface device, a digital effector with optical feedback of the fuel metering valve position, for future electronic controls for gas turbine engines. A digital effector (on-off solenoids driven directly by on-off signals from a digital electronic controller) with optical position feedback was fabricated coupled with the fuel metering valve and tested under simulated engine operating conditions. The testing indicated that a digital effector with optical position feedback is a suitable candidate, with proper development for future digital electronic gas turbine controls. The testing also identified several problem areas which would have to be overcome in a final production configuration.

Author


Acoustic data arc presented scaled to a full size engine by a factor of 8 on a 98.9 in (250 ft) arc and a 731.5 in (1200 ft) sideline.

D.L.G.


Acoustic data plots are presented which were obtained in the tests on scale nozzles for use on duct-burning turbofan engines.

D.L.G.
ACOUSTIC TESTS OF DUCT-BURNING TURBOPAN JET NOISE SIMULATION: COMPREHENSIVE DATA REPORT. VOLUME 2: MECHNICAL DESIGN AND AERODYNAMIC TEST RESULTS Final Report

The selection procedure is described which was used to arrive at the configurations tested, and the performance characteristics of the test nozzles are given. D.L.G.

N78-29958f General Applied Science Labs., Inc., Westbury, N.Y.
EXPERIMENTAL STUDY OF THE EFFECT OF CYCLE PRESSURE ON LEAN COMBUSTION EMISSIONS Final Report

Experiments were conducted in which a stream of premixed propane and air was burned under conditions representative of gas turbine operation. Emissions of NOx, CO, and unburned hydrocarbons (UHC) were measured over a range of combustor inlet temperature, pressure, and residence time at equivalence ratios from 0.7 down to the lean stability limit. At an inlet temperature of 600 K, observed NOx levels dropped markedly with decreasing pressure for pressures below 20 atm. The NOx levels are proportional to combustor residence time and formation rates were principally a function of adiabatic flame temperature. For adiabatic flame temperatures of 2050 K and higher, CO reached chemical equilibrium within 2 msec. Unburned hydrocarbon species dropped to a negligible level within 2 msec regardless of inlet temperature, pressure, or equivalence ratio. For a combustor residence time of 2.5 msec, combustion inefficiency became less than 0.01% at an adiabatic flame temperature of 2050 K. The maximum combustion efficiency observed was on the order of 1% and corresponded to conditions near the lean stability limit. Using a perforated plate flameholder, this limit is well represented by the condition of 1800 K adiabatic flame temperature. Author


A baseline compressor test stage was designed as well as a candidate rotor and two candidate stators that have the potential of reducing endwall losses relative to the baseline stage. These test stages are typical of those required in the rear stages of advanced, highly-loaded core compressors. The baseline stage A is a low-speed model of Stage 7 of the 10-stage AMAC compressor. Candidate Rotor B uses a type of meanline in the tip region that unloads the leading edge and loads the trailing edge relative to the baseline Rotor A design. Candidate Stator B embodies twist gradients in the endwall region. Candidate Stator C embodies airol sections near the endwalls that have reduced trailing edge loading relative to Stator A. Tests will be conducted using four identical stages of blading so that the designs described will operate in a true multistage environment. A.R.H.

LONG-TERM CFR ENGINE PERFORMANCE DETERIORATION: EVALUATION OF ENGINE 8/M 42-390 Final Report

The performance testing and analytical teardown of CF6-6D engine serial number 461-380 which was recently removed from a DC-10 aircraft is summarized. The investigative test program was conducted in order to determine cause of failure, and the performance testing included an in-bound test, a test following cleaning of the low pressure turbine airfoils, and a final test after leading edge rework and clearance of the fan blades. The analytical teardown consisted of detailed disassembly inspection measurements and airfoil surface finish checks of the as-received deteriorated hardware. Aspects discussed include the analysis of the test cell performance data, a complete analytical teardown report with a detailed description of all observed hardware distress, and an analytical assessment of the performance loss (degradation) relating measured hardware conditions to losses in both specific fuel consumption and exhaust gas temperature. A.R.H.


The technical program was comprised of two technical tasks. Task 1 encompassed the preliminary boron/aluminum fan blade design effort. Two preliminary designs were evolved. An initial design concept involved the analysis of infinite element material properties extracted from manufactured blades. A final design of 36 blades per stage was based on rule-of-mixture material properties. In Task 2, the same type of design was refined using more sophisticated analytical tool. Detailed finite element stress analysis and zero performance analysis were carried out to determine blade material frequencies and directional stresses. L.S.

N78-29105f Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div. 

Short term engine deterioration occurs in less than 250 flights on a new engine and in the first few flights following engine repair. While long term deterioration involves primarily hot section distress and compression system losses which occur at a somewhat slower rate. The causes for short-term deterioration are associated with clearance changes which occur in the flight environment. Analytical techniques utilized to examine the effects of flight loads and engine operating conditions on performance deterioration are presented. The role of gyroscopic, gravitational, and aerodynamic loads are discussed along with the effect of variations in core build clearances. These analytical results are compared to engine test data along with the correlation between analytically predicted and measured clearances and rub patterns. Conclusions are drawn and important issues are discussed. A.R.H.
Aircraft Gas Turbine Low-Power Emissions Reduction Technology Program Final Report

(NASA-CR-155454; Doc R76AEG408) Avail: NTIS
HC A06/MF A01 CSCL 21E

Advanced aircraft turbine engine combustor technology was used to reduce low-power emissions of carbon monoxide and unburned hydrocarbons to levels significantly lower than those which were achieved with current technology. This combustor design concept, which was designated as the hot-wall liner concept, the recuperative-cooled liner concept, and the catalyst recoverer concept, were compared in an engine test with a test engine to determine which concept provided the best overall performance. The engine test equipment was designed to allow for the attainment of a maximum test time of 100 h with a fuel consumption of 10.6 kg/h. At the end of the test, the engine was fully intact and in excellent condition.


(NASA-CR-155454; Doc R76AEG408) Avail: NTIS
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In order to understand the propagation of broadband sound from a device such as a jet engine, it is necessary to make fluctuating pressure measurements in the ducted airstream. However, in a flowing duct, fluctuating pressure energy can be due to both turbulence and sound traveling in the duct. By using the principal that sound waves and turbulent flow pressure perturbations travel at different velocities, a probe has been developed that provides the necessary to separate the energy due to sound from that due to turbulence. A mini-computer based FFT analysis of the probe measurements provides the overall level of the broadband sound in the duct as well as the spectral distribution of the sound energy. (Author)


Linear optimal control theory is applied to the control synthesis of a high bypass ratio, variable pitch, turbofan engine. The basic control philosophy is to use only a low order dynamic model of the plant coupled with the concept of integral control states so as to maintain control simplicity yet guarantee integral control of thrust, turbine temperature, and other important engine outputs. Linear simulation results indicate that the control system developed provides rapid control of small thrust perturbations and quickly eliminates the effect of unmodelled thrust and temperature disturbances. Large thrust accelerations are obtained in about one half second while the control maintains negligible overshoot in temperature and stall margins. (Author)


In this paper, a failure detection and correction strategy for turbofan engines is discussed. This strategy allows continuing control of the engines in the event of a sensor failure. An extended Kalman filter is used to provide the best estimate of the state of the engine based on currently available sensor outputs. Should a sensor failure occur, the control is based on the best estimate rather than the sensor output. The extended Kalman filter consists of essentially two parts; a nonlinear model of the engine and an update logic which causes the model to track the actual engine. Details on the model and update logic are presented. To allow implementation, approximations are made to the feedback gain matrix which result in a single feedback matrix which is suitable for use over the entire flight envelope. The effect of these approximations on stability and response is discussed. Results from a detailed nonlinear simulation indicate that good control can be maintained even under multiple failures. (Author)


Some of the most dramatic increases in the performance of turbojet and turbofan aircraft engines have been obtained as result of increased thermodynamic cycle temperature made possible by the use of film cooling techniques. The realization of the potential performance gains, however, is only possible if the quantity of cooling air and the aerodynamic mixing losses resulting from the injection of coolant in the form of film on the flowpath surfaces are minimized. Such a minimization requires a more complete understanding of the relationship between cooling and aerodynamics. A review is conducted of tests which have been conducted to determine the effects of coolant injection on turbine performance. The results obtained in the tests are compared with an analytical technique developed for predicting coolant injection effects. Particular attention is given to the effects of turbine cooling on overall cycle thermodynamic efficiency, taking into account incremental changes in turbine thermodynamic efficiency for various incremental changes in coolant flow rate. G.R.


A review is conducted of improvements which can be made with respect to the fuel consumption of current engines and new production versions of current engines. A description is presented of an engine diagnostics program which has the objective to identify and quantify the causes and sources of performance deterioration in the JT9D turbofan engine and to develop basic data which will be applied to minimize performance degradation of current and future engines. General areas where performance losses occur are examined, taking into account seals, blades and vanes, and cases. Potential performance improvement concepts are related to improved component aerodynamics, improved flowpath sealing, blade tip clearance control, improved turbine cooling effectiveness, improved turbine materials and coatings, duct and nozzle aerodynamic refinements, nacelle aerodynamic refinements, forced exhaust mixers, advanced nacelle materials, and advanced fuel control. G.R.
A real time digital simulation of a STOL propulsion system was developed which generates significant dynamics and internal variables needed to evaluate system performance and aircraft interactions using manned flight simulators. The simulation ran at a real-to-execution time ratio of 8.8. The model was used in a piloted NASA flight simulator program to evaluate the simulation technique and the propulsion system digital control. The simulation is described and results shown. Limited results of the flight simulation program are also presented.

Author
09 RESEARCH AND SUPPORT FACILITIES (AIR)

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

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

N78-13077# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COMBUSTOR FLUCTUATING PRESSURE MEASUREMENTS IN-ENGINE AND IN A COMPONENT TEST FACILITY: A PRELIMINARY COMPARISON

In a program to investigate combustor noise, measurements were made with a YF-102 engine of combustor internal fluctuating pressure and far field noise. The relationship of far field noise to engine internal measurements was ascertained. The relationships between combustor internal measurements obtained in an engine and those obtained in a component test facility were established by using a YF-102 combustor, instrumented identically with that used in the engine tests. The combustor was operated in a component test facility over a range of conditions encompassing engine operation. A comparison of the directly measured spectra at corresponding locations in the two tests showed significant differences. The results of two point signal analyses within each combustor were similar for both tests, indicating that the internal dynamics of the combustor as an acoustic source are preserved in a component test facility.

Author

N78-15089# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

THE ERDA/LaRC PHOTOVOLTAIC SYSTEMS TEST FACILITY

A test facility was designed, built, and tested to provide a place where photovoltaic systems may be assembled and electrically configured to evaluate system performance and characteristics. The facility consists of a solar cell array of an initial 10-kW peak power rating; test hardware for several alternate methods of power conditioning, a variety of loads, an electrical energy storage system, and an instrumentation and data acquisition system.

Author


The QCSEE (Quiet, Clean Short-haul Experimental Engine) Program was initiated by NASA to develop and demonstrate propulsion system technology for an advanced commercial STOL aircraft. One of the specific technical objectives was to provide technology for digital electronic control of future commercial engines. An element of this technology development was to evaluate the digital control in a simulated flight environment. In this connection a simulation program was initiated to evaluate the QCSEE UTW (Under-the-Wing) digital control system over a range of conditions encountered in typical airport operations. The goal of the simulation effort was to derive a real time digital propulsion
12 ASTRONAUTICS (GENERAL)

For extraterrestrial exploration see 91 Lunar and Planetary Exploration.


Over 50 papers from the spacecraft charging conference are included on subjects such as: (1) geosynchronous plasma environment, (2) spacecraft miniatures, (3) spacecraft materials characterization, (4) spacecraft materials development, and (5) satellite design and test. For individual titles, see N78-10130 through N78-10182.


The transient event counter is described, defining its operational characteristics, and presenting the preliminary results obtained through the first 90 days of operation including the Spring 1976 eclipse season. The results show that the CTS was charged to the point where discharges have occurred. The discharge induced transients have not produced any anomalous events in spacecraft operation. The data indicate that discharges can occur at any time during the day without preference to any local time quadrant. The number of discharges occurring in the 1 sec sample interval are greater than anticipated. Author

N78-10136f National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ACTIVE CONTROL OF SPACECRAFT CHARGING ON ATS-5 & ATS-6. Carolyn K. Purvus. Robert O. Bartlett (NASA Goddard Space Flight Center), and Sherman E. DeForest (California Univ., La Jolla). In its Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 107-120 refs. (For availability see N78-10129 01-12) Avail. NTIS HC A98/MF AO1 CSDL 22B

Effects of spacecraft ground potential of active emission of charged particles are being investigated through experiments using the ATS-5 and ATS-6 spacecraft. Each spacecraft is equipped with ion engine neutralizer which emits low energy charged particles. Despite great differences in design between the two spacecraft, they attain similar potentials in similar environments. Therefore, effects on spacecraft potential of neutralizer operations can be used to compare the effects of operating the two different neutralizers (hot wire filament and plasma jet). The neutralizers on both spacecraft were operated in eclipse conditions. Results of these operations are presented and spacecraft responses compared. Author


A simulation facility was established to determine the response of typical spacecraft magnetic substorm environment and to evaluate instrumentation that will be used to monitor spacecraft system response to this environment. Space environment conditions simulated include the thermal vacuum conditions of space, solar simulation, geomagnetic substorm electron fluxes and energies, and the low energy plasma environment. Measurements for spacecraft material tests include sample currents, sample surface potentials, and the cumulative number of discharges. Discharge transients were measured by means of current probes and oscilloscopes and are verified by a photomultiplier. Details of this facility and typical operating procedures are presented. Author


The test specimens were spacecraft paints, silveryed Teflon, thermal blankets, and solar array segments. The samples, ranging in size from 300 to 1000 sq cm were exposed to monoenergetic electrons from 2 to 20 keV at a current density of 1 nA/sq cm. The samples generally behaved as capacitors with strong voltage gradient at their edges. The charging characteristics of the silveryed Teflon, Kapton, and solar cell covers were controlled by the secondary emission characteristic. Insulators that did not discharge were the spacecraft paints and the quartz fiber cloth thermal blanket sample. All other samples did experience discharges when the surface voltage reached -8 to -18 kV. The discharges were photographed. The breakdown voltage for each sample was determined and the average energy lost in the discharge was computed. Author


A one-dimensional model for charging of samples is used in conjunction with experimental data taken to develop material charging characteristics for silveryed Teflon. These characteristics are then used in a one-dimension model for charging in space to examine expected response. Relative charging rates as well as relative charging levels for silveryed Teflon and metal are discussed. Author


Saturates in geomagnetically quiet areas are experiencing operational anomalies. These anomalies are believed to be due to the environment charging the spacecraft surfaces to a point where discharges occur. In designing future satellites for long term operation at geosynchronous altitude, it is important that designers have a specification that will give the total time per year, the particle flux density and particle energies that their satellites can be expected to encounter in these substorm environmental conditions. The limited data currently available on the environmental conditions are used to generate the provisional specification given in this report. Author
N78-10174# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEVELOPMENT OF ENVIRONMENTAL CHARGING EFFECT MONITOR FOR OPERATIONAL SATELLITES c18
N. John Stevens, John C. Surman, and Frank D. Berkoepe. In its Proc. of the Spacecraft Charging Technical Conf. 24 Feb. 1977 p 745-751 refs (For availability see N78-10129 01-12)
Avai: NTIS HC A99/MF A01 CSCL 228

Design details and design goals are given of an instrumentation package to monitor the effects of the environmental charging of spacecraft surfaces on the systems of operational spacecraft.

Author

N78-10175# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VIKING AND STP P78-2 ELECTROSTATIC CHARGING DESIGNS AND TESTING c18
R. O. Lewis, Jr. In its Proc. of the Spacecraft Charging Technical Conf. 24 Feb. 1977 p 753-772 Lakewood, Colo. (For availability see N78-10129 01-12)
Avai: NTIS HC A99/MF A01 CSCL 228

The design provisions of the Viking and the P78-2 (SCATHA) vehicles and a mathematical analysis of the effect of arcing on typical interface circuits are given. Results of verification testing of the analysis are presented as well as vehicle testing for tolerance to arcing.

Author

N78-18078# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INTERACTION OF LARGE, HIGH POWER SYSTEMS WITH OPERATIONAL ORBIT CHARGED PEARLITE ENVIRONMENTS c19

A potentially hazardous spacecraft environment interaction is discussed: The interaction of large high voltage systems with low energy (less than 50 eV) plasmas which can result in loss of power and/or arcing was examined. The impact of this class of interactions on the environment of which the system is part may be severe at low orbits where the ambient plasmas are densest. Results of experimental work and predictions of simple analytical models were presented and their implications for design of space systems were reviewed.

Author

N78-27142# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION OF MEANS FOR PERTURBING THE FLOW FIELD IN A SUPERSONIC WIND TUNNEL c19

The development status of a device for generating atmospheric turbulence in supersonic inlet testing is summarized. Emphases are desired aerodynamic and oscillation capabilities of the device, and the techniques that were considered and their drawbacks.

G G

N78-27143# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN OF AN AIR EJECTOR FOR BOUNDARY-LAYER BLEED OF AN ACOUSTICALLY TREATED TURBOPROP ENGINE INLET DURING GROUND TESTING c19

An air ejector was designed and built to remove the boundary-layer air from the inlet of a turboprop engine during an acoustic ground test program. This report describes: (1) how

the ejector was sized; (2) how the ejector performed; and (3) the performance of a scale model ejector built and tested to verify the design. With proper acoustic insulation, the ejector was effective in reducing boundary layer thickness in the inlet of the turbofan engine while obtaining the desired acoustic test conditions.

Author

DYNAMIC MODELING OF SPACECRAFT IN A COLLISON: NE-BEAM PLASMA c19
(Contracts NAS3-20119; DAA001-76-C-0121)
Avai: NTIS HC A98/MF A01 CSCL 228

A new computational model is described which can simulate the charging of complex geometrical objects in three dimensions. Two sample calculations are presented. In the first problem, the capacitance to infinity of a complex object similar to a satellite with solar array paddles is calculated. The second problem concerns the dynamical charging of a conducting cube partially covered with a thin dielectric film. In this calculation, the photoemission results in differential charging of the object.

Author

N78-14062# General Dynamics/Convair, San Diego, Calif.
CONCEPTUAL DESIGN FOR SPACELAB TWO-PHASE FLOW EXPERIMENTS c19

KC-135 aircraft tests confirmed the gravity sensitivity of two phase flow correlations. The prime component of the apparatus is a 1.5 cm dia by 90 cm fused quartz tube test section selected for visual observation. The water-cabin air system with water recycle was a clear choice for a flow regime pressure drop test since it was used satisfactorily on KC-135 tests Freon-11 with neither overboard dump or with liquid-recycle will be used for the heat transfer test. The two experiments use common hardware.

The experimental plan covers 120 data points in six hours with mass velocities from 10 to 640 kg/sec sq m and qualities 0.01 to 0.64. The apparatus with pump, separator, storage tank and controls is mounted in a double spacelab rack. Supporting hardware, procedures, measured variables and program costs are defined.

Author

CONCEPTUAL DESIGN FOR SPACELAB POOL BOILING EXPERIMENT c19

A pool boiling heat transfer experiment to be incorporated with a larger two-phase flow experiment on Spacelab was designed to confirm or alter results of earth normal gravity experiments which indicate that the hydrodynamic puk and minimum pool boiling heat fluxes vanish at very low gravity. Twelve small sealed test cells containing water, methanol or Freon 113 and cylindrical heaters of various sizes are to be built. Each cell will be subjected to one or more 45 sec tests in which the surface heat flux on the heaters is increased linearly until the surface temperature reaches a limiting value of 500 C. The entire boiling process will be photographed in slow motion. Boiling curves will be constructed from thermocouple and electric input data for comparison with the motion picture records. The conduct of the experiment will require no more than a few hours of operator time.

Author
BTH-25108S / Business and Technical Systems, Inc
Seabrook, Md
SEP ECKLE-87 AND HALLEY RENDEZVOUS STUDIES AND
IMPROVED E/C MODEL IMPLEMENTATION IN HILTOP
Final Report
J. L. Horsewood and F. I. Mann Feb 1978 29 p refs
(Contract NAS3-20850)
(NASA CR-136414, BTR-TR-78-55-Pr-1) Avail. NTIS
HC A03/MF A01 CSCL 22A
Studies were conducted to determine the performance
requirements for projected state-of-the-art SEP spacecrafts
hosted by the Shuttle/US to perform a rendezvous with
the comet Halley and a rendezvous with the comet Encke during its
1777 apparition. The spacecraft model of the standard HILTOP
computer program was assumed. Numerical and graphical results
summarizing the studies are presented.

BTH-25108S / Business and Technical Systems, Inc.
Seabrook, Md.
HELICENTRIC INTERPLANETARY LOW THRUST TRAJECTORY
OPTIMIZATION PROGRAM. SUPPLEMENT 1.
PART 2 Final Report
F. I. Mann and J. L. Horsewood Feb 1978 103 p refs
(Contract NAS3-20850)
(NASA CR-136414-Agg. BTR-TR-78-54-Suppl-1-Pr-2) Avail
NTIS HC A06/MF A01 CSCL 22A
The improvements made to the HILTOP electric propulsion
trajectory computer program are described. A more realistic
propulsion system model was implemented in which various thrust
subsystem efficiencies and specific impulse are modeled as
variable functions of power available to the propulsion system.
The number of operating thrusters are staged, and the beam
current is selected from a set of five for fixed constant voltages.
Based upon the application of variational calculus, the constant
beam voltages may be optimized individually or collectively.
The propulsion system logic is activated by a single program input
key in such a manner as to preserve the HILTOP logic. An
analysis describing these features, a complete description of
program input quantities, and sample cases of computer output
demonstrating the program capabilities are presented.

Author
13 ASTRODYNAMICS

Includes powered and free-flight trajectories and orbit and launching dynamics.


The original 12 cm hexagonal magneto-electrostatic containment (MEG) discharge chamber described by Moore in 1968 has been optimized for argon and xenon operation. Argon mass utilization efficiencies of 65 to 77 percent were achieved at keep-up plus-main discharge energy consumptions of 244 to 422 eV ion respectively. Xenon performance of 65 to 96 percent mass utilization were realized at 203 to 350 eV/ion. The paper discusses the optimization process and test results. (Author)
14 GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)

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

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


A test facility is being prepared for a 10,000-hour mission profile test of multiple electric propulsion thrust subsystems. The facility will be capable of simultaneously operating three 2.5-kW, 30 cm mercury ion thrusters and their power processing. The facility will permit conduction of a program of long-term tests to document thruster characteristics as a function of time and operating point to allow prediction of thruster performance for any mission profile. The thruster will be tested in a 7m by 10m vacuum chamber. Each thruster will be installed in a separate lock chamber so that it can be extended into, or extracted from, the main chamber without violating the vacuum integrity of the other thrusters. The thrusters will exhaust into a 5m by 5m frozen mercury target. The target and an array of cryopanels to collect sputtered target material will be liquid nitrogen chilled. Power processing units will be tested in an adjacent 1.5m by 2m vacuum chamber and will be temperature controlled by simulated heat pipes.

(Author)


This study of advanced electromagnetic ion thrusters for space propulsion was initiated to determine the suitability of the baseline 30-cm-thrust for future missions and to identify other thruster concepts that would better satisfy mission requirements. The general scope of the study was to review mission requirements, select thruster designs to meet these requirements, assess the associated thruster technology requirements and recommend short and long-term technology directions that would support future thruster needs. Preliminary design concepts for several advanced thrusters were developed to assess the potential practical difficulties of a new design. This study produced useful general methodologies for assessing both planetary and earth orbit missions. For planetary missions, the assessment was in terms of payload performance as a function of propulsion system technology level. For earth orbit missions, the assessment is made on the basis of cost (added sensitivity to propulsion system technology level).

(Author)
15 LAUNCH VEHICLES AND SPACE VEHICLES

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

870-121639° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CTB (Newbern): UNITED STATES EXPERIMENTS AND OPERATIONAL SUMMARY
(NASA-TM-738330) Award NTIS HC AO3/MF AO1 CSCL 22A

The Communications Technology Satellite launched in January 1976 and embodying the highest power transmitter in a communications satellites was considered. As a joint program between the U.S. and Canada, close coordination of the two countries was necessary since the management and control of experiments were done in real time. Criteria used by NASA for acceptance of the United States experiments are noted and acceptance procedures are described. The category for each accepted experiment is given. The modules employed for the 3 dozen experiments and the areas of management, coordination, and real-time operation are described. Some of the highlights associated with satellite utilization are given. Author

870-171277° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PUBLICATION OF A TABULAR-APPROXIMATED MULTILAYER INSULATION SYSTEM BY GAS DIFFUSION
Irving E. Summer Jan 1978 59 p, refs. (NASA TP 1127 E-92856) Award NTIS HC AO4/MF AO1 CSCL 228

The investigation was conducted on a multilayer insulation (MLI)-system mounted on a spherical liquid hydrogen propulsion tank. The MLI consisted of two blankets of insulation each containing 15 double aluminized Mylar radiation shields separated by double-wick net spacers. The gaseous nitrogen initially contained within the MLI system and vacuum chamber was purged with gaseous helium. Products from the MLI and step by step evacuation. The MLI panels were assumed to be merged primarily by means of gas diffusion. Overall test results indicated that nitrogen concentrations below 1 percent could be achieved. The test system was designed to achieve 1 percent nitrogen concentration within the MLI panels ranging from 68 minutes at the top of the tank to 158 minutes at the bottom of the tank. Four space hold thermal performance tests indicated that thermal degradation of the MLI system had occurred due to the purge tests conducted. The final measured heat input attributed to the MLI was 7.23 watts as compared to 7.18 watts for the initial baseline thermal performance test. Author

870-211188° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE PLASMA INTERACTION EXPERIMENT (PIEX) DESCRIPTION AND TEST PROGRAM
(NASA-TM 78883 E-93594) Award NTIS HC AO2/MF AO1 CSCL 22A

The plasma interaction experiment (PIEX) is a battery powered preprogrammed auxiliary payload on the LANDSAT C launch. The experiment is part of a larger program to investigate space plasma interactions with spacecraft surfaces and components. The experiments plasma densities and temperatures encountered during available telemetry coverage periods are deemed sufficient to determine first-order interactions between the plasma environment and the biased experimental surfaces. The specific objectives of the PIEX flight experiment are to determine the plasma coupling current and the negative ion flow density characteristic of selected array and a gold plated steel disk. Measurements will be made at a range of surface voltages up to plus minus 100 volts. The orbital energy is to range from 1 to 3000 electron densities. The experimental surfaces will be voltage biased in a preprogrammed step sequence to optimize the data returned for each plasma region and for the available telemetry coverage. Author

870-211260° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COMPARISON OF RUBBER INSULATION SYSTEMS FOR CHROMOGENICALLY-TANKED EARTH-BASED SPACE VEHICLES
(NASA-TM-73896 E-91582) Award NTIS HC AO2/MF AO1 CSCL 22B

Three reusable mission systems concepts were developed for use with propellant tanks of earth-based space vehicles. Two concepts utilized double-walled Kapton (DGK) or double-walled Mylar (DOM) multi-layer insulation (MLI), while the third utilized a high-bias-microsphere, load-bearing insulating (LB1) thermal performance materials. The system relies on the unique space hold (vacuum) conditions for simulating warm boundary temperatures of approximately 321 K. The resulting effective thermal conductivity was approximately 0.00008 W/m-K (Watt-heat-meter-seconds-meter-thermometers) - measured K - temperature for the MIL system (liquid hydrogen test results) and 0.00056 W/m-K for the LB1 system (liquid nitrogen test results corrected to liquid hydrogen temperature). Author

870-211269° National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PRELIMINARY CONCEPTS, SPECIFICATIONS, AND REQUIREMENTS FOR A ZERO-GRAVITY COMBUSTION FACILITY FOR SPACELAB
Richard D. Villen Jun 1978 51 p, refs. (NASA TP 79810 E-96546) Award NTIS HC AO4/MF AO1 CSCL 22B

The preliminary concept, specifications, and requirements of a reusable zero gravity combustion facility (1-GCFI) for use by experimenters aboard the space laboratory are described. The facility will be accessible to any experiment with the STS orbiter in which a space lab habitable segment and pallet segment are integral and for which mission plans specify induced accelerations of 0.0001 g or less for sufficient long periods so as to impact experiment performance. Author

870-191446° Georgia Inst of Tech, Atlanta Engineering Experiment Station
MILLIMETER WAVE SATELLITE CONCEPTS, VOLUME 1

The identification of technologies necessary for development of millimeter spectrum communication satellites was examined from a systems point of view. Development methodology based on the technical requirements of potential services that might be assigned to millimeter wave bands for identifying the viable and appropriate technologies for future NASA experiment research and development programs and testing of this methodology with selected user applications and services were the goals of the program. The entire communications network both ground and space sub-systems was studied. Cost, weight, and performance metrics for the sub-systems conceptual design for point to point and broadcast communications satellite and network comparisons between sub-system parameters and an overall link performance
are discussed along with baseline conceptual systems, sensitivity studies, mode adjustment analyses, identification of critical technologies and their risks, and brief research and development program scenarios for the technologies judged to be moderate or extensive risks. Identification of technologies for millimeter wave communication systems, and assessment of the relative risks of these technologies, was accomplished through subsystem modeling and link optimization for both point-to-point and broadcast applications.

Author


8789-311431 Raytheon Co. Wayland, Mass. Microwave and Power Tube Div DESIGN, FABRICATION AND TESTING OF A CFA FOR USE IN THE 94"A W POWER SATTELITE Final Report William C Brown Aug 1978 162 p re (Contract NAS3-20374) (NASA CR 158410. PT 5228) Avail: NTIS HC A08/MF A01 CSCL 229 A crossed field amplifier was designed to meet the performance objectives of high signal to noise ratio, an efficiency of 85%, a CW microwave power output of 5-5 kW, and a frequency of 2450 MHz. The signal to noise ratio achieved was better than 69 dB/MHz in a 2000 MHz band centered on the carrier. High circuit efficiency of 87% and a sharp turn on voltage current characteristic was achieved. The basic problem of maintaining good transfer of heat to the external radiator while providing for adequate connections to input and output was solved. Maximum efficiency achieved was 70% and gain and power level were below objectives. An investigation of causes of decreased performance indicated the poor field pattern in the cathode anode interaction area of the tube was a major cause. B.B.
17 SPACECRAFT COMMUNICATIONS, COMMAND AND TRACKING

Includes telemetry; space communications networks; astro-navigation; and radio blackout.

For related information see also 04 Aircraft Communications and Navigation and 32 Communications.

078-229199* National Aeronautics and Space Administration.

For just perceptible interference, an FM television signal interfering with another FM television signal must have an average power that is 26 to 37 db less than the wanted signal power. For an AM-VSB television signal interfering with an FM television signal, the AM-VSB television’s sync peak average power must be 18 to 31 db below the FM television signal’s average power. Also, when an FM television signal interferes with an AM-VSB signal, the average power of the FM signal should be 58 to 59 db below the sync peak average power of the AM-VSB television signal. The range of power ratios occur as a result of different TV scenes used in the tests and different FM-signal frequency deviations used. All tests were performed using 525 line, system M, color-television signals.

G.G.

078-23137* National Aeronautics and Space Administration.

A description of the methods used to measure component temperatures and heat-rejecting rates in a simulated space environment on output stage tubes (OST’s) developed for the Communications Technology Satellite is presented along with summaries of experimentally determined values. The OST’s were operated over the entire anticipated operating drive range, from the dc beam (zero drive) condition to the 6-db overdrive condition. The baseplate temperature was varied from 10 to 58°C with emphasis placed on the testing done at 45°C, the normal anticipated operating temperature. The heat-rejection rate of the OST baseplate ranged from 7.6 W for the dc beam condition to 184.5 W at the 6-db overdrive condition. The heat-rejection rate of the multistage depressed collector (MDC) cover ranged from 192.2 to 159.9 W for the same conditions. The maximum OST temperature measured on the MDC cover was 227°C during a dc beam test. The maximum temperature measured, also on the MDC cover, was 67.5°C at the end of an extended simulated eclipse test period. No effects were observed on the OST thermal characteristics due to vibration testing or temperature-reversal cycle testing.

Author
18 SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes spacecraft thermal and environmental control; and attitude control. In recent years, design and support systems have been a major concern for spacecraft that are used in space missions. This section discusses the design and performance of spacecraft that are used in space missions.

A78-21189 #1 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. CHARGING OF FLEXIBLE SOLAR ARRAY SUBSTRATES IN IDIYDOL ELECTRON BEAMS John V. Stansel and Steven J. Narciso. Mar. 1978. 32 p refs. (NASA-TM-73865; E-8455) Avail. NTIS HC A03/MF A01 CSCI 10A.


The objective of the ATS 5 and 6 Auroral Particle Experiments was to determine the environment at geosynchronous orbit. The objective was to characterize the spacecraft surfaces to detect surface charging effects.


Three reusable insulation systems concepts have been advanced for use with cryogenic tanks of earth-based spacecraft. Two concepts utilized double-goldened Kapton (DGK) or double-aluminized Mylar (DML) multilayer insulation (MLI), while the third utilized a hollow-glass-microsphere, load-bearing insulation (LBI). All three insulation systems have undergone experimental testing and evaluation under NASA-sponsored programs. Thermal performance measurements were made under space hold (vacuum) conditions for insulation warm boundary temperatures of approximately 291 K. The resulting effective thermal conductivity was approximately 0.00008 W/m-K for the MLI systems (liquid hydrogen test results) and 0.00544 W/m-K for the LBI system (liquid nitrogen test results corrected to liquid hydrogen temperature). The DGK MLI system experienced a maximum thermal degradation of 36 percent, the DML MLI system 15 percent, and the LBI system 6.7 percent due to repeated thermal cycling representing typical space flight conditions. Repeated exposure of the DAM MLI system to a high humidity environment for periods as long as 8 weeks provided a maximum degradation of only 24 percent.


Concepts are currently being advanced for space systems to be used for such activities as manufacturing, earth observation, scientific exploration, power generation and human habitation, in locations ranging from low earth orbit (300-500 km) to geosynchronous orbit and beyond. Many of these systems concepts envision large structures and high power levels, and consequently require higher operating voltages that have been used in space missions. The potential impact of interactions of space systems with their operational orbit charged particle environments on the systems’ performance must be accounted for in the design process. A potentially hazardous spacecraft-environment interaction is discussed, namely the interaction of large high voltage systems with low energy (less than 50 eV) plasma. It can result in loss of power, and or aging. The impact of this class of interactions on system operation is most severe at low orbits where the ambient plasma is dense. Results of experimental work and predictions of simple analytical models are presented and their implications for design of space systems are discussed.


As part of this effort to develop reliable, cost-effective spacecraft thermal control heat pipes, Lewis Research Center of NASA is conducting life tests on 30 commercially-available heat pipes in 10 groups of different design and material combinations. Materials are aluminum and stainless steel, and working fluids are methanol and ammonia. The formation of condensable gas is observed for times exceeding 11,000 hours. The heat transport capacities of the pipes are also determined. Considerable gas is found in two groups of methanol pipes; one group shows no gas. One group of ammonia pipes has no observable gas. Another group has much gas. Manufacturers’ processing schedules are examined for differences explaining the presence of gas. Heat transport capacity is found to be severely reduced in some pipes containing gas.

(Author)

The design of surface fusion propulsion acquisition systems using fine-mesh screens must take into account all factors that influence the liquid pressure differentials within the system. One of those factors is spacecraft vibration. Analytical models to predict the effects of vibration have been developed. A test program to verify the analytical model and to allow a comparative evaluation of the parameters influencing the response to vibration was performed. Screen specimens were tested under conditions simulating the operation of an acquisition system, considering the effects of such parameters as screen orientation and configuration, screen support methods, screen mesh, liquid flow and liquid properties. An analytical model, based on empirical coefficients, was most successful in predicting the effects of vibration.

(Author)


ADDJUST (Automatic Determination and Dissemination of Just Updated Steering Terms) is an automated computer and communication system designed to provide Atlas/Centaur and Titan Centaur launch vehicles with booster-phase steering data on launch day. Wind soundings are first obtained, from which a smoothed wind-velocity vs altitude relationship is established. Design for conditions at the end of the boost phase with initial pitch and yaw maneuvers, followed by zero total angle of attack through the filtered wind establishes the required vehicle attitude as a function of altitude. Polynomial coefficients for pitch and yaw attitude vs altitude are determined and are transmitted for validation and loading into the Centaur airborne computer. The system has enabled 14 consecutive launches without a flight wind delay.

V. P.


A new hollow glass microsphere insulation and a flexible stainless steel vacuum jacket were demonstrated on a flight weight cryogenic test tank, 1.17 m in diameter. The weight of the system is three times lighter than the most advanced vacuum-jacketed design demonstrated to date, a free standing honeycomb hard shell with a multilayer insulation system (for a Space Tug application). Design characteristics of the flexible vacuum jacket are presented along with a model describing the insulation thermal performance as a function of boundary temperatures and emissivity. Compressive load on the insulation and insulation gas pressure. Test data are compared with model predictions and with prior flat plate calorimeter test results. Potential applications for this insulation system or a derivative of this system include the cryogenic Space Tug, the Single Stage-to-Orbit Space Shuttle, LH2 fueled subsonic and hypersonic aircraft, and LNG applications.

(Author)
19 SPACECRAFT INSTRUMENTATION

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

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A segmental design and fabrication and assembly techniques were developed for a 1.8 m (6 ft) diameter parabolic concentrator for spacecraft application. This design and these techniques were adaptable to a low cost, mass-produced concentrator. Minimal machining was required. Concentrator segments of formed magnesium were used. The concentrator weighed only 1.8 kg/sq m (0.32 lbm/sq ft).

Author

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The environmental charging of satellite surfaces during geomagnetic storms is the apparent cause of a significant number of anomalous events occurring on geosynchronous satellites since the early 1970's. Electromagnetic pulses produced in connection with the differential charging of insulators can couple into the spacecraft harness and cause electronic switching anomalies. An investigation conducted to determine the response of the spacecraft surfaces to substorm particle fluxes makes use of a harness transient detector. The harness transient detector, called the Transient Event Counter (TEC), was built and integrated into the Canadian-American Communications Technology Satellite (ICTS). A description of the TEC and its operational characteristics is given and the obtained data are discussed. The data show that the satellite surfaces appear to be charged to the point that discharges occur and that the discharge induced transients couple into the wire harnesses.

G.R.
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 and Power, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

N78-13124* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. HYDROGEN FILM COOLED THRUST CHAMBER AND ITS EFFECT ON EROSION RATES OF VARIOUS ABLATIVE MATERIALS. Ned Hammond, William E. Roberts, and Louis M. Russell. Dec. 1977, 27 p. refs. (NASA-TP-1065. E-8908) Avail. NTIS HC A03/MF A01 21H. An experimental investigation was conducted to determine what arrangement of film-coolant-injection orifices should be used to decrease the erosion rates of small, high temperature, high pressure ablative thrust chambers without incurring a large penalty in combustion performance. All of the film cooling was supplied through holes in the inner row of injector elements and the chamber wall. The best arrangement, which had twice the number of holes as there were outer row injection elements, was also the simplest. The performance penalties, presented as a reduction in characteristic exhaust velocity efficiency, were 0.5 and 2.5 percentage points for the 10 and 20 percent cooling flows, respectively. The best film-coolant injector was then used to obtain erosion rates for 19 ablative materials. The throat erosion rate was reduced by a factor of 2.5 with a 10 percent coolant flow. Only the more expensive silica phenolic materials had low enough erosion rates to be considered for use in the nozzle throat. However, some of the cheaper materials might qualify for use in other areas of small nozzles with large throat diameters where the higher erosion rates are more acceptable.

N78-19085* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LIQUID ROCKET LINES, BELLOWS, FLEXIBLE HOSES, AND FILTERS. NASA Space Vehicle Design Criteria (Chemical Propulsion). Apr. 1977, 186 p. refs. Prepared by Rockwell Canoga Park, Calif. (NASA-SP-8123) Avail. NTIS HC A05/MF A01 21H. Fluid-flow components in a liquid propellant rocket engine and the rocket vehicle which it propels are interconnected by lines, bellows, and flexible hoses. Elements involved in the successful design of these components are identified and current technologies pertaining to these elements are reviewed. Assumptions and summaries to provide a technology base for a checklist of rules to be followed by project managers in guiding a design or assessing its adequacy. Recommended procedures for satisfying each of the design criteria are included.

N78-20281* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. STATUS OF SERT II SPACECRAFT AND JUNO THRUSTERS, 1978. W. R. Kartal and L. R. Ignaczak. 1978, 10 p. refs. Presented at the 13th Intern. Elec. Propulsion Conf. San Diego, Calif. 25-27 Apr. 1978, sponsored in part by AIAA and DGLR (NASA-TM-78827. E-9531) Avail. NTIS HC A02/MF A01 21C. The historical record of the SERT II spacecraft and ion thruster systems for 8 years since the February 1970 launch is reviewed. The original SERT II mission, one year duration, was planned with the spacecraft in a continuous sunlight orbit to provide continuous solar power. An extended mission, using intermittent power available from an earth shadowed orbit was performed during the past 5 years while waiting for the orbit to change again to continuous sunlight in early 1979. Continuous thruster testing is planned in 1978. Both spacecraft and ion thruster systems are near fullly functional when the solar array is illuminated. Thruster system 2 is fully operational. Thruster system 1 continues to demonstrate reliable capability, but the high-voltage-grid short remains.


N78-21236* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. PULSE IGNITION CHARACTERIZATION OF MERCURY ION THRUSTER CATHODE USING AN IMPROVED PULSE IGNITOR. E G Wintucky and R. P. Gruber. 1978, 20 p. refs. Presented at the 13th Intern. Elec. Propulsion Conf. San Diego, Calif. 25-27 Apr. 1978, copublished by AIAA and DGLR (NASA-TM-78858. E-9529) Avail. NTIS HC A02/MF A01 21C. An investigation of the high voltage pulse ignition characteristics of the 8 cm mercury ion thruster neutralizer cathode identified a low rate of voltage rise and long pulse duration as desirable factors for reliable cathode starting. Cathode starting breakdown voltages were measured over a range of mercury flow rates and tip heater powers for pulses with five different rates of voltage rise. Breakdown voltage requirements for the fastest rising pulse (2.5 to 3.0 kV/microsec) were substantially higher (2 kV or more) than for the slowest rising pulses (0.3 to 0.5 kV/microsec) for the same starting conditions. Also described is an improved, low impedance pulse ignitor circuit which reduces power losses and eliminates problems with control and packaging associated with earlier designs.

N78-21237* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. PLANNED FLIGHT TEST OF A MERCURY ION AUXILIARY PROPULSION SYSTEM 1: OBJECTIVES. SYSTEM DESCRIPTIONS, AND MISSION OPERATIONS. John C. Power. 1978, 48 p. refs. Presented at the 13th Intern. Elec. Propulsion Conf. San Diego, Calif. 25-27 Apr. 1978, copublished by AIAA and DGLR (NASA-TM-78858. E-9528) Avail. NTIS HC A03/MF A01 21C. A planned flight test of an 8 cm diameter, electron bombardment mercury ion thruster system is described. The primary objectives of the test is to flight qualify the 5 mN (1 mib) thruster system additional auxiliary propulsion applications. A seven year north-south stationkeeping mission was selected as the basis for the flight test operating profile. The flight test, which will employ two thruster systems, will also generate thruster system life tests. The spacecraft system space environment data, measure thruster-spacecraft interactions, and demonstrate thruster operation in a number of operating modes. The flight test is designated as SAMSO 601 and will be flown aboard the shuttle-launched Air Force space test program P80-1 satellite in 1981. The spacecraft will be 3-axis stabilized in its final 740 km circular orbit, which will have an inclination of approximately greater than 73 degrees. The spacecraft life time is three years.
N78-21206# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE 8200 CYCLE TEST OF AN 8-cm DIAMETER Hg ION THRUSTERS


An accelerated cycle test was conducted in which an 8-cm Engineering Model Thruster (EMT) prototype successfully completed 8200 on-off cycles and a total of more than 1300 hours of thruster operation at a 4.5 mN thrust level. Cathode tip heater powers required for starting and keeping voltages remained well within acceptable limits. The discharge chamber utilization and electrical efficiency were nearly constant over the duration of the test. It was concluded that on-off cyclic operation by itself does not appreciably degrade starting capability or performance of the 8-cm EMT.

Author
beam diameter as a function of radial position on the grid and accelerator grid hole diameter, and the high energy, high angle ion beam edge location. Discharge chamber properties evaluated were propellant utilization efficiency, minimum discharge power per beam amp, and minimum discharge voltage. 

Author

N78-21717$^\text{a}$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INVESTIGATION OF THE EFFECTS OF CERAMIC COATINGS ON ROCKET THRUST CHAMBER LIFE


Cylindrical rocket thrust chambers. cylinders were coated with a 0.203 mm (0.008 in) layer of zirconium oxide using a process that employed electrodeposition of metal to a spray coated mandrel. The cylinders were cyclically tested using hydrogen oxygen propellants at a nominal chamber pressure of 4.14 MN/sq m (600 psia) to show the effect of the coating on life. Both cylinders failed prematurely due to causes unrelated to the coatings. Post destructive analysis showed no cooling passage wall deformation. Where erosion of the coating occurred, the coating thickness stabilized at 0.061 mm (0.0024 in) within 80 cycles and remained well adhered throughout the tests.

Author

N78-23143$^\text{a}$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A MECHANICAL THERMAL AND ELECTRICAL PACKAGING DESIGN FOR A PROTOTYPE POWER MANAGEMENT AND CONTROL SYSTEM FOR THE 30 cm MERCURY ION THRUSTER


A prototype electric power management and thruster control system for a 30 cm ion thruster is described. The system meets all of the requirements necessary to operate a thruster in a fully automated mode. Power input to the system can vary over a full two to one dynamic range (0.20 to 400 V) for the solar array or other power source. The power management and control system is designed to protect the thruster, the flight system and itself from arcs and is fully compatible with standard spacecraft electronics. The system is easily integrated into flight systems which can operate over a thermal environment ranging from 0.3 to 5 AU. The complete power management and control system measures 45.7 cm (18 in.) x 15.2 cm (6 in.) x 114.8 cm (45 in.) and weighs 36.2 kg (79.7 lb). At full power the overall efficiency is estimated to be 87.4 percent. Three systems are currently being built and a full schedule of environmental and electrical testing is planned.

Author

N78-28142$^\text{a}$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A 30-cm MERCURY ION THRUSTER PERFORMANCE WITH A 1 kW CAPACITOR-DIOIDE VOLTAGE MULTIPLIER BEAM SUPPLY


A 1 kW solar array and capacitor-dioide voltage multiplier converter (S/A-CDVM) was successfully integrated with a 30 cm diameter mm to provide ion beam power. Measurements were made to compare steady state and transient response performance of a conventional bridge converter with the S/A-CDVM converter used for the ion beam supply. The ability to recover from screen to accelerator arc and promptly re-establish stable thruster performance was demonstrated. Solar array transient response to thruster arcing was measured. 

Author

N78-28144$^\text{a}$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SENSITIVITY OF 30-cm MERCURY BOMBARDMENT ION THRUSTER CHARACTERISTICS TO ACCELERATOR GRID DESIGN


The design of ion optics for beamnaming thrusters strongly influences overall performance and lifetime. The operation of a 30 cm thruster with accelerator grid open area fractions ranging from 43 to 24 percent was evaluated and compared with experimental and theoretical results. Ion optics properties measured included the beam current, extraction capability, the minimum accelerator grid voltage to prevent backstreaming ion

Author

N78-28174$^\text{a}$ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A THERMIONIC CONVERTER MODULE UTILIZING EMITTER AND COLLECTOR HEAT PIPES

Ernst Kroeger, James Morris, Gabor Miskolcsy (Thermo Electron Corp.), David P. Lieb (Thermo Electron Corp.), and Douglas B. Goodale (Thermo Electron Corp.) Jun. 1978 38 p refs (Contract NAS5-20270)

(NASA-TM-78841. E-9705) Avail: NTIS HC A03/MF A01 CSCL 10A

A thermionic converter module simulating a configuration for an out-of-core thermionic nuclear reactor was designed, fabricated, and tested. The module consists of three cylindrical thermionic converters. The tungsten emitter of the converter is heated by a tungsten, lithium heat pipe. The emitter heat pipes are immersed in a furnace, insulated by MULTI-FOIL thermal insulation, and heated by tungsten radiation elements. The performance of each thermionic converter was characterized before assembly into the module. Dynamic voltages, current, and power were taken using a 60 Hz sweep and computerized data acquisition over a range of emitter, collector, and cesium-reservoir temperatures. An output power of 215 W was observed at an emitter temperature of 1750 K and a collector temperature of 855 K for a two diode module. With a three diode module, an output power of 270 W was observed at an emitter temperature of 1800 K and a collector temperature of 875 K.

J. M. S.

A planned flight test of an 8-cm diameter, electron-bombardment mercury ion thruster system is described. The primary objective of the test is to flight qualify the 5 MN thruster system for auxiliary propulsion applications. A seven year north-south station-keeping mission was selected as the basis for the flight test operating profile. The flight test, which will employ two thruster systems, will also generate thruster system space performance data, measure thruster-spacecraft interactions, and demonstrate thruster operation in a number of operating modes. The flight test is designated as SAMS-601 and will be flown aboard the Shuttle-launched Air Force Space Test Program P80-1 satellite in 1981. The spacecraft will be 3-axis stabilized in its final 740 km circular orbit, which will have an inclination of at least 73 degrees. The spacecraft design lifetime is three years. (Author)


This is part II of a three-part paper describing the approved flight test of a mercury ion auxiliary propulsion system. The objectives of the flight test are summarized with reference to user application. The approach to accomplishment is presented as it applies to integrating the propulsion system with the host spacecraft USAF-TP-80-1. A number of known interface design considerations which affect the propulsion system and the spacecraft are discussed. Finally, analogs are drawn comparing the relationship of the organizations involved with the flight test with those anticipated for future operational missions. Attention is given to the viewpoint of the project office. (Author)


An accelerated cycle test was conducted in which an 8-cm Engineering Model Thruster (EMT) prototype was fully completed 5200 on-off cycles and a total of more than 1300 hours of thruster operation at a 4 m/s² thrust level. Cathode tip heater power required for starting and keepers voltages remained within acceptable limits. The discharge chamber utilization and electrical efficiency were nearly constant throughout the duration of the test. It was concluded that an off cycle operation by itself does not appreciably degrade starting capability or performance of the 8-cm EMT. (Author)
Power Management and Control system measures 68.7 cm x 19.2 cm x 114.8 cm and weighs 36.2 kg. At full power the overall efficiency of the system is estimated to be 87.4 percent. Three systems are currently being built and a full schedule of environmental and electrical testing is planned. (Author)
Proportion program, which led to the present 1-mb (4.5 mili) thruster system, is presented. The developmental history, performance, and features of each component of the system are traced over the past 10 years. Major components include the 8-cm diameter on-thruster, the power processor, and the prepropellant reservoir and distribution system. [Author]


877-10369* Hughes Research Labs, Malibu, Calif. Ion Physics Dept.

Several thruster system design concepts were evaluated and compared using the specifications of the most advanced 30 cm engineering model thruster, the technology base. The specifications in thruster performance required for the Halley's comet rendezvous mission were defined, and alternative thruster system concepts were designed. Confirmation testing and analysis of thruster and power processing components were performed, and the feasibility of satisfying extended performance requirements was verified. A baseline design was selected from the alternatives considered and the design analysis and documentation were refined. A program development plan was formulated that outlines the work structure considered necessary for developing, qualifying, and fabricating the flight hardware for the baseline thruster system within the time frame of a project to rendezvous with Halley's comet. An assessment was made of the costs and risks associated with a baseline thruster system as provided to the mission project under the plan. Critical procurements and interfaces were identified and defined. Results are presented. [Author]

877-11182* Hughes Research Labs, Malibu, Calif.

Several thruster system design concepts were evaluated and compared using the specifications of the most advanced 30 cm engineering model thruster as the technology base. Emphasis was placed on relatively high power missions (80 to 100 kW) such as a Halley's comet rendezvous. The specifications in thruster performance required for the Halley's comet mission were defined, and alternative thruster system concepts were designed. Confirmation testing and analysis of thruster and power processing components were performed. A baseline design was selected from the alternatives considered and the design analysis and documentation were refined. The baseline thruster system design features modular construction, conventional power processing and a concentrator to interface with the Space Station. A development plan was formulated that outlines the work structure considered necessary for developing the flight hardware for the baseline thruster system of a mission to rendezvous with Halley's comet during December 1988. [Author]

877-12349* TRW Defense and Space Systems Group, Redondo Beach, Calif.

A flight experiment and flight experiment package for a shuttle-borne flight test of an 8-cm mercury ion thruster was designed to obtain charged particle and neutral particle massless transport data that cannot be obtained in conventional ground based laboratory testing facilities. By use of both ground and space testing of ion thrusters, the flight performance of these ion thrusters, for either spacecraft applications, may be demonstrated. The flight experiment design for the ion thruster was defined in a broadly-reactive ion source, flight experiments and flight test sensors. From this larger test area and sensor set, an initial flight test configuration was selected with measurements in charged particle neutral transport, controllable neutral material transport, thrust and internal exhaust, ion beam and ion thrust beam/space plasma electrical equilibrium. Detailed measurement areas may be all be examined for a seven day shuttle test some mission and for available test time in the 50 to 100 hour period. [Author]

877-13124* Systems Science and Software, La Jolla, Calif.

The effect of interactions of spacecraft generated and naturally occurring plasmas with high voltage solar array components on an advanced solar electric propulsion system proposed for the Halley's Comet rendezvous mission was investigated. The spacecraft generated plasma consists of mercury ions and neutralizing electrons resulting from the operation of ion thrusters. The charge exchange plasma and associated hollow cathode neutrals. Quiescent results are given for the parasitic currents and power coupled into solar arrays with voltage fixed as a function of position on the array. [Author]

877-13123* Colorado State Univ Fort Collins Dept of Mechanical Engineering

The charge exchange plasma generated by an ion thruster was investigated experimentally using both 5 cm and 15 cm ion thrusters. Results are shown for wide ranges of radial distance from the thruster and origin along the beam direction. Considerations of test environment as well as distance from the thruster indicate that a valid simulation of a thruster on a spacecraft was obtained. Calculation procedure and a sample calculation of charge exchange plasma density and sublimation electron current, density are included. [Author]

877-19167* Colorado State Univ Fort Collins Dept of Mechanical Engineering

The measured ion beam divergence characteristics of two and three-grid multipole accelerator systems are presented.
Jrrmtmmnoa anwl -OR ruults tubs :ha hunmg pan.. 

An electrical prototype power processor was designed, fabricated and tested with a 30 cm mercury ion engine for primary space propulsion. The power processor unit used the thruster sense resonant inverter as the basic power stage for the high power beam and discharge supplies. A transistorized sense resonant inverter processed the remaining power for the tune power outputs. The power processor included a digital interface unit to process all input commands and external telemetry signals so that electrical propulsion systems could be operated with a central computer system. The electrical prototype unit included design improvements in the power components such as the thyristor, transistors, filters and resonant capacitors, and power transformers and inductors in order to reduce component weight, to minimize losses, and to control the component temperature rise. A design analysis for the electrical prototype is also presented on the component weight, losses, peak current and reliability estimate. The electrical prototype was tested in a thermal vacuum environment. Integration tests were performed with a 30 cm ion engine and demonstrated the electrical operational capability. Electromagnetic interference data was also recorded on the design to provide information for spacecraft integration. 

Author


Several power processor design concepts were evaluated and compared. Emphasis was placed on a 30-cm ion thruster power processor with a beam supply rating of 2.2 kV to 10 kV. Extensions in power processor performance were defined and were designed in sufficient detail to determine efficiency, component weight and cost, component reliability and thermal control. Preliminary electrical design, mechanical design, and thermal analysis were performed on a 40-W power transformer for the beam supply. Bidirectional mechanical structural and thermal control configurations were evaluated for the power processor, and preliminary estimates of mechanical weight were determined. A program development plan was formulated that outlines the work breakdown structure for the development, qualification, and fabrication of the power processor flight hardware. 

Author


The objective of this study was to establish a preliminary design of a Powerhead Breadboard Assembly PBA, for an 88 lb thrust hydrogen/tungsten oxide staged combustion engine for use in orbital transfer vehicle propulsion. Existing turbomachinery, preburner, and thrust chamber systems were integrated with an interconnecting ducting heat exchanger and a control system to complete the PBA design. Cycle studies were conducted to define starting transients and steady-state balances for the complete design. Specifications were developed for all valve applications and the system test was defined. 

Author

Calculations are made of the effect of interactions of spacecraft generated plasmas and high voltage solar array components on an advanced Solar Electric Propulsion system. The plasma consists of mercury ions and electrons resulting from the operation of ion thrusters and associated hollow cathode neutralizers. Because large areas of the sole array are at high potential and not completely isolated from the surrounding plasma the array can, under some conditions, collect excessive electron currents. Results are given for the parasitic currents collected by the solar arrays and means for reducing these currents are considered. (Author)


Measurements of the ion beam plume and efflux constituents of an Bcm mercury ion thruster have been carried out in the TRW 5 x 10 foot test chamber. Charged components (ion beam plume) were measured with an array of movable position Faraday cups and retarding potential analysers yielding both current density and particle energy determinations. Neutral components (ion beam efflux) were determined with a movable, position vibrating-spring device. Measurements of the ion beam plume were performed for a thruster both with and without a splitter shield. Analysis of data in terms of normalized efficiencies has been carried out and has been applied to an example calculation of efflux compatibility with a communications spacecraft. (Author)


A thrust system design has been established for an extended performance, 64 kW, 4900 sec specific impulse ion thruster. The configuration is comprised of ten thrusters configured with a power management and control subsystem in a modular thrust system design. The system design approach is an adaptation of that previously modified for the baseline technology, 2.7 kW, 3000 sec specific impulse ion thruster. The power management and control subsystem design includes a combination of individual electronics for each thruster and a set of electronics with redundancy that are common to all thrusters. The thermal dissipation of all electronics is removed with a common heat pipe radiator assembly. (Author)


Development of an Engineering Model Beam Mercury Ion Thruster System for Satellites Control has been successfully completed. This system operates at a specific impulse in excess of 2600 sec, produces a thrust of 5 mN with a total input power of 165 W; it has a dry mass of 16.6 kg and a mercury-propellant reservoir capacity of 8.75 kg. This paper summarizes the development work, the system characteristics and performance, and the tests undertaken to verify the design. (Author)


Two 30-cm ion thruster technology areas are investigated in support of the extended performance thruster operation required for the Halley's comet rendezvous mission. These areas include in evaluation of the thruster performance and lifetime characteristics at increased specific impulse and power levels, and the design and evaluation of a high-voltage propellant electrical isolator. Experimental results are presented indicating that all elements of the thruster design function well at the higher specific impulse and power levels. It is shown that the only thruster modifications required for extended-performance operation are a improving the ion optics assembly and a redesign of the propellant isolators. Experimental results obtained from three isolator designs are presented, and it is concluded that the design and development of a high-voltage isolator is possible using existing technology. (Author)


An Electrical Prototype Power Processor has been designed to the latest electrical and performance requirements for a flight-type 30-cm ion engine and includes all the necessary power, command, telemetry and control interfaces for a typical electric propulsion subsystem. The power processor was configured into seven separate mechanical modules that would allow subassembly fabrication, test and integration into a complete power processor unit assembly. The conceptual mechanical packaging of the electrical prototype power processor unit demonstrated the relative location of power high voltage and control electronic components to minimize electrical interactions and to provide adequate thermal control in a vacuum environment. Thermal control was accomplished with a conduction simulator attached to the base of the in-dudles. (Author)
23 CHEMISTRY AND MATERIALS

(GENERAL)

Includes biochemistry and organic chemistry.

N97-281172' National Aeronautics and Space Administration

Leaves Research Center, Cleveland, Ohio

BATTERY SEPARATORS: Patent Application


Filed 19 Apr 1978; 13 p.


NTIS HC AO3/MAO A1 CSCL 07C

The method disclosed is used to produce a polyvinyl alcohol sheet material wherein the polyvinyl alcohol is substantially free of 1.2 die1 units, and has an acetyl self cross-linked structure wherein the acetyl content is determined by the 1.2 die1 content in the sheet material prior to cross-linking. The sheet material product exhibits high conductivity hمد tensile strength, as well as minimal distorsion of the prebactirated polyvinyl alcohol sheet material.

N97-281173' National Aeronautics and Space Administration

Leaves Research Center, Cleveland, Ohio

ION PROPULSION FOR SPACECRAFT


(NASA TM-79502) Avail NTIS HC AO3/MF A01 CSCL 21C

The theory of the ion thruster propulsion system is discussed along with the Space Electric Rocket Test 1 and 2. The use of electric propulsion for stationkeeping and attitude control of geosynchronous satellites is described, and a comparison of thruster systems is presented.

N97-281176' National Aeronautics and Space Administration

Leaves Research Center, Cleveland, Ohio

THE FRICTION AND WEAR PROPERTIES OF SPUNNED HARD REFRUCTORY COMPOUNDS


(NASA TM 78895, E 3388) Avail NTIS HC AO3/MF A01 CSCL 110

Several refractory silicide, boride, and carbide coatings were examined. The coatings were applied to type 440C stainless steel surfaces by radio freq. sputtering. The friction and wear properties of the coatings were found to be related to stoichiometry and impurity content of the bulk coating as well as the degree of interfacial adherence between coating and substrate. Bulk coating stoichiometry could to a large extent be controlled by the application of a negative bias voltage during deposition. Adherence was promoted by the formation of an oxidized layer at the interface Delaborate preoxidation of the 440C produced enhanced adherence for many compounds which are related to the formation of a mixed oxide transition region.

N97-281176' National Aeronautics and Space Administration

Leaves Research Center, Cleveland, Ohio

FRICITION AND WEAR OF CARBON-GRAFITE MATERIALS FOR HIGH-ENERGY BRAKES


Caliper type brake simulation experiments were conducted on seven different carbon graphite materials formulations against a steel disk material and against a carbon graphite disk material. The effects of binder level, boron carbide (8B4C) additions, SiC additions, graphite fiber additions, and graphite cloth reinforcement on friction and wear behavior were investigated. Reductions in binder level additions of 8B4C and additions of SiC each resulted in increased wear. The wear rate was not affected by the addition of graphite fibers. Transition to severe wear and high friction was observed in the case of graphite-cloth-reinforced carbon sliding against a disk of similar composition. The transition was related to the disruption of a continuous graphite shear film that must form on the sliding surfaces if low wear is to occur.

A78-24810' Progress in advanced high temperature turbine materials, coatings, and technology. J. C. Freche and G. M. Ault


Several NASA sponsored beneficial studies have shown that very substantial benefits can be obtained by increasing material capability for aircraft gas turbines. Preglazed powder processing holds promise for providing superalloys with increased strength for turbine disc applications. The development of advanced powders, with very high density, disk alloys must be based on a design of optimum processing and heat treating procedures. Materials considered for high temperature application include oxide dispersion strengthened (ODS) alloys, directionally solidified superalloys, ceramics, directionally solidified eutectics, materials combining the high strength of a gamma prime strengthened alloy with the elevated temperature strength of an ODS, and composites. Attention is given to the use of high pressure turbine seals, approaches for improving environmental protection, and turbine cooling technology.

G.R.

N97-18094' Galles, S. H. Associates Columbus Ohio

MATERIALS SCIENCE EXPERIMENTS IN SPACE

Final Report

S. H. Galles B C Gissem M E Glickman J L Marmoge H Markowitz A S Nowick J D Vothoven and A F Witt Jan

1978 84 p. refs.

(Contract NASA 20049)

(NASA CR 2842) Avail NTIS AC AO1 CSCL 22A

The criteria for the selection of the experimental areas and individual experiments were that the experiment or area must make a meaningful contribution to the field of material science and that the space environment was either an absolute requirement for the successfull execution of the experiment or that the experiment can be more economically or more conveniently performed in space. A number of experimental areas and individual experiments were recommended for further consideration as space experiments. Areas not considered to be fruitful and others needing additional analysis in order to determine their suitability for conduct in space are also listed. Recommendations were made concerning the manner in which these materials science experiments are carried out and the related studies that should be pursued.

Author
24 COMPOSITE MATERIALS
Includes laminates.

N78-102177* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
CONSOLIDATION OF SILICON NITRIDE WITHOUT ADDITIVES
(NASA TM 73683 E 9228) Avail. NTIS HC AO2/MF AO1 C31 11D

The feasibility of producing a sound, dense Si3N4 body without additives was explored, using conventional gas hot isostatic pressing techniques and an uncommon hot isostatic pressing technique. These two techniques produce much higher pressure 275-413 MPa; m sq (40.000 - 60.000 psi) than hot pressing techniques. Evaluation was based on density measurements, macroscopic examination, both optical and electronic and X-ray diffraction analysis. The results are summarized as follows: (1) Si3N4 high density, greater than 95% of theoretical, without additions. (2) The higher density Si3N4 specimens appear to be associated with a greater amount of alpha to beta transformation. (3) Under high pressure, the alpha to beta transformation can occur at a temperature as low as 1150 C. (4) Grain deformation and subsequent recrystallization and grain refinement results from hot isostatic pressing of Si3N4. Author

N78-131387 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
EFFECT OF DISCONTINUITIES AS A MEANS TO ALleviate THERMAL EXPANSION MISMATCH DAMAGE IN LAMINAR COMPOSITES

An investigation of nickel/tungsten laminar composites showed that intentionally introduced discontinuities such as perforations through or grooves on the surface of the matrix laminate improved thermal expansion mismatch damage resistance. It was found that specimens having smooth matrix laminate surface were virtually destroyed by delamination in 21 or fewer fast cool cycles in which they were water quenched from 981 C. Specimens having exterior matrix laminate with discontinuities and relatively thin non-discontinuous surface matrix laminate resisted 50 similar cycles without evident delamination damage. Author

N78-13137 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
FRACTURE SURFACE CHARACTERISTICS OF OFF-AXIS COMPOSITES
(NASA TM 73700 E 90852J Avail. NTIS HC AO2/MF A01 C31 11D

The fracture surface characteristics of off-axis high modulus graphite fiber epoxy composite specimens were studied using a scanning electron microscope (SEM). The specimens were subjected to tensile loading at various angles (0 deg., 90 deg.) to the fiber direction. SEM photomicrographs of the fractured surfaces revealed three different load angle regions with distinct fracture characteristics. Based on these revelations, criteria were established which can be used to characterize fracture surfaces with respect to a predominant single stress mode. Author

N78-131087 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
MECHANICAL BEHAVIOR AND FRACTURE CHARACTERISTICS OF OFF-AXIS FIBER COMPOSITES. 1: EXPERIMENTAL INVESTIGATION

The mechanical behavior, fracture surface and fracture modes of undirectional high modulus graphite/epoxy composite subjected to off-axis tensile loads were investigated experimentally. The investigation included the generation of stress-strain-to-fracture data and scanning electron microscope studies of the fractured surfaces. The results led to the identification of fracture modes and distinct fracture surface characteristics for off-axis tensile loading. The results also led to the formulation of criteria for identifying and characterizing these fracture modes and the associated fracture surfaces. The results presented and discussed herein were used in the theoretical investigation and comparisons described in Part 2. These results should also provide a good foundation for identifying, characterizing, and quantifying fracture modes in both off-axis and angle plied laminates. Author

N78-10889* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
MECHANICAL BEHAVIOR AND FRACTURE CHARACTERISTICS OF OFF-AXIS FIBER COMPOSITES. 2: THEORY AND COMPARISONS

The mechanical behavior and stresses inducing fracture modes of undirectional high modulus graphite/epoxy composite subjected to off-axis tension loads were investigated theoretically. The investigation included the use of composite mechanics combined stress failure criteria and finite element stress analysis. The results are compared with experimental data and led to the formulation of criteria and convenient plotting procedures for identifying, characterizing and quantifying these fracture modes. Author

N78-17152* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
ADHESIVE COHESIVE STRENGTH OF A ZrO2-ZrO2-2 wt奥 Y2O3 McAlTa THERMAL BARRIER COATING
(INASAM TM 73792 E 9359) Avail. NTIS HC AO3/MF AO1 C31 11D

The room temperature adhesive cohesive strength of a 0.05-in thick ZrO2-2 wt. % Y2O3 McAlTa thermal barrier coating system (TBC) was investigated. The weakest link was the oxide Ni-Al interface region with a strength of 6.2 MN m2. The fracture was about half cohesive (oxide failure) half Ni-Al adhesion failure. 1 percent cohesive Ni-Al failure. The TBC failed in thermal shock tests at 950 C. Tensile and compression tests. The oxide stripped from the TBC had a cohesive strength of 24.6 MN m2. The Ni-Al had a cohesive strength of 25.1 MN m2. The Ni-Al and oxide failed primarily at particle boundaries. Author

N78-17153* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
THE EFFECTS OF ELECTRIC CURRENT ON THE FRACTURE OF OFF AXIS FIBER COMPOSITES
(INASAM TM 12826 E 9269) Avail. NTIS HC AO2/MF AO1 C51 11D

Finite element analyses were performed to investigate the
The effects of in-plane and out-of-plane eccentricities, bending or twisting, and thickness nonuniformity on the axial stress and strain variations across the width of off-axis specimens. The results are compared with measured data and are also used to assess the effects of these eccentricities on the fracture stress of off-axis fiber composites. 

Guidelines for detecting and minimizing the presence of eccentricities are described. 

**R78-17184**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

**MECHANICAL AND PHYSICAL PROPERTIES OF MODERN BORON FIBERS**

The results of accurate measurements of the modern boron fibers' Young's modulus, flexural modulus, shear modulus, and Poisson's ratio are reported. Physical property data concerning fiber density, thermal expansion, and resistance obtained during the course of the mechanical studies are also given.

**R78-17185**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

**THERMAL ENVIRONMENT EFFECTS ON STRENGTH AND IMPACT PROPERTIES OF BORON-ALUMINUM COMPOSITES**

Thermal effects on fracture strength and impact energy were studied in 50 volume percent unidirectional composites of 143 and 203 micron boron fibers in 6081 and 1100 aluminum matrices. For 6061 matrix composites, strength was maintained at approximately 400°C in the cyclic tests and higher than 400°C in the static tests. For the 1100 matrix composites, strength degradation appeared near 260°C after cycling and higher than 260°C in static heating. This composite strength degradation is attributed to a fiber degradation mechanism resulting from a boron-aluminum interface reaction. The impact energy absorption degraded significantly only above 400°C for both matrix alloys. Thus, while impact loss for the 6061 composite correlates with the fiber strength loss, other energy absorption processes appear to extend the impact resistance of the 1100 matrix composites to temperatures beyond where its strength is degraded. Interrupted impact tests on as-received and thermally cycled composites define the range of load over which the fibers break in the impact event.

**R78-18204**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

**AXIAL RESIDUAL STRESSES IN BORON FIBERS**

The thermal residual strain or deflection as a function of radius was determined from the fiber surface to the core including the average residual stress in the core. Such measurements on boron on tungsten (B/W) fibers show that the residual stress for 102-121-203 and 386 micron diameter fibers were similar being compressive at the surface and changing monotonically to a region of tensile within the boron. At approximately 25 percent of the original radius the stress reaches a maximum tensile stress of about 800 MPa and then decreases to a compressive stress near the tungsten binder core. Data were presented for 203 micron diameter B/W fibers that show annealing above 500°C reduces the residual stresses. A comparison between 102 micron diameter B/W and boron on carbon (B/C) shows that the residual stresses were similar in the outer regions of the fibers, but that large differences near the core were observed. The effects of these residual stresses on the fracture of boron fibers are discussed.

**R78-18205**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

**STRESSES IN AGLEUPE LAMINATES AND THEIR EFFECTS ON LAMINATE BEHAVIOR**

The evidence of the presence of laminar residual stresses in angle-ply laminates were transplotted cracks and warpage of unsymmetric laminates which occur prior to application of any mechanical load. Laminar residual stresses were measured using the embedded strain gage technique. These strains result from the temperature differences between core and room temperature and vary linearly within this temperature range. Laminar residual stresses were usually present in angle-ply fiber composite laminates. They were also present in unidirectional hybrids and superhybrids. For specific applications, the magnitudes of the laminar residual stresses were determined, and evaluated relative to the anticipated applied stresses. Particular attention was given to cyclic thermal loadings in applications where the thermal cycling takes place over a wide temperature range.

**R78-20254**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

**MEASUREMENT OF THE TIME-TEMPERATURE DEPENDENT DYNAMIC MECHANICAL PROPERTIES OF BORON-ALUMINUM COMPOSITES**

A flexural vibration test and associated equipment were developed to accurately measure the low strain dynamic modulus and damping of composite materials from 200°C to over 500°C. A basic test method involves the forced vibration of composite bars at their resonant free-free flexural modes in a high vacuum cryostat furnace and measurement of the resonant frequencies and the flexural test was verified by dynamic moduli and damping capacity measurements on 50 fiber volume percent boron/aluminum (B/Al) composites vibrating near 2000 Hz. The phase results were summarized to permit predictions of the B/Al dynamic behavior as a function of frequency, temperature, and fiber volume fraction.

**R78-20256**
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

**CORRELATION OF FIBER COMPOSITE TENSILE STRENGTH WITH THE ULTRASONIC STRESS WAVE FACTOR**

An ultrasonic acoustic technique was used to indicate the strength variations of tensile specimens of a graphite epoxy composite. A stress wave factor was determined and its value was found to depend on variations of the fiber resin bonding as well as fiber orientation. The fiber orientations studied were 0° (longitudinal), 10° (off axis), 90° (transverse), 0° (off-axis), 45° (off-axis), 90° (off-axis), and -45° (off-axis). The stress wave factor is an indicator of the tensile and shear strengths of composite materials. Stress wave factor was also found to be sensitive to strength variations associated with microcracks and differences in fiber/resin ratio.
R79-3123/1 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
HYDROGEN DISTILLATION: AN INITIAL ASSESSMENT
(NASA-TM-73771; E-9238) Avail: NTIS HC A02/MF A01 CSCL 11D

The in situ ply strengths in several composites were calculated using laminate fracture data for appropriate low modulus and high modulus fiber composites used in conjunction with the latest a.s. method. The laminate fracture data were obtained from tests on Modor-1 graphite/epoxy, AS-graphite/epoxy, boron/epoxy and E-glass/epoxy. The results showed that the calculated in situ ply strengths can be considerably different from those measured in unidirectional composites, especially the transverse strengths and those in angled laminates with transverse cracks.

Author

R79-2121/1 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
TITANIUM/BERYLIIUM LAMINATES: FABRICATION, MECHANICAL PROPERTIES, AND POTENTIAL AEROSPACE APPLICATIONS
(NASA-TM-73881; E-9508) Avail: NTIS HC A02/MF A01 CSCL 11D

The investigation indicated that structural laminates can be made which have a modulus of elasticity comparable to steel, fracture strength comparable to the yield strength of titanium, density comparable to aluminium, impact resistance comparable to titanium, and little or no notch sensitivity. These laminates can have stiffness and weight advantages over other materials including advanced fiber composites, in some aerospace applications where buckling resistance, vibration frequencies, and weight considerations control the design.

Author

R79-2216/1 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
METHOD FOR ALLEVIA
ing THERMAL STRESS DAMAGE IN COMPOSITES: Preliminary Application
C. A. Hoffman, J. W. West, and N. W. Orth, inventors (to NASA) Filed 8 Apr. 1978 18 p
(NASA-Ca
cass-72493-1; U.S. Patent-Appn-893887) Avail: NTIS HC A02/MF A01 CSCL 11D

According to the method of the invention discontinuities are positively introduced into the interface between layers so as to reduce the thermal stress produced by unequal expansion of the materials which make up the composite. Although a plurality of discrete elements could be used to form one of the layers, it has been found that a better result was obtained by producing holes in the metallic matrix layer or by forming grooves in a grid pattern in the layer. The apparent novel feature of the invention is the use of geometrical considerations to introduce discontinuities in the matrix of a composite material. This provides for the control of stresses that would otherwise unbound the constituents, cause peeling of the outer layers and cause the loss of strength properties of the composite when it is subjected to one or more thermal cycles.

NASA

R79-2428/1 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
THERMAL BARRIER COATINGS
(NASA-TM-78481) Avail: NTIS HC A02/MF A01 CSCL 11D

The gas turbines rely on a way to reach fuel flexibility and improved efficiency. Test/analytical results are encouraging for this new technology.

Author

R79-32101/1 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
EFFECTS OF MOISTURE PROFILES AND LAMINATE CONFIGURATION ON THE HYDRO STRESSES IN ADVANCED COMPOSITES
(NASA-TM-78978; E. 9755) Avail: NTIS HC A02/MF A01 CSCL 11D

An integrated hygro-thermo-mechanical theory was used to predict the effects of three moisture profiles on the ply hygro stresses in angled laminates. The moisture profiles were linear, parabolic and hyperbolic. Moisture content varied from 1 percent in the exposed ply to zero in the protected ply. The angled plies were of two generic configurations. The results obtained are summarized graphically to illustrate the effects of both moisture profile and laminate configuration. The results indicate that ply transverse tensile hygro stresses may reach sufficiently high magnitudes to cause transply cracking.

A.R.H.

R79-3214/1 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
ANALYSIS/DESIGN OF STRIP REINFORCED RANDOM COMPOSITES (STRIP HYBRIDS)
(NASA-TM-78865; E. 9733) Avail: NTIS HC A02/MF A01 CSCL 11D

Advanced analysis methods and composite mechanics were applied to a strip-reinforced random composite square panel with fixed ends to illustrate the use of these methods for the a priori assessment of the composite panel when subjected to complex loading conditions. The panel was assumed to be of E-glass random composite. The strips were assumed to be of three advanced unidirectional composites to cover a range of low, intermediate and high modulus stiffness. The panels were assumed to be subjected to complex loadings, to assess their adequacy as load carrying members in auto body, aircraft engine nacelle and windmill blade applications. The results show that strip hybrid panels can be several times more structurally efficient than the random composite base materials. Some of the results are presented in graphical form and procedures are described for use of these graphs as guides for preliminary design of strip hybrids.

A.R.H.

R79-3316/1 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
ACOUSTIC EMISSION TESTING OF COMPOSITE VESSELS UNDER SUSTAINED LOADING
(NASA-TM-78891; E. 9759) Avail: NTIS HC A02/MF A01 CSCL 11D

Acoustic emissions (AE) generated from Kevlar 49/epoxy composite pressure vessels subjected to sustained load-to-failure tests were studied. Data from two different transducer locations on the vessels were compared. It was found that AE from vessel well-mounted transducers showed a wide variance from those for identical vessels subjected to the same pressure loading. Emissions from boss-mounted transducers did, however, yield values that were relatively consistent. It appears that the signals from the boss-mounted transducers represent an integrated average of the emissions generated by fibers fracturing during the vessel tests. The AE from boss-mounted transducers were also independent of time for vessel failure. This suggests that a similar number of fiber fractures must occur prior to initiation of vessel failure. These studies indicate a potential for developing an AE test procedure for predicting the residual service life or integrity of composite vessels.

A.R.H.

Necessary to the development and understanding of brittle fiber reinforced composites is a means to statistically describe fiber strength and strain-to-failure behavior. A statistical characterization for multicomponent brittle fiber is presented. The method, which is an extension of usual Weibull distribution procedures, statistically considers the components making up a fiber (e.g., substrate, sheet, and surface) as separate entities and taken together as in a fiber. Tensile data for silicon carbide, fiber and for an experimental carbon-boron alloy fiber are evaluated in terms of the proposed multicomponent Weibull characterization. (Author)


A theory is developed for predicting the hydrotreatment thermal cycle of advanced composite structural composites. The combined hydrotreatment effects on the mechanical properties of unidirectional composites loaded along the material axis and off-axis, and of angled laminates are also evaluated. The materials investigated consist of neat PR 288 epoxy matrix resin and an AS-type graphite fiber/PR 288 resin unidirectional composite. S.C.S.


A study was conducted to determine the effect of processing parameters on the processability and properties of autoclaved fiber reinforced PMP pyramide composites. Composites were fabricated from commercially available graphite fabric and glass PMP pyramide prepreg materials. Process parameters investigated included degree of resin advancement, heating rate, and cure pressure. Composites were inspected for porosity by ultrasonic 'C' scan and phonographic log, and their mechanical properties for each set of process parameters and the effect of process parameters on composite mechanical properties at room temperature and 600 F. are described. (Author)


NASA Lewis Research Center research in the field of composite laminate residual stresses is reviewed and summarized. The origin of laminate residual stresses, evidence of their presence, experimental methods for measuring them, and theoretical methods for predicting them are described. Typical results are presented which show the magnitudes of residual stresses in various laminates including hybrids and superalloys and in other complex composite components. Results are also presented which show the effects of laminate residual stresses on laminate warpage and on laminate mechanical properties including fracture stresses. Finally, the major findings and conclusions derived therefrom are summarized. (Author)


Tungsten fiber reinforced superalloy composite (TFRS) impingement-cooled turbine blade inlet gas temperatures were calculated taking into account material spanwise stress, thermal conductivity, material oxidation resistance, fiber-matrix interaction, and coolant flow. Measured values of TFRS thermal conductivities are presented. Calculations indicate that blades made of 30 vol percent fiber content TFRS having a 12,000 N/m2 stress to density ratio while operating at 40 atm and a 0.06 coolant flow ratio could permit a turbine blade inlet gas temperature of over 1900 K. This is more than 150 K greater than similar superalloy blades. (Author)


A systematic study was conducted regarding the degradation of fracture strength and impact energy in commercial B-Al composites in both static and cyclic thermal environments. The composites used in the study contained approximately 50 vol % boron fibers, unidirectionally aligned in either a 6061 Al or Al 100 matrix. The tensile strength of the composites after 3000 thermal cycles as a function of upper cycle temperature are presented in graphs. The temperature at which the strength of 6061 Al matrix, B-Al composites were significantly degraded after 3000 cycles was noticeably higher than that for the 1100 Al matrix compositions. Static heating at 420 C resulted in degradation for the 6061 Al matrix composites. In the case of 1100 matrix composites, some degradation was observed at 420 C but markedly less than in the composites cycled to 420 C. G.R.


An ultrasonic-acoustic technique was used to indicate the stress variations of tensile specimens of a graphite-epoxy composite. A stress wave factor was determined and its value was found to depend on variations of the fiber-resin bonding as well as fiber orientation. The fiber orientations studied were 0 deg (longitudinal), 10 deg (off-axis), and 90 deg (transverse). The stress wave factor can indicate variations of the tensile and shear strengths of composite materials. The stress wave factor was also found to be sensitive to stress variations associated with porosity and differences of fiber-resin ratio. (Author)

The strength of the bond between metals and SiO2 is studied by measuring the static coefficient of friction of metals contacting alpha-quartz in ultrahigh vacuum. It was found that copper with either chemisorbed oxygen, nitrogen or sulphur exhibited higher contact strength on stoichiometric SiO2 than did clean copper. Since the surface density of states induced by these species on copper is similar, it appears that the strength of the interfacial bond can be related to the density of states on the metal surface. (Author)


The principles of ESCA (electron spectroscopy for chemical analysis) are described by comparison with other spectroscopic techniques. The advantages and disadvantages of ESCA as compared to other surface sensitive analytical techniques are evaluated. The use of ESCA is illustrated by actual applications to oxidation of steel and Row 41, the chemistry of lubricant additives on steel, and the composition of spurious deposited hard coatings. Finally, a bibliography of material that is useful for further study of ESCA is presented and commented upon. (Author)


A relatively simple flexural vibration test is developed for accurate measurement of the low-strain dynamic modulus and damping capacity of B-4I composite bar specimens from 200 C to over 500 C. The specimens are prepared from a 9-ply unidirectional panels containing 50 volume percent fibers composed of 203 micron commercial boron-on-tungsten fibers. The basic test technique consists of the forced flexural vibration of the composite bar specimen at two lowest free free symmetrical resonant modes in a high-vacuum cryostat furnace. Specimen damping is determined from calorimetric photographs of the free decay obtained after simultaneously removing the resonant drive signal and grounding the vibration drive electrode. The availability of time-temperature dynamic data coupled with the predictive accuracy of composite theory suggests a future potential for using such data in examining environmental effects on composite macrostructure and microstructure. (Sn)


The in situ ply strengths in several composites were calculated using a computational procedure developed for this purpose. Laminate fracture data for appropriate low modulus and high modulus fiber composites were used in the laminate analysis in conjunction with the method of least squares. The laminate fracture data were obtained from tests on Modor-I graphite/epoxy, AS-graphite/epoxy, boron/epoxy and E-glass/epoxy. The results obtained show that the calculated in situ ply strengths can be considerably different from those measured in unidirectional composites, especially the transverse strengths and those in angle-ply laminates with transply cracks. (Author)


A review of recent advances is presented for lightweight, high-performance composite pressure vessel technology that covers the areas of design concepts, fabrication procedures, applications, and performance; of vessels subjected to single-cycle burst and cyclic fatigue loading. Filament-wound fiberglass/epoxy composite vessels were made from S-glass, graphite, and Kevlar 49 fibers and were equipped with both structural and nonstructural closure systems. Structural efficiencies were attained which represented weight savings, using different liners, of 40 to 60 percent over all-aluminum pressure vessels. Significant findings in each area are summarized including data from current NASA Lewis Research Center contractual and in-house programs. (Author)


An electron bombardment ion thruster was used as a neutralized-ion-beam sputtering source to texture the surfaces of biological implant materials. The materials investigated included 316 stainless steel, titanium-6 aluminum, 4% vanadium, cobalt-20 chromium, 15% tungsten, cobalt-35 nickel, 20 chromium, 10 molybdenum, polytetrafluoroethylene; polyoxymethylene; silicone and polyurethane composite; 32%-carbon impregnated polyethylene; segmented polyurethane; silicone rubber, and alumina. Scanning electron microscopy was used to determine surface morphology changes of all materials after ion texturing. Electron spectroscopy for chemical analysis was used to determine the effects of ion texturing on the surface chemical composition of some polymers. Liquid contact angle data were obtained for ion-textured and untreated polymer samples. Results of tensile and fatigue tests of ion-textured metal alloys are presented. Preliminary data of tissue response to ion-textured surfaces of some metals, polytetrafluoroethylene, alumina, and segmented polyurethane have been obtained. (Author)


The effect of a preload cycle on the structural performance of three unidirectional composite laminates was studied. The composite laminates were a laminate composites (LC), a laminate representative of a filament wound tank (L2), and a laminate representative of a filament wound flange. The effect of three cycles of unidirectional loads on the laminate was studied. The loads developed static strength data, fatigue failure data, and residual static data after application of a predetermined number of fatigue cycles. For L1 specimens, there was a slight trend for the static
strength to be greater for preloaded specimens. After application of cyclic loading, however, the influence of preloading was insignificant. In L2 and L3 specimens there was no consistent difference in the static or fatigue results between preloaded and nonpreloaded specimens.

F. T. H.


Significant contributions of the three major areas of composite mechanics to the development of test methods are illustrated with selected examples. The areas of composite mechanics include composite micromechanics, composite macromechanics, and laminate theory. The examples can be considered to be representative of the contribution of composite mechanics to the development of composite test methods. The specific examples describe contributions such as criteria for selecting resin matrices for improved composite strength, the 10 deg off-axis tensile test, procedures for configuring hybrids, and the concept of reduced bending rigidities. The pertinent composite mechanics literature is given and supplemented by tabular and/or graphical data which illustrate the significance of the contribution. G. R.


NASA CR-135248) Aerv. NTIS HC A03/MF A01 CSci 11D

A two-dimensional hybrid stress finite element analysis is described which was used to study the local stress field around delamination cracks in composite materials. The analysis employs a crack tip singularity element which is embedded in a matrix layer between the cracks. Results are given for a unidirectional graphite/epoxy laminate containing a delamination emanating from a surface crack through the outside ply. The results illustrate several aspects of delamination cracks: (1) the localization of the singular stress domain within the layer, (2) the local concentration of stress in the ply adjacent to the crack, (3) the nature of the transverse normal and interlaminar shear stress distributions, and (4) the relative magnitudes of Ksub 1 and Ksub 2 associated with the delamination. A simple example of the use of the analysis in predicting delamination crack growth is demonstrated for a glass/epoxy laminate. The computations with experimental data show good agreement. Author


NASA CR-135301: Report No. NTIS HC A05/MF A01 CSci 11D

Halflume carbide was shown to be virtually inert when in contact with steam and was found to be effective at least 200 h at 1093 C (2000 F). Extensive interaction was noted with other superalloys such as HA 188. A continuous CVD HIC deposition process was developed for deposition of up to 8 microns on 14 mm (0 506 in.) SC tungsten core filament at rates as high as 8 m/min. The rate can be increased by increasing the depth of the reactor and the output of the power supply used in resistive heating of the filament substrate. The strength of HIC coated filament varies with thickness in a Griffith-like manner. The strength reduction was greater for HIC coatings than for tungsten coatings, presumably because of the greater ductility of tungsten. Author


Blade-like specimens were subjected to static ballistic impact testing to determine their relative FGD impact resistance levels. It was determined that a plus or minus 15 deg layup exhibited good impact resistance. The design of a large solid B4C/aluminum fan blade was conducted based on the FGD test results. The CFS fan blade was used as a baseline for these design studies. The solid boron/aluminum fan blade design was used to fabricate two blades. This effort enabled the assessment of the scale up of existing blade manufacturing details for the fabrication of a large B4C fan blade. Existing CFS fan blade tooling was modified for use in fabricating these blades. Author


NASA CR-135247) Aerv. NTIS HC A06/MF A01 CSci 11D

Stress wave propagation in a multilayer composite plate due to impact was examined by means of the anisotropic elasticity theory. The plate was modeled as a number of identical anisotropic layers and the approximate plate theory of Mindlin was then applied to each layer to obtain a set of differential equations of motion. Dispersion relations for harmonic waves and correction factors were found. The governing equations were reduced to difference equations via integral transforms. With given impact boundary conditions these equations were solved for an arbitrary number of layers in the plate and the transient propagation of waves was calculated by means of a Fast Fourier Transform algorithm. The multilayered plate problem was extended to examine the effect of damping layers present between two elastic layers. A reduction of the n/m laminar normal stress was significant when the thickness of damping layer was increased. The effect of damping was due to the softness of the damping layer. Finally, the problem of a composite plate with a crack on the interlaminar boundary was formulated. Author


NASA CR-135343) Aerv. NTIS HC A02/MF A01 CSci 11D

A low cost compressor rotor was designed and fabricated for a small jet engine. The rotor hub and blade keepers were compression molded with graphite epoxy. Each pair of metallic blades was held in the hub by a snap. All keepers were locked in place with circumferential windings. Feasibility of fabrication was demonstrated in this program. Author


NASA CR-135051: CASC NAS-75-006) Aerv. NTIS HC A04/MF A01 CSci 11D

The design fabrication, and assembly of hardware for testing the performance of a customized multilayer insulation are discussed. System components discussed include the thermal payload simulator, the modified cryoshroud, and a tank back pressure control device designed to maintain a constant liquid
boiling point during the thermal evaluation of the multilayer insulation. The thermal payload simulator would provide a constant temperature surface in the range of 20.8 to 417K (37 to 760°) for the insulated tank to view. The crystal bond was modified to establish a low temperature black body cavity while limiting liquid hydrogen usage to a minimum feasible rate. Author


IMPROVED REACTION SINTERED SILICON NITRIDE
Final Report
H. R. Baumgartner Mar. 1978 83 p refs
(Contract NAS3-18723)
(NASA CR-135291) Avail. NTIS HC A06/MA A01 CSCL 110

Processing treatments were applied to as-nitrided reaction sintered silicon nitride (RSSN) with the purpose of improving strength after processing to above 350 MN/m2 and improving strength after oxidation exposure. The experimental approach was divided into three broad classifications: sintering of surface-applied powders, ingot solution of a composition followed by further thermal processing, and infiltration of molten silicon and subsequent carburization or nitridation of the silicon. The impregnation of RSSN with solutions of aluminum nitrate and zirconium chloride, followed by heating at 1400-1500°C in a nitrogen atmosphere containing silicon monoxide, improved RSSN strength and oxidation resistance. The room temperature bend strength of RSSN was increased nearly fifty percent above the untreated strength with mean absolute strength up to 420 MN/m2. Strengths of treated samples that were measured after a 12 hour oxidation exposure in air were up to 90 percent of the original as-nitrided strength, as compared to retained strengths in the range of 35 to 60 percent for untreated RSSN after the same oxidation exposure. Author

N76-28132* TRW Equipment Labs, Cleveland Ohio

FIBER REINFORCED PMR POLYIMIDE COMPOSITES
P. J. Cagiano and W. E. Winters 15 May 1978 103 p refs
(Contract NAS3-20366)
(NASA CR-135377) TRW ER-7884F) Avail. NTIS HC A06/MA A01 CSCL 110

Commercially obtained PMR-15 polyimide prepreg with S-glass and graphite fiber reinforcements were evaluated along with in-house prepared glass and graphite cloth PMR 2 materials. A novel autoclave approach was conceived and used to demonstrate that both the PMR systems respond to 14 MPa (200 ps) autoclave pressures to produce void free composites equivalent to die molded laminates. Isothermal gravimetric analysis and subsequent mechanical property tests indicated that the PMR 2 system was significantly superior in thermo oxidative stability, and that S-glass reinforcements may contribute to the accelerated degradation of composites at 316°C (600° F) when compared to graphite fiber reinforced composites. Fully reversed bending fatigue experiments were conducted with a type of fixture unused for organic matrix composites. These studies indicated that the graphite fiber composites were clearly superior in fatigue resistance to the glass fiber reinforced material and that PMR matrix composite systems yield performance of the same order as composite materials employing other families of matrices. Author


Twelve fiber materials comprising water-felted fiber cakes and blanket insulation were subjected to furnace exposures at 1000, 1200, 1400, and 1800°C for up to 500 hours to establish the time-temperature limits below which these insulation materials can withstand repeated thermal cycles without detrimental shrinkage, thermal conductivity increase, or physical changes. Test samples were inspected periodically during the exposure cycles and weight loss and dimensional shrinkage were measured. Density, fiber crystallinity, and thermal conductivity were measured after exposure and properties were compared with those of unexposed controls. (Author)


This paper presents the results of a program investigating the effects of initial defects on the fatigue and fracture response of composite laminates. The structural laminates investigated were a typical angle-ply laminate, a polar/hoop-wound pressure vessel laminate, and a typical engine fan blade laminate. Defects investigated were full- and half-penetration circular holes, full- and half-penetration slits, and countersink holes. Results are presented showing the effects of the defect size and type on the static fracture strength, fatigue performance, and residual static strength. The results of inspection procedures are shown, describing the effect of cyclic and static loadings on damage propagation in composite laminates. The date in this study were used to define proof test levels as a qualification procedure in composite structure subjected to cyclic loading. (Author)
25 INORGANIC AND PHYSICAL CHEMISTRY

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

For related information see also 77 Thermodynamics and Statistical Physics.

N78-10226* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

FUEL COMBUSTOR Patent
Cael J. Marek, inventor (to NASA) Issued 4 Oct 1977 5 p

NASA Case LEW-12137-1; US-Patent-4,052,144,


A fuel combustor comprises a chamber with air and fuel inlets and a combustion gas outlet. The fuel is supplied to a vaporization zone and fuel and air are mixed in a pair of mixing chambers, each exemplified by a swirl can. The resultant mixture is directed into a combustion zone within the combustor. Heat pipes are arranged with one exchanger substantially in the combustion zone and the other end in the vaporization zone of its appropriate mixing chamber. Some of the heat of combustion is thus carried back upstream into the swirl cans, to vaporize the fuel as it enters the vaporization zone in the swirl can, thereby improving vaporization and fuel mixing.

Official Gazette of the U.S. Patent Office

N78-11207** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

EFFECT OF TRICHLOROFLUOROMETHANE AND MOLECULAR CHLORINE ON OZONE FORMATION BY SIMULATED SOLAR RADIATION

David A. Bittner and Edgar L. Wong Nov. 1977 22 p refs
NASA-TP-1093; E-0075) Available: NTIS HC A02/MF A01 CSCL 04A

Mixtures of air with either O2 or CFC3 were photolyzed in a reaction chamber by simulated solar radiation. Ozone formation was temporarily inhibited by O3 and irreversibly inhibited by CFC3. A chemical mechanism including gas phase and wall reactions was used to explain these results. The CFC3 is assumed to be adsorbed on the chamber walls and to poison the sites for O3 destruction.

N78-11319** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

FORMATION OF Na2SO4 AND K2SO4 IN FLAMES DOPED WITH SULFUR AND ALKALI CLAVES AND CARBONATES


NASA-TP-77841 Available: NTIS HC A02/MF A01 CSCL 218

High-pressure, free jet expansion, mass spectrometric sampling was used to identify directly and to measure reaction products formed in doped methane oxygen flames. Flames were doped with SO2 or CH3SH and sodium potassium chlorides or carbonates. Gaseous Na2SO4 or K2SO4 molecules were formed in residence times on the order of msec for each combination of dopants used. Composition profiles of combustion products were measured and compared with equilibrium thermodynamic calculations of product composition.

N78-11318** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

VOLATILE PRODUCTS FROM THE INTERACTION OF KOH WITH CCl4 AND LA2O3 IN CHLORIDIZING ENVIRONMENT


NASA-TP-73795 Available: NTIS HC A02/MF A01 CSCL 07D

Cool3 target collection techniques and high pressure mass spectrometric sampling were used to measure the relative rates of oxidative vaporization and to identify the volatile products emanating from samples of chromia and Mg-doped lanthanum chromite. The materials were exposed to partial pressures of KOH with and without H2O2 in one atmosphere of air flowing oxygen at elevated temperatures. Chromia and fresh samples of lanthanum chromite exhibited enhanced rates of oxidative vaporization upon exposure to thermal treatment of the samples. Kinetic data showed that the enhancements resulted from the heterogeneous formation of complex molecules of the type K2O2 sub 1.2 C02 and K2O sub 1.2 C02. Lanthanum chromite that had undergone prolonged oxidative vaporization exhibited no enhanced oxidation upon exposure to the reactants.

N78-11319** National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

INTERACTION OF NaCl(g) AND HCl(g) WITH CONDENSED Na2SO4


NASA-TP-73789 Available: NTIS HC A02/MF A01 CSCL 07D

The interaction of Na2SO4 with NaCl(g), HCl(g), and H2O(g) was studied in atmospheric pressure flowing air and oxygen at Na2SO4 temperatures of 900 and 1600 C. Thermomicrographic and high pressure mass spectrometric sampling techniques were used. Experimental results showed that the vaporized high rates of weight loss of Na2SO4 in the presence of NaCl(g) are due to the reaction Na2SO4(g) + 2HCl(g) + 2NaCl(g) + SO2(g) + H2O(g) + 1/2O2(g) being driven to the right in flowing gas systems. The HCl(g) is the product of hydrolysis of NaCl caused by small but significant amounts of H2O(g) present in the system. Thermochemical calculations are used to show that even with sub ppm levels of H2O(g) present, significant quantities of NaCl(g) are produced.

N78-11621* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

THE FLUORINATION OF COBALT AND ZINC

Patricia Marie O'Connell Jul. 1976 111 p refs
NASA-TP-73478: E-023) Available: NTIS HC A06/MF A01 CSCL 07D

The reaction of cobalt and zinc with gaseous fluorine was studied. Both temperature and pressure were variables, ranging from 298 to 1733 K and 50 to 625 torr. Both reactions were described by the parabolic rate law. The reaction was both temperature and pressure dependent. In the zinc reaction the vaporization rate of zinc above 573 K complicated the kinetics. The cobalt reaction was complex due to the formation of two fluorides. Parabolic rate constants were calculated from the temperature dependence of the reaction heat of reaction of 2.8 kcal-mole superscript for zinc and 4.8 kcal-mole superscript. 1 for cobalt in the low temperature range was estimated. Theoretical analysis indicated that the most probable mechanism for both reactions is cation diffusion through cation vacancies. Comparisons with reported oxidation kinetics were given.

Author
R78-17172+ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
RELEASE OF DISSOLVED NITROGEN FROM WATER DURING DEPRESSURIZATION
(Printed NASA-TM-73822, E. 14111-11) Avail NTIS: HC A02/MF A
CSCL 070

Experiments were run to study depressurization of water containing various concentrations of dissolved nitrogen gas. The primary case being room temperature water saturated with nitrogen at 4 MPa. In a static depressurization experiment, water with very high nitrogen content was depressurized at rates from 0.09 to 0.50 MPa per second and photographed with high speed movies. The pictures showed that the bubble population at a given pressure increased strongly with decreasing depressurization rate. Flow experiments were performed in an asymmetric condiverging-diverging nozzle and in a two-dimensional converging nozzle with glass walls. Depressurization gradients were roughly 500 to 1200 MPa per second. Both nozzles exhibited choked flow behavior even at nitrogen concentration levels as low as 4 percent of saturated. The flow rates were not independent of concentration level and could be computed as incompressible water flow based on the difference between stagnation and throat pressures, however, the throat pressures were significantly different between the two nozzles. Author

R78-18227+ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
DEPURATION OF CHEMICAL PROPERTIES OF SURFACES IN FRICTION, WEAR, AND LUBRICATION

(NASA-TM-8020) Avail. NTIS: HC A03/MF A01 CSCL 070

Chemical properties relative to their role in adhesion, friction, wear and lubrication discussed in this paper will include: (1) adsorption, both physical and chemical; (2) orientation of the solid as well as the lubricant; (3) surface energy; (4) surface segregation; (5) surface versus bulk metallographic effects; (6) electronic nature of the surface; and (7) bonding mechanisms. Author

R7-2029+ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
EFFECT OF NITRIC OXIDE ON PHOTOCHEMICAL OZONE FORMATION IN MIXTURES OF AIR WITH MOLECULAR CHLORINE AND WITH TC1H2OFLUOROMETHANE

(NASA-TP-1192) E.9297) Avail. NTIS: HC A02/MF A01 CSCL 070

Ozone formation in a reaction chamber at room temperature and atmospheric pressure was studied for the photolysis of mixtures of NO with either O2 or COF3 in air. Both O2 - NO and COF3 studies showed O3 formation during the entire 3 to 4 hour reaction. A chemical mechanism that explains the results was presented. An important part of this mechanism was the formation and destruction of chlorine nitrate. Calculations were performed with this same mechanism for COF3:NO:air mixtures at stratospheric temperatures, pressures, and concentrations. Results showed large reductions in steady-state NO concentrations in these mixtures as compared with pure air. Author

R7-2148+ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
APARATUS FOR EXT. ACTION AND SEPARATION OF A PREFERENTIALLY PHOTODISOCIATED MOLECULAR ISOTOPE INTO POSITIVE AND NEGATIVE IONS BY MEANS OF AN ELECTRIC FIELD Patent


R7-2814+ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
FORMULATION PLASTIC SEPARATORS FOR SOLUBLE ELECTRODES CELLS Patent Application
David W. Shebley, inventor (to NASA) Filed 3 Nov. 1977


Membranes containing a hydrophilic acid-insoluble sheet of a mixture of a rubber and a powered ion transport material were designed for use in oxidation-reduction (REDOX) electrolytic cells. The sheet of thermoplastic rubber and an ion transport material, which may be in the form of a film on a flexible substrate such as an enamel paper or paper was made by a double joking in a solvent and mixing with the ion transport material which is 20-50 volume percent as compared with 80-50 volume percent rubber. Preferred ion transport materials include a salt or a choline ion, a phosphonium, tertiary ammonium or quaternary ammonium, cation; a metal oxide, and a siliate or boron acid. NASA

R7-2618+ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
APPLICATION OF EBCA TO THE DETERMINATION OF STOICHIOMETRY IN SPATTERED COATINGS AND INTERFACE REGIONS

(NASA-TP-78886, E-9367) NTIS: HC A02/MF A01 CSCL 070

X-ray photoelectron spectroscopy was used to characterize radiofrequency sputter deposited films of real refractory compounds. Both the bulk film properties such as purity and stoichiometry and the character of the interfacial region between the film and substrate were examined. The materials were Cr2O3, Mo52, Mo2C, and Mo2C205 deposited on 440C steel. It was found that oxygen from the sputtering target was the primary impurity in all cases. Busing improves the film purity. The effect of busing on film stoichiometry is different for each compound. Comparison of the interfacial composition with friction data suggests that adhesion of these films is improved if a region of mixed film and iron oxides can be formed. Author

R7-2732+ National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
TARGETS FOR PRODUCING HIGH PURITY 1-233 Patent


Tellurium powder in improved targets is bombarded with a cyclotron beam to produce Xe 123. Flowing gas streams carry
the A123 through one cold trap which removes A123 that subsequently deposits to 1123. During this bombardment energy as deposited in the target material causing its temperature to raise. Some of the sublimed vapors and subsequently condensed on surfaces that are cooler than the vaporization temperature. Procedures used for the repeated bombardment of this condensed tellurium of the US Patent Office


Based on cooled target collision experiments and high pressure mass spectrometric sampling, oxidative vaporization rates and volatiles produced were evaluated for reactions of KC1 with Qo203 and LaO03 in oxidizing environments. It was found that the increased rates of oxidative vaporization upon exposure to the reactants were greater by chemical reaction of lanthanum chloride samples, and (2) these increased rates result from the heterogeneous formation of complex molecules such as KC1 sub 1,23003 and KOH sub 1,23003. No increased rates were observed for lanthanum chloride subjected to prolonged oxidative vaporization.

A78-2488 • Interaction of NaCl(g) and NaCl(g) with condensed Na2S04. C. A. Stearns, F. J. Kohl, G. C. Fryburg, and R. A. Miller (NASA Lewis Research Center, Cleveland, Ohio). Electrochemical Society, Symposium on High Temperature Metal Halide Chemistry, Atlanta, Ga., Oct. 9-14, 1977. Paper 20 p. 17 refs.

Na2S04-NaCl(g) interaction: were studied at a total pressure of one atmosphere of air or oxygen for various temperatures of Na2S04 and for various partial pressures of NaCl(g) and K2O(g). Mass spectrometric sampling techniques were used to identify and monitor gas phase species. Continuous recording of thermocouple and mass spectrometric measurements were conducted to determine condensed phase weight change rates. Experimental measurements were supplemented with thermodynamic calculations. Numerous experiments were performed at sample temperatures of 900 and 1000 C with 300 psig NaCl(g) in these experiments, the reproducibility of the Na2S04 vaporization weight loss rate and initial weight gain upon addition of NaCl(g) were found to be satisfactory. It was found that the addition of NaCl(g) to air flowing over Na2S04(1) at 900 and 1000 C enhances the rate of weight loss of Na2S04(1). This enhancement increases when H2O(g) is added to the air flow.


High pressure, free jet expansion, mass spectrometric sampling was used to identify directly and to measure reaction products formed in doped methane-oxygen flames. Flames were doped with SO2 or CH3SH and sodium or potassium chlorides or carbonates. Gaseous Na2S04 or K2S04 molecules were formed in residence time on the order of 1 ms for each combination of dopants used. Composition profiles of combustion products were measured and compared with equilibrium thermodynamic calculations of product composition. (Author)


X-ray photoelectron spectroscopy was used to characterize the chemical composition of 304 stainless steel surfaces run on a ball-on-disk apparatus under mild and severe wear conditions. In severe wear a sulfide was formed at the expense of the normal oxide. This was due to either chemic attack on the oxide or reaction with chrome metal exposed by the wear process. In the mild wear scar there was no evidence of either sulfide or metal. The oxide, however, was approximately twice as thick as the normal oxide on an unworn surface. The change in surface chemistry was a function of wear rate rather than load. (Author)


An important factor regarding the use of a pressured conical fluidized bed (PF1) providing gases for sealing a gas turbine is the turbine blade lifetime. However, very few data are currently available to predict exposed and confined rates produced by the effluent from a PF1. To assess the potential of a PF1 developed for aerodynamic application to reduce the environment it was decided to build a conical fluidized-bed test unit that could be employed to measure erosion and corrosion rates. Tests were conducted with a laboratory fluidized bed at an optimized pressure through the use of methanol. A data program was presented in the data obtained at the first 138 hrs of testing to evaluate the effluent from the tests under different test conditions. The test results had been made in determining the best operating conditions to improve the data and determination of the erosion and corrosion rates of typical blade materials.


Experiments were run to study depressurization of water containing various concentrations of dissolved nitrogen gas. The primary case being room temperature water saturated with nitrogen at 4 MPa. In a static depressurization experiment, water with very high nitrogen content was depressurized at rates from 0.099 to 0.50 MPa per second and photoluted with high speed mirrors. The pictures showed that the bubble relaxation at a given pressure increased strongly with decreasing depressurization rate. Bubble relaxation rapidly was the pressure needed for the initial incompressibility. Flow experiments were performed in an annular flow converging-diverging nozzle and in a fundamental flow divergent with planar velocity. Details of special test apparatus were nearly 500 to 1200 MPa per second. Ditto, waves traveled at the flow characteristic velocity given the difference between the two linear flight.
26 METALLIC MATERIALS

Includes all metal, chemical, and mechanical properties of metals, e.g., corrosion, and metalurgy.

N78-11232* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SECONDARY-ELECTRON EMISSION PROPERTIES OF CONDUCTING SURFACES WITH APPLICATION TO MULTISTAGE DEPRESSED COLLECTORS FOR MICROWAVE AMPLIFIERS
Ralph Forman Nov 1977 33 p refs (NASA TP 1087; E 9233) Avail NTIS HC AO3/MF AO1 CSCL 11F

To improve the efficiency of high power microwave tubes, low-temperature yield electrode surfaces for use in depressed collectors are needed. The secondary emission characteristics of a number of materials were investigated. The materials studied were beryllium, carbon (slovak and pyrolytic graphite), copper, titanium carbide and tantalum. Both total secondary yield data and relative reflected primary yield were measured. These measurements were made in conjunction with Auger spectroscopy so that the secondary emission characteristics could be determined as a function of surface contamination or purity. The results show that low atomic weight elements, such as beryllium and carbon, are the lowest reflected primary. The experiments showed that the rate of an electrode can markedly decrease secondary yield both for metal and reflected primaries. All factors considered, a textured pyrolytic graphite surface showed the greatest potential for use as an electrode surface in depressed collectors.

Author

N78-13818* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MECHANICAL PROPERTIES OF ION-BEAM-TEXTURED SURGICAL IMPLANT ALLOYS

An electron bombardment ion gun thruster was used as an ion source to texture surfaces of materials used to make orthopedic and/or dental prostheses or implants. The materials tested included 316 stainless steel, titanium 6% aluminum, 4% vanadium, and cobalt 20% chromium. 15% tungsten. To determine the effect of ion texturing on the ultimate strength and yield strength, stainless steel and Co Cr W alloy samples were textured to failure. Three types of samples of both materials were tested. One type was ion textured the texturc also had each sample to 300 C. Another type was simply heated to 300 C in an oven and the third type was untextured. Stress strain diagrams. 0.2% offset strength data, Vickers hardness data and area reduction data are presented. Fatigue specimens of ion textured and untextured 316 stainless steel and 1-6% AL 4% V were tested included as an ion textured sample is a 1-6% AL 4% V sample which was ion machined by means of Ni screen mask so as to produce an array of 140 mu m x 140 mu m x 60 mu m deep pits. Scanning electron microscopy was used to characterize the ion textured surfaces.

Author

N78-13182* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ROTOR TURBULENCE CRACK GROWTH RATES AND .20 DEG FRACTURE TOUGHNESS OF WELDED 1.1/4 INCH A.285 STEEL PLATE
John L Shannon, Jr and Walter Rzasnicki Nov 1977 22 p refs (NASA-TM 73847; E 9435) Avail NTIS HC AO2/MF AO1 CSCL 11F

Data are presented which were developed in support of a structural assessment of NASA LEWIS' 10 foot by 10 foot supersonic wind tunnel. Critical portions of which are fabricated from rolled and welded 1.1/4 inch thick A.285 steel plate.

Test material was flame cut from the tunnel wall and included longitudinal and circumferential welds. Parent metal, welds, and weld heat affected zones were examined in a fracture toughness were determined at 20 F. The estimated lowest tunnel operating temperature Crack growth rates were measured at room temperature, where growth rates in service are expected to be highest.

Author

N78-13182* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CYCLIC STRESS-STRAIN CURVE DETERMINATION FOR DSAC STEEL BY THREE METHODS
Alfred J Nachtigall 1977 6 p refs (NASA-TM-73816; E 9402) Avail NTIS HC AO2/MF AO1 CSCL 11F

The room temperature cyclic stress-strain was determined for DSAC low alloy steel by three different methods. The method that involves the use of a single specimen monotonic tension test after cyclic straining provided the best agreement with the accepted basic method which requires a number of companion specimen tests. The single specimen test is also the simplest to conduct.

Author

N78-15422* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FRICITION AND WEAR OF SEVERAL COMPRESSOR GAS-PATH SEAL MOVEMENTS
Robert C Bill and Donald W Wisander Jan 1978 42 p refs (NASA TP 1126; E 9276) Avail NTIS HC AO3/MF AO1 CSCL 11A

Rub interaction experiments were conducted on a series of sintered and plasma sprayed compressor gas path seal materials in contact with Ti6Al4V blade tip and knife edge rotors. The most rub tolerant materials investigated were sintered Nichrome and plasma sprayed nickel 25 percent graphite. The effectiveness of providing a compliant substrate for dense seal material coatings was also demonstrated. In general it was observed that rotor wear and high frictional energy generation rates accompanied smearing or surface delamination of the materials investigated. The onset of smearing was sensitive to rub interaction parameters and seal geometry. Two complementary models were proposed to account for the smearing tendency. One based on thermal effects the other on particulate escape effects. They were shown to be consistent with the experimental evidence at hand and together they predict that smearing with the onset of high energy rub conditions is favored when the incursion rates radial motion are low. Incursion depths are high. The seal geometry is of a knife edge character and the seal particle size is small. Author

N78-15422* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FEASIBILITY STUDY OF TUNGSTEN AS A DIFFUSION BARRIER BETWEEN NICKEL-CHROMIUM ALUMINUM AND GAMMA GAMMA PRIME: DELTA EUTECTIC ALLOYS
Stanley G Young and Glenn R Zallars Jan 1978 35 p refs (NASA TP 1131; E 9271) Avail NTIS HC AO3/MF AO1 CSCL 11F

Coating systems proposed for potential use on eutectic alloy components in high temperature gas turbine engines were studied with emphasis on deterioration of such systems by diffusion. A 1 mm thick W sheet was placed between eutectic alloys and a Ni/Co/Al layer at high test temperature of 1177 C for as long as 500 hours. Without the W barrier the delta phase of the eutectic deteriorated by diffusion of Ni into the Ni/Co/Al layer. Insertion of the W barrier stopped the diffusion of Ni from delta Chromium diffusion from the Ni/Co/Al into the gamma gamma prime phase of the eutectic was greatly reduced by the barrier. However, the barrier decreased with time and W diffused into both the Ni/Co/Al and the eutectic. When the delta plates were aligned parallel to the Ni/Co/Al layer he rather than perpendicularly diffusion into the eutectic was reduced.

Author
R78-18235* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

A study of the flow strength, creep resistance and diffusion welding characteristics of the tantalum alloy Ti-6Al-2Sn-1Ta-0.8Mo was conducted. Two mill-processed forms of this alloy were examined. The forged material was essentially processed above the beta transus while the rolled form was subjected to considerable work below the beta transus. Between 1150 and 1250 K the forged material was stronger and more creep resistant than the rolled alloy. Both forms exhibit superplastic characteristics in this temperature range. Strain measurements during diffusion welding experiments at 1200 K reveal that weld interfaces show no measurable effect on the overall creep deformation. Significant deformation appears to be necessary to produce a quality diffusion weld between superplastic materials. A soft interlayer inserted between mating surfaces was found to produce a crack extension model was developed wherein spontaneous stress

31 p refs (NASA-TM-73854; E-8441) Avail NTIS HC A03/MF A01

Author

R78-17812* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
TANTALUM MODIFIED FERRIC TRAP BASE ALLOYS Patent

A study of the flow strength, creep resistance and diffusion welding characteristics of the tantalum alloy Ti-6Al-2Sn-1Ta-0.8Mo was conducted. Two mill-processed forms of this alloy were examined. The forged material was essentially processed above the beta transus while the rolled form was subjected to considerable work below the beta transus. Between 1150 and 1250 K the forged material was stronger and more creep resistant than the rolled alloy. Both forms exhibit superplastic characteristics in this temperature range. Strain measurements during diffusion welding experiments at 1200 K reveal that weld interfaces show no measurable effect on the overall creep deformation. Significant deformation appears to be necessary to produce a quality diffusion weld between superplastic materials. A soft interlayer inserted between mating surfaces was found to produce a crack extension model was developed wherein spontaneous stress

Author

R78-17918* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
DIRECTIONALLY SOLIDIFIED EUTECTIC GAMMA-GAMMA NICKEL-BASE SUPERALLOYS Patent

A study of the flow strength, creep resistance and diffusion welding characteristics of the tantalum alloy Ti-6Al-2Sn-1Ta-0.8Mo was conducted. Two mill-processed forms of this alloy were examined. The forged material was essentially processed above the beta transus while the rolled form was subjected to considerable work below the beta transus. Between 1150 and 1250 K the forged material was stronger and more creep resistant than the rolled alloy. Both forms exhibit superplastic characteristics in this temperature range. Strain measurements during diffusion welding experiments at 1200 K reveal that weld interfaces show no measurable effect on the overall creep deformation. Significant deformation appears to be necessary to produce a quality diffusion weld between superplastic materials. A soft interlayer inserted between mating surfaces was found to produce a crack extension model was developed wherein spontaneous stress

Author

R78-17919* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
ELEVATED-TEMPERATURE FLOW STRENGTH, CREEP RESISTANCE AND DIFFUSION WELDING CHARACTERISTICS OF Ti-6Al-2Sn-1Ta-0.8Mo J Daniel Whittenberger and Thomas J Moore Dec 1977

A study of the flow strength, creep resistance and diffusion welding characteristics of the tantalum alloy Ti-6Al-2Sn-1Ta-0.8Mo was conducted. Two mill-processed forms of this alloy were examined. The forged material was essentially processed above the beta transus while the rolled form was subjected to considerable work below the beta transus. Between 1150 and 1250 K the forged material was stronger and more creep resistant than the rolled alloy. Both forms exhibit superplastic characteristics in this temperature range. Strain measurements during diffusion welding experiments at 1200 K reveal that weld interfaces show no measurable effect on the overall creep deformation. Significant deformation appears to be necessary to produce a quality diffusion weld between superplastic materials. A soft interlayer inserted between mating surfaces was found to produce a crack extension model was developed wherein spontaneous stress

Author

AAS-65272 - The fracture surface characteristics of off-axis pin joints: Composite specimens were studied using a scanning electron microscope (SEM). The specimens were subjected to radiographic analysis and tested in a single-ended, push-off 1977. AAS-77-770.

AAS-65273 - The fracture surface characteristics of off-axis pin joints: SEM particle-micrographs of the fracture surface revealed three different crack modes with distinct fracture characteristics. Based on these observations, criteria were established which can be used to characterize fracture modes with respect to a predominant fracture mode. (Author)


A general mathematical model for the prediction of performance of fluidized bed combustor (FBC) is developed. The basic elements of the model consist of: (1) hydrodynamics of gas and solids in the combustor (2) description of gas and solids contacting pattern (3) kinetics of combustion and (4) absorption of SO2 by reactors in the bed. The model is capable of calculating the combustion efficiency, axial bed temperature profiles, carbon hold-up in the bed oxygen and SO2 concentrations in the bubble and emulsion phases sulfur retention efficiency and particulate carry-over by elimination. The effects of bed geometry, excess air, location of heat transfer oils, the bed calcium to sulfur ratio in the feed solids are examined. The calculated results are compared with experimental data. Agreement between the calculated results and the observed data are satisfactory in most cases. Recommendations to enhance the accuracy of prediction of the model are suggested. (Author)


The existing literature on the combustion of liquid fuel pools is reviewed to identify the physical and chemical aspects which require an improved understanding. Among the pre-ignition and post-ignition processes a delineation was made of those which seem to uniquely benefit from studies in the essential environment offered by spaceflight. The role played by the gravitational constant in analytical and experimental justifications was developed. The analytical justifications were based on hypothesis, models, and dimensional analysis; whereas the experimental justifications were based on an examination of the range of gravity and gravity-dependent conditions possible in the earth based laboratories. Some preliminary expeditions into the question of feasibility of the proposed space lab experiment are also reported. (Author)
(NRM-19821)* National Aeronautics and Space Administration Lewis Research Center. Cleveland, Ohio
PRINCIPLES OF ESCA AND APPLICATION TO METAL CORROSION, COATING AND LUBRICATION
(NASA TM 78839) Avail NTIS HC AO2/MF AO1 CSCI 11F
The principles of ESCA (electron spectroscopy for chemical analysis) were described by comparison with other spectroscopic techniques. The advantages and disadvantages of ESCA as compared to other surface sensitive analytical techniques were evaluated. The use of ESCA was illustrated by actual applications to oxidation chemistry of fully dense silicon carbide addenda on steel and the composition of sputter deposited hard coatings. A bibliography of material that was useful for further study of ESCA was presented and commented upon. Author

(NTB-21289)* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STRENGTH ENHANCEMENT PROCESS FOR PREALLOYS POWDER SUPERALLOYS
A technique involving superplastic processing and high pressure autoclaving was applied to a nickel-base prealloyed powder alloy. Tensile strengths as high as 2865 MPI at 480°C were obtained with as superplastically deformed material. Appropriate treatments yielding materials with high temperature tensile and stress rupture strengths were also devised. Author

(NTB-21287)* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STRAIGHTENING OF PARTITIONING BEHAVIOR OF THE NICKEL BASE SUPERALLOYS, RENE-80 AND IN-100
A study was made to assess the ability of the method of straightening partitioning. (SRP), to both correlate and predict high temperature cyclic fatigue lives of nickel base superalloys to gas turbine applications. The partitioned straingrange versus life relationships for unalloyed Rene-80 and cast IN-100 were also determined from the curvature normalized Strainrange Partitioning equations. These were used to predict the cyclic lives of the partitioned tests. The life predictions of the method was verified for cast IN-100 by applying the baseline results to the data the prediction of a series of samples strain cycling tests with multiple load periods at constant strain. It was concluded that the method of SRP can correlate and predict the cyclic lives of partitioned specimens of the nickel base superalloys evaluated in this program. Author

(NASA-TP 11883 E 8414) Avail NTIS HC AO2/MF AO1 CSCI 11F
Fretting fatigue experiments conducted on 304 stainless steel using a flexural fatigue test arrangement with bonded on fretting pads demonstrated that fatigue life is reduced by at least a factor of 10 in the 295 to 334 MPa (128,500 to 48,500 psi) nominal flexural fatigue stress range in addition experiments in which the fretting pads were removed after selected numbers of cycles, followed by continuous fatigue without fretting. These experiments showed that continued fretting beyond 50,000 cycles does not significantly further reduce fatigue life of 304 stainless steel at 317 MPa (468,000 psi). Microscopic examination of the fretted contact area revealed fracture initiation sites as well as numerous cracks that did not propagate to failure. Flexural fretting fatigue experiments performed on mild steel showed an insensitivity of fatigue life to the incidence of fretting under repeated stress conditions of from 182 to 217 MPa (23,500 to 31,500 psi). Author

(NTB-22289)* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
HIGH TOUGHNESS HIGH STRENGTH IRON ALLOY Patent Application
A steel alloy is produced which exhibits excellent strength and toughness characteristics at cryogenic temperatures. The alloy consists essentially of about 10 to 18 percent by weight nickel about 0.1 to 1 percent by weight aluminum and 0.0 to about 0.003 by weight of at least one of the following additional elements: copper, lanthanum, tantalum, titanium, vanadium, yttrium, zirconium and the rare earth metals with the balance being essentially iron. The steel alloy is produced by a process which includes cold rolling at room temperature and subsequent heat treatment at temperatures ranging from 500 to 850°C and possesses a fracture toughness ranging from 200 to 230 ksi square root of psi and yield strength: up to 230 ksi. NASA

(NTB-23182)* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE ROLE OF TEMPSMAL SHOCK IN CYCLIC OXIDATION
The effect of thermal shock on the spanning of oxides from the surface of several commercial alloys was determined. The average cooling rate was varied from approximately 2400°C per second to less than 1°C per second during cyclic oxidation tests in air. The tests consisted of one hundred cycles of one hour at the maximum temperature (1100 or 1200°C) for 20 minutes plus 4 minutes of dwell in the metal which is in turn results in changing the oxide failure mode from corrosive to tensile. Tensile failures were characterized by cracking of the oxide and little loss while compressive failures were characterized by explosive loss of platelet of oxide. This behavior was confirmed in examination of mechanically stressed oxide scabs. The results show that shocked oxides spalled less than the allowed loss rate with the exception of '70' NiAl. The materials failed in a brittle manner rather than by plastic deformation. Author

(NTB-24389)* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NEW ALLOYS TO CONSERVE CRITICAL ELEMENTS

N78-24336# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

"Cyclic Oxidation of Coated Oxide Dispersion Strengthened ODS Alloys in High Velocity Gas Streams at 1100 Deg C" (May 1985). NASA TM 87877.

N78-26198# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

"Role of Alloying Elements in Adhesive Transfer and Friction of Copper Base Alloys" (January 1978). NASA TP 15768.

N78-29169# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio


N78-29215# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio


N78-29216# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio


N78-29217# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio


N78-29218# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio


N78-29219# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

Elements were studied at 1200, 1300, and 1400 °C for times (NASA TM 78942, DOE/NASA/2593 78/1). Available.

Some compounds with oxides and sulfates that reacted preferentially with monoclinic zirconia (Na2SO4, K2SO4, MgO, BaSO4) were classified in four groups: (1) oxides that did not react with zirconia, (2) compounds that reacted completely with both, (3) compounds that reacted preferentially with monoclinic zirconia, and (4) compounds that reacted preferentially with cubic zirconia. (V205, P205).


N78-20206
National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SIMULATIONS OF A SINGLE-STAGE LITHIUM BROMIDE WATER ABSORPTION COOLING UNIT

A computer model of a LiBr H2O single stage absorption machine was developed. The model utilizing a given set of design data such as water flow rate and inlet and outlet temperatures of these flow rates but without knowing the interior characteristics of the machine (heat transfer rates and surface areas) can be used to predict or simulate off-design performance. Results from 13 off-design cases for a given commercial machine agree with the published data within 2 percent.

N78-32110
National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

THE EFFECT OF FUEL-TO-AIR RATIO ON BURNER-RIG HOT CORROSION

Samples of a cobalt base alloy (Mar M 509), were subjected to hot corrosion in a Mach 0.3 burner rig. The corrosion was NaCl added as an aqueous solution to the combustion products of a sulfur containing Jet A fuel. The metal temperature was fixed at 900 °C. The extent of hot corrosion increased by a factor of three as the fuel to air mass ratio was increased from 0.033 to 0.050. Because the depositing salt was always Na2SO4, the increased attack appeared to be related to the gas composition.

N78-31211
National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

LONGITUDINAL SHEAR BEHAVIOR OF SEVERAL OXIDE DISPERSION STRENGTHENED ALLOYS

Two commercial oxide dispersion strengthened (ODS) alloys, MA 753 and MA 754, and three experimental ODS alloys, MA 757L, MA 754E, and MA 6000E were tested in shear at 760 °C. Comparisons were made with other turbine blade and vanes alloys. All of the ODS alloys exhibited less shear strength than directionally solidified MA M 200. When conventionally cast B 1900, the strongest ODS alloy tested. MA 755E was comparable in both shear and tensile strength to the familiar directionally solidified austenitic alloy gamma/alpha prime, delta. Substantial improvements in shear resistance were found for all alloys when the geometry of the specimen was changed from one generating a transverse tensile stress in the shear area to one generating a transverse compressive stress. Finally, 760 °C shear strength as a fraction of tensile strength was found to increase linearly with the log of the transverse tensile stress.

N78-32121
National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECTS OF COMPOSITIONAL CHANGES ON THE PERFORMANCE OF A THERMAL BARRIER COATING SYSTEM
Currently proposed thermal barrier systems for aircraft gas turbine engines consist of NiCrAlY bond coating covered with an insulating oxide layer of yttria stabilized zirconia. The effect of yttrium concentration (from 0.15 to 1.08 wt%) in the bond coating and the yttria concentration (4 to 24.4 wt%) in the oxide layer were evaluated. Furnace natural gas oxygen torch, and Mach 1 burner rig cyclic tests on solid specimens and air cooled blades were used to identify trends in coating behavior. Results indicate that the combinations of yttrium levels between 0.15–0.35 wt% fit the bond coating and the yttria concentration between 6–8 wt% in the zirconia oxide layer were the most adherent and resistant to high temperature cyclic exposure.

Author

N78 312137 National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

EFFECTS OF THERMOELECTICAL PROCESSING ON STRENGTH AND TOUGHNESS OF IRON-12 PERCENT-NICKEL REACTIVE METAL ALLOYS AT 196 C

Joseph R Stephens and Walter R Wittke Aug 1978 36 p

(NASA TP 1308 E 9533) Avail N115 HC A02 MF A01 CS CL

N78 331902 National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

LONG TERM HOT HARDNESS CHARACTERISTICS OF FIVE THROUGH HARDENED BEARING STEELS


St Louis Mo

(NASA TP 1341 E 9533) Avail NTIS HC A02 MF A01 CS CL

Five vacuum melted bearing steels tempered to various room temperature hardnesses AISI 52100 and the tool steels AISI M1 AISI M50 Halmco and W8 49 were studied Hardness measurements were taken on AISI 52100 at room temperature and at elevated temperatures after soaking at temperatures to 478 K (1400 F) for as long as 1000 hours. Hardness measurements were also taken on the tool steels after soaking them at temperatures to 700 K (1800 F) for as long as 1000 hours. None of the tool steel tempered during soaking and AISI 52100 did not temper when soaked at 366 K (1200 F) for 1000 hours. However, AISI 52100 that was initially hardened to room temperature hardness of 62.5 or 64.5 lost hardness during the first 500 hours of the 1000 hour soak tests at temperatures greater than 394 K (700 F) but the maintained its hardness during the final 500 hours of soaking. Similarly AISI 52100 initially hardened to room temperature hardness of 60.5 lost hardness during the first 500 hours of the 1000 hour soaking at temperatures greater than 422 K (750 F) but it maintained its hardness during the final 500 hours of soaking. A R H


A program was undertaken to develop an iron base alloy having a fracture toughness of 220 MPa sq root meters with a corresponding yield stress of 1.4 GPa (200 ksi) at 190 C. An Fe 12Ni alloy was selected as the base alloy. Factors considered include reactive metal additions; effects of interstitial impurities; strengthening mechanisms, and weldability. The goals of this program were met in an Fe 12Ni 0.5SiAl alloy strengthened by thermomechanical processing or by precipitate strengthening with 2 percent Cu. The alloy is well suited with the weld metal and heat affected zone in the post weld annealed condition having toughness equivalent to the base alloy. (Author)


Volatilization of oxides during cyclic oxidation of commercial superalloys Inconel P/M Rene 41, Stellite 6B, and GE 1543 was studied at 1200 C. A quantitative analysis of oxide scale deposits revealed that oxides of tungsten, molybdenum, manganese and chromium volatilized preferentially from the oxide scales. Aluminiun and silicon were not detected in scale deposits. A long-time exposure to 1200 C produced a protective oxide scale. (Author)


An investigation was performed on As HIP Rene 95 to obtain additional information on the variation of the amount of gamma prime with solution temperature near the gamma prime solvus temperature and the resulting effect on tensile and stress rupture strength. As HIP Rene 95. The amount of gamma prime phase was found to increase at a rate of about 0.2 per degree Kelvin as the temperature decreased from the solvus temperature to about 50 C below the gamma prime solvus temperature. This change in the amount of gamma prime phase with decreasing solution temperature was observed to be primarily associated with decreasing solubility of Ti and Nb and increasing solubility of C in the gamma prime phase. As HIP Rene 95 solution at either 1170 or 1115 C and subsequently water quenched and tested aged for 4 hours at 815 C followed by 24 hours at 1650 C the highest temperature tested is significantly greater yield strength at room temperature and 930 C as well as a greater room temperature ultimate strength. Also higher stress rupture lives at 1250 C were associated with the higher yield strength. (Author)


The burners of four alloys was studied in cyclic tests in a Mach 8 burner rig chamber. Exposure time varied from 10 hours to 10 days. In 1536 and 1561 a salt free alloy (MM 306) and an iron base alloy based on W and Mo.
alloy (304 stainless steel) were studied at temperatures of 700, 900, 900, and 1000°C with various salt concentrations and compositions. The relative resistance of the alloys to hot corrosion attack was found to vary with temperature and with liquid concentration and composition of the injected salt solution. Results indicate that the corrosion of these alloys is a function of both the presence of salt condensed as a liquid on the surface and of the composition of the gas phases present.


An experimental study was conducted to determine whether oxide dispersion strengthened (ODS) Ni-base alloys in wrought form are subject to creep degradation effects similar to those found in thin-gage sheet. The bar products evaluated included ODS Ni, ODS NiCr, and advanced ODS NiCrAl types. The alloys included microstructures ranging from an essentially perfect single crystal to a structure containing very small elongated grains. Tensile specimens were creep tested at various stress levels at 1365 K and then tensile tested at room temperature. Low residual tensile properties, change in fracture mode, appearance of dispersed fine grains, grain boundary cavitation, and internal oxidation are interpreted as creep degradation effects. The amount of degradation depends on creep strain, and degradation appears to be due to diffusional creep which produces dispersed fine grains around grain boundaries acting as vacancy sources.


Cast specimens of nickel-base superalloys 713C and Mar-M200 with nominal additions of 0.5% and 1% S were evaluated for oxidation and corrosion resistance, tensile and shear rupture properties, microstructure, and phase relations. Results are compared with those of an earlier study of the effects of Si on Ni base alloys at 1365 K. Similar effects on all the superalloys. It improves oxidation resistance but the improvement in 713C and Mar-M200 was considerably less than in B 1900. Hot corrosion resistance is improved somewhat. Si has a detrimental effect on mechanical properties in particular, shear strength, tensile ductility. Si has two obvious microstructural effects. It increases the amount of gamma prime precipitated in the matrix and promotes a more Ni-saturated Laves phase in the alloys containing Si. These mechanical effects are not apparent for the degradation of mechanical properties.


A956E, a high nickel-iron experimental oxide dispersion strengthened iron base sheet alloy MA 956E (Fe 96.4% Cr 6.5% C 0.5% O 0.5% Si 0.5% Mn). The 1365 K in-air properties, particularly those strength, elongation, and ductility, are higher than those of the base alloy. It appears that MA 956E is not easily subject to slow strain rate deformation. Rather than deform under creep loading conditions, the alloy apparently fails by a crack nucleation and growth mechanism. Fortunately, there appears to be a threshold work stress which crack nucleation and growth do not occur.


Gas turbine blades and vanes for the 1980s call for new materials with high operational temperature capability. The potential increase of from 40 to 110°C in operational temperature capability predicted for directionally solidified eutectics is a larger increment than currently available alloys than previously obtained in any new turbine blade alloy. The paper discusses the properties of gamma-gamma prime eutectic and NiTaC-13 directionally solidified fast generation eutectics for use at gas turbine blade materials. A few of the most promising general generation eutectics for blade application are gamma gamma prime alpha, NiTaC 3116A) and for vane applications (gamma beta, COLTA 74) are also discussed. Attention is given to mechanical properties, such as transverse ductility and shear strength, that can be inherently critical in a directionally solidified eutectic. Further R&D requirements for properties, cost, and lower cost processing technology are identified S.D.
were covered with etched dimples. Metallographic sections of specimens deformed at 77 K showed that these features form at the intersections of slip bands or deformation twins with grain or twin boundaries. Ordering and higher interstitial levels increase the local strain in slip bands resulting in void nucleation, lower macroscopic strains and lower KIC values.

(Author)


A study has been made to determine the method of surface-partitioning in Rene 80 and 100. High-temperature low cycle fatigue lives of Rene 80 and 100 have also been determined from the study by normalized fatigue partitioning method. These were used to predict the cyclic loads of the Rene 80 and 100. Rene 80 has been found to exhibit similar behavior in fatigue life and test results of its use which show the necessity of high cycle fatigue testing with multiple load periods at constant stress. It is concluded that the method of surface-partitioning can correlate and predict the cyclic life of laboratory specimens of the nickel base superalloys evaluated in this program.

(Author)


An inexpensive device for producing surface cracks in a polycrystalline material is described along with results on its use which show the surface crack shape in bending fatigue from a crack starter shown. The growth pattern for any crack is uniquely defined by the crack starter configuration and appears to be independent of alloy. Shape changes are substantial and all growth curves tend toward a common growth curve. Circular cracks tend to become elliptical with an associated increase in stress intensity factor. This increase accelerates the crack growth rate and proximity to the critical flaw size. Through cracks produced by the extension of a surface crack in a bending stress field will have lengths more than twice the critical size and stress intensity factor. The results demonstrate the necessity of taking into account changing crack shape in the calculation of structural life when bending is a significant component of the stress field.

(Author)


A resonant fatigue apparatus for producing surface cracks of controlled size and shape is described along with results on its use which show how the shape of the surface crack changes and grows in bending fatigue from a crack starter shown. The growth pattern for any crack is uniquely defined by the crack starter configuration and appears to be independent of alloy. Shape changes are substantial and all growth curves tend toward a common growth curve. Circular cracks tend to become elliptical with an associated increase in stress intensity factor. This increase accelerates the crack growth rate and proximity to the critical flaw size. Through cracks produced by the extension of a surface crack in a bending stress field will have lengths more than twice the critical size and stress intensity factor. The results demonstrate the necessity of taking into account changing crack shape in the calculation of structural life when bending is a significant component of the stress field.

(Author)


Material from a single heat of cast and wrought Udiment 700 was processed and/or heat treated to produce five material conditions with identical chemical compositions but with distinct microstructural variations, and then evaluated for susceptibility to hydrogen embrittlement. Two processed and/or heat treated conditions exhibited significantly improved resistance to hydrogen embrittlement, as compared to wrought material. No degradation in notch or smooth tensile strength occurred, and average ductilities of 25 percent reduction of area were determined for 2 hydrogen evaluation procedures. For the most severe hydrogenation procedure, ductility levels were reduced to 15 percent. These improvements were attributed to smaller grain boundaries and decreased grain size.


The effect of thermal shock on the spalling of oxides from the surfaces of several commercial alloys was determined. The average cooling rate was varied from approximately 200°C/sec to less than 1°C/sec during cyclic oxidation tests in air. The tests consisted of one hundred cycles of one hour at the maximum temperature (1100 or 1200°C). The alloys were HGS-875, TD-Ni, TD NiAl, IN-601, IN-702, and B-1000 plus Hf. Thermal shock resulted in deformation of the metal which in turn resulted, in most cases, in changing the oxide failure mode from compressive to tensile. Tensile failures were characterized by cracking of the oxide and little loss, while compressive failures were characterized by explosive loss of platelets of oxide. The thermally shocked samples spilled less than the slow cooled samples with the exception of TD NiAl. This material failed in a brittle manner rather than by plastic deformation. The HGS-875 and TD Ni did not spall during either type of cooling. Thus, the effect of thermal shock on spalling is determined, in large part, by the mechanical properties of the metal.


Previous studies and surveys on availability of domestic reserves have shown that chromium is a most critical element within the U.S. metal industry. More precisely, the bulk of chromium is consumed in the production of stainless steels, specifically Type 304 stainless steel (304SS) which contains 18% Cr. The present paper deals with means of reducing chromium in commercial stainless steels by substituting more abundant or less expensive elements with the intent of maintaining the properties of 304SS. The discussion focuses on some of the oxidation and corrosion properties of new substitute stainless steels with only 12% Cr, which represents a potential saving of 33% of the chromium consumed in the production of 304SS. The alloying elements substituted for Cr in 304SS are selected according to their potential for protective oxide formation during high temperature oxidation, those are Al, Si, Ti, Y, and much metal which is 99.7% rare earth metals containing 50 to 55% cerium. Other alloying elements to impart corrosion resistance are Mn, Mo, and V.


A cleaning process for removing interstitial contaminants from superalloy powders after wet grinding is described. Typical analyses of oxygen, carbon, nitrogen, and hydrogen in ball milled WA20 superalloy samples after hydrogen plus vacuum cleaning are presented. The hydrogen cleaning step involves heating retorts containing superalloy powder twice under flowing hydrogen with a 24 hour hold at each temperature. The vacuum step involves heating cold-pressed billets two hours at an elevated temperature at a pressure of 10 microPa. It is suggested that the hydrogen plus vacuum cleaning procedure can be applied to superalloy containing other substances in other industrial processes.
and NASA.

An outline is presented of approaches for treating multihulls on the basis of the local joint convergence method. The method has been employed in the case of two highly characterized multihulls, including a 304 stainless steel studied in Japan and a low alloy carbon steel studied in England. The method makes use of the same functional form for all materials. Only the constants are varied for each multihull. Completely computerized procedures are employed for the determination of the constants. Once the basic analysis has been performed, the relationships for various members in the same system are achieved by adding linear expressions of log stress, changing only two constants in the equations to represent a selected heat. G.R.


A heuristic mathematical basis is proposed for the experimental correlations found between ultrasonic propagation factors and fracture toughness factors in metallic materials. A crack extension model is proposed wherein spontaneous stress (elastic) waves produced during microcracking are instrumental in promoting the onset of unstable crack extension. Material microstructural factors involved in this process are measurable by ultrasonic probing. Experimental results indicate that ultrasonic attenuation and velocity measurements will produce significant correlations with fracture toughness properties and also yield strength. (Author)


An investigation was conducted to determine the effects of substituting less strategic elements for Cr on oxidation and corrosion resistance of AISI 304 stainless steel. Cyclic oxidation resistance was evaluated at 870 °C. Corrosion resistance was determined by exposure of specimens to a boiling copper-rich solution of copper sulfate and sulfuric acid. All substrates for Cr include Al, Mn, Mo, Si, Ti, V, Y, and muck metal. A level of about 12% Cr was the minimum amount of Cr required for adequate oxidation and corrosion resistance in the modified composition 304 stainless steels. This represents a Cr saving of 23%. 2% Cr, plus 7% Al, plus 3% Mo, and 12% Cr plus 1% Si, were identified which exhibited oxidation and corrosion resistance comparable to AISI 304 stainless steel. (Author)


Thirty-three commercial high-temperature Fe-, Ni-, and Co-base alloys were oxidized in air at 815 C (1500 F) for ten 1000-hour cycles. Specific weight change versus time curves were derived and the 10,000-hour surface oxides were analyzed by X-ray diffraction. The alloys were ranked by a combination of appearance and metal loss estimates derived from gravimetric data. (Author)


Techniques utilizing strain-range partitioning may be used to estimate the effects of the environment on the high-temperature, low-cycle, creep-fatigue resistance of alloys. Three levels of ductility-normalized strain-range-partitioning life relations are discussed: (1) strain-range partitioning relations from ductility data, (2) strain-range partitioning relations scaled by ductility ratios, and (3) strain-range partitioning life relations with measured PP lines. The procedure has demonstrated good agreement with available creep-fatigue data. S.C.S.


The paper assesses the effect of overlay coating and substrate composition on the kinetics of coating depletion by interdiffusion. This is accomplished by examining the constitution, kinetics and activation energies for a series of diffusion couples primarily of the Ni-Al/Al-Ni system influencing the range in temperature and times up to 500 °C. A general procedure is developed for analyzing diffusion in multicomponent systems. It is shown that by introducing the concept of beta-source strength, which can be determined from appropriate phase diagrams, the Wagner solution for consumption of a second phase in a seminfinite couple is successfully applied to the analysis of multicomponent systems. Thus, correlation of the composition ratio constants with couple composition, total and interdiffusion activation energies, and interdiffusion coefficients are determined. S.D.


Oxide Dispersion strengthened (ODS) Ni-Al alloy systems were exploited for turbine engine vanes which would be used for the space shuttle thermal protection system. Available commercial and developmental advanced ODS alloys were evaluated, and three were selected based on established vanes property goals and manufacturing criteria. The selected alloys were evaluated in an engine test. Candidate alloys were screened by strength, thermal fatigue resistance, oxidation and sulfidation resistance. The Ni-18Gc (13 to 36-ThC2) system was identified as having attractive high temperature oxidation resistance. Subsequent work also indicated exceptional sulfidation resistance for these alloys G.H.


Beta alumina tubes having walls 100 microns thick 300 microns and 146 microns were fabricated by using a binder utilizing Ford producibility binder and fabrication systems. Tulas prepared by this method have properties similar to tubes prepared by autoclave pressing and sintering, i.e., density greater than 98% of theoretical and a helium leak rate less than 0.1 x 10 to the
specimens, 11,000 thermal cycles without cracking Only 2 of the 21 foil overlay specimens exhibiting cracking in 7,000 cycles. Bistening of the foil did occur for 2 alloys by 500 cycles. Oxidation of the alloy brazed combination was limited at the test maximum test temperature of 740°C. 


THE EFFECT OF MICROSTRUCTURE AND STRENGTH ON 
THE FRACTURE TOUGHNESS OF AN 18 Ni. 300 GRAD MARAGING STEEL. Final Report 


(NASA CR-135268. OHU. NASA) Avail. NITIS 

HC AO5/MF AO1 CSCL 11F 

Fractography and metallographic sectioning were used to investigate the influence of microstructure and strength on the fracture toughness (KIC) and fracture mechanism in an 18 Ni. 300 grade maraging steel. Increased yield strength from 1442 to 2070 MN/m2 through precipitation hardening results in a KIC loss from 143 to 55 MN/m2 supercritical 3/2. TiCN T25. and TiC inclusions in sizes from 1 to 8. 1 to 15, and 0.1 to 2 microns respectively serve as silt for void nucleation and lead to fracture by the dimpled rupture process in all strength levels considered. TiC nucleated dimples occupy more than half the fracture area in all conditions. Voids nucleation rates and resultant number of dimples per unit area of fracture increase with increasing yield strength Average dimple size decreases with increasing strength and/or overage with a decrease from the deformation amount of void growth measured by sectioning tensile specimen Void growth is assisted by crack branching along a path of TiC inclusions Coalescence occurs in the highest strength materials by a combination of TiC void nucleation and premature separation at strengthening precipitates. 

N7B-18296® Kentucky Univ. Lexington. Dept of Metallurgical Engineering and Materials Science 

THE EFFECT OF MINOR ADDITIONS OF TITANIUM ON 
THE FRACTURE TOUGHNESS OF Fe-12%ALLOYS AT 77K 


H. Conrad. C. Yin. and G. Sargent 16 Jan. 1978 92 p refs (Grant NED-3126) 

(NASA CR-135351) Avail. NITIS HC AO5/MF AO1 CSCL 11F 

Titanium additions ranging from 0.18 to 0.99 atomic percent and heat treatments of 2 hours at 550, 655 and 820 °C respectively followed by a water quench were considered. Cubic and rectangular shaped incluions were noted in the SEM fractographs of the alloys with the Ti additions. A fine precipitate was observed by TEM for the Fe-12.47 Ti BTI alloy at 550 °C this precipitate was not observed for the 685 and 820 °C heat treatments of the same alloy Auger mapping of the fracture surfaces indicated a weak to moderate association of the interstitials C. N and O with Ti. The degree of which depended on the particular interstitial and the heat treatment temperature 


THERMAL FATIGUE AND OXIDATION DATA OF SUPERALLOYS INCLUDING DIRECTIONALLY SOLIDIFIED EUTECTICS 

V L Hill and V E Humphreys Jun 1977 66 p refs (Contract NASA-17787) 

(NASA CR-135272. IITRI-B6124A) Avail. NTIS 

HC AO5/MF AO1 CSCL 11F 

Thermal fatigue and oxidation data were obtained on 61 specimens, representing 15 discrete alloy compositions or fabricating techniques and three coating systems. Conventionally fabricated alloys included V57. MM 200, Rene 77, Rene 128, MM 248, MM 509, IN 738, IN 792, Hi, and MM 200 + Hi. The directionally solidified alloys were MM 200, MM 200 single crystal, MM 200 bicrystal. Cellular gamma/gamma delta. and lamellar gamma/gamma delta. The coatings systems included NICO41 on IN 738, IN 792 - Hi. MM 200 DS, MM 200 DS single crystal, and cellular gamma/gamma. delta and NICO41P on lamellar gamma/gamma. delta. Crack initiation survival rates were recorded for all alloys, with and without coatings. All uncoated alloys, except MM 509, exhibited significant oxidation weight loss in 75,000 to 15,000 cycles. MM 509 specimens had weight losses only slightly higher than coated specimens through 7,500 cycles. All coated specimens had low weight loss. 


EXPERIMENTAL TRANSIENT AND PERMANENT DEFORMATION STUDIES OF STEEL-SPHHERE-IMPACTED OR EXPLOSIVELY-IMPULSED ALUMINUM PANELS 

Emmet, A. W. Redmond. J. A. Rodal. and Thomas C. Stapphoann May 1977 144 p refs 

(Grant NGR-22-009339) 

(NASA CR-135315. ASRL TR 154-12) Avail. NITIS 

HC AO7/MF AO1 CSCL 11F 

The sheet explosive loading technique (SELT) was employed to obtain elastic plastic large deflection. 3 d transient and/or permanent strain data on simple well-defined structural specimens and materials included flat plate. 1561 aluminum panels with all four sides ideally clamped via integral construction. The SELT loadng technique was chosen since it is both convenient and provides force function information of wall response. These data will be useful for evaluating pertinent J. structural response prediction methods. 

N7B-20310® California Univ. Berkeley. Lawrence Berkeley Lab. 

THE DESIGN OF AN Fe-12%Mn-0.2%Ti ALLOY STEEL FOR LOW TEMPERATURE USE. Final Report 

S K Hong and J M Morrjs Jr B Dec 1977 107 p 

(Grant NGR-05-005-582) 

(NASA CR-135310) Avail. NITIS HC AO5/MF AO1 CSCL 11F 

An investigation was made to improve the low temperature mechanical properties of Fe-8% Mn-0.2% Ti alloy steels. A two-phases plus - gamma aging in combination with cold working or hot working was identified as an effective treatment. A potential application as a Ni-free cryogenic steel was shown for this alloy. It was also shown that an Fe-8%Mn steel could be grain refined by a purely thermal treatment because of its dislocated martensitic structure and absence of allotropies. A significant reduction of the ductile brittin tr~~.was obtained in this alloy. The nature and origin of
bridle fracture in Fe-Mn alloys were also investigated. Two embrittling regions were found in a cooling curve of an Fe-
12Mn-0.2Ti steel which was shown to be responsible for intergranular fracture. Auger electron spectroscopy identified no
segregation during solution-annealing treatment. Avoiding the embrittling zones by controlled cooling led to a high cryogenic
toughness in a solution-annealed condition. 

Author

N78-21288f Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
MANUFACTURE OF ASTROLOY TURBINE DISK SHAPES
BY HOT ISOSTATIC PRESSING, VOLUME 1 Final Report
(Contract NAS3-20072)
NASA CR-135409, PWA-5574-12-Vol-1
Avail. NTIS HC A05/MF A01 C5CL 11F

The Materials in Advanced Turbine Engines project was
carried out to demonstrate container technology and establish
manufacturing procedures for fabricating direct Hot Isostatic
Pressing (HIP) of low carbon Astroloy to ultrasonic disk shapes.
The HIP processing procedures including powder manufacture
and handling, container design and fabrication, and HIP confor-
mation techniques were established by manufacturing five HIP
disks. Based upon dimensional analysis of the first three disks,
container technology was refined by modifying the container tooling
which resulted in closer conformity of the HIP surfaces to the
sonic shape. The microstructure, chemistry, and mechanical
properties of two HIP low carbon Astroloy disks were charac-
terized. One disk was subjected to a ground base experimental
engine test, and the results of HIP low carbon Astroloy were
analyzed and compared to conventionally formed Waspaloy. The
mechanical properties of direct HIP low carbon Astroloy exceeded
all property goals and the objectives of reduction in material
input weight and reduction in cost were achieved. 

Author

N78-21288f United Technologies Research Center, East Hartford, Conn.
STUDY OF THE EFFECTS OF GASEOUS ENVIRONMENTS
ON SULFIDATION ATTACK OF SUPERALLOYS
Final Report
John G. Smegil and Norman S. Bornstein Nov. 1977 166 p
refs
(Contract NAS3-20039)
NASA CR-135348, R77-12613-5
Avail. NTIS HC A05/MF A01 C5CL 11F

Studies were conducted to examine the effect of the gaseous
corrodents NaCl, HCl, and NaOH on the high temperature oxidation
and Na2SO4-induced corrosion behavior of the alumina former
NiAl, the chromia former Ni-25 wt % Cr, elemental C, and the
superalloy 8-1900. Experiments were conducted at 900 and
1050 C in air in the presence and absence of the gaseous
corrodents. Effects involving both reaction rates and microstruc-
tural changes in oxide morphology were observed due to the
presence of these corrosives at levels anticipated to be present
in operating industrial and marine gas turbines. The effect of
gaseous NaCl, HCl, and possibly NaOH on NiAl in simple oxidation
was to remove aluminum from below the protective alumina
layer and to simultaneously weaken the adherence of the protective
alumina oxide scale to the substrate. The aluminum removed
from below the oxide scale was redeposited on its surface as
Al2O3 whiskers. With respect to the chromia formers,
gaseous NaCl and HCl promoted breakaway oxidation kinetics
and changes in the microstructures of the oxide scales. 

Author
27 NONMETALLIC MATERIALS

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

N77-102349 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

IMPROVED PERFORMANCE OF SILICON NITRIDE-BASED HIGH TEMPERATURE CERAMICS
"NASA-TM-73719, 9-2698" Avail: NATS HC 003/MF A01 CSCL 11H

Recent progress in the production of S3N4 based ceramics is reviewed. (1) High temperature strength and toughness of hot pressed S3N4 were improved by using a high purity powder and a stabilizing 202 additive. (2) Impact resistance of hot pressed S3N4 was increased by the use of a crushable energy absorbing layer. (3) The oxidation resistance and strength of reaction sintered S3N4 were improved by impregnation of reaction sintered silicon nitride with solutions that oxidize AI2O3 or 202. (4) beta prime SA10N compositions and sintering aids were developed for improved oxidation resistance or improved high temperature strength.

Author

N77-102369 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

FRICTION AND WEAR OF SINGLE-CRYSTAL AND POLYCRYSTALLINE MAGNESIUM ZINC FERRITE IN CONTACT WITH METALS
Kazuhisa Miyoshi (Kanazawa Univ.) and Donald H. Buckley 1977 28 p refs
"NASA-TP-1059" Avail: NATS HC 003/MF A01 CSCL 109

Sliding friction experiments were conducted with single crystal (SCF) and hot-pressed polycrystalline (HPF) magnesium-zinc ferrite in contact with various metals. Results indicate that the coefficients of friction for SCF and HPF are related to the relative chemical activity of those metals in high vacuum. The more active the metal, the higher the coefficient of friction. The coefficients of friction for both SCF and HPF were the same and much higher in vacuum than in a gaseous or inert atmosphere. All the metals tested transferred to the surface of both SCF and HPF in sliding. Both SCF and HPF exhibited cracking and fracture with sliding. Cracking in SCF is dependent on crystallographic characteristics. In HPF, cracking depends on the orientation of the individual crystallites.

Author

N77-122279 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

EFFECTIVENESS OF VARIOUS ORGANOMETALLIC AS ANTIWEAR ADDITIVES IN MINERAL OIL
Donald H. Buckley Nov 1977 20 p refs
"NASA-TP-1096" Avail: NATS HC 003/MF A01 CSCL 11H

Sliding friction experiments were conducted with 1040 steel contactor, 302 stainless steel, and lubricated with various organometallics in mineral oil. Auger emission spectroscopy was used to determine the element present in the wear contact zone. The results indicate that there are organometallics which are as effective as antwear additives when commonly used zinc dialkyl dithiophosphate. These include dimethyl cadmium triphenyl lead thioethers, and trimethyl tin chloride. The additives were examined in concentrations to 1 weight percent with dimethyl cadmium at concentrations of 0.5 weight percent and higher. Cadmium was detected in the contact zone. Cement in the detection of cadmium and lead was decreased by the friction coefficient was observed. All additives examined reduced friction but only two were able to achieve wear levels comparable to that observed with a -dialkyl dithiophosphate.

Author

N77-152779 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

EFFECT OF THERMAL EXPOSURE ON LUBRICATING PROPERTIES OF POLYIMIDE FILMS AND POLYIMIDE-BONDED GRAPHITE FLUORIDE FILMS
Robert L. Fusaro Jan 1978 26 p refs
"NASA-TP-1125, 11-0827" Avail: NATS HC A03/MF A01 CSCL 11G

The effect of thermal exposure on the weight loss, adherence, friction, and wear properties of polyimide films and polyimide bonded graphite fluoride films was investigated. Films bonded to 304 stainless steel or 440C-HI steel were thermally exposed at temperatures of 315, 345, 370, or 400 C for 100 hours or more and then evaluated, using pin-on-disk machine, at temperatures of 25, 315, or 345 C in an atmosphere of dry or moist air. Polyimide films were brittle after thermal exposure. Polyimide bonded graphite fluoride films had adherence and gave low friction and wear results, thus they appear to be good candidates for solid lubrication applications where long thermal soak times are prevalent.

Author

N77-152789 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

TRIMMERIZATION OF AROMATIC NITRILES: Patent
Li-Chen Hsu, inventor (to NASA) Issued 6 Dec 1977 18 p Filed 10 Oct 1974 Supercedes N74-34579 (12 - 24, p 2914)

Trizine compounds and cross-linked polymer compositions were made by heating aromatic nitriles to a temperature in the range of about 100 C to about 700 C in the presence of a catalyst or mixture of catalysts. Aromatic nitride-modified terminated and/or appendaged imide, benzimidazole, imidazopyrrololine, quinoline, and other condensation type prepolymers or their precopolymer products were treated with or without a filler by the aforementioned catalytic trimimerization process. Official Gazette of the U.S. Patent Office

Author

N77-152799 National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

FRICTION AND WEAR OF POLYETHYLENE OXIDE POLYMER HAVING A RANGE OF MOLECULAR WEIGHS
Donald H. Buckley Jan 1978 17 p refs
"NASA-TP-1129, 9-2696" Avail: NATS HC A02/MF A01 CSCL 11G

Sliding friction and wear experiments were conducted at light loads. 25 to 253 g, with various molecular weights of the polyethylene oxide polymer sliding on itself and iron. Results of the experimental investigation indicate that (1) the coefficient of friction for the polymer decreases with increasing molecular weight. (2) the coefficient is higher for the polymer sliding on itself, than for the polymer sliding on iron. (3) by sufficiently high load, localized surface melting occurs and the friction coefficient is the same for the polymer sliding on itself and iron. (4) fracture cracks develop in the sliding wear track at higher load. but lower sliding velocities reflecting a strain rate sensitivity to crack initiation. and (5) the friction coefficient for the polymer sliding on iron increases with the formation of a polymer film on the iron surface.

Author
thermal shock exposures similar to those that might be encountered under severe engine start up and shut down sequences. All of the experimental concepts consisted of plasma sprayed TiO2 on the high temperature side of the blade tip seal seal. Between the TiO2 and a cooled dense metal backing various intermediate layer concepts intended to mitigate thermal stresses were incorporated. Performance was judged on the basis of the number of thermal shock cycles required to cause loss of seal material through spallation. The most effective approach was to include a low modulus sintered metal pad between the TiO2 and the metallic backing. It was also found that reducing the density of the TiO2 layer significantly improved the performance of specimens with plasma sprayed metal/ceramic composite intermediate layers.

Author


Thermal mechanical analysis was employed to monitor the penetration temperature of a low temperature epoxy resin. Both neat resin and E-glass composite samples were examined. The effects of cure temperature variation and moisture content on the apparent glass transition temperature were determined.

Author


Current PMR Polyimide prepreg technology utilizes methanol or ethanol solvents for preparation of the PMR prepreg solutions. The volatility of these solvents limited the tack and drape retention characteristics of unprotected prepreg exposed to ambient conditions. Studies conducted to achieve PMR 15 Polyimide prepreg with improved tack and drape characteristics were described. Improved tack and drape retention were obtained by incorporation of an additional monomer. The effects of various levels of the add monomer on the thermal oxidative stability and mechanical properties of graphite fiber reinforced PMR 15 composites exposed and tested at 316 C (600 F) were discussed.

Author

N78-20332† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio FLUORIDE PLESSSTIS COATINGS FOR USE ON AX B2 JU ET AL. 1978 14 p refs. Presented at the 33rd Ann Conf. on Composite Materials San Francisco 3-7 Apr 1978 sponsored by Am Inst. of Mining Metallurgical and Petroleum Engineers (NASA TM-78241) Avail NTIS HC A02/MF A01 CSCL 11C

The use of fluoride sputtered coatings for use as mirror and wear resistant reflective compounds (carbon) -based structures was reviewed. The spitting and run conditions for these coatings as well as the corresponding coatings were evaluated with regard to the following: coefficient of wear endurance load and mechanical properties. The tribological and mechanical properties to both metal and nonmetal substrates were investigated. The sputtering and run conditions for these coatings as well as the corresponding coatings were evaluated with regard to the following: coefficient of wear endurance load and mechanical properties. The tribological and mechanical properties to both metal and nonmetal substrates were investigated. The sputtering and run conditions for these coatings as well as the corresponding coatings were evaluated with regard to the following: coefficient of wear endurance load and mechanical properties. The tribological and mechanical properties to both metal and nonmetal substrates were investigated.
R78-31294‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FRICITION AND METAL TRANSFER FOR SINGLE CRYSTAL SIlicon carbide IN CONTACT WITH VARIOUS METALS IN VACUUM
Shimming fricition experiments were conducted with single-crystal silicon carbide in contact with transition metals (tungsten, tantalum, molybdenum, tungsten, molybdenum, and cobalt), copper, and aluminum. Results indicate the coefficient of friction for a silicon carbide-metal system is related to the bond character and relative chemical activity of the metal. The more active the metal, the higher the coefficient of friction. All the metals examined transferred to the surface of silicon carbide in sliding. The chemical activity of metal to silicon and carbon and shear modulus of the metal may play important roles in metal transfer and the form of the wear debris. The less active and greater resistance to shear the metal has, with the exception of tungsten and molybdenum, the less transfer to silicon carbide. Author

R78-21295‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
WEAR OF SINGLE-CRYSTAL SILICON CARBIDE IN CONTACT WITH VARIOUS METALS IN VACUUM
Sliding friction experiments were conducted in vacuum with single crystal silicon carbide (0001) surface in contact with transition metals (tungsten, tantalum, molybdenum, and cobalt), copper, and aluminum. The hexagonal shaped cracking and fracturing of silicon carbide that occurred is believed to be due to cleavages of both the prismatic and basal planes. The silicon carbide wear debris, which was produced by brittle fracture, sheet or rolls on both the metal and silicon carbide and produces grooves and indentations on these surfaces. The wear scars of aluminum and titanium, which have much stronger chemical affinity for silicon and carbon are generally rougher than those of the other metals. Fracturing and cracking along the grain boundary of rhodium and tungsten were observed. These may be primarily due to the greater shear modulus of the metals. Author

R78-22222‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE EFFECT OF MICROSTRUCTURE ON HYDROGEN EMBSMENTMENT OF THE NICKEL-BASE SUPERALLOY, UDIMET 700
Hugh R. Gray 1978 32 p. refs. Presented at the 19th Struct. Dyn. Mater Conf, Bethesda, Md 3-5 Apr. 1978 sponsored by the AIAA and the Am. Soc. of Mech. Engrs. (NASA TM-73772, E-9524) Avail. NTIS HC AO3/MF AO1 CSCL 118 Material from a single heat of cast and wrought Udimet 700 was processed and or heat treated to produce material conditions with identical chemical compositions but with distinct microstructural variations and then evaluated for susceptibility to hydrogen embrittlement. Two preoxidation powders (conditions exhibited significant improvement in hydrogen embrittlement compared to wrought material. No degradation in notch or smooth tensile strengths occurred as average ductile fracture at 25 percent reduction in area were determined for hydrogen evaluation procedures. For the most severe hydrogenation procedures, average reduction in area were reduced to 15 percent. These measurements were attributed to cleaner grain boundaries and decreased grain size. Author

R78-22243‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EXPERIMENTAL EVALUATION OF FUEL PREP-SATATION SYSTEMS FOR AN AUTOMOTIVE GAS TURBINE CATALYTIC COMBUSTO
Robert R. Yavond 1977 22 p. refs. Presented at the 2nd Workshop on Catalytic Combust. Raleigh, N. C. sponsored by EPA Prepared for DOE (NASA TM-788660, DOE/NASA-1011-78/23, E-9565) Avail. NTIS HC AO2/MF AO1 CSCL 21D Spatial fuel distributions, degree of vaporization, pressure drop and air velocity profiles were measured. Three aspirate injectors and an air-assist nozzle were tested. Air swirlers were used to improve the spatial fuel-air distribution. The work was done in a 24" test section combustor. Tests were conducted with a pressure of 0.30 GPa, intertemperatures up to 800 K, fuel velocities up to 0.200 m/s, and air-velocity ratios up to 0.020. The fuel was used. The best results were obtained with an aspirate configuration that used multiple cones to provide high velocity air for atomization and also straightened the inlet airflow. With this configuration, spatial uniform fuel-air distributions were obtained with mixing lengths greater than 1.8 mm. In this length, vaporization of the fuel was 3.8 percent complete at an inlet air temperature of 700 K. The total pressure loss was 1.0 percent with a reference velocity of 20 m/s and 0.25 percent at 10 m/s. The fuel viscosity was uniform across each and no autoignition reactions were observed. Author

R78-23231‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
KINETICS OF IMIDIZATION AND CROSSLINKING IN PSEUT POLYMIDE RESIN
Richard W. Lauver 1977 24 p. refs. Presented at the 9th Central Reg Meeting of the Am. Chem. Soc, Charleston, W. Va. 12-14 Oct. 1977. Submitted for publication (NASA TM-78444, E-9561) Avail. NTIS HC AO2/MF A01 CSCL 21D Infrared spectroscopy and differential scanning calorimetry were employed to study the imidization and crosslinking kinetics of nonimidated and imidated thermoset-epoxy prepolymer with PMR for polymerization of monomer reactants. The optical and thermal analyses were performed on resin specimens which had been isothermally aged at temperatures appropriate for imidization (170 to 204 C) and crosslinking (275 to 325 C); condensation occurred rapidly, approximately 0.01 min at short times, while times longer than approximately 0.5 hour the rate decreases significantly, approximately 0.001 min. The crosslinking reaction exhibits first order kinetics during the initial portion of the reaction and its rate appears to be limited by the equilibrium of the rearrangement of the alkenes. After the initial stage of the reaction the crosslinking reaction shows an increase dependence on the molecular weight of the initial oligomers. This effect is generally due to the increase dilution and decreased mobility of the initial oligomers. Author

R78-28216‡ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PRESSURELESS SINTERED ALUMINUM LOW AMOUNTS OF SINTERING AID
Alan A. Shuler 1978 16 p. refs. (NASA TM-1246, E-9527) Avail. NTIS HC AO2/MF A01 CSCL 110 Two large diameter, 103.0 cm (40.6 in.), 0.64 cm (0.25 in.) wall diameter, and 0.034 cm (0.001 in.) wall thickness, stainless steel, was used to form a model of 1200 and several segments made of Beta 21 (Ni Al-Mo-Cr) were subjected to various cyclic and static test conditions. These tests included exposures of the samples to temperatures up to 593°C (1100°F) for 16 hours in an air environment and for a 30 day exposure. The samples were tested for a 3.4 and for a stronger bond with a 3.4 weight percentage 1.5. Author
Catalytic decomposition of methanol for onboard hydrogen generation


The steam reforming of an equimolar mixture of methanol and water on a copper chromite catalyst was studied at three furnace temperatures and at feed space velocities from 800 to 2800 per hour. The hydrogen space velocity could be related to the 1050°C temperature for the equation: \[ \text{Ti} = \frac{\text{A} \times \text{omega} \times \text{at} \times \text{T} \times \text{temperature}}{\text{of the hydrogen reactant}} \]

The reactor was used to estimate the size of an onboard hydrogen reactor for automotive applications. Such a reactor would need only about 0.8 liter of catalyst to produce 7630 STH liters (15 lb) of hydrogen per hour. This quantity of catalyst would fit into nine tubes 178 centimeters along and 2.54 centimeters in inside diameter which is smaller than most mufflers. The reactor products would contain 12 to 13 percent more chemical energy than the incoming methanol and water.

Author

Sputtering technology in solid film lubrication


Potential and present sputtering technology is discussed as it applies to the deposition of solid film lubricants, particularly MoS2. The MoS2 films used in this study were very thin, the selection of the sputtering parameters and substrate condition was very critical as reflected by the lubricating properties. It was shown with sputtered MoS2 films that the lubricating characteristics are strongly dependent on the sputtering parameters (power density, pressure, sputter etching, dc basing, etc.) and the substrate temperature, chemistry, topography, and the environmental conditions during the sputtering process. Electron microscopy and other surface sensitive analytical techniques illustrate the resulting changes in sputtered MoS2 film morphology and chemistry which directly influence the film adherence and frictional properties.

Author

A comparison of the lubrication mechanisms of graphite fluoride and polyethylene disulfide films


A microscopic study of 44C steel sliding surfaces lubricated by graphite fluoride and polyethylene disulfide solid lubricant rubbed film was conducted. The sliding surfaces along with the friction wear and oxidative damage observed as a function of the number of sliding revolutions in three different atmospheres (air, dry air, and dry argon) were found to be relatively similar. that a dynamic thin layer lubricant was used and a rubbing mechanism of the rubbing surfaces and the adhesion of the rubbing surfaces and the adhesion of the rubbing surfaces and the adhesion of the rubbing surfaces and the adhesion of the rubbing surfaces and the adhesion of the rubbing surfaces. The wear was found to be dependent on the hardness of the rubbing surfaces and the adhesion of the rubbing surfaces.

Author

Effects of pressure and temperature on hot pressing a sialon


Mixed powders (10 m/o A1203 40 m/o S3N4) were hot pressed at temperatures and pressures from 1350 to 1750 C and 35 to 27.5 MPa (50 to 40000 psi). Fully dense sialon bodies are obtained at temperatures and pressures as low as 1550 C and 0.5 ksi. The fully dense bodies contain Beta phase and X-phase. There is some evidence that plastic deformation has contributed to densification.

Author

The use of ion beam cleaning to obtain high quality cold welds with minimal deformation


A variation of cold welding is described which utilizes an ion beam to clean mating surfaces prior to joining in a vacuum environment. High quality solid state welds were produced with minimal deformation.

Author

Effects of oxygen and nitrogen interactions on friction of single crystal silicon carbide


Friction studies were conducted with single crystal silicon carbide contacting silicon carbide and titanium after having been exposed to oxygen and nitrogen in various forms. After they had been sputter cleaned, the surfaces were (1) exposed to gaseous oxygen and nitrogen (oxidation), (2) ion bombarded with oxygen and nitrogen, or (3) reacted with oxygen (SC only). Auger emission spectroscopy was used to determine the presence of oxygen and nitrogen. The results indicate that the surfaces of silicon carbide with reacted and ion bombarded oxygen ions give higher coefficients of friction than do oxygen sputter cleaned surfaces. The effects of oxygen on friction may be related to the relative chemical, thermodynamic properties of silicon, carbon, and titanium for oxygen. The adsorbed films of oxygen, nitrogen, and mixed gases of oxygen and nitrogen on sputter cleaned, oxygen ion bombarded, and oxygen reacted surfaces generally reduce friction. Adsorption to silicon carbide is relatively weak.

Author

Pressureless sintered beta prime S3N4 solid solution: Fabrication, microstructure, and strength

Sam Dutta, 1977. 19 p. refs. Presented at the Fall Meeting of the Basic Sci Div of the Am. Ceram Soc Hyannis, Mass. 25-28 Sep 1977. NASA-TP-78950: Avail NTIS HC A02 MF A01 CSCL 11F S3N4 Alin and A12O3 were used as base constituents in a study of the pressureless sintering of beta prime S3N4 solid solution as a function of temperature. XRD, S02, and x-ray diffraction were used to promote liquid phase sintering. The sintered specimens were characterized with respect to density, microstructure, strength, oxidation, and thermal shock resistance. Density greater than 96 percent of the theoretical density was essentially pressureless sintering at 1725°C. The microstructure consisted of...
essentially of fine-grained beta phase Si3N4 solid solution at the major phase. Modulus of rupture strengths up to 483 MPa were achieved at moderate temperature (1000 C) but decreased to 228 MPa at 1380 C. This substantial strength loss was attributed to a glassy grain boundary phase formed during cooling from the sintering temperature. The best oxidation resistance was observed by a composition containing 3 mol% Y2O3-SiO2 additives. Water quench thermal shock resistance was equivalent to that of reaction sintered silicon nitride but lower than hot pressed silicon nitride. A.R.H.

N78-28246* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SUBSTITUTION OF CERAMICS FOR HIGH TEMPERATURE ALLOYS

The high-temperature capability of ceramics such as silicon nitride and silicon carbide can result in turbine engines of improved efficiency and lower maintenance. The variation of mechanical properties with temperature and the use of ceramics in different sizes of gas turbine components are considered. These are the large utility turbines, advanced aircraft turbines, and small automotive turbines. Special consideration is given to each of these applications when one considers substituting ceramics for high temperature alloys. The effects of material substitutions are reviewed in terms of engine performance, operating economy, and secondary effects. A.R.H.

N78-30239* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

FRICITION AND WEAR OF METALS WITH A SINGLE-CRYSTAL LABORATORY GRIT OF SILICON CARBIDE: EFFECT OF SHEAR STRENGTH OF METAL

Sliding friction experiments were conducted with spherical, single-crystal silicon carbide grits in contact with various metals and with metal ingots in contact with silicon carbide grits. Results indicate that (1) the friction force in the plowing of metal and (2) the groove width (corresponding to the volume of the groove) are related to the shear strength of the metal. That is, they decrease linearly as the shear strength of the bulk metal increases. Grooves are formed in metals primarily from plastic deformation, with occasional metal removal. The relation between the groove width D and the load W can be expressed by W/kD, where k is a constant which satisfies Meyer's law. A.R.H.

N78-31236* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF ATTITUDE MILLING ON THE REACTION SINTERING OF SiC-NITRIDE

Silicon powder was ground in a steel attrition mill under nitrogen. An exposed powder was compacted placed in RhMn, and reaction sintered in nitrogen 4% v/v hydrogen. For longer grinding times oxygen content, surface area and compactability of the powder increased, and both alpha-beta ratio and degree of crystallinity during sintering increased from content remained constant. A.R.H.


The aligned structures which result from the directional solidification (DS) of ceramic zirconia are of interest because of their potential for use in electronic devices and as structural materials. Techniques for growing DS ceramic zirconia are briefly discussed. The principles and controlling parameters of DS zirconia growth are described. The criteria for plane-front growth and the effect of growth rate on interfacial or interboundary spacing is discussed. Examples of the effect of growth parameters on the alignment of the microstructure are given. Examples of the mechanical properties of directionally solidified oxide-oxide ceramics are also cited. A.R.H.


Powder mixtures of 40 mol% Si3N4-60 mol% Al2O3 were hot-pressed at 4000 psi at various holding temperatures from 1100 to 1700 C. Scanning and transmission electron microscopy results were correlated to X-ray phase analysis and density measurements. The progressively developed microstructure was used to interpret the densification behavior of SiAlON. A.R.H.


A simple two-layer plasma sprayed thermal barrier coating system was developed which has the potential for protecting high temperature air-cooled gas turbine components. Of the initially examined coatings, the most promising system is an MCrAlSi-16Gc-5Al-0.6Y (in wt.) bond coating (about 0.005 to 0.010 cm thick) and a 2Cr2O3-12Y2O3 (in wt.) thermal barrier coating (about 0.05 to 0.06 cm thick). This barrier coating was used to lower the metal temperature of the air-cooled airfoil. The coating was applied over 300 cycles at 0.1 to 0.18 cm surface temperature and 275 cycles (1 h at 1490 C surface temperature) without cracking or spalling. No separation of the thermal barrier from the bond coating or the bond coating from the substrate was observed. A.R.H.


Sputtered CrC2, CrC2, and MoS2 wear-resistant films (0.06 to 3.5 microns thick) were deposited on metal and glass surfaces. Electron transmission, electron diffraction, and scanning electron microscopy were used to determine the microstructural characteristics. Strong adherence was obtained with the sputtered films. Internal stresses and defect crystallographic growth structures of various configurations within the film have progressively more undesirable effects for film thickness greater than 1.5 microns. Sliding contact and rolling element bearing tests were also performed with these sputtered films. A.R.H.

Results are given for ion beam texturing of polyimide (Kapton) and fluoroinserted ethylene octyfone (Teflon) by means of a 30 cm electron bombardment ion source. Ion beam textured Kapton and Teflon surfaces are found to be beneficial for various beam energies, current densities, and exposure times. The optical properties and sheet resistance are measured after each exposure. Provided in the paper are optical spectral data, resistivity measurements, calculated absorptance and emissivity measurements, and surface structure SEM micrographs of various texturing of Aron ions. It is found that Kapton becomes conducting and Teflon nonconducting when ion beam texturing. Textured Kapton exhibits large changes in the transmittance of solar absorptance, but only slight changes in reflectance. Surface texturing of Teflon may allow better adherence of subsequent sputter deposited films for a high absorptance value. The results are valuable in spacecraft charging applications. S.D.


An investigation was conducted to determine the nature of the deformation and fracture of SiC carbide and its effects on friction properties. Friction experiments were conducted with hemispherical and conical diamond riders sliding on the basal plane of silicon carbide. The results indicate that, when deformation is primarily elastic, the friction does not depend on crystallographic orientation and there is no detectable fracture or cracking. However, plastic deformation occurs, silicon carbide exhibits anisotropic friction and deformation behavior. Surface fracture crack patterns surrounding wear tracks are observed to be of three types. The crack geometries of two types are generally independent of orientation, the third crack, however, depends on the orientation. All surface cracks extend into subsurface. (Author)


The role of powder and process characterization in producing high-quality silicon nitride and silicon carbide components for gas turbine applications is described. Some of the intrinsic properties of various forms of Si3N4 and SiC are listed and limitations of such materials' availability have been pointed out. The essential features/parameters to characterize a batch of powder have been discussed including the standard techniques for such characterization. In process characterization, parameters in sintering, reaction sintering, and hot pressing processes are discussed including factors responsible for strength limitations in ceramic bodies. It is inevitable that significant improvements in material properties can be achieved by reducing or eliminating the strength limiting factors with consistent powder and process characterization along with process control. (Author)


Measurements of the Young's modulus, flexural modulus, shear modulus and Poisson's ratio for boron fibers prepared by modern deposition techniques are reported. Physical properties of the boron fibers, including density, thermal expansion and resistance, are also surveyed. In addition, prediction of the total deformation strain in an anelastic boron fiber subjected to tensile or flexural stress is discussed. J.M.B.


Fluoropolymer etching and deposition techniques including thermal evaporation, RF sputtering, plasma polymerization, and ion beam sputtering are reviewed. Etching and deposition mechanisms and material characteristics are discussed. Ion beam sputter etch rates for polytetrafluoroethylene (PTFE) were determined as a function of ion energy, current density, and ion beam power density. Ion beam etch rates and strengths were measured for epoxy bonds to various ion beam sputtered fluoropolymers. Coefficients of static and dynamic friction were measured for fluoropolymers deposited from ion bombarded PTFE. (Author)


Results are presented for temperature (1130, 1430, 1540), 1500 Cl slow strain-rate compression tests on cylindrical specimens of hot-pressed Si3N4 of the HS 130 brand under various compressive loads. The results are presented in terms of number of longitudinal cracks, percent increase in diameter, percent decrease in length and percent loss in weight. Scanning electron micrographs are presented of cylindrical surfaces of compression specimens tested at 1430 C for

5- to 8-fraction experiments were conducted with single crystal silicon carbide content in contact with various metals. Results indicate the coefficient of friction is related to the relative chemical activity of the materials. The higher the metal, the higher the coefficient of friction. All the materials tested responded to silicon carbide. The chemical activity of the metal and its shear modulus may play important roles in metal transfer, the form of the wear debris and the surface topography of the metal wear scar. The more active the metal and the less resistance to shear, the greater the transfer to silicon carbide and the lower the shear scar on the surface of the metal. Hexagonal shaped transfer and transfer turned by channels of both prismatic and basal planes is observed on the silicon carbide surface. (Author)

A78-47585 \( ^* \) - Pressureless sintered beta-prime S34N solid solution - Fabrication, microstructure, and strength. S. Dutta (NASA, Lewis Research Center, Cleveland, Ohio, American Ceramic Society, Fall Meeting, Hyatt Regency, Mass., Sept. 26-29, 1977, Paper, 10 p, illus.)

Pressureless sintering of beta-prime S34N solid solution was studied as a function of temperature using S34N-41N, and A103 as base constituents. Y2O3 and SiC additions were used to promote liquid phase sintering. The sintered specimens were characterized with respect to density, microstructure, strength, oxidation, and thermal shock resistance. Density greater than 98 percent of theoretical was achieved by pressureless sintering at 1750°C. The microstructure consisted essentially of the gamma-beta-prime S34N solid solution with some beta-prime S34N in the as-sintered phase. Resistance of sintered specimens to 400°C exposure at medium temperature -1000°C but decreased at 228 M Pa at 120°C. This substantial strength loss was attributed to a glassy grain boundary phase formed during cooling from the sintering temperature. The oxidation resistance was evaluated by a composite containing 3 mol % Y2O3 and SiC addition. Water vapor thermal shock resistance was equivalent to that of uranium nitride fuel but lower than hot-pressed silicon nitride. (Author)


Ceramic materials include silicon nitride and silicon carbide are currently receiving a great deal of attention as potential materials for advanced gas turbine engines. The potential advantage offered by ceramics in terms of high temperature capability which can result in turbine engines of increased efficiency. Other advantages when compared to the metal and metal allois include lower gas and heat mass availability, lower weight, higher component resilience, and potentially lower cost. Use of ceramics as these different sizes of gas turbine engines are combined for large scale, advanced gas turbine engines, and advanced aerojet engines. The effect of improved performance and efficiency as a result of high-temperature ceramics can be measured in terms of engine performance, operating economy, and secondary effects. (Author)

A78-50524 \( ^* \) - Effect of attrition milling on the reaction sintering of silicon nitride. T. P. Herbel, T. K. Glasgow (NASA, Lewis Research Center, Cleveland, Ohio, and H. C. Yeh (Cleveland State University, Cleveland, Ohio, American Ceramic Society, Annual Meeting 26th Detroit, Mich., May 7-12, 1978, Paper 18 p Briefs Contract NE-77-A 31 1040)

Silicon powder was ground in a steel attrition mill under nitrogen. As-exposed powder was compacted, pre-fired in helium, and reaction sintered in nitrogen + 6% hydrogen. Longer grinding times, oxygen content, surface area and compatibility of the powder increased, and both alpha-beta ratio and degree of initiation during sintering increased, from contents remained constant. (Author)

N78-10201B \( ^* \) - Owens-Illinois, Inc., Toledo, Ohio

IMPROVED CERAMIC HEAT EXCHANGE MATERIAL Interim Report

H L McCollister Sep 1977 40 p (Contracs NAS3-15973, EC-77-A-31-1011)

NASA CR-136293, CONS/733-1) Avail NTIS

HC A03/MF A01 CSCL 11B

Improved corrosion resistant ceramic materials that are suitable for use as regenerative heat exchangers for vehicular gas turbines is reported. Two glass-ceramic materials, C-144 and C-145, have superior durability towards sulfuric acid and sodium sulfate compared to lithium aluminate (LAS) Corning heat exchange material 9455. Material C-144 is a leached LAS material whose major crystalline phase is silica kaerite plus mullite, and C-145 is a LAS kaerite solid solution (S.S.) material. In comparison to material 9455, material C-144 is two orders of magnitude better in dimensional stability to sulfuric acid at 300°C and one order of magnitude better in stability to sodium sulfate at 1000°C. Material C-145 is initially two times better in stability to sulfuric acid, and about one order of magnitude better in stability to sodium sulfate. Both C-144 and C-145 have less than 0.01% delta L thermal expansion from ambient to 1000°C and good dimensional stability of less than approximately 0.01% delta L, after exposure to 1000°C for 100 hours. The glass-ceramic fabrication process produced a hexagonal honeycomb matrix having a 35% open frontal area, 50 micrometer wall thickness, and less than 5% porosity. Author

N78-13208B \( ^* \) - General Electric Co., Philadelphia, Pa

IMPROVED CERAMIC HEAT EXCHANGER MATERIAL Interim Report

H W Rauch Nov 1977 35 p ref (Contracs NAS3-15986, EC-77-A-31-1011)

NASA CR-136293, CONS/733-1) Avail NTIS

HC A03/MF A01 CSCL 11G

Various ceramic materials in the form of small, monolithic bars were screened as candidate materials in heat exchanger structures for automotive gas turbine engines. Small bar-shaped specimens of the honeycomb were used to measure thermal, chemical, and mechanical properties and for macro- and microstructure examinations. Cylindrical honeycomb specimens about 15.2 cm diameter and 10.2 in thick are currently being tested in a gas turbine engine. Data obtained from testing the bar-shaped honeycomb specimens of GE-3200 and from testing bar-shaped honeycomb specimens - Corning 9455 were compared. Results indicate that GE-3200 has significantly better resistance to sulfuric acid and to sodium chloride than Corning 9455, thermal expansion of GE-3200 is higher than that of Corning 9455, mechanical properties of GE 3200 are higher in the tangential direction, but lower in the radial direction than Corning 9455, and, during thermal cycling between rT 1000°C and rT -1100°C, GE-3200 tends to elongate while Corning 9455 tends to slightly contract. Overall assessment of GE-3200 properties, ease of material preparation, ready adaptability to honeycomb fabrication, and refractoriness qualify this new material as a candidate for heat exchanger application in automotive gas turbine engines. Author
Toughness Final Report
(Contact NAS 5319731)
INAS-CR-135308 R77-912252-23) Avail. NTIS
HC AO/MA AO CSCL 11B

The application of energy absorbing surface layers to SIN-3H, and SiC was investigated. Among the layers studied were microcracked materials such as iron nitride and a silicon-zircon mixture and porous materials such as reaction sintered SIN-3H. Energy absorption due to microcrack extension upon impact was found not to be an important mechanism. Instead, the fivefold improvement in Charpy and ballistic impact at elevated temperature (1250 C) and 1370 C) found for S7213S was due to plastic deformation while similar improvement found for silicon-zircon mixtures at RT was due to crushing of the porous material. Due to thermal expansion mismatch, these two materials could not withstand thermal cycling when used as energy absorbing surface layers on SIN-3H. Reaction sintered SIN-3H layers on dense SIN-3H were found to give up to a sevenfold increase in ballistic impact resistance due to crushing of the layer upon impact. High porosity (45%) large particle size H3 S7 Nan layers fabricated from 100 - 200 mesh Si powder gave better impact improvement than less porous (30%) small particle size layers fabricated from 125 mesh Si powder. Author


Results are presented regarding experiments intended for improving the strength and oxidation resistance of reaction-sintered SIN-3H (HSN), improving the strength and oxidation resistance of reaction-sintered SIN-3H (HSN), and improving the strength and oxidation resistance of reaction-sintered SIN-3H (HSN). It is shown that the use of ZrO2 instead of MgO as a sintering aid improved the room-temperature and high-temperature flexural strength of HSN, in addition to enhancing the rupture strength and Charpy impact resistance. The use of crushable energy absorbing layers increased the impact resistance of HSN. Impregnation of HSN with solutions that oxidize to AI2O3 or ZrO2 resulted in increased binding strength at room temperature. Beta prime Si-Al-O-N sintered to full density by means of the sintering aids GdO2, Y2O3, and ZrO2 yielded the greatest strength with Y2O3 and the greatest oxidation resistance with ZrO2. S.D.


Dines traction fluid must be a fluid or solid under operating conditions. Infrared spectra on bulk polymer of various types of fluid were used to determine the surface and oil film temperatures. Polystyrene spindles were made to study molecular alignment. Static friction tests were made at temperatures between 20 and 260 K, with the traction fluid present. The film thickness was also measured. The friction fluid showed both the high friction temperatures, as well as the greatest degree of molecular alignment. A plot of the decrease in the film and surface temperatures is shown, and is a student pocket guide for tests. In conclusion, the authors proposed a model of fluid film interaction between parallel rough surfaces that introduces the traction factor.
28 PROPELLANTS AND FUELS

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

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

N78-13285# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

HYDROCARBON GROUP TYPE DETERMINATION IN JET FUELS BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY


A technique to determine the hydrocarbon group type composition in jet fuels is described. The method is based on the use of a capillary column packed with a cross-linked polystyrene/divinylbenzene stationary phase and a flame ionization detector. The results obtained from laboratory prepared samples are in good agreement with those from commercial fuels. The method has been applied to the analysis of a large number of fuels, including those from various countries.

N78-14177# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

PERFORMANCE AND EMISSIONS OF A CATALYTIC REACTOR WITH PROPANE, DIESEL, AND JET A FUELS


Tests were made to determine the performance and emissions of a catalytic reactor operated with propane, No. 2 diesel, and Jet A fuels. A 12-cm-diameter and 16-cm-long catalytic reactor using a proprietary noble metal catalyst was operated at an inlet temperature of 100 K, a pressure of 300,000 Pa and reference velocities of 10 to 15 m/s. No significant differences between the performance of the three fuels were observed when 98.5 percent purity propane was used. The combustion efficiency for 99.8 percent purity propane tested later was significantly lower, however. The diesel fuel contained 135 ppm of bound nitrogen and consequently produced the highest NOx emissions of the three fuels. As much as 85 percent of the bound nitrogen was converted to NOx. Steady-state emissions goals based on half the most stringent proposed automotive standards were met when the reactor was operated at an adiabatic combustion temperature higher than 1350 K with all fuels except the 99.8 percent purity propane. With that fuel, a minimum temperature of 1480 K was required.

N78-17229# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ALTERNATIVE AIRCRAFT FUELS


The efficient utilization of fossil fuels by future jet aircraft may necessitate the broadening of current aviation turbine fuel specifications. The most significant changes in specifications would be an increased aromatics content and a lower final boiling point. In order to minimize refinery energy consumption and costs these changes would increase the freezing point and might lower the thermal stability of the fuel, and could cause increased pollutant emissions, increased combustor liner temperatures, and poorer ignition characteristics. The effects that broadened specification fuels may have on present day jet aircraft and engine components and the technology required to use fuels with broadened specifications are discussed.

N78-188285# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

JET AIRCRAFT HYDROCARBON FUELS TECHNOLOGY

John P. Longwell, ed. 1978 64 p Workshop held at Cleveland, Ohio, 7-8 Jun. 1977 (NASA-CP-20333; E-8487) Avail. NTIS HC AO4/MF AO1 CSCL 210

A broad specification, refereed fuel was proposed for research and development. This fuel has a lower, closely specified hydrogen content and higher fuel boiling point than the fuels currently in use. A program was developed to determine properties of the fuel and to test the effects of the proposed fuel on combustion and engine performance. The results of this program include performance data for engines running on the proposed fuel, and a demonstration that the fuel is capable of meeting the specified performance requirements.

N78-20381# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR OBTAINING THERMODYNAMIC AND TRANSPORT PROPERTIES OF AIR AND PRODUCTS OF COMBUSTION OF ASTM-A-1 FUEL AND AIR


A computer program for determining desired thermodynamic and transport property values by means of a three-dimensional pressure, fuel-air ratio, and either enthalpy or temperature interpolation routine was developed. The program calculates temperature (or enthalpy), molecular weight, viscosity, specific heat at constant pressure, thermal conductivity, and steam content. The program is written in FORTRAN. The output at each point is written to a file.

N78-24358# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

ION BEAM SPUTTER ETCHING AND DEPOSITION OF FLUOROPOLYMERS


Fluoropolymer etching and deposition techniques including thermal evaporation, RF sputtering, plasma polymerization, and ion beam sputtering are reviewed. Etching and deposition mechanism and material characteristics are discussed. Ion beam sputter etch rates for polytetrafluoroethylene (PTFE) were determined as a function of ion energy, current density and ion beam power density. Peak strengths were measured for epoxy bonds to various ion beam sputtered fluoropolymers. Coefficients of static and dynamic friction were measured for fluoropolymers deposited from ion bombarded PTFE.

Author
ATOMIC HYDROGEN STORAGE METHOD AND APPARATUS Patent
US Patent Office CSCI 21D
Atomic hydrogen, for use as a fuel or as an explosive, is stored in the presence of a strong magnetic field in distorted layered compounds such as molybdenum disulfide or an elemental layer material such as graphite. The compound is maintained at liquid helium temperatures and the atomic hydrogen is collated on the surfaces of the layered compound which are exposed during deamination (decalcination). 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 Office

IMPACT OF FUTURE FUEL PROPERTIES ON AIRCRAFT ENGINEER AND FUEL SYSTEMS
Avail: NTIS HC 62/2/MF AO1 CSCI 21D
This paper describes and discusses the propulsion system problems that will most likely be encountered if the specifications of hydrocarbon-based jet fuels must undergo significant changes in the future and, correspondingly, the advances in technology that will be required to minimize the adverse impact of these changes on jet engine performance. Several investigations conducted are summarized. Illustrations are used to describe the relative effects of selected fuel properties on the behavior of propulsion system components and fuel systems. The selected fuel properties and the areas of most interest are described, and programs that are under way to address these needs are briefly discussed.

CHARACTERISTICS AND COMBUSTION OF FUTURE HYDROCARBON FUELS
As the world supply of petroleum crude oil is being depleted, the supply of high-quality crude oil is also dwindling. This dwindling supply is beginning to manifest itself in the form of crude oils containing higher percentages of aromatic compounds, sulfur, nitrogen, and trace constituents. The result of this trend is described and the change in important crude oil characteristics as related to fuel properties is discussed. As available petroleum is further depleted, the use of synthetic crude oils (those derived from coal and oil shale) may be required. The principal properties of these synrudes and the fuels that can be derived from them are described. In addition to the changes in the supply of crude oil, increasing competition for middle-distillate fuels may result in specifications being broadened in future fuels. Is the resultant potential changes in fuel properties may have on combustion and thermal stability characteristics is illustrated and discussed in terms of ignition, soot formation, carbon deposition, flame radiation, and emissions.

IMPACT OF BROAD-SPECIFICATION FUELS ON FUTURE JET AIRCRAFT
Jack Grobman, in NASA Langley Res. Center, COTL Transport Technol. 1978 217-233 (For primary document see N76-27046 18-01)
The effects that broad specification fuels on aircraft and engine components were discussed along with the improvements in component technology required to use broad specification fuels without sacrificing performance, reliability, maintainability, or safety.

Simulation of the heat transfer characteristics of LNOX, R. C. Henderski (NASA, Lewis Research Center, Cleveland, Ohio) American Institute of Chemical Engineers, Heat Transfer Conference, Salt Lake City, Utah, Aug. 15-17, 1977, ASME Paper 77-HT-9, 8 p. 10 refs. Members, $5.00, nonmembers, $7.00.
In connection with proposals for a second generation shuttle, it has been suggested that the engine regenerative coolant be the oxidizer rather than a fuel. The feasibility of such an approach depends on the suitability of oxygen for the cooling function. The information currently available concerning the heat transfer characteristics of liquid oxygen (LOX) in the near critical region at elevated pressures is not sufficient for an evaluation. It is, therefore, proposed to make use of data from similar fluids for a simulation of the heat transfer characteristics of LOX.

Quantitative agreement appears satisfactory provided the proper level or adjusting constant can be determined.

Results are given for the analysis of some jet and diesel fuel samples which were prepared from oil shale and coal synrudes. Thirty-two samples of varying chemical composition and physical properties were obtained. Hydrocarbon types in these samples were determined by fluorescent indicator adsorption (FIA) analysis, and the results from three laboratories are presented and compared. Recently, rapid high performance liquid chromatography (HPLC) methods have been proposed for hydrocarbon group type analysis, with some suggestion for their use as a replacement of the FIA technique. Two of these methods were used to analyze some of the samples, and these results are also presented and compared. Two samples of petroleum-based jet fuel are similarly analyzed.

Results are given for the analysis of some jet and diesel fuel samples which were prepared from oil shale and coal synrudes. Thirty-two samples of varying chemical composition and physical properties were obtained. Hydrocarbon types in these samples were determined by fluorescent indicator adsorption (FIA) analysis, and the results from three laboratories are presented and compared. Recently, rapid high performance liquid chromatography (HPLC) methods have been proposed for hydrocarbon group type analysis, with some suggestion for their use as a replacement of the FIA technique. Two of these methods were used to analyze some of the samples, and these results are also presented and compared. Two samples of petroleum-based jet fuel are similarly analyzed.
DEVELOPMENT OF AN EXPERIMENT FOR DETERMINING THE AUTOIGNITION CHARACTERISTICS OF AIRCRAFT-TYPE FUELS


An experimental test apparatus was developed to determine the autoignition characteristics of aircraft type fuels in premixing preheated passages at elevated temperatures and pressures. The experiment was designed to permit independent variation and evaluation of the experimental variables of pressure, temperature, flow rate, and fuel-air ratio. A comprehensive review of the autoignition literature is presented. Performance verification tests consisting of measurements of the ignition delay times for several lean fuel-air mixture ratios were conducted using Jet-A fuel at inlet air temperatures in the range 600 K to 1000 K and pressures in the range 9 atm to 30 atm. Author

COMPUTER MODEL FOR REFINERY OPERATIONS WITH EMPHASIS ON JET FUEL PRODUCTION. VOLUME 1: PROGRAM DESCRIPTION Final Report


A FORTRAN computer program is described for predicting the flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuel of varying and fixed point and hydrogen content specifications. The program has provision for shale oil and coal oil in addition to petroleum crudes. A case study, feature permits dependent cases to be run for parametric or optimization studies by input of only the variables which are changed from the base case. Author

COMPUTER MODEL FOR REFINERY OPERATIONS WITH EMPHASIS ON JET FUEL PRODUCTION. VOLUME 2: DATA AND TECHNICAL BASES Final Report


The FORTRAN computer program predicts the flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuel of varying and fixed point and hydrogen content specifications. The program has provision for shale oil and coal oil in addition to petroleum crudes. A case study, feature permits dependent cases to be run for parametric or optimization studies by input of only the variables which are changed from the base case. The report has sufficient detail for the information of most readers. Author


An investigation was conducted to determine the technical problems in the conversion of a significant portion of a barrel or either shale oil or coal synthetic crude oil into a suitable aviation turbine fuel. Three syntheses were used, one from shale and two from coal, chosen as representative of typical crude from future commercial production. The material was used to produce jet fuels of varying specifications by distillation, hydrotreating, and hydrocracking. Attention is given to mixture requirements, hydrotreating process conditions, the methods used to analyze the final products, the conditions for shale oil processing, and the coal liquid processing conditions. The results of the investigation show that jet fuels of defined specifications can be made from oil shale and coal synecrates using readily available commercial processes. G.R.
31 ENGINEERING (GENERAL)

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

N78-17237* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
CLOSED LOOP SPRAY COOLING APPARATUS Patent
Avail US Patent Office CSCL 13G
A closed loop apparatus for spraying coolant against the back of a radiation target is described. The coolant was circulated through a closed loop with a bubble of inert gas being trapped around the target. Mesh material was disposed between the bubble and the surface of the liquid coolant which was below the bubble at a predetermined level. In a second embodiment, no inert gas was used; the bubble consisting of a vapor produced when the coolant was sprayed against the target.

Official Gazette of the U.S. Patent Office

N78-22287* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
APPLIED ROUTH APPROXIMATION
Walter C. Merrill Apr 1978 40 p refs
(NASA-TP-1231 E-9114) Avail NTIS HC A03 MF A01 CSCL 128

The Routh approximation technique for reducing the complexity of system models was applied in the frequency domain to a 16th order state variable model of the F100 engine and to a 43rd order transfer function model of a launch vehicle boost pump pressure regulator. The results motivate extending the frequency domain formulation of the Routh method to the time domain in order to handle the state variable formulation directly. The time domain formulation was derived and a characterization that specifies all possible Routh similarity transformations was given. The characterization was computed by solving two eigenvalue-eigenvector problems. The application of the time domain Routh technique to the state variable engine model is described, and some results are given. Additional computational problems are discussed, including an optimization procedure that can improve the approximation accuracy by taking advantage of the transformation characterization.

Author

N78 30303* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
GAS TURBINE PROJECT STATUS
Avail NTIS HC A02 MF A01 CSCL 21A

The state of the art of automobile gas turbine technology, particularly with respect to fuel economy and emissions, was defined. An advanced gas turbine system is proposed which incorporates significant advances in technology and has a fifty to sixty percent gain in fuel economy over the spark ignition engine, while meeting the same goals of the improved gas turbine engine.

J.A.M.
CATALYTIC COMBUSTION FOR THE AUTOMOTIVE GAS TURBINE ENGINE


Fuel-air premixing-prevaporizing systems and commercial catalysis were studied as part of a demonstration of a low emissions combustor for an automotive gas turbine engine. A fuel preparation system which would supply a fuel-air mixture which was uniform to within + or - 10 percent of the mean fuel-air ratio, with 90 percent fuel vaporization and with no autogenous is described. The catalytic reactor was required to produce emissions which were low enough to meet the most stringent proposed U.S. automotive standards. The overall pressure drop for both systems was to be less than 3 percent, with 1 percent allowed in the fuel-air preparation system and the remainder in the catalytic reactor.

B.B.


(Access NASA-178177)

(Access NASA-CR-135342)

(MSC-D564116)

HC A12/MF A01 CSCL 228

A light weight, vacuum jacketed, load bearing cryogenic insulation system was developed and tested on a 1.17-m (46-in) spherical test tank. The vacuum jacket consists of 0.08 mm (0.033 in.) thick stainless steel formed into a wedge design that allows elastic jacket movements as the tank shrinks (cools) or expands (warms up or is pressurized). Hollow glass spheres, approximately 60 micrometers in diameter with a bulk density of 0.069 g/cc (4.3 lb cubic foot), provide the insulating qualities and one atmosphere load bearing capability required. The design, fabrication, and test effort developed the manufacturing methods and engineering data needed to scale the system to other tank sizes, shapes, and applications. The program demonstrated that thin wall jackets can be formed and welded to maintain a required vacuum level of 0.013 Pa yet flexi axially for multiple uses. No significant shifting or breakage of the microspheres occurred after 3 simulated Space Tug flight cycles on the test tank and a hundred 1 atmosphere load cycles in a flat plate calorimeter. The test data were then scaled to the Space Tug LO2 and LH2 tanks, and weight, thermal performance, payload, performance, etc., costs were compared with a helium purged multilayer insulation system.

Author

HIGH RESOLUTION MASKS FOR ION MILLING PORES THROUGH SUBSTRATES OF BIOLOGICAL INTEREST

Sandia S. Duvan June 1978, 41 p. refs

(Access NASA-21054)

(Access NASA-CR-135435, HRI-361) Available NTIS HC A03/MF A01 CSCL 13H

The feasibility was investigated of electrochemically oxidizing vapor deposited aluminum coatings to produce porous aluminum oxide coatings with submicron pore diameters and with straight channels normal to the substrate surface. Porous aluminum oxide coatings were produced from vapor deposited aluminum coatings on thin stainless steel (304), copper, Teflon (FEP) and Kapton substrates and also on pure aluminum substrates. Scanning electron microscope examination indicated that porous oxide coatings can be produced with straight channels, appropriate pore diameters and none or minimal intervening residual aluminum. The oxide coatings on the copper and Kapton substrates had the straightest channels and, in general, were superior to those fabricated on the other substrate materials. For oxide coatings fabricated at 500 V and 300 V pore diameters were 0.4-0.6, and 0.3-0.4, respectively. Estimated direct labor and materials costs to prepare an oxide mask is anticipated to be about $45-$5 per square foot.

FOS
32 COMMUNICATIONS

Includes land and global communications; communications theory; and optical communications.
For related information see also 04 Aircraft Communications and Navigation and 17 Spacecraft Communications, Command and Tracking.

N78-10946f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

DISASTER WARNING SYSTEM STUDY SUMMARY
B. F. LeRoy, J. E. Maly, R. C. Brealey, C. E. Provencher, H. A. Schumaker, and M. E. Valgora
Oct. 1977 21 p
(NASA-TM-73877, E-9365) Avail. NTIS HC AO2/MF AO1 CSCL 178

A conceptual satellite system to replace or complement NOAA's data collection, internal communications, and public information information. Data for Dec. 1971-1980 was defined. Program cost and cost sensitivity to variations in communications functions are analyzed. Author

N78-13228f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

PERFORMANCE OF THE 120kHz, 200 WATT TRANSMITTER EXPERIMENT PACKAGE FOR THE HERMES SATELLITE

Performance characteristics from on-orbit tests of the Transmitter Experiment Package (TEP) for the Hermes Satellite are presented. The TEP consists of a Power Processing System (PPS), an Output Stage Tube (OST) and a Variable Conductance Heat Pipe System (VCHPS), all of which are described. The OST is a coupled-cavity Traveling Wave Tube (TWT) with a Multistage Degressed Collector (MDC) and a stepped velocity-tapered slow wave structure for efficiency enhancement. It has an RF output power of 233 watts and overall efficiency of 50.75 percent at a center band frequency of 12.06 GHz. The PPS provides the required operating voltages, regulation, control and protection for the OST. The VCHPS consists of a fin radiator and three dual-artery stainless steel heat pipes using methanol and a mixture of inert gases. Test results presented include efficiencies, RF output power and body current. A discussion of thermal nonlinearities which occurred is presented. Author

N78-13228f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

A DIGITALLY IMPLEMENTED COMMUNICATIONS EXPERIMENT UTILIZING THE HERMES (CTS) SATELLITE

The Hermes (CTS) experiment program made possible a significant effort directed toward new developments which will reduce the costs associated with the distribution of satellite services. Advanced satellite transponder technology and small insensitive earth terminals were demonstrated as part of the Hermes program. Another system element that holds promise for reduced transmission cost is associated with the communication link implementation. An experiment is described which uses CTS to demonstrate digital link implementation and its advantages over conventional analog systems. A Digitally Implemented Communications experiment which demonstrates the feasibility and efficiency of digital transmission of television video and audio. Author

N78-18339f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

UTILIZATION OF NASA LEWIS MOBILE TERMINALS FOR THE HERMES SATELLITE

The high power of the Hermes satellite enables two-way television and voice communication with small ground terminals. The Portable Earth Terminal (PET) and the Tr. reportable Earth Terminal (TET) were developed and built by NASA - Lewis to provide communications capability to short-term users. The NASA - Lewis mobile terminals are described in terms of antennas, equipment, and on-board equipment, as well as operation aspects, including use in the field. The section on demonstrations divides the uses into categories of medicine, education, technology and government. Applications of special interest within each category are briefly described. Author

N78-18339f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

MEDIUM POWER VOLTAGE MULTIPLERS WITH A LARGE NUMBER OF STAGES

Voltage multiplier techniques are extended to medium power levels to larger multiplication ratios. A series of dc-dc converters were built, with from 20 to 45 stages and with power levels up to 130 watts. Maximum output voltages were about 10,000 volts. Author

N78-18339f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

THE 20/30 GHz SATELLITE SYSTEM TECHNOLOGY NEEDS ASSESSMENT

Rain attenuation in the 20/30 GHz bands, and the resultant impact on system design costs were estimated for a variety of satellite communications system concepts. Results of previous and current NASA Lewis contractural and in-house studies on system design are reported as well as market studies conducted to evaluate the concepts and test their relevance against forecasted market needs. The 20/30 GHz bands appear attractive economically and, with certain technology, appear to offer a virtually unlimited spectrum resource. This attractiveness is especially relevant to high density trunking where there is insufficient traffic to justify dual - link site diversity. Author

N78-33329f National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

AN AIRBORNE METEOROLOGICAL DATA COLLECTION SYSTEM USING SATellite RELAY (ASAR)

telephone voice and high-bit-rate data is also described. Presentation of the experiment concept which concentrates on the evaluation of full-duplex digital television in the teleconferencing environment is followed by a description of unique equipment that was developed. Author

Attention is given to an investigation being conducted by NASA Lewis and Comsat Laboratories which uses the Hermes (CTS) satellite to explain digital link implementation and the advantages it provides over conventional analog systems. The experiment consists of developing several video, audio, and data digital communications techniques. S.C.S.


The paper describes the portable earth terminal (PET) and the transportable earth terminal (TET) which enable two-way television and voice communication. Both terminals were developed by NASA and utilize the high power of the Hermes satellite. PET is a bus-type vehicle which has receiving equipment for full duplex color television and which can transmit programs originating in either the on-board PET studio or in nearby buildings. PET has a collapsible 2.4-m diameter parabolic antenna interfacing with a 500-watt 14-GHz wideband TV transmitter and a 12-GHz wideband TV receiver system. TET uses two parabolic reflector antennas, 3 m and 1.2 m in diameter, mounted on a flat trailer towed by a truck. TET can receive and relay color TV signals, and its narrowband transmitter can serve as a return audio link permitting a question-and-answer format. Also described are uplink and downlink performance characteristics, operation procedures, and field demonstrations which enabled personnel at several hospitals to participate in a distant medical conference. M.L.


This paper presents forecasts of likely changes in broadcast satellite technology, the technology of ground terminals, and the technology of terrestrial communications competitive with satellites. The impacts of these changes in technology are then assessed, using a cross-impact model of U.S. domestic telecommunications, to determine the consequences of various possible changes in communications satellite technology. These consequences are discussed in terms of various possible services, for households, businesses, and specialized customers, which might become economically viable as a result of improvements in satellite technology. (Author)


A Ku-band satellite earth terminal capable of providing two way voice/facsimile teleconferencing, 128 Kbps data, telephone, and high-speed image relay services is described. Optimum terminal cost and configuration are presented as a function of FDMA and TDMA approaches to multiple access. The entire terminal from the antenna to microphones, speakers and facsimile equipment is considered. Component cost versus performance has been projected as a function of size of the procurement and predicted hardware innovations and production techniques through 1985. The lowest cost combinations of components have been determined in a computer optimization algorithm. The system requirements including terminal ERIP and G/T, satellite size, power per space transmitter, satellite antenna characteristics, and link propagation outage were selected using a computerized system cost/performance optimization algorithm. System cost and terminal size and performance requirements are presented as a function of the size of a nationwide U.S. network. Service costs are compared with typical conference travel costs to show the viability of the proposed terminal. (Author)


The present study identifies potential satellite services, examines the technology necessary for efficient implementation of these services, and determines minimum service cost versus user network size. The generic satellite services evaluated comprise TV and radio distribution (for retransmission), video teleconferencing (interactive), audio/facsimile teleconferencing (interactive), multiplexed data/voice (point-to-point), and satellite-supported land mobile. Satellite costs are based on extrapolations from ongoing commercial satellite programs. Production methods, new technology, and effect of production quantities on present and future production costs are examined to provide information on earth station equipment cost versus the variable 'b'. Six different launch vehicles ranging from a Delta 2914 to a dedicated Shuttle and three frequency bands and both broadcast (no echo capability) and fixed service satellites are considered to assess the effect of satellite size on cost and performance. It is assumed that the user pays only for his prorate share of the space segment costs. S.D.
A satellite land mobile system using mobile radios in the UHF band, and Ku band Communications Routing Terminals (earth stations) for a nationwide connection from any mobile location to any fixed or mobile location, and from any fixed location to any mobile location is proposed. The proposed nationwide satellite land mobile service provides telephone network quality (1 out of 100 blockage) service, complete privacy for all the users, operation similar to the telephone network, alternatives for data services up to 32 Kbps data rates, and a cost effective and practical mobile radio compatible with system sizes ranging from 10,000 to 1,000,000 users. Seven satellite alternatives (ranging from 30 ft diameter dual beam antenna to 210 ft diameter 77 beam antenna) along with mobile radios having a sensitivity figure of merit (G/T) of -18 dB/deg K are considered. Optimized mobile radio user costs are presented as a function of the number of users with the satellite and mobile radio alternatives as system parameters.

(Author)
33 ELECTRONICS AND ELECTRICAL ENGINEERING

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

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

N78-11401* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

INSTRUMENT TO AVERAGE 100 DATA SETS
George B. Tuma, Arthur G. Birchenough, and William J. Rice
Oct. 1977 19 p
NASA-TP-1056: E-9169
Avail: NTIS HC AO2/MF AO1 CSCL 09C

An instrumentation system is currently under development which will measure many of the important parameters associated with the operation of an internal combustion engine. Some of these parameters include mass-fraction burned, oxygen concentration, and the indicated mean effective pressure. One of the characteristics of an internal combustion engine is the cycle-to-cycle variation of these parameters. A curve averaging instrument has been produced which will generate the average curve over 100 cycles.

Of any engine parameter, the average curve is described by 2048 discrete points which are displayed on an oscilloscope screen to facilitate recording and is available in real time. Input can be any parameter which is expressed as a ± or ± 10-volt signal.

Operation of the curve-averaging instrument is defined between 100 and 6000 rpm. Provisions have also been made for averaging as many as four parameters simultaneously, with a subsequent decrease in resolution. This provides the means to correlate and perhaps interrelate the phenomena occurring in an internal combustion engine. This instrument has been used successfully on a 1975 Chevrolet V8 engine, and on a Continental 8 cylinder aircraft engine. While this instrument was designed for use on an internal combustion engine, with some modification it can be used to average any cyclically varying waveform.

Author

N78-13320* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

POSSIBLE DAMAGE TO DC SUPERCONDUCTING MAGNETS DUE TO THE HIGH FREQUENCY ELECTROMAGNETIC WAVES
NASA-TM-73808: Avail NTIS HC AO2/MF AO1 CSCL 09C

Experimental data are presented in support of the hypothesis that a dc superconducting magnet coil does not behave strictly as an inductor, but as a complicated eddy current device capable of supporting electromagnetic waves. Travel times of nanosecond pulses and evidence of sinusoidal standing waves were observed on a prototype four-layer solenoidal coil at room temperature. Ringing observed during switching transients appears as a sequence of multiple reflected square pulses whose durations are related to the layer lengths. Without sinusoidal excitation of the coil, the voltage amplitude between a pair of points on the coil is maxima at those frequencies such that the distance between the midpoint of half wavelength in free space Evidence indicates that any disturbance, such as that resulting from switching or sudden fault, initiates multiple reflections between layers, thus raising the possibility for sufficiently high voltages to cause breakdown.

Author

A sustained-arc ignition system was developed for internal combustion engines. It produces a very-long-duration ignition pulse with an energy in the order of 100 millijoules. The ignition pulse waveform can be controlled to predetermined actual ignition requirements. The design of the sustained-arc ignition system is presented in the report.

Author

N78-17288* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

PARTICLE PARAMETER ANALYZING SYSTEM Patent
David G. Hansen (TRW Inc., Redondo Beach, Calif.) and Neal L. Roy, inventors (to NASA) (TRW Inc., Redondo Beach, Calif.)

An X-Y plotter circuit apparatus is described which displays an input pulse representing particle parameter information, that would ordinarily appear on the screen of an oscilloscope as a rectangular pulse, as a single dot positioned on the screen where the upper right hand corner of the input pulse would have appeared. If another event occurs, and it is desired to display this event, the apparatus is provided to replace the dot with a short horizontal line.

Official Gazette of the U.S. Patent Office

N78-17289* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

NOISE AS A TOOL FOR EVALUATING THE ACTIVATION OF CATHODES
NASA-TM-73895: E-9520: Avail NTIS HC AO2/MF AO1 CSCL 09C

Measurements at low frequencies, of the shot noise current from space charge limited cathodes always produced results substantially in excess of theoretical predictions. Measuring the ratio (I sub eq)/S yielded a relation (I sub eq)/S = 1.288 V sub k - 1.288 kV sub k/sub I sub eq, independent of the operating point of the diode (mode) as long as all parts of the cathode had a full space charge controlled emission. This method was so sensitive as to permit detection of cathode temperature changes by 1 K, thus it allowed a powerful screening method between well and poorly activated cathodes, superior to dip tests and other current-voltage methods.

Author

N78-19887* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

UP-DATE OF TRAVELING WAVE TUBE IMPROVEMENTS
NASA-TM-78852: E-9572: Avail NTIS HC AO2/MF AO1 CSCL 08C

A brief survey is presented of areas of progress on traveling wave tube designs. Data demonstrates the effect of multistage depressed collectors, the design of which is made possible by powerful NASA computer programs. Other topics include beam refocusing, RF circuit losses, and cathode testing.

Author

N78-21372* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

NASA CHARGING ANALYZER PROGRAM: A COMPUTER TOOL THAT CAN EVALUATE ELECTROSTATIC CONTAMINATION
NASA-TM-73889: E-9526: Avail NTIS HC AO2/MF AO1 CSCL 08C
A computer code, the NASA Charging Analyzer Program (NASCAP), was developed to study the spacecraft charging problem at the high altitudes of the Spacecraft Charging at High Altitudes (SCATHA) satellite. The code treats the material properties of a spacecraft in a self-consistent manner and calculates the electric fields in space due to the charged particles. The charged particles in the electric field can be computed to determine if these particles enhance surface charging. A possible model of the space vehicle charging at the high altitudes of the Spacecraft Charging at High Altitudes (SCATHA) satellite was developed in the NASA LCSA mission to investigate the possibility of electromotive force. The results indicate that differential voltages will exist between the spacecraft ground surfaces and the insulator surfaces. The electric fields from this differential charging can enhance the contamination of spacecraft surfaces.

Author


A liquid-nitrogen-cooled magnet has been designed to produce 30 tesla in steady operation. Its feasibility was established by a previously reported parametric study. To ensure the correctness of the heat transfer relationships used, supercritical neon heat transfer tests were made. Other tests made before the final design included tests on the effect of the magnetic field on pump motors, and tests on the cryogenic adhesives; and simulated flow studies for the coolant. The magnet will be made of two pairs of coils, cooled by forced convection of supercritical neon. Heat from the supercritical neon will be rejected through heat exchangers which are made of roll-bonded copper and are submerged in a pool of saturated liquid neon. A partial vacuum was to identify the tooling required to wind the magnet. This was followed by winding a prototype pair of coils. The prototype winding established procedures for fabricating the final magnet and revealed minor changes needed in the final design.

Author

A technique has been developed for introducing a nonreciprocal siren in a traveling-wave tube design. It employs an output coupler followed by a ferrite isolator, a variable phase shifter, and an input coupler. The input and output couplers are similar to those already needed at the ends of the tube. The isolator and phase shifter are similar to commercially available waveguide components. A computer simulation has suggested the technique may yield a significant improvement in efficiency.

S.C.S.


Studies of a d.c. superconducting magnet coil indicate that the large coil behaves as a straight waveguide structure. Voltages between layers within the coil sometimes exceeded those recorded at terminals where protective resistors are located. Protection of magnet coils against such excessive voltages could be accomplished by impedance matching throughout the coil system. The wave phenomena associated with superconducting magnetic coils may create an instability capable of converting the energy of a quiescent d.c. superconducting coil into dissipative ac energy, even in cases when dielectric breakdown does not take place.

J.M.B.


In isolated cases a pole may be encountered in a previously published solution for the fields in a klystron gap. Formulas, permitting the critical combinations of parameters to be defined, are presented. It is noted that the region of inaccuracy surrounding the pole is sufficiently small and that a 0.1% change in the field changing parameter is enough to avoid it.

S.C.S.


A: Auger spectrometer in ultrahigh vacuum was used to measure the secondary emission properties of a number of candidate collector materials including beryllium, carbon, (anod and pyrolitic graphite), copper, titanium carbide and tantalum. The technique used in the test is that the surface chemical contaminants could be determined just before the secondary emission characteristics of the surface were measured. Pyrolytic graphite roughened by sputter etching showed the most favorable results for depressed collector use.

B.J.


Performance characteristics from on-orbit tests of the Transmitter Experiment Package (TEP) for the Hermes Satellite are presented. These tests were conducted from February 8, 1976 through August 8, 1977. The TEP consists of a Power Processing System (PPS), an Output Stage Tube (OST) and a Variable Conductance Heat Pipe System (VC/HS), all of which are described. The OST is a coupled cavity traveling wave tube with a multistage depressed collector and a stepped velocity tapered slow wave structure for efficiency enhancement. It has an RF output power of 233 W and overall efficiency of 50.75% at a center band frequency of 12.060 GHz. The PPS provides the required operating voltages, regulation, control and protection for the OST. The VCHPS consists of a fin radiating and three dual-anode stainless steel heat pipes using methanol and a mixture of inert gases. Test results presented include efficiencies, RF output power and body current. A discussion of thermal anomalies which occurred is presented.

(Author)


NASA research in the area of traveling wave tube technology is reviewed with emphasis on the basic physics of guns and collectors and a computer model for the interaction between the electron beam and the RF circuit. The design of a multistage depressed collector, capable of multiplying tube efficiency by a factor of two or more, is presented; one such design has been adopted for commercial traveling wave tube production. A three-dimensional model of electron trajectories toward the collector also receives attention, as does the problem of RF circuit losses.

J.M.B.

A78-12426 # Hughes Aircraft Co., Torrance, Calif. Electronics Div.

STUDY OF 42 AND 89 GHZ COUPLED CAVITY TRAVELING-WAVE TUBES FOR SPACE USE

J. B. Kennedy, L. Tenmaru, and P. S. Wolcott Jun 1977 1771 p. ref. (Contract NAS3 19701)

(NASA CR 134670: W 04553) Available: NTIS HC A08/MF A01 CSCL 08A

Designs were formulated for four CW millimeter wavelength traveling wave tubes having high efficiency and long life. Three of these tubes in the 42 to 44 GHz frequency region develop power outputs of 100 to 300 watts with overall efficiencies of typically 45 percent. Another tube which covers the frequency range of 84 to 86 GHz provides a power output of 200 watts at 25 percent efficiency. The cathode current density in each design was 1A/sq cm. Each tube includes metal ceramic construction, periodic permanent magnet focusing a step velocity taper, an electron beam focusing section, and a radiation cooled three stage depressed collector. The electrical and mechanical design for each tube type is discussed in detail. The results of thermal and mechanical analyses are presented.

Author

A78-13228 # May Development Corp., San Diego, Calif.


Maxv. Douglass, Robert Laubre, and Sherman DeForest Aug 1977 104 p. ref. (Contract NAS3-20118)

(NASA CR-135258) Available: NTIS HC A08/MF A01 CSCL 08C
Interactions between the solar sail and the natural plasma environment were examined for deleterious impacts upon the operation of the sail and its associated payload. Electrostatic charging of the sail in the solar wind and in near earth environments were examined. Deployment problems were studied. An analysis of electromechanical oscillations coupling the sail to the natural plasma was performed. As a result of these studies, it was concluded that none of these effects will have a significant negative impact upon the sail operation. The natural environment will be significantly perturbed and this will preclude measurements of electric and magnetic fields from an attached payload. Author


A description is given of the physical models employed in the NASCAP (NASA Charging Analyzer Program) code, and several test cases are presented. NASCAP dynamically simulates the charging of an object made of conducting segments which may be electrically isolated or partially conductive. The object may be subject to either ground test or space user-specific environments. The simulation alternately treats (1) the tendency of materials to accumulate and emit charge when subject to plasma environment, and (2) the consequent response of the charged particle environment to an object's electrostatic field. Parametrized formulations of the emission properties of materials subject to bombardment by electrons, protons, and sunlight are presented. Values of the parameters are suggested for clean aluminum, Al2O3, clean magnesium, MgO, SiO2, kapton, and teflon. A discussion of conductivity in thin dielectrics subject to radiation and high fields is given, together with a sample calculation. Author


The NASCAP (NASA Charging Analyzer Program) code simulates the charging process of a complex object in either tenuous plasma or ground test environment. Detailed specifications needed to run the code are presented. The object definition section OBDEF allows the test object to be easily defined in the cubic mesh. The test object is composed of conducting sections which may be wholly or partially covered with thin dielectric coatings. The potential section, POTENT, obtains the electrostatic potential in the space surrounding the object. It uses the conjugate gradient method to solve the finite element formulation of Poisson's equation. The CHARGE section of NASCAP conducts charge redistribution among the surface cells of the object as well as charging through radiation bombardment. NASCAP has facilities for extensive graphical output, including several types of object display plots, potential contour plots, space charge density contour plots, current density plots, and particle trajectory plots. Author

N78-13597# Case Western Reserve Univ. Cleveland Ohio Engineering Design Center ADAPTION OF ION BEAM TECHNOLOGY TO MICROFABRICATION OF SOLID STATE DEVICES AND TRANSDUCERS James A. Topch Nov. 1977 43 p. refs (Grant NAG 3-131) (NASA CR 135534) Avail. NTIS HC A03/MF A01 CSCL OBC

It was found that ion beam texturing of silicon surfaces can be used to increase the effective surface area of MOS capacitors. There is, however, a problem with the dielectric breakdown. Preliminary work was begun on the fabrication of ion implanted resistors on textured surfaces and the potential improvement of wire bond strength by bonding to a textured surface. In the area of ion beam sputtering, the techniques for sputtering PVC were developed. A PVC target containing valnomyvnt was used to sputter an ion selective membrane on a field affect transistor to form a potassium ion sensor. Author


A power conditioner was developed which used a capacitor diode voltage multiplier to provide a high voltage without the use of a step-up transformer. The power conditioner delivered 1200 Vac at 100 watts and was operated off a 120 Vac line. The efficiency was in excess of 90 percent. The component weight was 197 grams. A modified boost add circuit was used for the regulation. A short circuit protection circuit was used which turns off the drive circuit upon a fault condition, and recovers within 5 ma after removal of the short. High energy density polystyrene capacitors and high speed diodes were used in the multiplier circuit. Author


A process of fabricating superconducting Nb3Ge tapes by chemical vapor deposition (CVD) has been developed and tapes up to 10 meters long fabricated. The typical properties achieved were critical temperature T sub c - 20 K, upper critical field H sub c2 , 28 tesla, H sub c2 - H sub c 3 4 x 10 to the 2nd power. The relative depression of T sub c and H sub c2 compared with the best thin film samples sputtered on sapphire was due to the presence of NbGeA3 second-phase particles used as flux pinning centers and to strains induced by thermal mismatch with Hastelloy B tape substrates. A peculiar field dependence of flux pinning force that was observed in both CVD and sputtered Nb3Ge indicated a premature pin-breaking mechanism or a phase inhomogeneity. Directions of further optimization work were defined. Author


Cylindrical wound metallized film capacitors rated 2 micron f 500 VDC that had an energy density greater than 0.3 J/g and flat flexible metallized film capacitors rated at 2 micron f 500 VDC that had an energy density greater than 0.1 J/g were developed. Polysulphone polycarbonate and polyvinylene fluoride (PVF2) were investigated as dielectrics for the cylindrical units. PVF2 in 80 micron m thickness was employed in the final components of both types. Capacitance and dissipation factor measurements were made over the range 25 C to 100 C and 10 Hz to 10 kHz. No pre-life-test burnout was performed and
se of ten cylindrical units survived a 2500 hour AC plus DC life test. Three of the four failures were instant mortality. All but two of the six components survived 400 hours. Finished energy densities were 0.104 J/cm² at 500 V and 0.300 J/cm² at 300 V, the energy density being limited by the availability of thin PTFE films.

(Author)

N76-25385TRW Defense and Space Systems Group, Redondo Beach, Calif. Power Conversion Electronics Dept.


The overall objective of the program is to provide the engineering tools to reduce the analysis, design, and development effort and thus the cost, in achieving the required performance for switching regulators and dc-dc converter systems. The program was both tutorial and application oriented. Various analytical methods were described in detail and supplemented with example cases, and those with standardizations appear to be reduced into computer-based subprograms. Major program efforts included those concerning small and large signal control dependent performance analysis and simulation, control circuit design, power circuit design and optimization, system configuration study, and system parameter optimization. Techniques including discrete time domain, conventional frequency domain, Lagrange multiplier, nonlinear programming, and control design synthesis were employed in these efforts. To enhance interactive communication between the modeling and analysis subprograms and the user a working prototype of the Data Management Program was developed to facilitate expanding the future subprogram capabilities increase. Author

N76-25381TRW Defense and Space Systems Group, Redondo Beach, Calif. Dept. of Electrical Engineering


A state-space averaging method for modeling switching dc-to-dc converters for both continuous and discontinuous conduction modes is developed. In each case the starting point is the unified state-space representation, and the end result is a complete linear circuit model for each conduction mode, which correctly represents all essential features, namely, the input, output, and transfer properties (static dc as well as dynamic ac small-signal). While the method is generally applicable to any switching converter, it is extensively illustrated for the three common power stages (buck, boost, and buck-boost). The results for these converters are then easily tabulated owing to the fixed equivalent circuit topology of their canonical circuit model. The insights that emerge from the general state-space modeling approach lead to the design of new converter topologies through the study of generic properties of the cascade connection of basic buck and boost converters. F. O. S.


Presently, hybrid Remote Power Controllers (RPC's) are in production and prototype units are available for systems utilizing 28VDC, 120VDC, 110VAC/400 Hz and 230VAC/400 Hz. This paper describes RPC development in a new area of application: HVDC distribution systems utilizing 270/300VDC. Two RPC current ratings, 1 amp and 2 amps, were selected for development as they are adequate to control 90% of project load systems. The various aspects and trade-offs encountered in circuit development are discussed with special focus placed on the circuits that see the greatest of the high dc potentials. The comprehensive evaluation tests are summarized which confirmed the RPC compliance with the specifications and with system/load compatibility requirements. In addition, present technology status and new applications are summarized. (Author)


Using discrete time state variable representation, a generalized computer-aided modeling and analysis of dc-dc converters is presented. The methodology provides exact modeling and is applicable to all types of power stages and duty-cycle control, including continuous and discontinuous inductor current operation. Converter stability, transient behavior and audio susceptibility can be analytically evaluated and predicted. The generalization theory of the proposed approach to converter modeling and analysis is presented first, followed by a demonstration example applying the theory to a constant frequency buck converter operating in continuous and discontinuous inductor current mode. Excellent agreement with laboratory test data has been observed. (Author)
34 FLUID MECHANICS
AND HEAT TRANSFER

Includes boundary layers; hydrodynamics; fluidics; mass transfer; and boiling cooling.
For related information see also 02 Aerodynamics and 77 Thermodynamics and Statistical Physics.

N78-10416# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
THE DESIGN OF HYDRAULIC PRESSURE REGULATORS
THAT ARE STABLE WITHOUT THE USE OF SENSING LINE
RESTRICTORS OR FRICIONAL DAMPERS
Harold O. Wright 1977 22 p. refs. Presented at Natl. Conf. on
(NASA-TM-X-73887: E-9220) Avail NTIS HC A02/MF A01
CSCL 20D

Parameters controlled in design determine the stability of hydraulic pressure regulators in service. The non-linear sensing line restrictor can provide stability, but degrades the transient response. Linear damping is not always physically realizable and is sensitive to clearance and vacuums. Design relationships are analytically derived through which regulators can be made to be stable without the use of either of these damping means. The analytical differences between the parameters derived and those in the equations are discussed. An analytically derived circuit component that satisfies an otherwise unstable regulator and its experimental verification is described.

Author

N78-10417# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
RELEASE OF DISSOLVED NITROGEN FROM WATER
DURING DEPRESSURIZATION TRANSIENTS:
PRELIMINARY REPORT
Water Reactor Safety Inform. Meeting, Gettysburg, Md.
7-11 Nov. 1977; sponsored by Nuc. Regulatory Comm.
(NASA-TM-73822: E-8411) Avail NTIS HC A02/MF A01
CSCL 20D

An experiment was run to study depressurization of water containing various concentrations of dissolved nitrogen gas, the primary reason being room temperature water saturated with nitrogen at 4 MPa. The experiment had two major components both visual: a static depressurization experiment and a flow through a pressure gradient experiment in the static depressurization experiment, water which had been bubbled with nitrogen for from 1 to 28 days was depressurized at from 0.09 to 0.50 MPa/second. The transient was photographed with high speed movies. The pictures showed that the bubble population increased strongly with decreasing depressurization rate and weakly with increased bubble time. The water was always very nearly saturated with nitrogen Bubbles rarely appeared before the pressured reached P sub zero/2 and in some instances levels of P sub zero/5 would show no bubbles. Flow experiments were performed in two nozzles; an asymmetric converging-diverging nozzle and a two-dimensional converging nozzle with glass sidewalls. Depressurization rates were roughly 0.5 x 1000 to 12 x 1000 MPa/second. Both nozzles exhibited choked flow behavior even at nitrogen concentration levels as low as 4 percent saturation.

Author

N78-13961# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
ON THE LOCALNESS OF THE SPECTRAL ENERGY
TRANSFER IN TURBULENCE
Penn. 21-23 Nov. 1977
(NASA-TM-37824: E 9376) Avail NTIS HC A02/MF A01
CSCL 20D

By utilizing available experimental data for net energy transfer spectra for homogeneous turbulence contributions PIIK prime 1 to the energy transfer at a wavenumber k from various other wavenumbers k prime 1 are calculated. This is done by fitting a truncated power - exponential series in k and k prime 1 to the experimental data for the net energy transfer TLU and using known properties of PIIK prime 1. Although the contributions PIIK prime 1) obtained by using various assumptions do not differ significantly. It seems clear from the results that for a region where the energy entering a wavenumber band dominates that leaving, much of the energy comes from wavenumbers within about an order of magnitude smaller. That is, the energy transfer is rather local. This result is not significantly dependent on Reynolds number. For lower wavenumbers, where more energy leaves than enters a wavenumber band, the energy transfer into the band is more local, but much of the energy then leaves at distant wavenumbers.

Author

N78-13966# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECT OF AEROSOL VELOCITY ON MEAN DROP
DIAMETERS OF WATER SPRAYS PRODUCED BY PRESSURE
AND AIR ATOMIZING NOZZLES
Meeting, Atlanta, Ga. 27 Nov. - 2 Dec. 1977
(NASA-TM-73740: E-9304) Avail NTIS HC A02/MF A01
CSCL 20D

A scanning radiometer was used to determine the effect of aerosol velocity on the mean drop diameter of water sprays produced by pressure atomizing and air atomizing fuel nozzles used in previous combustion studies. Increase in mean drop diameters from 23 to 53.4 microns per second reduced the Sauter mean diameter by approximately 50 percent with both types of fuel nozzles. The use of a sonic cup attached to the tip of an air assist nozzle reduced the Sauter mean diameter by approximately 40 percent. Test conditions included aerosol velocities of 23 to 53.4 microns per second at 283 K and atmospheric pressure.

Author

N78-13372# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECTS OF FILM INJECTION ANGLE ON TURBINE VANE
COOLING
James W. Gawin and 1977 24 p. refs
(NASA-TM-1085: E-9254) Avail NTIS HC A02/MF A01
CSCL 20D

Film injection from discrete holes in the suction surface of a turbine vane was studied for hole sizes (1) slanted 30 deg to the suction surface in the streamwise direction and (2) slanted 30 deg to the suction surface in the streamwise direction toward the hub. The holes were near the throat area in a five-row staggered array with 8-diameter spacing. Mass flux ratios were as high as 1:2. The data were obtained in an annular sector cascade at conditions where both the ratio of the boundary layer momentum thickness and of the momentum thickness Reynolds number were typical of an advanced turbine engine at both takeoff and cruise. Wall temperatures were measured downstream of each of the rows of holes. Results of the study are expressed as a comparison of cooling effectiveness between the in-line angle injection and the compound angle injection as a function of mass flow ratio. These heat transfer results are also compared with the results of a reference flow visualization study. Also included is a closed-form analytical solution for temperature within the film cooled wall.

Author

N78-14313# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL EVALUATION OF PREMIXING-
PREVAPORIZING FUEL INJECTION CONCEPTS FOR A GAS
TURBINE CATALYTIC COMBUSTOR
Winter Ann. Meeting, Atlanta, Ga. 27 Nov. - 2 Dec. 1977
(Contract EC 77-3 10111)
HC A02/MF A01 CSCL 20D

Experiments were performed to evaluate a premixing--prevaporizing fuel system to be used with a catalytic
N78-17386* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
MAGNETIC HEAT PUMPING Patent
Gerald V. Brown, inventor (to NASA) Issued 17 Jan. 1978
0780)
(NASA-Case-LEW-12508-1; US-Patent-4,059,026;
A ferromagnetic or ferrimagnetic element is used to control
the temperature and applied magnetic field of the element
to cause the state of the element as represented on a temperature-
magnetic entropy diagram, to repeatedly traverse a loop. The
loop may have a first portion of concurrent substantially isothermal
or constant temperature and increasing applied magnetic field,
a second portion of lowering temperature and constant applied
magnetic field, a third portion of isothermal and decreasing applied
magnetic field, and a fourth portion of increasing temperature
and constant applied magnetic field. Other loops may be
four-sided, with two other sides of lower field and higher.
The total regenerator is used to enhance desired cooling or heating
effects, with variable magnetic fields or varying temperatures
including three-sided figures traversed by the representative
point.
Official Gazette of the U.S. Patent Office

N78-17399* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
METHOD FOR CALCULATING CONVECTIVE HEAT-
TRANSFER COEFFICIENTS OVER TURBINE VANE SUR-
FACES Daniel J. Geantner and James Suuc Jan. 1978 18 p. ref
(NASA-TP-1124, E-8324) Avail NTIS HC 02/28-MF A01
CSCL 200
A method for calculating laminar, transitional, and turbulent
convective heat-transfer coefficients for turbine vane surfaces
is described. An approximate integral solution method produced
results in good agreement with a finite-difference solution.
Comparisons between the two are presented. The integral solution
results agreed well with the finite-difference solution results in
the laminar and turbulent regions. Differences in calculating the
start of transition produced a later starting point for the
approximate integral solution's transitional flow regime.

N78-17340* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
HIGH TEMPERATURE SURFACE PROTECTION
Stanley R Levine 1978 17 p. refs. Presented at Spring
Review Conf. of the Inst of Metallurgists, Cardiff, Wales.
7ID Aug 1978
(NASA TM 7387 E-9477) Avail NTIS HC 02/28-MF A01
CSCL 200
A list of the MAC/AI type are the basis for high temperature
surface protection systems in gas turbines. M can be one or
more of Ni, Co, or Fe, and X denotes a reactive metal added to
enhance oxide scale adherence. The selection and formation as
well as the oxidation, hot corrosion, and thermal fatigue
performance of MAC/AI coatings are discussed. Coatings covered
range from simple aluminides formed by pack cementation to
the more advanced physical vapor deposition overlay coatings
and development plasma spray deposited thermal barrier
coatings.

N78-17361* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
ACCELERATED LIFE TESTS OF SPECIMEN HEAT PIPES
FOR COMMUNICATION TECHNOLOGY SATELLITE (CTS)
ref. (NASA-TM-73846: E-9433) Avail NTIS HC 02/28-MF A01
CSCL 200
A gas-loaded variable conductance heat pipe of stainless
steel with methanol working fluid identical to one now on the
CTS satellite was life-tested in the laboratory at accelerated
conditions for 14,200 hours, equivalent to about 70,000 hours
at flight conditions. The noncondensable gas inventory increased
about 20 percent over the original charge. The observed gas
increase is estimated to increase operating temperature by about
2.2 C, insufficient to harm the electronic gear cooled by the
heat pipe in the satellite. Tests of maximum heat input against
devaporator elevation agree well with the manufacturer's predic-
tions.

N78-18336* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
THERMAL BARRIER COATING SYSTEM Patent
Stephen Securce and Curt H. Laibert, inventors (to NASA) Issued
(14 - 14, p. 1772)
US Patent Office, CSCL 200
A coating system which contains a bond coating and a
thermal barrier coating is applied to metals such as turbine
blades and provides both low thermal conductivity and
improved adherence when exposed to high temperature gases
or liquids. The bond coating contains Ni/AlY and the thermal
barrier coating contains a reflective oxide. The reflective oxides
ZrO2-Y203 and Zr02-Mg0 have demonstrated significant utility
in high temperature turbine applications.

N78-20488* National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio.
THE ROLE OF DROP VELOCITY IN STATISTICAL SPRAY
DESCRIPTION J. F. Groeneweg, M. M. El-Walid (Wisc Univ.
Madison), P. S. Myers (Wisc Univ. Madison), and O. A. Uyehara (Wisc. Univ.
Madison) 1978 14 p. refs. Presented at 1st Int. Conf. on
Liquid Atomization and Spray Systems, Tokyo, 29-31 Aug
CSCL 200
The justification for describing a spray by treating drop velocity
as a random variable on an equal statistical basis with drop
size was studied experimentally. A double exposure technique
using fluorescent drop photography was used to make size and
velocity measurements at selected locations in a steady air
spray formed by a swit atomizer. The size velocity data were
sampled to construct bivariate spray density functions to
describe the spray immediately after formation and before
downstream propagation. Bimodal density functions were formed by
environment interaction during downstream propagation. Large differences were also found between spatial mass density and
mass flux size distribution at the same location.

Author
EVALUATION OF COMMERCIALLY AVAILABLE SPACECRAFT-TYPE HEAT PIPE


As part of an effort to develop reliable, cost effective spacecraft thermal control heat pipes, life testing on 30 commercially available heat pipes in 10 groups of different design and material combinations were conducted. Results for seven groups were reported herein. Materials are aluminum and stainless steel, and working fluids are methanol and propylene. The formation of non-condensable gas was observed for times exceeding 11,000 hours. The heat transport capacities of the pipes were also determined.

BOUNDARY LAYER ANALYSIS OF A CENTAUR STANDARD SHROUD


An analytical boundary layer investigation was carried out in conjunction with an experimental wind tunnel test to determine the discharge characteristics of the Centaur shroud ascent vent system on the Titan/Centaur launch vehicle. The problem was estimating the effect of the local boundary layer on the vent discharge for Mach numbers ranging from 0.8 to 1.56. The growth of the boundary layer along the vehicle was influenced by the interaction with flanges protruding into the flow and by the longitudinal corrugations in the vehicle surface. The effects of the flanges and corrugations were treated by approximate techniques. In addition, boundary layer calculations were made for a 3 percent model of the launch vehicle compared with experimental results.

NUMERICAL SPATIAL MARCHING TECHNIQUES FOR ESTIMATING DUCT ATTENUATION AND SOURCE PRESSURE PROFILES


A numerical method was developed that could predict the pressure distribution of a ducted source from far field pressure

inputs. Using an initial value formulation, the two-dimensional homogeneous Helmholtz wave equation (no steady flow) was solved using a spatial marching techniques. The Von Neumann method was used to develop numerical schemes which describe how sound frequency and grid spacing affect numerical stability. At the present time, stability considerations limit the approach to high frequency sound. Sample calculations for both hard and soft walls indicate favorably to known boundary value solutions. In addition, assuming that reflections in the duct are small, this initial value approach was successfully used to determine the attenuation of a single soft wall duct. Compared to conventional finite difference or finite elements boundary value approaches, the numerical marching techniques is orders of magnitude shorter in computation time and required computer storage and can be easily employed in problems involving high frequency sound.

STIFFNESS OF STRAIGHT AND TAPERED ANNULAR GAS PATH SEALS


Radial stiffness of annular (ring-type) gas path seals are calculated for both constant-clearance designs and tapered designs for which the inlet clearance is larger than the outlet clearance. Under some conditions a constant clearance seal can have a negative stiffness. This undesirable property can be completely eliminated by use of tapered seals. Leakage rates are only moderately higher in tapered seals.

DEGREE OF VAPORIZATION USING AN AIR BLAST TYPE INJECTOR FOR A PREMIXED-PREVAPORIZED COMBUSTOR


Vaporization data that could be useful in designing premixed prevaporized fuel prepreparation systems for gas turbine combustors are presented. The effect of the experimental parameters on vaporization was found to be - T sub i in sec 0.18 (V sub ref) - 381. P sub in 1.35/203000 where E is the degree of vaporization in percent, T sub i in the inlet air temperature in K

78-223885/ National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

HIGH TEMPERATURE HEAT PIPE RESEARCH AT NASA LEWIS RESEARCH CENTER


High temperature refractory metal heat pipes with alkali metal working fluids, for use in thermal systems, were studied. The main effort involved a concept for an out-of-core thermionic nuclear reactor power system. For this a lithium filled heat pipe of 335 cm length with 15 kW capacity was built in several modifications. One of them ultimately tested. Fabrication studies included the manufacture of a heat pipe tube of wire reinforced tantalum by chemical vapor deposition (CVD) and the extension to an reinforced pipe with integral anodes made by the CVD process. A lithium filled CVD tungsten heat pipe of about 3 kW capacity ran several thousand hours above 1800 K.

Materials compatibility studies of several liquid metals in tantalum alloy pipes were performed.
over the range 450 to 700 K, the residence time in ns over the range 4.3 to 239 ns. V sub ref the reference velocity in m/s over the range 5 to 22 m/s. \( \rho \) sub P sub in the inlet pressure in MPa over the range 0.18 to 0.85 MPa. Jet A and Diesel fuel 2 fuel velocities were measured for the effect of inlet air temperature and were found to have nearly identical results

**N77-26039** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio FLOW COMPENSATING PRESSURE REGULATOR Patent Edward F. Bash, inventor (to NASA) issued 19 Apr. 1978 98 pages 21 Mar. 1977 Supersedes N77-20408 (16 - 11, p. 14631)

An apparatus for regulating pressure of treatment fluid during aphthologic procedures is described. Flow sensing and pressure regulating diaphragms are used to modulate a flow control valve. The pressure regulating diaphragm is connected to the flow control valve to urge the valve to an open position due to pressure being applied to the diaphragm by bias means such as a spring. The flow sensing diaphragm is mechanically connected to the flow control valve and urges it to an open position because of the differential pressure on the diaphragm generated by a flow of incoming treatment fluid through an orifice in the diaphragm. A bypass connection with a variable restriction is connected in parallel relationship to the orifice to provide for adjusting the sensitivity of the flow sensing diaphragm. A multiple lever linkage system is utilized between the center of the second diaphragm and the flow control valve to multiply the force applied to the valve by the other diaphragm and reverse the direction of the force.


Ten basic steps are established for an analog method that measures control system response parameters. An example shows how these steps were used on a speed control portion of an auxiliary power unit. The equations and calculations necessary to describe the subsystem are given. The mechanization schematic and simulation diagram for obtaining the measured response parameters of the control system using an analog circuit are explained. Methods for investigating the various effects of the control parameters are described. It is concluded that the optimum system should be underdamped enough to be slightly oscillatory during transients.


Two-dimensional duct flow computations for radial distributions of velocity, temperature, and electrical conductivity are reported. Calculations were carried out for the flow conditions representative of a hydrogen-oxygen combustion driven MHD duct. Results are presented for profiles of developing flow in a smooth duct and for profiles of fully developed pipe flow with a specified streamwise shear stress distribution. The predicted temperature and electrical conductivity profiles for the developing flows compare well with available experimental data.

**N78-25374** National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio TACCT: A COMPUTER PROGRAM FOR THE TRANSIENT THERMAL ANALYSIS OF A COOLED TURBINE BLADE OR VANE EQUIPPED WITH A COOLANT INSERT. 1. USERS MANUAL Raymond E. Gaugler Aug. 1978 78 pages (NADA TP-1271: E-9564) Avail NTIS HC AO5/MA01 CSCL 21E

A computer program to calculate transient and steady state temperatures, pressures, and coolant flows in a cooled axial flow turbine blade or vane with an impingement insert is described. Coolant side heat transfer coefficients are calculated internally in the program, with the user specifying either impingement or convection heat transfer at such internal flow stations. Spent impingement or flow losses in cooling detection and re-discharged through the trailing edge and through film cooling holes. The ability of the program to handle film cooling is limited by the external flow model. Sample problems, with tables of input and output are included in the report. Input to the program includes a description of the blade geometry, coolant supply conditions,
outside thermal boundary conditions, and wheel speed. The blade wall can have two layers of different materials, such as a ceramic thermal barrier coating over a metallic substrate. Program output includes the temperature at each node, the coolant pressures and flow rates, and the heat-transfer coefficients.

Author

N77-25407* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. LIQUID PROPELLANT RE CONFIGURATION IN A LOW- GRAVITY ENVIRONMENT

Irving E. Sumer, Jan 1978 52 p (NASA-TM-78598; E 9718) Avail NTIS HC A04/MA01 CSCL 20D

An emerging empirical analysis relating to the regeneration of liquids in cylindrical tanks due to propulsive settling in a low gravity environment was extended to include the effects of geyser formation in the Weber number range from 4 to 10. Estimates of the minimum velocity increment required to be imposed on the propellant tank to achieve liquid regeneration were made. The resulting Bond numbers, based on tank radius, were found to be in the range from 3 to 5, depending upon the initial liquid level with higher Bond number required for high initial liquid level. The resulting Weber numbers, based on tank radius and the velocity of the liquid leading edge, were calculated to be in the range from 6.8 to 8.6 for cylindrical tanks having a freewind ratio of 2.0 with Weber numbers of somewhat greater values for longer cylindrical tanks. Therefore, appeared to be advantageous to allow small cylinders to form and then desiccate into the surface of the collected liquid in order to achieve the minimum velocity increment. The Bond numbers which define the separation between regions in which geyser formation did and did not occur due to propulsive settling in a spherical tank configuration ranged from 2 to 8 depending upon the liquid level.

N77-33896* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ENGINEERING IN THE 21ST CENTURY


Reasonable evolutionary trends in federal outlays for aerospace research and development predict a continuing decline in real resources (1970 dollars) until the mid eighties and a growth thereafter to the 1970 level by 2000. Yet well below the 1966 peak Employment levels will parallel this trend with no shortage of available personnel. These trends are characteristic of the aerospace industry. Shifts in emphasis toward the economic use of resources, rather than the minimum cost at any cost, and toward missions aligned with societal needs and broad national goals will accompany these trends. These shifts in outlook will arise in part in academia, and will, in turn, influence engineering education. By 2000 space technology will have achieved major advances in the management of information, in space transportation, in space structures, and in energy. The economics of space systems must be the primary consideration if the space program foreseen for the 21st century is to become an actuality.

Author


 Forced convection and subsaturated boiling heat transfer data for liquid nitrogen and liquid neon were obtained in support of a design study for a 30 tank cryo-magnet cooled by forced convection of liquid neon. This design precedes liquid neon boiling in the flow channels as they are too small to handle vapor flow. Consequently, it was necessary to determine boiling incipience and convective boiling heat transfer data as a function of flow rate. The accuracy of the correlating equations was then evaluated. A technique was also developed to calculate the position of boiling incipience in a uniformly heated flow channel. Comparisons made with the experimental data showed a prediction accuracy of plus or minus 18 percent.

Author


 previously reported vaporization time data of liquid nitrogen drops in film boiling on a flat plate are about 30 percent shorter than predicted from standard laminar film boiling theory. This theory, however, had been found to successfully correlate the data for conventional fluids such as water, ethanol, benzene, or carbon tetrachloride. This paper presents experimental evidence that some of the discrepancy for cryogenic fluids results from the ice contamination due to condensation. The data indicate a fairly linear decrease in droplet evaporation time with the diameter of the ice crystal residue. After correcting the raw data for ice contamination along with convection, a comparison of theory with experiment shows good agreement.

Author


 A simplified expression to estimate surface temperatures in forced convection boiling was developed using a liquid nitrogen data base. Using the principal of corresponding states and the Kutateladze relation for maximum pool boiling heat flux, the expression was normalized for use with other fluids. The expression was applied also to neon and water. For the neon data base, the agreement was acceptable with the exclusion of one set suspected to be in the transition boiling regime. For the water data base at reduced pressure greater than 0.05 the agreement is generally good. At lower reduced pressures, the water data scatter and the calculated temperature becomes a function of flow rate.

Author


 Two phase and gaseous choked flow data for fluid nitrogen were obtained for a test section which was a long constant area duct of 16.200 L/D with a developing diffuse attached topology. Flow rate data were taken along five isotherms (reduced temperature of 0.31, 0.69, 1.06, 1.12, and 2.34) for reduced pressures to 3. The flow rate
data were mapped in the usual manner using stagnation conditions at the inlet mixing chamber upstream of the entrance length. The results are predictable by a two-phase homogenous equilibrium turbulence flow model which includes wall friction. A simplified theory which in essence describes the long tube region from the high acceleration choking region also appears to predict the data reasonably well, but about 16 percent low. (Author)

**A78-17481**  

Boundary layer velocity and temperature profiles were measured for nitrogen near its thermodynamic critical point flowing past a horizontal flat plate. The heated surface was oriented both facing upward and downward. The results were compared to earlier work in which measurements were made for vertically upward flow. The boundary layer temperature ranged from below to above the thermodynamic critical temperature for wall temperatures below the thermodynamic critical temperature there was little variation between the velocity and temperature profiles in the three orientations. In all three environments the point of crossing into the critical temperature region is marked by a significant flattening of the velocity and temperature profiles and a decrease in heat transfer coefficient. As the heat flux and, consequently, wall temperature are further increased significant changes occur in the velocity and temperature profiles. Examination of near-critical heat transfer in these three flow orientations offers insights into the relative role of buoyancy forces in this regime. (Author)

**A78-17508**  

In the state of Lennard-Jones liquid drops are observed in a variety of mechanical states. Theories are presented which predict the frequency of oscillation and show that the observed relaxation times of oscillations depend on the model of the drop's response in the minimum energy state of oscillation. High speed photographic techniques were used to record the motion of these model systems and substantiate these theories. An incident wave was also found for water drops in film boiling below which free oscillations do not exist. In addition to these oscillations, photographic sequences are presented which show that wave motion can exist along the circumference of the drop following the study of free oscillations, the system was mounted on a shaking table and the drop subjected to a range of forced frequencies and accelerations. (Author)

**A78-20682**  

A computer program to calculate transient and steady-state temperatures, pressures, and coolant flow in a cooled turbine blade or vanes with an impingement insert is described. Input to the program includes a description of the blade geometry, coolant supply conditions, and the coolant supply conditions and net flow. Coolant side heat transfer coefficient are calculated internally in the program, with the effect of specifying the mode of heat transfer at each internal flow station. Program output includes the temperature at each node, the coolant rates and flow rates, and the inside heat transfer coefficients. A sample problem is discussed. (Author)

**A78-22344**  

An explicit representation for the unsteady motion on a transversely sheared mean flow is obtained which corresponds to the gust motion on a uniform mean flow. The important features of this motion are discussed. It is shown that its velocity, pressure, and vorticity are all induced by a disturbances field which is a linear combination of the vorticity and particle-displacement fields and is everywhere frozen in the mean flow. The general ideas are illustrated by considering the scattering of a gust by half-plane embedded in a shear flow. (Author)

**A78-34860**  

Data for the energy transfer function are used to estimate the degree of localities of energy transfer in homogeneous turbulence. It is found that in regions where the velocity and temperature spectra and also in those heat transfer coefficients. As the heat flux and, consequently, wall temperature are further increased significant changes occur in the velocity and temperature profiles. Examination of near-critical heat transfer in these three flow orientations offers insights into the relative role of buoyancy forces in this regime. (Author)

**A78-32749**  

The mercury propellant tank system developed for use with solar electric propulsion was studied to analytically determine the resonant frequencies of the tank system and compare with the anticipated natural frequency of the spacecraft. The system consisted of a stainless steel spherical shell and a hemispherical elastic diaphragm which separates the mercury propellant and the gaseous nitrogen propellant. The linear analysis tool used was the NASTRAN program. Six mathematical models, which represent various amounts of mercury in the tank system were developed. Resonant frequencies for each magnitude were obtained for each of the six models considered. The results show that the lowest resonant frequency for the tank system is about 100 percent greater than the anticipated control frequency of the spacecraft. (Author)

**A78-35618**  

In the course of studies of thermionic power plants for space applications, high temperature heat pipes have been designed and built for small metal working fluids. Fabrication of tungsten and reinforced tantalum pipes by chemical vapor deposition is discussed. The development of reinforced pipes with integral internal structures is described. Fabrication of coating techniques is also mentioned. The feasibility of using lithium, sodium, potassium, calcium or mercury as the working fluid in the heat pipes is also investigated. Operation of a lithium filled heat pipe of about 3 kW capacity for several thousand hours is reported. (J.M.)

The problem of closure in turbulence in the case of two-point correlations resides in the existence of two unknowns $E$ and $W$, the energy spectrum function and the transfer function, respectively, in the spectrum equation. In the case of weak turbulence, $W$ is negligible. In case of higher closures, closure can be effective by neglecting the inertia term in the highest order term used. Specifying a certain number of spectra at an initial time is also a way of getting around the closure problem. A simple case of turbulent shear flow is then considered, where two-point correlation equations are used and the velocity is broken into mean and fluctuating components. This yields a differential equation for the energy spectrum, the three terms of which are the energy spectrum, production term and dissipation term. They are plotted for a particular time. Similar analyses and comparisons with experiment are made for pipe and boundary layer flows. P.T.H.


An experimental and analytical investigation was conducted to determine the free surface shapes of circular jets impinging normal to sharp-edged disks in zero gravity. Experiments conducted in a zero gravity drop tower yielded three distinct flow patterns which were classified in terms of the relative effects of surface tension and inertial forces. An order of magnitude analysis was conducted indicating regions where viscous forces were not significant when computing free surface shapes. The free surface analysis was simplified by transforming the governing potential flow equations and boundary conditions into the inverse plane. The resulting nonlinear equations were solved numerically and comparisons were made with the experimental data for the inertia dominated regime. (Author)


The two diffusers employed in the investigation had the same overall area ratio but different prediffuser area ratios and suction slot geometries. Velocity profile and diffuser pressure recovery performance data were obtained at ambient pressure and temperature, with inlet Mach numbers ranging from 0.18 to 0.41 and suction rate varying from zero to 18% of total inlet mass flow rate. On the basis of the reported investigation it is concluded that suction stabilized vortex flow diffusers show promise for application in combustors because of relatively high static pressure recovery and low total pressure loss obtained in a short length. Performance obtained using a narrow angle 17 degree prediffuser was superior to that obtained with a prediffuser having a 14 degree included angle. G.R.


Vaporization data are presented which could be useful in designing premixed-prevaporized fuel preparation systems for gas turbine combustors. Lean, premixed-prevaporized combustion systems are being developed because they operate with low flame temperatures and, therefore, produce low levels of nitrogen oxides. Parametric tests of the effect of inlet air temperature, length (residence time), reference velocity, pressure and fuel-air ratio on the degree of vaporization are reported. Jet A and Diesel no 2 fuel were tested. A formula is provided which shows the effect of inlet air temperature, residence time, reference velocity, and pressure on the degree of vaporization for a constant fuel-air ratio of 0.020. The results of the effect of inlet air temperature on the degree of vaporization using Jet A and Diesel no 2 are nearly identical. G.R.
A visual investigation of turbulence in stagnation flow about a circular cylinder was carried out in order to gain a physical insight into the model advocated by the Karman-averaging theory. Motion pictures were taken from three different viewpoints, and a frame by frame examination of selected movie strips was conducted. Qualitative and quantitative analyses of the flow events focused on tracing the temporal and spatial evolution of a cross-vortex tube outlined by the entrained smoke filaments. The visualization supplied evidence verifying: (1) the selective stretching of cross-vortex tubes which is responsible for the amplification of cross vorticity and, hence, of streamwise turbulence; (2) the streamwise tilting of stretched cross-vortex tubes; (3) the existence of a coherent array of vortices near the stagnation zone; (4) the interaction of the amplified vorticity with the body laminar boundary layer; and, (5) the growth of a turbulent boundary layer.

LS


The use of dimensionless parameters to study fluid flows that occur in a reduced gravity environment is discussed. The significance of the Marangoni instability is considered and the use of dimensionless parameters to investigate problems such as thermosolutal and diffusion-capillary flow is described. Characteristics of fluid flow in space are described, and the relation and interaction of motions due to capillarity and buoyancy is examined. M.L.
35 INSTRUMENTATION AND PHOTOGRAPHY

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

For serial photography see 43 Earth Resources. For related information see also 06 Aircraft Instrumentation and 1:J Spacecraft Instrumentation.

N78-13487 * National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
RELIABILITY ANALYSIS OF FORTY-FIVE STRAIN-GAGE SYSTEMS MOUNTED ON THE FIRST FAN STAGE OF A YF-100 ENGINE
Raymond Holanda and Lloyd M. Fraese Sep. 1977 20 p
(AIAA-TM-73724; E-9274) Avail: NTIS HC A02/MF A01 CSCL 14B

The reliability of 45 state-of-the-art strain gage systems under full scale engine testing was investigated. The flame spray process was used to install 23 systems on the first fan rotor of a YF-100 engine, the others were epoxy cemented. A total of 99 percent of the systems failed in 11 hours of engine operation. Flame spray system failures were primarily due to high gage resistance, probably caused by high stress levels. Epoxy system failures were principally erosion failures, but only on the concave side of the blade. Lead-wire failures between the blade-to-disk jump and the control room could not be analyzed.

Author

N78-15483 * National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
RECOVERY AND RADIATION CORRECTIONS AND TIME CONSTANTS OF SEVERAL SIZES OF SHIELDED AND UNSHIELDED THERMOCOUPLE PROBES FOR MEASURING GAS TEMPERATURE
George E. Glawe, Raymond Holanda, and Lloyd N. Krause Jan 1978 30 p
(AIAA-TM-1098; E-9289) Avail: NTIS HC A02/MF A01 CSCL 14B

Performance characteristics were experimentally determined for several sizes of a shielded and unshielded thermocouple probe designs. The probes are of swaged construction and were made of type K wire with a stainless steel sheath and shield and MgO insulation. The wire sizes ranged from 0.03- to 1.02-mm diameter for the unshielded design and from 0.16- to 0.81-mm diameter for the shielded design. The probes were tested through a Mach number range of 0.2 to 0.8 through a temperature range of room ambient to 1420 K, and through a total-pressure range of 0.03 to 0.22 MPa (0.3 to 22 atm). Tables and graphs are presented to aid in selecting a particular type and size. Recovery corrections, radiation corrections, and time constants were determined.

Author

N78-23028 * National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
APPLICATION OF FLUIDICS TO NEW CONTROL COMPONENTS
Miles O. Duston, Vernon D. Gebben, and Robert E. Wallhagen
In NASA, Washington, Fourth Inter-Zent Control Systems Conf. Jan 1978 p 365-386 refs (For availability see N78-23010 13-99)
Avail: NTIS HC A22/MF A01 CSCL 20D

A low cost, portable instrument has been developed with which emittance can be measured by comparison to a standard. A reflector collects infrared radiation from a heated sample onto a low mass, black detector and the temperature rise of the black detector is measured with a thermocouple and meter. Graphical examples are presented for determination of emittance from measurements made on a sample at any known temperature.

Author


A low cost, portable instrument has been developed with which emittance can be measured by comparison to a standard. A reflector collects infrared radiation from a heated sample onto a low -mass, black detector and the temperature rise of the black detector is measured with a thermocouple and meter. Graphical examples are presented for determination of emittance from measurements made on a sample at any known temperature.

Author


A miniature drag force anemometer is described which is capable of measuring dynamic velocity head and flow direction. The anemometer consists of a silicon cantilever beam 2.5 mm long, 1.5 mm wide, and 0.25 mm thick with an integrated diffused strain gage bridge, located at the base of the beam, as the force measuring element. The dynamic of the beam are like that of a second order system with a natural frequency of about 42 kHz and a damping coefficient of 0.007. The anemometer can be used in both forward and reverse flow. Measured flow characteristics up to Mach 0.5 are presented along with application examples including turbulence

Author


A technique has been developed to automatically correct for drifts in the radiometric sensitivity of the detector channels in a direct-reading emission spectrometer. The method utilizes a 1000 W tungsten-halogen reference lamp to illuminate the detectors through the same optical path as that traversed during the analysis of the sample. Detector channel responses to the light are compared to those for the same light intensity at the time of analytical calibration. This corrects for the drift. It is noted that with the exception of positioning the lamp, the procedure is fully automatic.

S.C.S.


Various types of instrumentation for the development of propulsion systems are discussed. For the steady-state measurement of local temperature, pressure and flow velocity, manifolds include a multielement probe, calibrated thermocouple probes, and a probe designed for low gas velocities, pressure measuring devices for high speed rotors, and instruments for data pickup from rotating members. For the dynamic measurements of the same factors attention is given to 2 mm diameter pressure transducers, flush diaphragm transducers, resistance thermometers, and miniature transducers for velocity measurements. Instruments for compressor and turbine blade instrumentation are described with reference to a pyrometer for mapping turbine blade surface temperature, a capacitance method for monitoring rotor clearance measurements, and optical detection procedures for blade vibration amplitude.

S.C.S.
An ultraviolet spectrophotometer (UVS) to measure downward solar fluxes from an aircraft or other high altitude platform is described. The UVS uses an ultraviolet diffuser to obtain large angular response with no aiming requirement, a twelve-position filter wheel with narrow (2 nm) and broad (20 nm) bandpass filters, and an ultraviolet photodiode. The columnar atmospheric ozone above the UVS (aircraft) is calculated from the ratios of the measured ultraviolet fluxes. Comparison with some Dobson station measurements gives agreement to 2%. Some UVS measured ozone profiles over the Pacific Ocean for November 1976 are shown to illustrate the instrument's performance.

National Aeronautics and Space Administration

Power spectral noise characteristic performance of the Teledyne two degree-of-freedom dry tuned gimbal gyroscope was determined. Tests were conducted using a current configuration SGX 5 gyro in conjunction with test equipment with minor modification. Long term bias stability tests were conducted as well as some first difference performance tests. The gyro, test equipment, and the tests performed are described. Results are presented.


In order to form metal vapors for neutral beam studies, an electron-beam heater and a power supply have been designed. The source, which measures about 30 x 50 x 70 mm, consists of a filament, accelerating plate (defined by pole pieces), and a supported target. The electrons from the filament are focused by the field penetration through a 2 mm slot in the high voltage cage. They are then accelerated to about 5 kV to a ground plate. The electrons then follow a path in the magnetic field and strike the sample to be heated on its front surface. The assembly is attached to a water-cooled base plate. The electron beam source has produced beams of Ts and C particles with densities of about 10 to the 8th power/cm 3. S.C.S.
36 LASERS AND MASERS

Inclades parametric amplifiers.

NASA-13421** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SMALL-SIGNAL GAIN DIAGNOSTIC MEASUREMENTS IN A FLOWING C02 PIN DISCHARGE LASER

Small-signal gain diagnostic measurements were conducted on a closed loop, high power, carbon dioxide laser to assess the coupling between gas flow velocity and resonator saturation. Parameters investigated included cavity and discharge power. Results of gain measurements within and downstream of the excitation volume are presented for a laser gas composition He:N2:CO2 of 10:7:1 at 80 torr. The gain at constant discharge power was observed to be dependent upon discharge power level and time. An important result of this study is that the effects of gain swept downstream of the discharge region must be considered in the resonator design if efficient extraction of stored optical energy is desired.

Author

NASA-13438** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DISTRIBUTION OF E/N AND X SUB E IN A CROSS-FLOW ELECTRIC DISCHARGE LASER

The spatial distribution of the ratio of electric field to neutral gas density on a flowing gas, multiple pin-to-plane discharge was measured in a high-power, closed loop laser. The laser was operated at a pressure of 140 torr (1:7:20, CO2: N2: He) with typically a 100 meter/second velocity in the streamer. Centimeter discharge volumes E/N ratios ranged from 2.7 x 10 to the minus 16th power to 1.4 x 10 to the minus 16th power volts/cm along the discharge while the electron density ranged from 2.8 x 10 to the 10th power to 1.2 x 10 to the 10th power cm/3.

Author

NASA-13441** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A REVIEW OF THE THERMOELECTRONIC LASER ENERGY CONVERTER (TELEC) PROGRAM AT LEWIS RESEARCH CENTER

The investigation of the Thermo Electron Lasr Energy Converter (TELEC) concept began with a feasibility study of a 1 megawatt sized TELEc system. The TELEc was to use either cesium vapor or hydrogen on the plasma medium. The cesium vapor TELEc was practical and was calculated conversion efficiency of greater than 48% following this study, a small TELEc cell was fabricated which demonstrated the conversion of the small amount of laser power to electrical power. The cell developed a short circuit current of 0.7 amperes and an open circuit voltage, as extrapolated from volt-ampere curves of about 1.5 volts.

Author


Measurements have been conducted of the effect of the convection of ions and electrons on the discharge characteristics in a large scale laser. The results are presented for one particular distribution of ballistic resistance. Values of electric field, current density, input power density, ratio of electric field to neutral gas density (E/N), and electron number density were calculated on the basis of measurements of the discharge properties. In a number of graphs, the E/N ratio, current density, power density, and electron density are plotted as a function of row number (downstream position) with total discharge current and gas velocity as parameters. From the dependence of the current distribution on the total current, it appears that the electron production in the first two rows significantly affects the current flowing in the succeeding rows. G.R.


The feasibility of delivering substantial quantities of optical power to a satellite in low earth orbit from a ground based high energy laser (HEL) coupled to an adaptive antenna was investigated. Diffraction effects, atmospheric transmission efficiency, adaptive compensation for atmospheric turbulence effects, including the effective bandwidth requirements for correction, and the adaptive compensation for thermal blooming were examined. To evaluate possible HEL sources, atmospheric investigations were performed for the CO2 (12-I0-1812) isotope, CO and DF wavelengths using output antenna locations of both sea level and mountain top. Results indicate that both excellent atmospheric and adapation efficiency can be obtained for mountain top operation with a micron isotope laser operating at 9.1 um or a CO laser operating single line (P10) at about 6.0 (C-12-C02-1812um, which is a close second in the evaluation. Four adaptive power transmitter system concepts were generated and evaluated, based on overall system efficiency, reliability, size and weight, advanced technology requirements and potential cost. A multiple source phased array was selected for detailed conceptual design. The system uses a unique adaptation technique of phase locking independent laser oscillators which allows it to be both relatively inexpensive and most reliable with a predicted overall power transfer efficiency of 53%.

Author
A theoretical and experimental investigation is presented of inverse Bremsstrahlung absorption of CW CO\textsubscript{2} laser radiation in flowing gases seeded with alkali metal. In order to motivate this development, some simple models are described of several space missions which could use laser powered rocket vehicles. Design considerations are given for a test cell to be used with a welding laser, using a diamond window for admission of laser radiation at power levels in excess of 10 kW. A detailed analysis of absorption conditions in the test cell is included. The experimental apparatus and test setup are described and the results of experiments presented. Injection of alkali metal and steady state absorption of the laser radiation were successfully demonstrated, but problems with the durability of the diamond window at higher powers prevented operation of the test cell as an effective laser powered thruster.

The results of a two-year investigation into the possibility of developing continuous wave excimer lasers are reported. The program included the evaluation and selection of candidate molecular systems and discharge pumping techniques. The K Ar/K\textsubscript{2} excimer dimer molecules and the xenon fluoride excimer molecule were selected for study; each used a transverse and capillary discharges pumping technique. Experimental and theoretical studies of each of the two discharge techniques applied to each of the two molecular systems are reported. Discharge stability and fluorine consumption were found to be the principal impediments to extending the XeF excimer laser into the continuous wave regime. Potassium vapor handling problems were the principal difficulty in achieving laser action on the K Ar/K\textsubscript{2} system. Of the four molecular systems and pumping techniques explored, the capillary discharges pumped K Ar/K\textsubscript{2} system appears to be the most likely candidate for demonstrating continuous wave excimer laser action primarily because of its predicted lower pumping threshold and a demonstrated stability advantage.

A one-dimensional energy equation, with constant pressure and area, was used to model the LSC wave. The equation balances convection, conduction, laser energy absorption, radiation energy loss and radiation energy transport. Solutions of this energy equation were obtained to give profiles of temperature and other properties, as well as the relation between laser intensity and mass flux through the wave. The LSC wave was then calculated through a variable pressure, variable area streamtube to accelerate it to high speed, with the propulsion application in mind. A numerical method for coupling the LSC wave model to the streamtube flow was developed and a sample calculation was performed. The result shows that 42% of the laser power has been radiated away by the time the gas reaches the third. It was concluded that in the radially confined flows of interest for propulsion applications, transverse velocities would be less important than in the unconfined flows where air experiments have been conducted.

Closed cycle CO\textsubscript{2} and CO\textsubscript{2} electric discharge lasers were studied. An analytical investigation assessed scale-up parameters and design features for CO\textsubscript{2} closed cycle, continuous wave, unsteady resonator, electric discharge laser systems operating in space and airborne environments. A space based CO\textsubscript{2} system was also examined. The program objectives were the conceptual designs of six CO\textsubscript{2} systems and one CO\textsubscript{2} system. Three airborne CO\textsubscript{2} designs, with one, five, and ten megawatt outputs, were produced. These designs were based upon five minutes run times. Three space based CO\textsubscript{2} designs, with the same output levels, were also produced, but based upon one year run times. In addition, a conceptual design for a one megawatt space based CO\textsubscript{2} laser system was also produced. These designs include the flow loop, compressor, and heat exchanger, as well as the laser cavity itself. The designs resulted in a laser loop weight for the space based five megawatt system that is within the space shuttle capacity. For the one megawatt systems, the estimated weight of the entire system including laser loop, solar power generator, and heat radiator is less than the shuttle capacity.

A method of alignment of nuclei for a gamma ray laser and a means of achieving preferential emission of radiation along the crystal axes are studied. Atomic alignment was achieved by materials researchers who made composite structures composed of needle-like single crystals all with the same orientation and all pointing in the same direction contained in a matrix of cobalt or nickel. The proposed method of preferential emission of radiation along the aligned needles is to have a symmetric field gradient at the nucleus and a sequence of excited levels of spin and parity 2(\pm) and 0(\pm). The proposed scheme reduces the density of excited states required for lasing and reduces the linewidth due to inhomogeneous broadening. Mossbauer absorption experiments intended to test these ideas are outlined.
37 MECHANICAL ENGINEERING

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

N78-10467* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
OIL COOLING SYSTEM FOR A GAS TURBINE ENGINE Patent

A gas turbine engine fuel delivery and control system is provided with means to recirculate all fuel in excess of fuel control requirements back to aircraft fuel tank, thereby increasing the fuel pump heat sink and decreasing the pump temperature rise without the addition of valuable other than that normally employed. A fuel/oil heat exchanger and associated circuitry is provided to maintain the high oil temperature in heat exchange relationship with the cool engine fuel. Where anti-icing of the fuel filter is required, means are provided to maintain the fuel temperature entering the filter at or above a minimum level to prevent freezing thereof. Fluid circuitry is provided to route hot engine oil through a plurality of heat exchangers disposed within the system to provide for selective cooling of the oil.

Official Gazette of the U.S. Patent Office

N78-10468* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
IMPACT ABSORBING BLADE MOUNTS FOR VARIABLE PITCH BLADES Patent

A variable pitch blade and blade mount are disclosed which are suitable for propellers, fans and the like which have improved impact resistance. Compress fans blades and blade mounting arrangements permit the blades to pivot relative to a turbine hub about an axis generally parallel to the centerline of the engine upon impact of a large foreign object, such as a bird. Centrifugal force recovery becomes the principal energy absorbing mechanism and a blade having improved impact strength is obtained. Official Gazette of the U.S. Patent Office

N78-10474* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
STABILITY OF NUMERICAL INTEGRATION TECHNIQUES FOR TRANIENT ROTOR DYNAMICS Albert F. Kaschik 1977 22 p refs
(NASA-TP-1092: E-9252) Avail: NTIS HC AO2/MF AO1 CSCl 21E

A finite element model of a rotor bearing system was analyzed to determine the stability limits of the forward backward and centered Euler Runge Kutta. Milne, and Adams numerical integration techniques. The analysis concludes that the highest frequency mode determines the maximum time step for a stable solution. Thus the number of mass elements should be minimized. Increasing the time step can avoid stability problems. For a uniform shaft with 10 mass elements operating at approximately the first critical speed the maximum time step for the Runge Kutta, Milne, and Adams methods is that which corresponds to approximately 1 degree of shaft movement. This is independent of rotor dimensions.

Author

N78-19430* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
METHOD OF FORMING METAL HYDRISE FILMS Patent
Supersedes N78-18282 (14-0051100)


The substrate to be coated (which may be of metal, glass or the like) is cleaned, then chemically and by off-substitution in a vacuum chamber. In an ultra-high vacuum system, vapor deposition by a sublimator or ejection coats a cooled substrate disposed around the substrate with a thin film of hydride forming metal which getters any contaminant gas molecules. A shutter is then opened to allow hydride forming metal to be deposited as a film or coating on the substrate. After the hydride forming metal coating is formed, deuterium or other hydrogen isotopes are bred into the vacuum system and dissipated into the metal film or coating to form a hydride of metal film. Higher substrate temperatures and pressures may be used if various parameters are appropriately adjusted.

Official Gazette of the U.S. Patent Office

N78-13439* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

Basic assembly configurations of the mechanical face seal are discussed and some advantages associated with each are listed. Various seal components are cooled, and functions pointed out. The technique of seal pressure balancing and its application are described, and the concept of the PV factor, its different forms and limitations are discussed. Brief attention is given to seal lubrication since it is covered in detail in a companion paper. Finally, the operating conditions for various applications of low pressure seals (aircraft transmissions) are listed, and the seal failure mode of a particular application is discussed. Author

N78-17384* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
VARIABLE CYCLE GAS TURBINE ENGINES Patent
James Edward Johnson (GE, Cincinnati) and Tom Foster, inventors (to NASA) (GE, Cincinnati) Issued 27 Dec 1977 10 p Filed
2 Jun 1975 Sponsored by NASA

A technique, method, and apparatus were designed for varying the bypass ratio and modulating the flow of a gas turbine engine in order to achieve improved mixed mission performance. Embodiments include gas flow control system for management of core and bypass stream pressure comprising diverter valve means downstream of the core engine to selectively mix or separate the core and bypass exhaust streams. The flow control system may also include variable geometry means for maintaining the maximum airflow at a matched design level at all flight velocities. Earth preferred embodiment thus may be converted from a high specific thrust mixed flow cycle at supersonic velocities to a lower specific thrust separated flow turbine system at subsonic velocities with a high degree of flow variability in each mode of operation.

Official Gazette of the U.S. Patent Office

Author
peroral film thicknesses are outlined. Particular attention is given to primary ring responses (seal vibration) to rotating seal face runout. This response analysis reveals three different vibration models with secondary seal friction being an important parameter. Leakage flow inlet pressure drop and effects of asymmetrical seating face deformations are discussed. Experimental data on self-acting seal faces operating under simulated gas turbine conditions are given. Also a spiral groove seal design operated to 244 m/sec (800 ft/sec) is described.

Author


Results of selected NASA research programs on rolling-element and fluid-film bearings, gears, and elastohydrodynamic lubrication are reported. Advances in rolling-element bearing materials technology, which have resulted in a significant improvement in fatigue life, and which make possible new applications for rolling bearings, are discussed. Research on wear-resistant, fluid-film bearing, suitable for very high-speed applications, is discussed. An improved method for predicting gear pitting life is reported. An improved formula for calculating the thickness of elastohydrodynamic films (the existence of which help to define the operating regime of concentrated contact mechanisms such as bearings, gears, and cams) is described.

Author

T87-184258 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. STATISTICAL MODEL FOR ASPERITY-CONTACT TIME FRACTION IN ELASTOHYDRODYNAMIC LUBRICATION Steven M Sidor and John J Coy (US Army R and T Lab., Cleveland) Feb 1978 41 p. refs (NASA TP-1130, E-9265) Avail NTIS HC AO3/MF A01 CSCL 131

Relations for the asperity contact time fraction during elastohydrodynamic (EHD) lubrication of a typical ball bearing are presented. The analysis is based on a two-dimensional random surface model, and actual profile traces of the bearing surfaces were used as statistical sample records. The results of the analysis show that transition from 90 percent contact to 1 percent contact occurs within 0.004 microns film thickness range of approximately 4 to 5. This thickness ratio is several times larger than reported in the literature where one-dimensional random surface models were used

Author

T87-196123 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. FRICTION AND WEAR OF SELECTED METALS AND ALLOYS IN SLIDING CONTACT WITH AISI 440C STAINLESS STEEL IN LIQUID METHANE AND IN LIQUID NATURAL GAS Donald W. Wisander Feb 1978 18 p. refs (NASA TP-1190, E-9185) Avail NTIS HC AO2/MF A01 CSCL 20K

Aluminum, titanium, beryllium, nickel, iron, copper, and several copper alloys were run in sliding contact with AISI 440C stainless steel in liquid methane and natural gas. All of the metals run except copper and the copper alloys of tin and lead showed severely galled wear scars. Friction coefficients varied from 0.2 to 1.0. The lowest being for copper, copper 7 wt % tin and copper 8 wt % tin-22 wt % lead. The wear rate for copper was two orders of magnitude lower than that of the other metals run. An additional order of magnitude of wear reduction was achieved by the addition of tin and/or lead to copper

Author

T87-206135 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. PREDICTED AND EXPERIMENTAL PERFORMANCE OF JST-LUBRICATED 120-MILLIMETER-BORE BALL BEARINGS OPERATING TO 2.5 MILLION DH Harold H. Coo and Erwin V. Zarefsky Apr 1978 28 p. refs (NASA TP-1198, E-9288) Avail NTIS HC AO3/MF A01 CSCL 131

Bearings inner and outer race temperatures and friction power losses were calculated using two computer programs. The values obtained were compared with previously reported experimental data for 120 mm bore bearings which operated at thrust loads of 122 240 N (500 lb) shaft speeds to 20 800 rpm and with two lubricant flow rates. One program correctly predicted the power loss, while the other, called SHAFTER, provided a good prediction of both est temperatures and power losses

Author
N70-214756 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. ROLLING-ELEMENT FATIGUE LIFE OF AISI M-50 AND 18-8-1 BAILS Richard J. Parker and Erwin V. Zaretsky Apr. 1978 18 p refs. (NASA-TP-1202: E-9350) Avail. NTIS HC A02/MF A01 CSCL 131

Rolling element fatigue studies were conducted with AISI M-50, EFR 18-8-1, and VAR 18-8-1-1. Groups of 12.7 mm (.125 in) diameter balls of each material were tested in the five ball fatigue tester. Test conditions included a load of 1540 N (347 lb) giving a maximum Hertz stress of 5820 MPa (800 000 psi), a shaft speed of 10 700 rpm, and a contact angle of 30 deg. Tests were run at a race temperature of 330 K (150 F) with a type 2 ester lubricant. The rolling element fatigue life of AISI M-50 was not significantly different from that of EFR 18-8-1 or VAR 18-8-1-1 based on a statistical comparison of the test results. Author

N70-214757 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. FERROGRAPHIC ANALYSIS OF WEAR PARTICLES FROM SLIDING ELASTOHYDRODYNAMIC EXPERIMENTS William R. Jones, Jr., H. S. Nagaraj (Mechanical Technology, Inc., Latham, N. Y.), and Ward O. Whar (Georgia Inst. of Tech., Atlanta) Apr. 1978 31 p refs. (NASA-TP-1230: E-9300) Avail. NTIS HC A03/MF A01 CSCL 20K

The Ferrograph was used to analyze wear debris generated in a sliding elastohydrodynamic contact. The amount of wear debris correlates well with the ratio of film thickness to composite surface roughness (A ratio). The general wear level parameter and the wear severity index yielded similar correlations with average A ratios. Essentially all the generated wear particles were of the normal rubbing wear type. The Ferrograph was more sensitive in detecting the wear debris than was the commonly used emission spectograph. Author


A fuel control system is reported for automotive-type gas turbines and particularly advanced gas turbines utilizing variable geometry components to improve misalignment and reduce pollutant emissions. The fuel control system compensates for fuel density variations, inlet temperature variations, turbine vane actuation acceleration and turbine braking. These parameters are utilized to control various actives, spool valves and p-ports. Official Gazette of the U.S. Patent Office

N70-25846 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. PROPOSED DESIGN PROCEDURE FOR TRANSMISSION SHAFTING UNDER FATIGUE LOADING Stuart K. Loewenthal Apr. 1978 10 p refs. To be presented at the 5th Ann Meeting of the Nat'l Conf on Power Transmission, Pitts Meet, 7-9 Nov. 1978, sponsored by the Nat'l Inst of Technol (NASA-NT-78827: E-9657) Avail. NTIS HC A02/MF A01 CSCL 131

A new standard for the design of transmission shafting is reported. Computed was the diameter of rotating solid steel shafts under combined cyclic bending and steady torsion. The formula is based on an elliptical variation of endurance strength with time, exhibited by combined stress fatigue data. Fatigue factors are cited to correct specimen bending endurance strength data for use in the shaft formula. A design example illustrates how the method is to be applied. G G
Some load limits and self-lubricating properties of plain spherical bearings with molded graphite fiber-reinforced polyimide liners to 320 C

(NASA-TM-78835. E-9679) Avail. NTIS HC A02/MF A01 CSDL 131

Plain spherical bearings with molded liners of self-lubricating graphite fiber-polyimide composite were developed and their dynamic load capacities were determined. Liners were prepared by transfer molding a polymer resin-fiber-mix into the space between the ball and outer race, the completing polymerization under heat and pressure. Bearing dynamic load capacities were in excess of 140 MPa (20,000 psi) from room temperature to 260 C and about 70 MPa (10,000 psi) at 320 C. Friction coefficients were about 0.20 at room temperature and light loads and tended to decrease with increasing temperature and loads to about 0.10 at uniform bearing temperature of 200 C or higher produced a bearing preload which could be alleviated by providing an initial internal diametral clearance of 0.06 to 0.10 mm.

N78-37485*/ National Aeronautics and Space Administration
ELASTOHYDRODYNAMIC FILM THICKNESS MEASUREMENTS OF ARTIFICIALLY PRODUCED SURFACE DENTS AND MICROHINDERS
(NASA-TM-78849. E-9983) Avail. NTIS HC A03/MF A01 CSDL 131

Elastohydrodynamic (EHD) film thickness measurements using optical interferometry were made of artificially produced dents and grooves under rolling and sliding conditions. These measurements are compared to stylus traces of the dent and groove profiles to determine the local deformation associated with micro-EHD pressure generation. The surface geometry associated with the dents and grooves became intimately involved in the lubrication process itself, causing local pressure variations that substantially deformed the local surface geometry, particularly under sliding conditions. The rolling results implied surface imprinted fatigue, and the sliding results showed clearly the EHD surface interactions that must occur prior to scuffing failure. J.A.M

N78-38468/* National Aeronautics and Space Administration
Lews Research Center. Cleveland, Ohio.
FILTRATION EFFECTS ON BALL BEARING LIFE AND CONDITION IN A CONTAMINATED LUBRICANT
(NASA-TM-78807. E-9418) Avail. NTIS HC A03/MF A01 CSDL 131

Ball bearings were fatigue tested with a contaminated lubricant and with a contaminated lubricant under four levels of filtration. The test filters had absolute particle removal ratings of 3. 30, 49, and 105 microns. Aircraft turbine engine contaminants were injected into the filter's supply line at a constant rate of 125 microliters per bearing hour. Bearing life and running track condition generally improved with finer filtration. The experimental lives of 3 and 30 micron filter bearings were statistically equivalent, approaching those obtained with the contaminated lubricant bearings. Compared to these bearings, the lives of the 49 micron bearings were statistically lower. The 105 micron bearings experienced gross wear. The degree of surface distress, weight loss, and probable failure mode were dependent on filtration level, with finer filtration being clearly beneficial.

N78-28467/* National Aeronautics and Space Administration
Lews Research Center. Cleveland, Ohio.
GRAPHITE-FIBER-REINFORCED POLYIMIDE LINERS OF VARIOUS COMPOSITIONS IN PLAIN SPHERICAL BEARINGS
(NASA-TM-78909. E-9288) Avail. NTIS HC A02/MF A01 CSDL 131

A plain spherical bearing design with a ball diameter of 28.6 mm, a race length of 12.7 mm, and a 1.7-mm-dicth, molded composite liner was used. The liner material is a self-lubricating composite of graphite-fiber-reinforced polyimide resin (GFR-Pi). The liner is prepared by transfer molding a mixture of one part chopped graphite fiber and one part partially polymerized resin into the space between the ball and the outer race, and then completing the polymerization under heat and pressure. Several liner compositions were evaluated: two types of polyimide, condensation and addition, two types of graphite fiber, low and high modulus, and four powder additives - cadmium oxide, cadmium sulfide, graphite flake, and molybdenum disulfide. The bearings were oscillated at + - 18 deg at 1 Hz for 20 kilometers under a radial unit load of 29 MN m (4300 psi) at dry air at 25, 200, or 315 C. Both types of fiber and polyimide gave low friction and wear. A simple equation was developed to fit the wear-time data and adequately predict wear to 100 hours.

Author
N76-32449* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
METHOD OF COLD WELDING USING ION BEAM TECHNOLOGY
Patent Application
Bernard L. Sater, inventor (to NASA) Filed 28 Jul. 1978
10 p.
(NASA-Case-LEW-12982-1; US-Patent-Appl-SN-5200641) Avail:
NTIS HC A02/MF A01 CSCL 13H
A method is described for cold welding metals in a vacuum using ion beams to prepare the surfaces of metals to be joined. The figure is a schematic diagram of an ion beam apparatus for carrying out the method. An expellant gas is stored in a high pressure tank and delivered to the ion source assembly. The ion source produces a unidirectional beam of gas molecules with uniform energy which, in a vacuum environment, is directed onto each surface to be joined and effectively sputters away the contaminant oxide layer to expose clean underlying metal. When the surfaces to be joined are sufficiently clean, they are pressed together with pressure adequate to assure that their lapse are brought into intimate contact throughout the area to be joined. This process provides a solid state cold weld with metal-to-metal bonding without causing gross deformation due to plastic flow and thinning of the metal at the joint. NASA

N76-32095* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
LEWIS RESEARCH CENTER SUPPORT OF CHRYSLER UPGRADED ENGINE PROGRAM
E L Warren in DOE Highway Vehicle Systems Mar 1978
p 143-146 (For primary document see N78-30283 21-31) Avail:
NTIS HC A02/MF A01 CSCL 21A

N76-32014* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
STIRLING ENGINE PROJECT STATUS
R G Ragade in DOE Highway Vehicle Systems Mar 1978
p 241-243 (For primary document see N78-30283 21-31) Avail:
NTIS HC A02/MF A01 CSCL 21A

N76-32018* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
INITIAL TEST RESULTS WITH SINGLE CYLINDER RHEOMATIC DRIVE STIRLING ENGINE
James E Carroll in DOE Highway Vehicle Systems Mar 1978
p 254-258 (For primary document see N78-30283 21-31) Avail:
NTIS HC A02/MF A01 CSCL 13I

N76-32019* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MATERIALS TECHNOLOGY ASSESSMENT FOR STIRLING ENGINES
Joseph R Stephens in DOE Highway Vehicle Systems Mar 1978
p 267-274 (For primary document see N78-30283 21-31) Avail:
NTIS HC A02/MF A01 CSCL 21A

N76-32086* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
LIQUID ROCKET ENGINE TURBOPUMP ROTATING-SHAFT SEAL DESIGN NASA Space Vehicle Design Criteria, Chemical Propellants
(NASA-SP-1121) Avail: NTIS HC A08/MF A01 CSCL 11A
A monograph is organized and presents, for effective use in design, the significant experience and knowledge accumulated in development and operational programs to date. It reviews and assesses current practices, and from these it establishes firm guidance for achieving greater consistency in design, increased reliability in the design, and greater precision in the design effort. The monograph is divided into two major sections: state of the art design criteria. G.Y.

N76-32085* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
EFFECT OF GEOMETRY ON HYDRODYNAMIC FILM THICKNESS
(NASA-TP-1287; E-9347, AVRADCOM-TR-78-18) Avail: NTIS HC A02/MF A01 CSCL 20K
The influence of geometry on the nothermal hydrodynamic film separating two rigid solids was investigated. Pressure-viscosity effects were not considered. The minimum film thickness is derived for fully flooded conjunctions by using the Reynolds conditions. It was found that the minimum film thickness had the same speed, viscosity, and load dependence as Kapitsa's classical solution. However, the incorporation of Reynolds boundary conditions resulted in an additional geometry effect. Solutions using the parabolic film approximation are compared with those using the exact expression for the film in the analysis. Contour plots are shown that indicate in detail the pressure developed between the solids.

N76-33648* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
THE PRACTICAL IMPACT OF ELASTOHYDRODYNAMIC LUBRICATION
(NASA-TR-78987; E-9786) Avail: NTIS HC A02/MF A01 CSCL 13I
The use of elastohydrodynamics in the analysis of rolling element bearings is discussed. Relationships for minimum film thickness and tractive force were incorporated into computer codes and used for bearing design. The lambda parameter (ratio of film thickness to composite surface roughness) was shown to be important in predicting bearing life and failure mode. Results indicate that at values of lambda below 3 failure modes other than the classic subsurface initiated fatigue can occur.

N76-33647* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
MINIMUM FILM THICKNESS IN ELLIPTICAL CONTACTS FOR DIFFERENT REGIMES OF FLUID-FILM LUBRICATION
Bernard J Hamrock and Duncan Dowson (Leaves Univ., Eng.)

A linear regression by the method of least squares - made on the geometric variables that occur in the equation for elliptical-contact deformation. The ellipticity and the complete elliptic integrals of the first and second kind are expressed as a function of the $x$-plane principal radius. The ellipticity was varied from 1 (circular contact) to 10 (a configuration approaching line contact). The procedure for solving these variables without the use of charts or a high-speed computer would be quite tedious. These simplified equations enable one to calculate easily the elliptical-contact deformation to within 3 percent accuracy without resorting to charts or numerical methods. (Author)


An annular seal is analyzed in which the inlet clearance is larger than the outlet clearance. The flow path may be either stepped or tapered. This design produces radial stiffnesses 1.7 to 14 times that of a constant clearance seal having the same minimum clearance. When sealing high-pressure fluids, such as seal can improve rotor stability and can be used to shift troublesome critical speeds to a more suitable location. (Author)


An analysis was conducted for oil jet lubrication on the disengaging side of a gear mesh. Results of the analysis were computerized and used to determine the oil jet impingement depth for several gear ratios and oil jet to pitch line velocity ratios. An experimental program was conducted on the NASA gear test rig using high-speed photography to experimentally determine the oil jet impingement depth on the disengaging side of mesh. Impingement depth reached a maximum at gear ratio near 1.6 where churning by the teeth was found to be the chief cause of churning. The main impingement depth is zero above a gear ratio of 1.172 for a jet velocity to pitch line velocity ratio of 1 and is similar for other velocity ratios. The impingement depth for gear and pinion are equal and approximately one-half the maximum at a gear ratio of 1.6. Impingement depth on either the gear or pinion may be improved by relocation of the jet from the pitch line or by changing the jet angle. Results of the analysis were verified by experimental results using a high-speed camera and a well lighted oil jet. (Author)


Life tests were conducted at three different loads with three groups of 8.9 cm, pitch diameter spur gears made of vacuum remelted AISI 8310 steel. Life was found to vary inversely with load to the 4.3 and 5.1 power at the L-10 and L-50 life levels, respectively. The Weibull slope varied linearly with maximum Hertz contact stress, having an average value of 2.6. The last data when compared to AGMA standards showed a steeper slope for the load-life diagram. (Author)


The elastic distortion of the inner ring of an experimental 3,000,000 DN roller bearing is investigated analytically. The geometry of the bearing is unusually complex and for this reason a bearing with an axially symmetric inner ring and shaft is also analyzed. Only the inner ring and shaft are considered using a two-dimensional finite element computer program which enables interference between these components to be accommodated. The results for the experimental bearing suggest that the elastic distortions are modest in relation to the design clearances. However, the variation of the radial deflection of the raceway may be significant for some circumstances and the interference is adopted between the ring and shaft appears to be questionable low. (Author)


The performance of 120 65 mm bore tapered roller bearings investigated at shaft speeds up to 15,000 rpm. Temperature distribution and thrust load generation were determined as a function of shaft speed, radial and thrust loads lubricant flow rate, and lubricant inlet temperature. Lubricant was supplied either by jets or by a combination of holes through the core directly to the cone-rib contact and jets at the roller small end. Cone-rib lubrication significantly improved high-speed tapered roller bearing
performance, yielding lower cone-face temperatures and lower powder loss and allowing lower lubricant flow rates for a given stirred condition. Bearing temperatures increased with increased shaft speed and decreased with increased lubricant flow rate. Bearing power loss increased with increased shaft speed and increased lubricant flow rate. (Author)


This paper reviews the various techniques and surface tools available for the study of the atomic nature of the wear of materials. These include chemical etching, X-ray diffraction, electron diffraction, scanning electron microscopy, low-energy electron diffraction, Auger emission spectroscopy analysis, electron spectroscopy for chemical analysis, field ion microscopy, and the atom probe. Properties of the surface and wear surface regions which affect wear such as surface energy, crystal structure, crystallographic orientation, mode of dislocation behavior, and cohesive bonding are discussed. A number of mechanisms involved in the generation of wear particles are identified with the aid of the aforementioned tools. (Author)


A direct acting hydraulic pressure regulator design which incorporates stability margin, response, and droop margin is developed. The over-sensing regulator system does not involve a non-linear sensing line restrictor (which may degrade transient response) or linear damping (which is sensitive to clearance and viscosity). The direct acting hydraulic pressure regulator makes use of the technique of lead network stabilization (i.e. the tuned stabilizer concept). An analytically derived circuit pressure regulator is tested to study the stability limit under a parallel capacitive plus resistive load and the stabilizing effect of the tuned stabilizer.

J.M.B.


A complete numerical solution is presented to the problem of isothermal elastohydrodynamic lubrication of elliptical contacts for low elastic modulus materials operating under fully flooded conditions. No assumption is made for the pressure or film thickness within the contact, and compressibility and viscous effects are taken into account. Because of the dimensionless representation of the coordinates, the actual Herztian contact ellipse becomes a circle regardless of the value of the ellipticity parameter. A minimum film thickness relation and a central film thickness relation are derived from examining 17 different cases. Contour plots for detailed illustration of the pressure distribution and film thickness in the conjunction are provided. S.D.


Poropgraphy analysis was used to determine the type and quantities of wear particles generated during accelerated rolling contact fatigue tests. The NASA five-ball rolling contact fatigue tester was used. Ball specimens were made of AISI 52100, a corrosion-resistant high-temperature bearing steel. The lubricant was a super-refined mineral oil. Conditions included a maximum Hertz stress of 9.82 billion P and a shaft speed of 10,000 rpm. Four types of wear particles were observed: normal rubbing wear particles, fine spall particles, spheres, and friction polymer. (Author)


Experimental data are presented for the unbalance response of a flexible, ball bearing supported rotor to speeds above the third lateral bending critical. Values of sines of bearing moments obtained from measured data are compared to theoretical values obtained from short bearing approximation over a frequency range from 5000 to 31,000 cycles/min. Experimental response for an undamped rotor is compared to that of one having oil scribes film damping at the bearings. Unbalance applied varied from 0.02 to 18.1 gcm. (Author)


An analysis was made of the two-dimensional solidification of an ingot being cooled and withdrawn vertically downward from a mold consisting of parallel walls of finite length. Heat transfer analysis shows how the thinness of the interface is related to the ingot thickness. The withdrawal rate, the heat addition from the superheated liquid metal, and the temperature difference available for cooling. This provides an understanding of the conditions that will yield a maximum rate of casting while achieving the desired thinness of the interface. The results are interpreted with respect to the conditions for obtaining a perfectly aligned eutectic structure by directional solidification. In this process an additional constraint must be included that relates the ingot withdrawal rate and the heat transfer rate from the liquid metal to the solidification interface. (Author)


Basic assembly configurations of the mechanical face seal are described and some advantages associated with each are listed. The various forms of seal components (the primary seal, secondary seal, etc.), are illustrated, and functions pointed out. The technique of leak pressure balancing and its application is described and the concept of the PV factor, its different forms and limitations are discussed. Brief attention is given to seal lubrication since it is covered in detail in a companion paper. Finally, the operating conditions for various applications of low pressure seals (aircraft transmission seals are listed, and the seal failure modes of a particular application is discussed (Author)
The technology areas are system steady-state and transient performance prediction techniques, compressor and turbine design and performance prediction programs and effects of geometry, combustor technology and advanced concepts, and ceramic coatings and materials technology. (Author)


Results of selected NASA research programs on rolling-element and fluid-film bearings, gears, and elastohydrodynamic lubrication are reported. Advances in rolling-element bearing material technology, which have resulted in a significant improvement in fatigue life, and which make possible new applications for rolling bearings, are discussed. Research on whir-resistant, fluid-film bearings, suitable for very high-speed applications, is discussed. An improved formula for calculating the thickness of elastohydrodynamic films (the existence of which help to define the operating regime of concentrated contact mechanisms such as bearings, gears, and cams) is described. (Author)


The importance of sealing technology in the U.S. industrial chemical-oriented society in regard to maintenance and environmental contamination is pointed out. It is stated that seal performance (leakage, life) is directly related to seal lubrication, which is a mechanism not well understood. Current thinking in regard to seal lubrication is reviewed, the effect of energy dissipation in the thin lubricating film separating the sealing faces is pointed out, and the results of vaporization due to heating are illustrated. Also, hydrodynamic lubrication is reviewed, and an inherent tendency for the seal to operate with angular misalignment is pointed out. Recent work on hydraulic effects is summarized and the conditions for seal instability are discussed. Four different modes of seal lubrication are postulated with the mode type being a strong function of speed and pressure. (Author)


The real area of contact between two solid surfaces is only a small portion of the apparent area. Deformation of these areas can result in solid state contact throughout surface films. For clean solid to solid contact, strong adhesion bonds exist across the interface. Under these conditions many properties of the solid such as the metallurgical and chemical nature of metals can influence friction, wear and mechanical behavior. The presence of gases, liquids, and solid films on the surface of solids alter markedly tribological characteristics. These surface films can also considerably change the mechanical effects of solid state contact on bulk material behavior. (Author)


Self-acting seals are described in detail. The mathematical models for obtaining a seal force balance and the equilibrium operating film thickness are outlined. Particular attention is given to primary ring response (seat vibration) to rotating seat face runout. This response analysis reveals three different vibration modes with secondary seal friction being an important parameter. Leakage flow, seat pressure drop and effects of thermodynamic and nonthermodynamic seal face deformations are discussed. Experimental data on self-acting face seals operating under simulated gas turbine conditions are given; these data show the feasibility of operating the seal at conditions of 345 N/sq cm and 152 m/s sliding speed. Also a spiral groove seal design operated to 244 m/s is described. (Author)


The NASA Lewis Research Center (LRC) has conducted, and has sponsored with industry and universities, extensive research into many of the technology areas related to gas turbine propulsion systems. This aerospace-related technology has been developed at both the component and systems level, and may have significant potential for application to the automotive gas turbine engine. This paper summarizes the technology and lists the associated references.

Much of the data relative to the properties of surfaces that have been used in the past in analyzing, interpreting and predicting adhesion, friction and wear behavior for solid surfaces is now suspect. With the advent of analytical surface tools, careful and complete characterization of surfaces indicates that very frequently the outermost layers of solid surfaces are markedly different in chemistry than had been previously thought. These layers, as will be shown, are extremely important in adhesion, friction and wear behavior. Some of the properties to be discussed in the paper relative to their role in adhesion, friction, wear and lubrication will include: (1) adsorption, both physical and chemical; (2) orientation of the solid as well as the lubricant; (3) surface energy; (4) surface segregation; (5) surface versus bulk metallurgical effects; (6) electronic nature of the surface; and (7) bonding mechanisms. (Author)


Ideal and non-ideal conditions for multiplane balancing are addressed. Methodology and procedures for identifying optimum balancing configurations and for assessing, quantitatively, the penalties associated with non-optimum configurations were developed and demonstrated. The problems introduced when vibration sensors are supported on flexible mounts were assessed experimentally and the effects of flexure movement on the rotor on balancing were investigated. A general purpose method for predicting the threshold of instability of an asymmetric rotor was developed, and its predictions are compared with measurements under different degrees of asymmetry. (Author)


The feasibility of converting a spark ignition aircraft engine to the diesel cycle was investigated. Procedures necessary for converting a single cylinder GT310-520 described as well as a single cylinder diesel engine test program. The modification of the engine for the hot port cooling concept is discussed. A digital computer graphics simulation of a twin engine aircraft incorporating the diesel engine and Hot Port concept is presented showing some potential gains in aircraft performance. Sample results of the computer program used in the simulation are included. (Author)


A 3B.1 mm (1.5 inch) diameter Hyridal Compliant Surface Air Lubricated Journal Bearing was designed and tested to obtain bearing performance characteristics at both room temperature and 315 C (600 F). Testing was performed at various speeds up to 80,000 rpm with varying loads. Rotating sensors provided an opportunity to examine the film characteristics of the compliant surface bearing. In addition to providing minimum film thickness values and profiles, many other insights into bearing operation were gained such as the influence of bearing fabrication accuracy and the influence of smooth foil deflection between the bumps. (Author)


An experimental evaluation and a 100-hour endurance test were performed on a spiral groove geometry, self-acting face seal. The seal was tested and operated successfully at maximum conditions of 243.8 m/s surface speed, 199.9 N/sq cm air pressure, and 645.4 K (702 F) air temperature. The maximum speed condition of 243.8 m/s was obtained at a shaft speed of 72,500 rpm. Seal wear, gas leakage, and sealing element temperature were monitored during the test. Condition of the seal at the completion of the test was documented and found acceptable for further use. The spiral groove wear rates measured during the endurance test indicates a minimum potential seal life of over 2700 hours. Seal air leakage measured during the test program is within the range considered acceptable for consideration for use in a small gas turbine engine. (Author)


A new seal concept, the negative lift circumferential type seal, was evaluated under simulated helicopter transmission conditions. The bore of the circumferential seal contains step type geometry which produces a negative lift that lifts the
AERODYNAMIC PERFORMANCE OF CONVENTIONAL AND
ADVANCED DESIGN Labyrinth seals with solid-
smooth and honeycomb lands


(NASA CR-135307, EDR-9339) AIP NTIS
HC A12/ MF A01 CSCL 11A

Labyrinth air seal static and dynamic performance was
evaluated using solid, smooth, and honeycomb lands. Ongoing
and advanced seal designs. The effects on leakage of
land surface roughness, smooth, and honeycomb land
profile, and groove in
able lands, and honeycomb land cell size and depth were
studied using a standard labyrinth seal. The effects of rotation
on the optimum seal lengths were also investigated.
Selected geometric and aerodynamic parameters for an advanced
seal design were evaluated to derive an optimum seal
configuration. The rotational energy requirements were also
measured to determine the inherent friction and pumping
energy absorbed by the various seal lands and land configurations tested
in order to properly assess the net seal system performance
level. Results indicate that (1) seal leakage can be significantly
affected by honeycomb or smooth lands, (2) rotational
energy absorption does not vary significantly with the use of a
solid smooth, an abradable, or a honeycomb land, and
(3) optimization of an advanced lab seal design produced a
configuration that had leakage 25% below a conventional smooth seal.

EMERGENCY AND MICROFILM LUBRICATION AND
COOLING OF BEARINGS FOR ARMY HELICOPTERS


(NASA CR-135195, SKF AL77T0321) AIP NTIS
HC A06/ MF A01 CSCL 13A

An analysis and system study was performed to provide
design information regarding lubricant and coolant flow rates and
flow paths for effective utilization of the lubricant and coolant
in a once-through oil mist (microfil) and coolant system. A
system was designed, manufactured, coupled with an existing
mfg and evaluation tests were performed using 46 mm bore
split inner angular contact ball bearings under 1778N (400 lb)
thrust load. An emergency lubrication aspirator system was also
manufactured and tested under lost lubricant conditions. The
testing demonstrated the feasibility of using a mist oil and coolant
system to lubricate and cool a high-speed helicopter engine
mashaft bearing. The testing also demonstrated the feasibility
of using an emergency aspirator lubrication system as a viable
survivability concept for helicopter mainshaft engine bearing for
periods as long as 30 minutes.

ROLLING ELEMENT FATIGUE TESTING OF GEAR MATERIALS


(NASA CR-135411, Doc. 77-AEG-289) AIP NTIS
HC A06/ MF A01 CSCL 13A

Rolling element fatigue lives of eleven alloys were evalu-
ated. The alloys studied were three nitriding alloys (Super
Nitraloy, Nitraloy 13B, and Nitraloy N) four case carburizing
alloys AISI 9310, CBS 600, CBS 1000M and Vasco X-2); and
four through-hardening alloys (Vasco Matrix II, AISI W-1, AISI
S 2 and AISI 0 2). Several different heat treatments and/or
matelizing processes were studied on the three carburizing alloy
steels. Metallographic analyses were made before and after the
RC tests. Test data were statistically analyzed using the Weibull
distribution function. B 10 lives were compared versus VIM VAR
AISI M 5 and carburized VAR AISI 9310, as reference alloys.

DETROIT DIESEL ALLISON, INDIANAPOLIS, IND.

STUDY AND PROGRAM PLAN FOR IMPROVED HEAVY
gas turbine engine ceramic component development

Final Report

(NASA CR-135230, UCNS/500641; DDA-EDR-9068) AIP NTIS
HC A08/ MF A01 CSCL 21A

A fuel economy of 2.13 mg/l/h (0.38 lb/hr) brake specific
fuel consumption (BSFC) through use of ceramic materials,
with conformance to current and projected fade of noise and
emission standards was demonstrated and a commercially viable
equivalent engine is in development. Study results show that increased turbine
inlet and regenerator inlet temperatures, through the use of ceramic materi-
sables, the greatest amount to achieving
fuel economy goals. Further, improved component efficiencies (for the compressor, gasifier, power turbine, and
regenerator data) show significant additional gains in fuel economy. Fuel
saved in a 500,000 miles engine life, risks involved in development, and engine related life cycle costs for fleets
(100 units) of trucks and buses were used as criteria to see
t work goals for the planned program.

MECHANICAL TECHNOLOGY, INC., Latham, N. Y.

HYDRODYNAMIC AIR LUBRICATED COMPLIANT SUR-
FACE BEARING FOR AN AUTOMOTIVE GAS TURBINE
ENGINES: 2. MATERIALS AND COATINGS

Final Report
Bharat Bhushan, David Rusciotto, and Stanley Grey, July 1978,
130 p.

(NASA CR-135402, CONS/9427-2) AIP NTIS
HC A07/ MF A01 CSCL 11A

Material coatings for an air lubricated, compliant journal
bearing for an automotive gas turbine engine were exposed
to service test temperatures of 540 C and 850 C for 300 hours,
and to 10 temperature cycles from room temperatures to the
service test temperatures. Selected coatings were then put on
journal and partial arc foils and tested in start-stop cycle tests
at 14 kPA (2 psi) loading for 2000 cycles. Half of the tests
were performed at a test chamber service temperature of
540 C (1000 F) and 650 C (1200 F), another half were performed
at room temperature. Based on test results, the following
combinations and their service temperature limitations are
recommended: H 800 TM (G10 and graphite) on foil versus
chrome carbide on journal up to 370 C (700 F); NASA PS 120
(Triballoy, 400 silver and Car2 on journal versus metal-on-foil)
up to 540 C (1000 F) and Kaman DES on journal and foil up to
640 C (1200 F) Kaman DES coating system was further
tested successfully at 35 KPA (5 psi) loading for 2000 start
stop cycles.

GENERAL ELECTRIC CO., CINCINNATI, OHIO

(ROLLING ELEMENT FATIGUE TESTING OF GEAR MATERIALS

(NASA CR-135412) AIP NTIS
HC A06/ MF A01 CSCL 13A

Rolling element fatigue lives of eleven alloys were evalu-
ated. The alloys studied were three nitriding alloys (Super
Nitraloy, Nitraloy 13B, and Nitraloy N) four case carburizing
alloys AISI 9310, CBS 600, CBS 1000M and Vasco X-2); and
four through-hardening alloys (Vasco Matrix II, AISI W-1, AISI
S 2 and AISI 0 2). Several different heat treatments and/or
matelizing processes were studied on the three carburizing alloy
steels. Metallographic analyses were made before and after the
RC tests. Test data were statistically analyzed using the Weibull
distribution function. B 10 lives were compared versus VIM VAR
AISI M 5 and carburized VAR AISI 9310, as reference alloys.

References
A78-324429* Tennessee Univ. Space Inst., Tullahoma.
TRANSMISSION DYNAMICS OF A FLEXIBLE ROTOR WITH
SQUEEZED FILM DAMPERS Final Report
D F Buono, L. O. Schleizer, R. G. Hall, Ill., and D. H. Hieber
Sep 1978 88 p refs
(Contract NAS1-18523)
(NASA-CR-3050; PWA-5548-91) Avail NTIS
HC 100/5F 482L NSCL 131
A series of simulated blade loss tests are reported on a
test rotor designed to operate above its second bending critical
speed. A series of analyses were performed which predicted the
transient behavior of the test rig for each of the blade loss
tests. The scope of the program included the investigation of
transient rotor dynamics of a flexible rotor system, similar to
modern flexible jet engine rotors, both with and without squeezed
film dampers. The results substantiate the effectiveness of squeeze
film dampers and document the ability of available analytical
methods to predict their effect on power and behavior of the rotor.
G G

A78-29608 * Dynamic tooth loads and stressing for high
contact ratio spur gears. R. W. Cornell and W. W. Westervelt
(United Technologies Corp. Hamilton Standard Div., Windsor Locks,
Conn.). American Society of Mechanical Engineers Design Engineering
77 DET 101, 8 p, 10 refs. Members, $1.50, nonmembers, $3.00.
Contact No. NAS1-17859
A time history, closed form solution is presented for a dynamic
model of spur gear systems for all practical contact ratios. The
analysis determines the dynamic response of the gear system and the
associated tooth loads and stressing. The dynamic model assumes the
two gears act as rigid inertia and the teeth act as a variable spring of
dynamic system excited by the meshing action of the teeth.
Included in the analysis are the effects of the nonlinearity of the
tooth pair stiffness during mesh, the tooth errors, and the tooth
profile modification. Besides reviewing the features, solution, and
program of this analysis, preliminary results from applying the
analysis are presented, which show that tooth profile modification,
system inertia and damping, and system critical speeds can affect
the dynamic gear tooth loads and stressing significantly.

A78-23447 Influence of adsorbed fluids on the rolling
contact deformation of MgO single crystals. K. F. Dufrane ( Battelle
Columbus Laboratories, Columbus, Ohio). In: Wear of materials -
1977. Proceedings of the International Conference, St. Louis, Mo.,
NAS1-6753
Basic phenomena associated with rolling contact deformation
were studied using MgO as a model bearing material. A hardened
steel ball was rolled on MgO single crystals in slow speed reciprocating
motion and in high speed circular motion. The resulting
deformation was studied by dislocation etch-pit techniques. The
presence of adsorbed fluids, such as silicone oil, white mineral oil,
and toluene, with slow-speed sliding caused a dramatic change in slip
mode and premature surface spalling compared with similar experi-
ments in air or under water. In contrast, dimethyl formaldehyde
inhibited these slip processes. The results are consistent with the
dependence of dislocation mobility on adsorbed species. High speed
hydrodynamic rolling with mineral oil lubrication produced a
different slip phenomenon entirely from the slow speed rolling. The
slip bands resembled those produced in tensile tests, and all slip
apparently initiated at subsurface sites.

A78-31590 * Development and fabrication of a diffusion
welded Columbian alloy heat exchanger. W. F. Zimmerman, E. C.
Duderstadt, O. Wehn (General Electric Co., Evendale, Ohio), and R.
H. Tiltran (NASA, Lewis Research Center, Cleveland, Ohio).
American Institute of Mining, Metallurgical, and Petroleum En-
Paper A78-61, 18 p, Contract No. NAS1-18541.
A Mini Brayton space power generation system required the
development of a Columbian alloy heat exchanger to transfer heat
from a radiaototope heat source to a He/Xe working fluid. A
light-weight design featured the simultaneous diffusion welding of
148 longitudinal fins in an annular heat exchanger about 8-1/2 in. in
diameter, 13-1/2 in. in length and 1/4 in. in radial thickness. To
complete the heat exchanger, additional gas ducting elements and
attachment supports were added by GTA welding in a vacuum-
pumped inert atmosphere welding chamber. The development re-
quired the modification of an existing large size hot isotropic press to
achieve HIP capabilities of 2600 F and 10,000 psi for at least 3 hr.
Excellent diffusion welds were achieved in a high-quality component
which met all system requirements. (Author)
38 QUALITY ASSURANCE AND RELIABILITY

Includes product sampling procedures and techniques; and quality control.


Details of the method used to measure the stress wave factor are described. Frequency spectra of the stress waves are analyzed in order to clarify the nature of the wave phenomena involved. The stress wave factor was measured with simple contact probes requiring only one-side access to a part. This is beneficial in nondestructive evaluations because the waves can run parallel to fiber directions and thus measure material properties in directions assumed by actual loads. The technique can be applied where conventional through transmission techniques are impractical or where more quantitative data are required. The stress wave factor was measured for a series of graphite/polyimide composite panels, and results obtained are compared with through transmission immersion ultrasonic scans. Author


Progress in the application of ultrasonic techniques to nondestructive measurement of mechanical strength of engineering materials is reviewed. A dormant concept in nondestructive evaluation (NDE) is invoked: the availability of ultrasonic methods that can be applied to actual parts to assess their potential susceptibility to failure under design conditions is discussed. It was shown that ultrasonic methods yield measurements of elastic modulus, microstructure, hardness, fracture toughness, tensile strength, yield strength, and shear strength for a wide range of materials (including many types of metals, ceramics, and fiber composites). It was also indicated that although most of these methods were shown feasible in laboratory studies, more work is needed before they can be used on actual parts in processing, assembly, inspection, and maintenance lines. Author

A78-45433*# Quantitative ultrasonic evaluation of mechanical properties of engineering materials. A. Vary. INASA, Lewis Research Center, Cleveland, Ohio. National Bureau of Standards and American Society for Nondestructive Testing. International Symposium on Ultrasonic Materials Characterization 1st, Gaithersburg, Md., June 7-9, 1978. Paper. 37 p. 55 refe. Current progress in the application of ultrasonic techniques to nondestructive measurement of mechanical strength properties of engineering materials is reviewed. Even where conventional NDE techniques have shown that a part is free of overt defects, advanced NDE techniques should be available to confirm the material properties assumed in the part's design. There are many instances where metallic, composite, or ceramic parts may be free of critical defects while still being susceptible to failure under design loads due to inadequate or degraded mechanical strength. This must be considered in any failure prevention scheme that relies on fracture analysis. This review will discuss the availability of ultrasonic methods that can be applied to actual parts to assess their potential susceptibility to failure under design conditions. (Author)


The fabrication process and transfer characteristics for solid state radiographic image transducers (radiographic amplifier screens) are described. These screens are for use in realtime nondestructive evaluation procedures that require large format radiographic images with contrast and resolution capabilities unavailable with conventional fluoroscopic screens. The screens are suitable for in-motion on-line radiographic inspection by means of closed circuit television. Experimental effort was made to improve image quality and response to low energy (5 kV and up) X-rays. Author


Rolling element fatigue lives of nine alloys were evaluated in Rolling Contact RC tests. Tests included a Hertzian stress at 4.828 MPa (700 psi), a rolling speed of 6.23 m/sec (245 m/sec). Tests were run with a Type I oil (MIL-L-7800G) at room temperature. 8-10 lives (10% failure rate) of alloys were compared versus reference alloys, VIM-VAR AISI M-50 and VAR AISI 9310. Six case carburizing alloys (AISI 9310, C85600, C851000M, EX80014, Vasco X-2 and EX80063) and three through hardening alloys (AISI M-50, Vasco Max350 and Vasco M-50) were evaluated. showed RCF performance inferior or equivalent to that of AISI 9310 and AISI M-50. It was also found that the effects of vacuum melting process, different tempering temperatures, freemeshing cycle during heat treating, shot peening, hard plating and chrome plating employed in the present investigation did not significantly affect RCF life. G.Y.
39 STRUCTURAL MECHANICS

Includes structural element design and weight analysis; fatigue; and thermal stress.


N78-12449"f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

**NASTRAN USE FOR CYCLIC RESPONSE AND FATIGUE ANALYSIS OF WIND TURBINE TOWERS**


Avail: NTIS HC A20/MF A01 CSCL 20K

A procedure is described which uses NASTRAN coupled with fatigue criteria via a postprocessor to determine the cyclic response and to assess the fatigue resistance (fatigue life) of wind turbine generator towers. The cyclic loads to which the tower may be subjected are entered either in a quasi-static approach though static load subcases (Rigid Format 1) or through the direct dynamic response (Rigid Format 9) features of NASTRAN. The fatigue criteria are applied to NASTRAN output data from either rigid format through an externally written user program embedded in a postprocessor.

Author

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N78-13477"f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

**AN INTEGRATED THEORY FOR PREDICTING THE HYDROTHERMOMECHANICAL RESPONSE OF ADVANCED COMPOSITE STRUCTURAL COMPONENTS**


(NASA-TM-73812; E-9372) Avail: NTIS HC A03/MF A01 CSCL 20K

An integrated theory is developed for predicting the hydrothermomechanical (HTM) response of fiber composite components. The integrated theory is based on a combined theoretical and experimental investigation. In addition to predicting the HTM response of components, the theory is structured to assess the combined hydrothermal effects on the mechanical properties of unidirectional composites loaded along the material axis and off-axis, and those of angled laminates. The theory developed predicts values which are in good agreement with measured data at the micromechanics, macromechanics, laminate analysis and structural analysis levels.

Author

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N78-19528"f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

**MODE I ANALYSIS OF A FACE CRACKED PLATE SUBJECTED TO ROTATIONALLY CONSTRAINED END DISPLACEMENTS.**


(NASA-TM-73777) Avail: NTIS HC A02/MF A01 CSCL 20K

Mode I stress intensity coefficients and crack mouth displacement coefficients were obtained by planar boundary collocation analysis of face cracked plates subjected to rotationally constrained and displacements. Results are presented for plates with height-to-width ratio varying from 1.0 to 8.0 and crack depth-to-plate width ratios in the range 0.1 to 0.8.

Author

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N78-19528"f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

**SHAR STRENGTH OF METAL - ZIRCONIUM CONTACTS**


(NASA-TM-73820) Avail: NTIS HC A02/MF A01 CSCL 20K

The strength of the bond between metals and Zircaloy was studied by measuring the static coefficient of friction of metals contacting alpha-quartz in ultra-high vacuum. It was found that copper with either chemisorbed oxygen, nitrogen, or sulphur exhibited higher contact strength than did clean copper. Since the surface density of states induced by these species on copper is similar, it appears that the strength of the interfacial bond can be related to the density of states on the metal surface.

Author

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N78-23471"f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

**INTERPOLATION AND EXTRAPOLATION OF CREEP RUPTURE DATA BY THE MINIMUM COMMITMENT METHOD. PART 1: FOCALE-POINT CONVERGENCE**


(NASA-TM-78881; E-9814) Avail: NTIS HC A06/MF A01 CSCL 20K

A specialized variation of the minimum commitment method is obtained by expressing the relation log P = AP log t + P - G where t is the rupture time, P a function of temperature and G a function of stress. The term A was considered a structural stability parameter because it was found that the more unstable the material, the higher was the negative value of A required to fit the data. The functional forms of P and G were still left to be determined from the station values determined by analysis. The extensions that were made through the development of the above equation are discussed. The discussion provides descriptions of how to implement the method both manually or by computer code. The method is illustrated in detail for Astroloy - a nickel base alloy for which the particular lot available showed embrittlement instability involving a phase precipitation. It is also applied to a number of other steels, nickel base alloys, and aluminum alloys.

Author

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N78-23472"f National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

**INTERPOLATION AND EXTRAPOLATION OF CREEP RUPTURE DATA BY THE MINIMUM COMMITMENT METHOD. PART 2: OBIQUE TRANSLATION**


(NASA-TM-78882; E-9815) Avail: NTIS HC A03/MF A01 CSCL 20K

A new concept is introduced whereby the creep-rupture isothermals are generated by an oblique translation of the master curve plotted on the conventional coordinates. For most materials a constant translation angle of around 5 deg relative to the horizontal axis is satisfactory. However, for highly unstable materials such as a heat of Astroloy subject to slight phase precipitation, an angle as high as 15 deg may be required. For best results the translation angle should depend on temperature, the lower temperatures requiring a lower angle. The method is, in fact, a generalization of other approaches but it allows for the other types of temperature effects than only those displayed by elastic modulus E. Implementation of the method can be accomplished either by manual-graphical means or completely by computer, the major advantage being the ease of manual analysis. The method is illustrated for the unstable heat of Astroloy. Good results were obtained.

Author

The Minimum Commitment Method was applied to two sets of data for which multiple heat information was available. For one alloy, a 304 stainless steel studied in Japan, data on nine well characterized heats were used, while for a proprietary low alloy carbon steel studied in the United Kingdom data were available on seven heats in many cases to very long rupture times. For this preliminary study no instability factors were used. It was discovered that heat-to-heat variations would be accounted for by introducing heat identifiers in the form A : B log sigma where sigma is the stress and the constants A and B depend only on the heat. With these identifiers all the data could be collapsed onto a single master curve, even though there was considerable scatter among heats. Using these identifiers together with the average behavior of all heats made possible the determination of an accurate constitutive equation for each individual heat. Two basic approaches are discussed for applying the results of the analysis.

Author


CSCL 20K.

Analysis of high temperature low cycle fatigue of AISI 304LC and 316 stainless steels by the method of strain range partitioning results in four separate strain range versus life relationships, depending upon the way in which creep strain and plastic strain are combined within a cycle. Fractography is used in this investigation of the creep-fatigue interaction associated with these cycles. The PP and PC cycle fractures were transgranular. The PC cycle resulted in fewer cycles of initiation and shorter total cyclic life for the same applied elastic strain range. The CC cycle had mixed transgranular and intergranular fracture, fewer cycles of initiation than PP or PC. The CP cycle had fully intergranular cracking, and failed in fewer cycles than were required for cracks to initiate for PP, PC, and CC.

Author


CSCL 115D.

The impetus of composite mechanics on composite test methods and/or interpreting test results is described by using examples from composite micromechanics, composite mechanics, and failure theory. The specific examples include contributions such as criteria for selecting test matrices for improved composite strength, the 10 deg off axis tensile test criteria for configuring hybrids and superhybrids for improved impact resistance and the reduced bending rigidity concept for buckling and vibration analysis.

G G


The line method of analysis is applied to the Navier-Cauchy equations of elastic equilibrium to calculate the displacement field in a finite geometry bar containing a variable depth rectangular surface crack under extensionally applied uniform loading. The application of this method to these equations leads to coupled sets of simultaneous ordinary differential equations whose solutions are obtained along sets of lines in a discretized region. Using the obtained displacement field, normal stresses, and the stress-intensity factor variation along the crack periphery are calculated for different crack depth to bar thickness ratios. Crack opening displacements and stress-intensity factors are also obtained for a through-thickness, center-cracked bar with variable thickness. The reported results show a considerable potential for using this method in calculating stress-intensity factors for commonly encountered surface crack geometries in finite solids.

Author


Mode I stress intensity factors were computed for compact specimens by the boundary collocation method. Results are presented for ratios AT/RO in the range 0.3 to 0.8, where AT is the distance from the specimen center to the crack tip for a specimen of diameter 2R0.

Author


Hollow cylindrical bars were tested in a rolling contact fatigue tester to determine the effects of material and outside diameter on inside diameter (OD/ID) ratios on fatigue failure modes and subsequent failure propagation. The range of applied loads with OD/ID ratios of 2.0, 1.6, 1.4, and 1.2 resulted in maximum tangential stresses ranging from 165 to 655 MPa at the bore surface. Flexural failures of the hollow test bars occurred when the bore stress was 490 MPa or greater with AISI 52100 hollow bars and 338 MPa or greater with AISI 50 hollow bars. Good correlation was obtained in relating the failures of these hollow bars with flexural failures of drilled disks from full-scale bearing test published previously.

Author


Two advances in the numerical techniques of utilizing the BIF method are presented. The boundary unknowns x representing parabolas over each interval which are integrated in closed form. These integrals are listed for ease of use for problems involving crack tip singularities. These singularities are included in the boundary integrals so that the stress intensity factor becomes just one more unknown in the set of boundary unknowns thus avoiding the uncertainties of plotting and extrapolating techniques. The method is applied to the problems of a notched beam in tension and bending with excellent results.

Author
for three values of stretch for three values of cross-section diameter and for three values of groove width. All test data points were plotted. In addition, trend summary plots were presented which compare the effect of material, temperature, amplitude, squeeze, stretch, cross-section diameter, and groove width. Ring deflections under a static load for different material were presented; and effective static stiffness values were compared with dynamic values.

Author:

N78-214056* Boeing Aerospace Co., Seattle, Wash:

ANALYSIS AND TEST OF DEEP FLAWS IN TIN SHEETS OF ALUMINUM AND TITANIUM, VOLUME 1: PROGRAM SUMMARY AND DATA ANALYSIS Contractor Report, Jul. 1978 - Dec. 1977 R. W. Finger Apr. 1978 189 p refs 2 Vol. (Contract NAS3-19697) (NASA-CR-135369; D180-24613-1) Avail. NTIS HC A05/MF A01 CSCL 20K Six thicknesses of 2219-T87 aluminum base metal surface flaw and center crack specimens ranging from 0.83 to 0.935 mm (0.0327 to 0.0375 in.) were tested at temperatures ranging from 295K to 30K. Additionally, 61A-4V STA titanium base metal specimens were tested in three thicknesses 3.18, 2.03, and 1.02 mm (0.126, 0.080, and 0.040 in.) at room temperature. All tests were conducted on uniaxial specimens. Results were analyzed and compared with previously developed data to establish a criterion for proof testing thin walled pressure vessels. The data analysis and exact flaw size dimensions are presented.

Author:

N78-214067* Boeing Aerospace Co., Seattle, Wash:

ANALYSIS AND TEST OF DEEP FLAWS IN THIN SHEETS OF ALUMINUM AND TITANIUM, VOLUME 2: CRACK OPENING DISPLACEMENT AND STRESS-STRAIN DATA Contractor Report, Jul. 1976 - Dec. 1977 R W Finger Apr. 1978 213 p 2 Vol. (Contract NAS3-19697) (NASA-CR-135370; D180-24613-2) Avail. NTIS HC A10/MF A01 CSCL 20K Static fracture tests were performed on surface flawed specimen of aluminum and titanium alloys. A simulated proof overload cycle was applied prior to all of the cyclic tests. Variables included in each test series were flaw shapes and thickness. Additionally, test temperature was a variable for the aluminum test series. The crack opening displacement and stress-strain data obtained are presented.

Author:

N78-324507* Mechanical Technology, Inc., Latham, N.Y.

DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING PROPERTIES OF ELASTOMERS IN ENGINEERING APPLICATIONS, PART 4: TESTING OF ELASTOMERS UNDER A ROTATING LOAD Contractor Report, Oct. 1976 - Mar. 1977 M. S. Darlow and A. J. Smalley Nov. 1977 87 p refs (Contract NAS3-18548) (NASA-CR-135355; MTI-78TR18-PL-4) Avail. NTIS HC A05/MF A01 CSCL 20K A test rig designed to measure stiffness and damping of elastomer cartridges under a rotating load excitation is described. The test rig employs two independently driven wheels in a motor which runs to 60,000 RPM as the excitation mechanism. A variable resonant mass is supported on elastomer elements and the dynamic characteristics are determined from measurements of input and output acceleration. Five different cartridges are considered: three of these are buttons cartridges having buttons located in pairs, with 120 between each pair. Two of the cartridges contain 360 elastomer rings with circular cross-section. Dynamic stiffness and damping are measured for each cartridge and compared with predictions at different frequencies and different strain.

Author:
An evaluation of the cyclic behavior of three aircraft engine turbine disk materials was conducted to compare their relative crack initiation and crack propagation resistance. The disk alloys investigated were Inconel 718, hot isostatically pressed and forged powder metallurgy Rene 95, and as-hot-isostatically pressed Rene 95. The objective was to compare the hot isostatically pressed powder metallurgy alloy forms with conventionally processed superalloys as represented by Inconel 718. Cyclic behavior was evaluated at 650°C under continuously cycling and a fifteen minute tenatious hold time cycle to simulate engine conditions. Analysis of the test data were made to evaluate the strain range partitioning and energy exhaustion concepts for predicting hold time effects on low cycle fatigue.

Author
43 EARTH RESOURCES
Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry; and aerial photography.
For instrumentation see 35 Instrumentation and Photography.

N78-14482* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
IN-SITU LASER RETORTING OF OIL SHALE Patent
Harvey S. Bloomfield, inventor (to NASA) issued 6 Dec. 1977
5 p. Filed 29 Jan. 1977 Supersedes N77-18429 (15-08,
p 1176)
(NASA-Case-LEW-12217-1; US-Patent-4,061,180;
Oil shale formations are retorted in situ and gaseous
hydrocarbon products are recovered by drilling two or more wells
into an oil shale formation underneath the surface of the ground.
A high energy laser beam is directed into the well and fractures
the region of the shale formation. A compressed gas is forced
into the well that supports combustion in the flame front ignites
by the laser beam, thereby retorting the oil shale. Gas-sea
hydrocarbon products which permeate through the fractured regio
are recovered from one of the wells that were not exposed to
the laser system. Official Gazette of the U.S. Patent Office

N78-32810* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
AERIAL TERMOGRAPHY FOR ENERGY CONSERVATION
illustrations.
(NASA-TM-78969: E-8711) Avail. NTIS HC A02/MF A01
CSCL 14E
Thermal infrared scanning from an aircraft is a convenient
and commercially available means for determining relative rates
of energy loss from building roofs. The need to conserve energy
as fuel costs makes the mass survey capability of aerial
thermography an attractive adjunct to community energy
awareness programs. Background information on principles of
aerial thermography is presented. Thermal infrared scanning
systems, flight and environmental requirements for data
acquisition, preparation of thermographs for display, major users
and suppliers of thermography, and suggested specifications for
obtaining aerial scanning services were reviewed.
S.S.
44 ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells and batteries; global sources of energy; fossil fuels; geophysical conversion; hydroelectric power; and wind power.

For related information see also 07 Aircraft Propulsion and Power, 20 Spacecraft, Propulsion and Power, 28 Propellants and Fuels, and 85 Urban Technology and Transportation.

N78-13627# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. SOLAR CELL HIGH EFFICIENCY AND RADIATION DAM-
AGE, 1977 221 p ref. Conf. held at Cleveland, 18-19 May 1977 (NASA-CP-2020). Note, NTIS HC A10/MF AO1 CSCL 10A Silicon solar cell analyses and fundamental measurements, silicon cell technology, gallium arsenide research and technology, and radiation effects on silicon and gallium arsenide cells, are reported. For individual titles, see N78-13528 through N78-
13551.

N78-13628# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. SUMMARY OF THE NASA SPACE PHOTOVOLTAIC RESEARCH AND TECHNOLOGY PROGRAM. Henry W. Brandhorst Jr. In its Solar Cell High Efficiency and Radiation Damage 1977 p 3-6 (For availability see N78-13527 04-44). Note: NTIS HC A10/MF AO1 CSCL 1A. Low cost solar cells and arrays with high end-of-life efficiency are evaluated through two approaches: one, to obtain increased device efficiency at no increase in cost and two, to reduce the manufacturing costs of space solar cells and arrays. Technological efforts encompass high efficiency epitaxial cells, high efficiency wraparound contact solar cells, economical diffusion sources, automated cell fabrication, and development of easily applied, durable cover glasses. The examination of ion implanted profiles tailored junctions and additional development of screen printed contact technology to cell development are also considered. Author

N78-13634# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. IMPURITY CONCENTRATIONS AND SURFACE CHARGE DENSITIES ON THE HEAVILY DOPED FACE OF A SILICON SOLAR CELL. J. Weinberg and Lon Hau (Wayne State Univ.) In NASA Lewis Res Center Solar Cell High Efficiency and Radiation Damage 1977 p 6B-79. Note (For availability see N78-13527 04-44). Note: NTIS HC A10/MF AO1 CSCL 10A. Increased solar cell efficiencies are attained by reduction of surface recombination and variation of impurity concentrations profiles at the n+ surface of silicon solar cells. Diagnostic techniques are employed to evaluate the effects of specific materials preparation methodologies on surface and near surface concentrations. It is demonstrated that the MOS C V method, when combined with a bulk measurement technique, yields more complete concentration data than are obtainable by either method alone. Specifically, new solar cell MOS C V measurements are combined with bulk concentrations obtained by a successive layer removal technique utilizing measurements of sheet resistance and Hall coefficient. Author

N78-13608# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. SOME BASIC CONSIDERATIONS OF MEASUREMENTS INVOLVING COLLECTED DIRECT SUNLIGHT. An-Ti Chai 1976 18 p ref. Presented at Terrest P. V. Mesa Workshop, Baton Rouge, La 10 Nov 1976. Note: NTIS HC A29-1022). The measurements made to the interior testing procedures are described. The calibration of reference cells and the selection of their holders are covered. Considerations include view angle and optical and thermal matching. Atmospheric factors which


N78-14829# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. REAL-TIME AND ACCELERATED OUTDOOR ENDURANCE TESTING OF SOLAR CELLS. America P. Forester and Evelyn Anthognoi. Aug 1977 28 p ref. Presented at 1977 Photovoltaics Solar Energy Conf., Luxembourg, 27-30 Sep 1977. Sponsored by Comm. of the European Communities. Note: N78-14829 (14-9, pi 120). Note: NASA Case LEW-73743, E 8310. ERA/NA-1022/77/17, US Patent. NTIS HC A10/MF AO1 CSCL 10A. A real-time and accelerated outdoor endurance testing was performed on a variety of samples of interest to the National Photovoltaic Conversion Program. The real-time tests were performed at seven different sites and the accelerated tests were performed at one of those sites. The tests are being performed on a large number of solar cells and solar cell modules produced by the manufacturers for the ERDA program. Results indicate that suitable cover materials are glass and plastic thin films. The aging test conditions and the results of the testing are factors in the selection of solar cell module covers and encapsulants. Author

N78-14632# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. TERRESTRIAL SOLAR CELL CALIBRATION AND MEASUREMENT PROCEDURES. Henry W. Brandhorst Jr. Sep 1977 16 p ref. Presented at 1977 Photovoltaics Solar Energy Conf., Luxembourg, 27-30 Sep 1977. Sponsored by Comm. of the European Communities. Note: N78-14632 (14-9, pi 120). Note: NASA-TM-73788 E 8353, ERA/NA-1022/77/20, US Patent. NTIS HC A02 MF AO1 CSCL 1A. An experimental system was developed for the calibration of the conversion efficiency of terrestrial solar cells. The system and its components are described. The calibration of the conversion efficiency of terrestrial solar cells is described. The calibration efficiency of reference cells is described. The design of the holders is described. Considerations are given to the design of the holders. The design of the holders is described. Considerations include view angle and optical and thermal matching. Atmospheric factors which
affected the calibration and performance of solar cells are discussed. The most critical atmospheric parameter appears to be water vapor. Techniques for matching reference cells to cells or arrays are also described. Data showing errors in performance under artificial sunlight simulators due to mismatch of reference and test cells are presented. Finally, measurement procedures and data transformations needed to obtain the performance of solar cells and arrays in outdoor natural sunlight are described.

Author

N78-14630† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOLAR ENERGY METER

An instrument was developed to continuously integrate the energy available in incident light on a specifically oriented surface. The unit was designed for outdoor use in remote locations and is capable of operation over a temperature range of -30 to +60 C with good accuracy. The unit is weather resistant, requires low power, has a high input impedance, is inexpensive, and has a visual readout and analog output for recording.

Author

N78-14631† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANION EXCHANGE MEMBRANES FOR ELECTROCHEMICAL OXIDATION-REDUCTION ENERGY STORAGE SYSTEM

Oxidation-reduction couples in concentrated solutions separated by appropriate ion selective membranes were considered as an attractive approach to bulk electrical energy storage. A key problem is the development of the membrane. Several promising types of anionic membranes are discussed which were developed and evaluated for redox energy storage systems. For example, polymers of ethyleneglycolmethacrylate with either 2-vinylpyridine or vinylbenzyl chloride gave stable resistance values compared to the copolymer of vinylbenzylchloride and divinylbenzene. A polyvinylchloride film anumted with tetrachloroethyleneohime had a low resistance but a high ion transfer rate. A slurry coated vinylpyridine had the lowest ion transfer rate. All these membranes functioned well in laboratory cells at ambient temperatures with the acid chloride oxidant/reductant system. Fe 3, Fe 2/Ti 3. Ti 4.

Author

N78-15642† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BLACK CHROME ON COMMERCIALLY ELECTROPLATED TIN AS A SOLAR SELECTIVE COATING

The visible properties of black chrome electroplated on commercially electroplated tin were measured for various black chrome plating times for both the solar and infrared spectra. The values of absorptance and emittance were calculated from the measured reflectance values. The results indicate that the optimum combination of the highest absorptance in the solar region and the lowest emittance in the infrared of the black chrome plated on commercially electroplated tin is obtained for a black chrome plating time of between one and two minutes.

Author

N78-15869§ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ERDA/NASA 100 KILOWATT MOD-O WIND TURBINE OPERATIONS AND PERFORMANCE

The ERDA/NASA 100 kW wind turbine is operating at the NASA Plum Brook Station near Sandusky, Ohio. The operation of the wind turbine has been fully demonstrated and includes start-up, synchronization to the utility network, blade pitch control for control of power and speed, and shut-down. Also, fully automatic operation has been demonstrated by use of a remote control panel, 50 miles from the site, similar to what a utility dispatcher might use. The operation systems and experience with the wind turbine loads, electrical power and aerodynamic performance obtained from testing are described.

Author

N78-16434† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
APPROXIMATE METHOD FOR CALCULATING FREE VIBRATIONS OF A LARGE WIND-TURBINE TOWER STRUCTURE

A set of ordinary differential equations were derived for a simplified structural dynamic lumped-mass model of a typical large wind turbine tower structure. Dunkley's method was used to arrive at a solution for the fundamental frequencies of the tower. The ERDA/NASA 100 kW wind turbine tower structure was modeled, and the fundamental frequencies were determined by the simplified method described. The approximate fundamental frequencies for the tower agree within 10 percent with test data and predictions analyzed.

Author

N78-16435† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC REFRIGERATION APPLICATION: ASSESSMENT OF THE NEAR-TERM MARKET

This foreign and domestic market assessment was performed as part of the Tests and Applications Project being conducted by NASA-LRAC as part of the Department of Energy's (DOE) National Photovoltaic Program. One of the objectives of that program was to stimulate the demand for photovoltaic power systems so that appropriate markets would be developed in concert with the increasing photovoltaic production capacity. The refrigeration application represented a possible market for photovoltaics. Hence, a brief survey of potential applications was conducted. Both refrigerators and refrigeration systems were considered in the assessment although the primary emphasis is on refrigerators of 9 cu ft or less. Three user sectors were examined: (1) government, (2) commercial/institutional and (3) public general.

Author

N78-17406† National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WIND TURBINE GENERATOR ROTOR BLADE CONCEPTS WITH LOW COST POTENTIAL
T L Sullivan T P Cahill, D G Garr, Jr (United Technologies Corp. Windsor Locks Conn) and H W Gewurz (Karman Aerospace Corp) Dec 1977 38 p refs Presented at the 23rd Natl. SAMPE Symp. Anaheim Calif. 2-4 May 1978

Author
Four processes for producing blades are examined. Two use filament winding techniques and two involve forging a mold or form to produce all or part of a blade. The processes are described and a comparison is made of cost, material properties, design and free vibration characteristics. Conclusions are made regarding the feasibility of each process to produce low cost, structurally adequate blades.

Author


The DOE/NASA 100 kilowatt wind turbine generator system was synchronized with a large utility network. The system equipment and procedures associated with the synchronization process were described. Time history traces of typical synchronizations were presented indicating that power and current transients resulting from the synchronizing procedure are limited to acceptable magnitudes. Author


The program structure is presented. The activities of the thermochemical cycles program are grouped according to the following categories: (1) specific cycle development, (2) support research and technology, (3) cycle evaluation. Specific objectives and status of on-going activities are discussed. Chemical reaction rates for the production of hydrogen are presented. Efficiency and economic evaluations are also discussed. G.Y.

Author

N78-174699® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio TECHNICAL AND ECONOMIC FEASIBILITY STUDY OF SOLAR/FOSSIL HYBRID POWER SYSTEMS Harvey S. Bloomfield and James E Colognesi Dec 1977 70 p ref (NASA-TM-73820; E-8409) Avail. NTIS HC AO4/MF AO1 CSCI 10B

Results show that new hybrid systems utilizing fossil fuel augmentation of solar energy can provide significant capital and energy cost benefits when compared with solar thermal systems requiring thermal storage. These benefits accrue from a reduction of solar collection area that results from both the use of highly efficient gas and combined cycle energy conversion subsystems and elimination of the requirement for long-term energy storage subsystems. Technical feasibility and fuel savings benefits of solar hybrid retrofit to existing fossil fuel gas and vapor cycle powerplants were confirmed. However, economic viability of steam cycle retrofit was found to be dependent on the thermodynamic and operational characteristics of the existing powerplant.

Author

N78-175618® National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio SIMPLIFIED MODELING FOR WIND TURBINE MODAL ANALYSIS USING NASTRAN Timothy L. Sullivan In its Wind Turbine Structural Dyn. 1978 p 31-38 ref (For availability see N78-19418 10-44) Avail. NTIS HC AO3/MF AO1 CSCI 10A

A detailed finite element model of the MOD-O wind turbine tower was reduced to six beam elements (stick model). The method used to calculate the properties of the beam elements in the stick model was explained and the accuracy of the stick model in predicting natural frequencies and mode shapes was examined. Computer times were compared and several applications were given where the stick model was used. From results obtained from the MOD-0 tower it is concluded that a tower of this type can be modeled as a simple cantilever beam for modal analysis. However, the model should be limited to tower torsional modes and tower bending modes where the mode shape resembles a cantilever beam first bending mode shape.

Author
N78-16825* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

INFLUENCE OF WIND TURBINE FOUNDATION

Henry T. Yes. In its Wind Turbine Structural Dyn. 1978 p 103-108 (For availability see N78-19819 10-64).

Avail. NTIS HC A13/MF A01 CSSL 10A.

A 200 kw Mod-O wind turbine was modeled using a 3 lump mass-spring system for the superstructure and a rotational spring for the foundation and supporting soil. Natural frequencies were calculated using soil elastic moduli varying from 3000 to 22,400 psi. The reduction in natural frequencies from the rigid foundation case ranged up to 20 percent. Author.

N78-16825* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SUMMARY OF STATIC LOAD TEST OF THE MOD-O BLADE


Avail. NTIS HC A13/MF A01 CSSL 10A.

A static load test was performed on the spare Mod-O wind turbine blade to define load transfer at the root end of the blade, and to determine the analysis of this particular type of blade construction (frame and stringer). Analysis of the load transfer from the root end to the shank tube predicted a step change in spanwise stress in the airfoil skin at station 81.5 inches (STA 815). For flute bending a 40% reduction in spanwise stress was predicted, and for edgewise bending a 6% reduction. Experimental results verified the 40% reduction for flute bending, but indicated about a 30% reduction for edgewise bending. Author.

N78-19825* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

DOE/NASA MOD-0 100KW WIND TURBINE TEST RESULTS

John C. Glasgow. In its Wind Turbine Structural Dyn. 1978 p 117-150 (For availability see N78-19816 10-64).

Avail. NTIS HC A13/MF A01 CSSL 10A.

The wind turbine demonstrates the capability of automatic unattended operation, including startup, achieving synchronism, and shutdown as dictated by wind conditions. During the course of these operations, a wealth of engineering data was generated. Some of the data which is associated with rotor and machine dynamics encountered, and the machine modifications incorporated as a solution are presented. These include high blade loads due to excessive nacelle yawing motions, and power oscillations. The results of efforts to correlate measured wind velocity with power output and wind turbine loads are also discussed. Author.

N78-19825* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

POWER OSCILLATION OF THE MOD-O WIND TURBINE


Avail. NTIS CSSL 10A.

The Mod-O power has noise components with varying frequency patterns. Magnitudes reach more than forty percent power at the frequency of twice per rotor revolution. Analysis of a simple torsional model of the power train predicts less than half the observed magnitude and does not explain the shifting frequency of the noise patterns. Author.

N78-19832* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

METHODS OF ATTENUATING WIND TURBINE GAS GENERATOR OUTPUT VARIATIONS

Harold W. Yost. In its Wind Turbine Structural Dyn. 1978 p 179-186 (For availability see N78-19816 10-64).

Avail. NTIS HC A13/MF A01 CSSL 10A.

Wind speed variation, tower blockage and structural and
was compared to that of utility line extensions and diesel generators. The potential domestic demand was defined in both the government and commercial sectors. The foreign demand and social benefits from the use of photovoltaic systems in the developing countries were also discussed briefly. It was concluded that a near-term domestic market of at least 12 MW min and a foreign market of about 10 GW exists.

Author

PHOTOVOLTAIC WATER PUMPING APPLICATIONS: ABSTRACT OF THE NEAR-TERM MARKET

(NASA-TM-78847; E 9656; DOE/NASA/1022-78/28) Avail
NTIS HC AO2/2MF AO1 CSCL 108

Water pumping applications represent a potential market for photovoltaics. The price of energy for photovoltaic systems was compared to that of utility line extensions and diesel generators. The potential of domestic demand was defined in the government, commercial/institutional and public sectors. The foreign demand and sources of funding for water pumping systems in the developing countries were also discussed briefly. It was concluded that a near-term domestic market of at least 240 megawatts and a foreign market of about 6 gigawatts exist.

Author

DETERMINATION OF THE ZINCATE DIFFUSION COEFFICIENT AND ITS APPLICATION TO ALKALINE BATTERY PROBLEMS

(NASA TM 73879; E 9466) Avail NTIS HC AO2/MF AO1 CSCL 104

The diffusion coefficient for the zincate ion at 24°C was found to be 9.9 x 10^-10 m^2/sec or 30 x 10^-10 m^2/sec at 30°C. Comparison of these values with literature values at different temperature concentrations show that the Stokes-Einstein equation is obeyed. The diffusion coefficient is characteristic of the zincate ion (not the cathode) and independent of its concentration. Calculations with the measured value of the diffusion coefficient show that the zinc concentration in an alkaline zincate half cell becomes uniform throughout in tens of hours by diffusion alone. Diffusion equations are derived which are applicable to finite size chambers. Details and discussion of the experimental method are also given.

Author

REDOX FLOW CELL DEVELOPMENT AND DEMONSTRATION PROJECT CALENDAR YEAR 1978
Dec 1977 48 p refs

(NASA TM 73883; E 9534) Avail NTIS HC AO3/MF AO1 CSCL 104

The major focus of the effort was the key technology issues that directly influence the fundamental feasibility of the overall redox concept. These include the development of a suitable semi-permeable separator membrane for the system, the screening and study of redox couples to achieve optimum cell performance and the carrying out of systems analysis and modeling to develop system performance goals and cost estimates.

Author

PHOTOVOLTAIC POWER SYSTEM TESTS ON AN 8-KILOWATT SINGLE-PHASE LINE-COMMUTATED INVERTER
John E. Hoover Feb 1978 18 p refs


Efficiency and power factors measured as functions of solar array voltage and current. The effects of ir rise shunt capacitance and series resistance were determined. Tests were conducted from 16 to 75 percent of the 8 kW rated inverter input power. Measured efficiencies ranged from 70 percent to 88 percent at about 60 percent of rated inverter input power. Power factor ranged from 0.68 to 0.72 percent. Author

RESULTS OF MODULE ELECTRICAL MEASUREMENT OF THE DOE 48-KILOWATT PROCUREMENT
Henry B. Curtis Feb 1978 20 p refs


Current-voltage measurement have been made on terrestrial solar cell modules of the DOE/JPL Low Cost Silicon Solar Array procurement Data on short circuit current, open circuit voltage, and maximum power for the four types of modules are presented in a normalized form, showing the distribution of the measured values. Standard deviations from the mean values are also given. Tests of the statistical significance of the data are discussed.

Author

EFFLUENT CHARACTERIZATION FROM A CONICAL PRESSURIZED FLUID BED

(NASA TM 73883; E 9524) Avail NTIS HC AO2/MF AO1 CSCL 104

To obtain useable corrosion and erosion results it was necessary to have data with several levels of particulate material in the hot gases. One level of particulate loading was as low as possible so that ideally no erosion or corrosion occurred. A conical fluidized bed was used to obtain some degree of filtration through the top of the bed which would not be highly fluidized. This would minimize the filtration requirement for the hot gases or conversely the amount of particulate matter in the hot gases after a given level of filtration by cyclones and/or filters. The data obtained during testing characterized the effluent from the bed at different test conditions. A range of bed heights, fluidization air flow rates, and pressure, and differential pressure were represented. These tests were made to determine the best operating conditions prior to using the bed to determine erosion and corrosion rates of typical turbine blade materials.

Author

SOME PROPERTIES OF LOW-VAPOR-PRESSURE BRAZE ALLOYS FOR THERMIONIC CONVERTERS
Virginia Bue 1976 14 p refs Presented at the Intern Plasma Sci Conf Monterey, Calif sponsored by IEEE

(NASA TM 78567; E 9598) Avail NTIS HC AO2/MF AO1 CSCL 104

Property measurements were made for arc melted, rod shaped specimens. Density and dc electrical resistivity at 250 K were measured for various binary eutectic alloys. Thermal conductivity was inferred from the electrical conductivity using the Wiedemann-Franz Law. Lorenz relation linear thermal expansion from 80 K to two fluids melting point under a helium atmosphere was measured for Zr 21.7 wt percent Ru, Zr 13 wt percent W, Zr 22.3 wt percent Nb, Nb 66.7 wt percent Ru, and Zr 28.7 wt percent Ta.

Author

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Author

Seven computer codes for predicting performance and loads in large, horizontal-axis wind turbines were used to calculate blade bending moments for two operational conditions of the 100 kW Mod-0 wind turbine. Results were compared with test data on the basis of cyclic loads, peak loads, and harmonic contents. Four of the seven codes include rotor-tower interaction and three were limited to rotor analysis. With a few exceptions, all calculated loads were within 25 percent of nominal test data.

Author


A comparison and assessment of 10 advanced utility power cycles on a consistent basis and to a common level of detail were analyzed. Substantial emphasis was given to a combined cycle system integrated with low-Btu gasifiers. Performance and cost results from that study were presented for these combined-cycle systems together with a comparative evaluation of the effects of the gasifier type and performance and the interface between the gasifier and the power system.

Author


A 1/40th scale model of a tower concept designed for a MOD-1 wind power turbine was tested in a low-speed wind tunnel. Wake wind speed profiles were measured and from these were determined local values of wake minimum velocity, average velocity ratio, and width over a range of tower elevations and wind approach angles. Comparison with results from two other all tubular models (MOD-0 and eight leg design) tested earlier in the same tunnel indicated that wake width and flow blockage at the rotor plane of rotation were slightly larger for the MOD-1 tower than for the other two models. The differences in wake characteristics were attributed to differences in tower geometry and member dimensions.

Author


Low speed wind tunnel tests were conducted to determine the flow characteristics of the wake downwind of a 1/25th scale all tubular eight leg tower concept suitable for application to the DOE NASA MOD-0 wind power turbine. Measurements were made of wind speed profiles, and from these were determined the wake local minimum velocity, average velocity, and width for several wind approach angles. These data are presented herein along with tower shadow photographs and comparisons with data from an earlier test. A four leg tower model constructed of tubular members. Values of average wake velocity defect and average ratio of wake width to blade radius for the eight leg model were determined to be around 0.17 and 0.30, respectively, at the plane of the rotor blade. These characteristics suggest that the tower wake of the eight leg concept is slightly less than that of the four leg design.

Author


Thermionic conversion data obtained from a variable gap cesium diminioide with a hot pressed, sintered lanthanum hexaboride emitter and an arc melted lanthanum hexaboride collector are presented. Performance curves cover a range of operating temperatures. Emitter 1500 to 1700 K, collector 750 to 1000 K, and cesium reservoir 370 to 510 K. Calculated values of emitter and collector work functions and barrier index are also given.

Author
N78-25837 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SOLAR CELL COLLECTOR Patent
John C. Evans, Jr. inventor (to NASA) Issued 4 Apr 1978
5 p Filed 22 Feb 1977 Supersedes N77-17564 (15 - 08, p 1052)

(NASA Case LEW 12552.1: US Patent 4,082,589;

A method is provided for the fabrication of a photovoltaic device which possesses an efficient collector system for the conduction of the current generated by incident photons to the external circuitry of the device

Official Gazette of the U.S. Patent Office

N78-25838 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

METHOD OF MAKING ENCAPSULATED SOLAR CELL MODULES Patent
Evelyn A. Magnuson and Amarco F. Forsten, inventors (to NASA) Issued 11 Apr 1978 4 p Filed 30 Nov 1976 Supersedes N77-15450 (15 - 08, p 0769)


Electrical connections to solar cells in a module are made at the same time the cells are encapsulated for protection. The encapsulating material is embossed to facilitate the positioning of the cells during assembly.

Official Gazette of the U.S. Patent Office

N78-25839 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

METHOD FOR PRODUCING SOLAR ENERGY PANELS BY AUTOMATION Patent
John C. Evans Jr. inventor (to NASA) Issued 18 Apr 1978
11 p Filed 25 Apr 1977 Supersedes N77-22615 (15 - 13, p 1744)


A solar cell panel was fabricated by photocuring a pattern of interconnects made of an electroplated copper and by laminating the panels to the bus bars. The sections were then stacked with a thin, reflective metal foil followed by a layer of a silicate-oxide scale, such as InAsO or InSnO. The interconnections were bonded between the protective sheet at the sites of the interconnector and a conductive substrate by conductive metal filled epoxy to complete the fabrication of an integrated solar panel.

Official Gazette of the U.S. Patent Office

N79-25830 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

INORGANIC-ORGANIC SEPARATORS FOR ALKALINE BATTERIES Patent
Dean W. Sheidley, inventor (to NASA) Issued 18 Apr 1978
4 p Filed 7 Sep 1977 Supersedes N76-31874 (14 - 22, p 2890)


A flexible separator is required for use between the electrodes of Ni-Cd and Ni-Zn batteries using alkaline electrolytes. The separator was made by coating a porous substrate with a battery separator composition. The coating material included a rubber-based resin copolymer, a plasticizer and inorganic and organic fillers which comprised 5% by volume or less of the coating as finally dried. One or more of the filler materials, whether organic or inorganic, is preferably active with the alkaline electrolyte to produce pores in the separator coating. The plasticizer was an organic material which is hydrosolylized by the alkaline electrolyte to improve conductivity of the separator coating.

Official Gazette of the U.S. Patent Office

N79-25851 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio


Phonon Degradation Effect in Terrestrial Solar Cells

N79-25852 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SOLAR CELL SYSTEM HAVING ALTERNATING CURRENT OUTPUT Patent Application

A P-N junction solar cell modified by fabricating an integrated circuit inverter on the back of the cell to produce a device capable of generating an alternating current output was developed. In another embodiment integrated circuit power conditioning electronics is incorporated in a module containing a solar cell power supply.

N79-25853 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

ELECTROCHEMICAL CELL FOR REBALANCING REDOX FLOW SYSTEM Patent Application

An electrochemical cell for rebalancing redox flow systems such as those used in electrolytic cells which utilize reduction and oxidation of one redox couple is used in a redox flow cell. The fluids were aqueous solutions of HCl each including a different metal...
chloride salt and were separated by a membrane which was permeable to certain ions. A provision of a rebalancing cell is provided which allows gas from undesirable side reactions and/or from an independent source to rebalance the anode and cathode fluids in a REDOX system. NASA

N78-28568# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
CEBES THERMIONIC CONVERTERS HAVING IMPROVED ELECTRODES Patent Application
James F. Means, inventor (E 514). Filed 1 May 1978. 9 p
(NASA Case LEW 120393: US-Patent Appl 901892) Avail. NTIS HC A02/MF A01 CSCL 10A

A high electric-power output thermionic converter is reported that uses a combination of lanthanum hexaboride and cesium vapor, which is adsorbed on the lanthanum hexaboride electrodes, results in lower emitter and collector work functions to produce a thermionic converter with high current density and voltage output. The lanthanum hexaboride emitters and collector electrodes employed in the cesium thermionic converter can be either in the monocrystalline or polycrystalline state. NASA

N78-28566# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
IMPROVED BACK WALL CELL Patent Application
(NASA Case LEW 122262, US-Patent Appl 899123) Avail. NTIS HC A02/MF A01 CSCL 10A

Back wall solar cells are described that consist of a first material of one conductivity type with one face more heavily doped to form a field region to receive radiant energy. A layer of opaque metal forms a Schottky barrier applied to the opposite face. A grid contact previous to the radiant energy was applied to the region of the heavily doped material for electrical contact. Separate control of either the anode junction or the Schottky diode junction is available for efficient collection of light. NASA

N78 28568# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
METHOD FOR FABRICATING SOLAR CELLS HAVING INTEGRAL COLLECTOR GRIDS Patent Application
John C. Evans, Jr., inventor (to NASA). Filed 23 Dec 1977. 17 p
(NASA Case LEW 128192, US-Patent Appl 863770) Avail. NTIS HC A02/MF A01 CSCL 10A

A photovoltaic device was designed which possesses an integral metal grid incorporated into the solar cell. The grid system is formed from the metal elements of the transparent, conductive mixed metal oxide coating, which is in contact with the oxide coating which constitutes the barrier of the devices with the semiconductor substrate. NASA

N78 285642# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
TRANSIENT RESPONSE TO THREE-PHASE FAULTS ON A WIND TURBINE GENERATOR Ph.D. Thesis - Toledo Univ. Leonard J. Godt, June 1978. 146 p. refs (NASA TM 78902; E 9638) Avail. NTIS HC A07/MF A01 CSCL 10A

In order to obtain a measure of its responses to short circuits a large horizontal axis wind turbine generator was modeled and its performance was simulated on a digital computer. Simulation of short circuit faults on the synchronous alternator of a wind turbine generator, without resort to the classical assumptions generally made for that analysis, indicates that maximum clearing times for the system tied to an infinite bus are longer than the typical clearing times for equivalent capacity conventional machines. Also, maximum clearing times are independent of tower shadow and wind shear. Variation of circuit conditions produce the modifications in the transient response predicted by analysis. P.R.A.

N78-28564# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
STATUS OF WRAPAROUND CONTACT SOLAR CELLS AND ARRAYS

Solar cells with wraparound contacts provide the following advantages in array assembly. (1) eliminates the need for discretely formed, damage susceptible series tabs. (2) eliminates the gap problem by allowing the use of uniform covers over the entire cell surface. (3) allows higher packing factors by reducing the additional series spacing formerly required for forming, and routing the series tab, and (4) allows the cell bonding to the interconnect system to be a non-conductive function wherein series contacts can be made at the same time parallel contacts are made. Author

N78-28564# National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
PRELIMINARY EVALUATION OF GLASS RESIN MATERIALS FOR SOLAR CELL COVER USE

The glass resins were deposited by several techniques on 200 micron thick cells and on 50 microns thick wafers. The covered cells were exposed to ultraviolet light in vacuum to an intensity of 10 UV energy equivalent solar constants at air mass zero for 728 hr. The exposure was followed by a single long thermal cycle from ambient temperature to 150 C. Visual inspection of the samples indicated that all samples had darkened to varying degrees. The loss in short circuit current was found to range from 6% to 24%, depending on the resin formulation. Another test over 40 glass resin-coated silicon wafers withstand 15 thermal cycles from 160 to 196 C in one or more of the thickneasses tested. Several of the resin-coated wafers were tested at 85 C and 90% relative humidity for 170 hr. No change in photovoltaic appearance was detected. Author
two inverter test stations, a battery storage system, interface with local load and the utility grid, and instrumentation and control necessary to make a feasible operating facility. Expansion to 20 kW is planned for 1978. Test results and operating experience are summarized to show the variety of work that can be done with this facility.

G.Y.


The Department of Energy has developed a program to effect a large reduction in the price of photovoltaic modules, with significant progress already achieved toward the 1980 goal of 50 cents/watt (1975 dollars). Remaining elements of a P/V power system (structure battery storage, regulation, control, and weather, are also significant cost items. The costs of these remaining elements are referred to as Balance of System (BOS) costs. The BOS costs are less well defined and documented than module costs. The Lewis Research Center (LERC) in 1978 and 1979 has determined the costs of each test power systems which will be installed in 1978. These costs were divided into five categories and analyzed. A regression analysis was performed to determine correlations of BOS Costs per peak watt with power size for these photovoltaic systems. The statistical relationship may be expressed as for flat plate, OC systems ranging from 100 to 4,000 peak watts. A survey of suppliers was conducted for comparison with the predicted BOS cost relationship.

Author
developmental test bed for the Mod-0A operational wind turbines which are currently used on utility networks. The mechanical and control system are described as they evolved in operational tests and some of the experience with various systems in the downwind rotor configurations are elaborated.

G.G.

N78-28633† National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

DOE/NASA MOD-0A WIND TURBINE PERFORMANCE
for presentation at the 12th Interscience Energy Conversion Eng.
Conf., San Diego, Calif. 20-25 Aug. 1978
Contract E(49-28)-1004
NTIS. HC AO2/MF AO1 CSCL 10A

Design and operation of a large wind turbine at Clayton,
New Mexico is reported. This is the first of three identical 200 kW
wind turbines to be operated on electric utility networks. A comparison between its predicted and measured power versus wind speed performance is presented.

G.G.

N78-20854† National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

DESCRIPTION AND STATUS OF NASA-LERC/DOE
PHOTOVOLTAIC APPLICATIONS SYSTEMS
Anthony F. Rataczak 1978 10 p. ref. Presented at the
13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 June
1978; sponsored by the IEEE (Contract E(49-26)-1022)
NTIS. HC AO2/MF AO1 CSCL 10A.

Designed, fabricated and installed were 16 geographically
dispersed photovoltaic systems. These systems are powering a
refrigerator, highway warning sign, forest lookout tower, remote
weather stations, a water chiller at a wastewater testing center, and insect
survey traps. Each of these systems is described in terms of load
requirements, solar array and battery size, and instrumentation
and controls. Operational experience is described and present
status is given for each system. The P/V power systems have
proved to be highly reliable with almost no problems with modules
and very few problems overall.

Author

N78-29065† National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

DESIGN AND FABRICATION OF A PHOTOVOLTAIC POWER
SYSTEM FOR THE PAPAGO INDIAN VILLAGE OF SCHU-
CHULI (GUNSIGHT), ARIZONA
William J. Bifano, Anthony F. Rataczak, and William J. Ice 1978
10 p. Presented at the 13th Photovoltaic Specialists Conf.,
Washington, D. C., 5-8 June 1978; sponsored by the IEEE
(Contract E(49-26)-1022)
NTIS. HC AO2/MF AO1 CSCL 10A

A stand alone photovoltaic power system for installation in
the Papago Indian village of Schuchuli is being designed and
fabricated to provide electricity for village water pumping and
basic domestic needs. The system will consist of a 3.2 kW
peak photovoltaic array, controls, instrumentation, and
storage batteries located in an electrical equipment building and
a 120 volt dc village distribution network. The system will power a
2 HP dc electric motor.

Author

N78-27820† National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

SELF-RECONFIGURING SOLAR CELL SYSTEM Patent
Application
Robert P. Gruber, inventor (to NASA) Filed 19 June 1978
NTIS. HC AO2/MF AO1 CSCL 10A

An improved solar cell system is reported that utilizes control
circuits to switch some of its cells so that they can be either

N78-37828† National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

COST OF PHOTOVOLTAIC ENERGY SYSTEMS AS DETER-
MINED BY BALANCE-OF-SYSTEM COSTS
(NASA-TM-78957, E-9708) Avail. NTIS. HC AO2/MF AO1
CSCL 10B

The effect of the balance-of-system (BOS) i.e., the total
system less the photovoltaic portion plus installation, on the
cost of multikilowatt flat-plate systems is examined. Present BOS
rates are in the range of 10 to 16 dollars per peak watt (1978
dollars). BOS rates represent approximately 50% of total system
cost. The possibility of future BOS cost reduction is examined.
It is concluded that, given the nature of BOS costs and the
lack of comprehensive national effort focussed on cost reduction,
it is unlikely that BOS costs will decline greatly in the next
several years. This prognosis is contrasted with the expectations
of the Department of Energy Photovoltaic Program goals
and pending legislation in the Congress which require a BOS
cost reduction of an order of magnitude or more by the
mid 1980s.

Author

N78-28007† National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

AN IMPROVED METHOD FOR ANALYSIS OF HYDROXIDE
AND CARBONATE IN ALKALINE ELECTROLYTES CON-
TAINING ZINC
Margaret A. Redd 1978 14 p. ref. To be presented at the
15th meeting of the Electrochem. Soc., Inc. Pittsburgh,
15 Oct 1978
(NASA-TM-78961) Avail. NTIS. HC AO2/MF AO1 CSCL 10C

A simplified method for titration of carbonate and hydroxide
in alkaline battery electrolytes is presented, involving a saturated
KSCN solution as a complexing agent for zinc. Both hydroxide
and carbonate can be determined in the titration, and the
complexing reagent is readily prepared. Since the pH at the end
point is shifted from 8.3 to 7.9-8.0, cresol purple or phenolphthalein
red are used as indicators rather than phenolphthalein. Bromocresol
green is recommended for determination of the second end point
of a pH of 4.3 to 4.4.

Author

N78-28014† National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio

COMPARISON OF THREE EXPERIMENTAL METHODS
USED IN DETERMINING THE THERMAL PERFORMANCE
OF FLAT-PLATE SOLAR COLLECTORS Ph.D. Thesis - Kansas
Univ.
(NASA-TM-78929, E-9688) Avail. NTIS. HC AO2/MF AO1
CSCL 10A

Three experimental methods for evaluating the thermal performance of flat-plate solar collectors are presented. The
methods are classified according to the nature of the ambient
conditions encountered during experimental testing. The classifica-
tions are: (1) steady state, (2) quasi steady state, and (3) unsteady
state. Experimental tests on two solar collectors were conducted
in an indoor solar simulator, and also out of doors. From the
eperimental collector data, the collector efficiency factors, which
describe the steady state behavior of a collector, were determined
for each experimental method. A parameter identification
method based upon a discrete gradient optimization technique
was used to determine the collector parameters from unsteady
state data. Such a method would allow on line data reduction
and would enable speedy determination of the collector efficiency
factors from transient data. The design, construction and operation
of the test rig which was used to obtain the experimental data
are also described.

Author
A preliminary study of the sulfur electrode in organic solvents suggests that the system warrants further investigation for use in a low temperature (100 deg to 120 C) Na-S secondary battery. A qualitative screening was undertaken at 120 C to determine the solubilities and stabilities of Na2S and Na2S2 in representatives of many classes of organic solvents. From the screening and quantitative studies, two classes of solvents were selected for work: amides and cyclic polyalkalenes. Voltammetric and Na-S cell charge discharge studies of sulfide solutions in organic solvents (e.g., N, N-dimethylformamide) at 120 C suggested that the reversibilities of the reactions on Pt or high density graphite were moderately poor. However, the sulfur electrode was indeed reducible (and oxidizable) through the range of elemental sulfur to Na2S. Reactions and mechanisms are proposed for the oxidation reduction processes occurring at the sulfur electrode. Author

L.S.

N78-29567"/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE AND STABILITY ANALYSIS OF A PHOTOVOLTAIC POWER SYSTEM Final Report


The performance and stability characteristics of a 10 kVA photovoltaic power system are studied using linear Bode analysis and a nonlinear analog simulation. Power conversion efficiencies, system stability, and system transient performance results are given for system operation at various levels of solar insolation. Additionally, system operation and the modeling of system components for the purpose of computer simulation are described. F.O.S.

L.S.

N78-29568"/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE WIND TURBINE GENERATORS


The development associated with large wind turbine systems is briefly described. The scope of this activity includes the development of several large wind turbines ranging in size from 100 kW to several megawatt levels. A description of the wind turbine systems, their programmatic status, and a summary of their potential costs is included.

L.S.

N78-29569"/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL ENERGY STORAGE FOR INDUSTRIAL WASTE HEAT RECOVERY


The program is examined for waste heat recovery and reuse through thermal energy storage in five specific industries: 1) primary aluminum; 2) cement; 3) food processing; 4) paper and pulp; and 5) iron and steel. Preliminary results from Phase I feasibility studies suggest energy savings through fossil fuel displacement approaching 0.1 quadrillion Btu in the 1985 period. Early implementation of recovery technologies with minimal development appears likely in the food processing and paper and pulp industries, development of the other three categories, though equally desirable, will probably require a greater investment in time and dollars.

L.S.

N78-29577"/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STORAGE SYSTEMS FOR SOLAR THERMAL POWER


The development status is reviewed of some thermal energy storage technologies specifically oriented toward providing direct heat storage for solar central power systems and solar total energy systems. These technologies include sensible heat storage in cements and latent heat storage using both active and passive heat exchange processes. In addition, selected thermal storage concepts which appear promising for a variety of advanced solar thermal system applications are discussed.

L.S.

N78-29578"/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UTILIZATION OF SOLAR ENERGY IN DEVELOPING COUNTRIES: IDENTIFYING SOME POTENTIAL MARKETS


The potential use of solar electricity generated from photovoltaic cells is examined for nineteen developing nations. Energy and economic profiles are summarized for each country. A comparison is made between the use of autogeneration and photovoltaics in a rural area of Haiti.

Author

L.S.

N78-29583"/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE 200-KILOWATT WIND TURBINE PROJECT


The three 200 kilowatt wind turbines described, compose the first of three separate systems. Proposed wind turbines of the two other systems, although similar in design, are larger in both physical size and rated power generation. The overall objective of the project is to obtain early operation and performance data while gaining initial experience in the operation of large horizontal-axis wind turbines in typical utility environments. Several of the key issues addressed include the following: (1) impact of the variable power output (due to varying wind speeds) on the utility grid (2) compatibility with utility requirements (voltage and frequency control of generated power) (3) demonstration of unattended, fail-safe operation (4) reliability of the wind turbine system (5) required maintenance and (6) initial public reaction and acceptance.

L.S.

N78-31832"/ National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INITIAL TEST RESULTS WITH A SINGLE-CYLINDER RHOMBIC-DRIVE STIRLING ENGINE Final Report


A 4 kW (6 hp), single cylinder, rhombic drive Stirling engine was restored to operating condition, and preliminary characteriza-
A method for determining the atmospheric boundary layer and surface exchange processes in the atmosphere.

The importance of understanding the relationship between the surface and the atmosphere is highlighted. The study focuses on the atmospheric boundary layer (ABL) and its influence on surface processes.

Key points:
1. The ABL is crucial for understanding the exchange of energy, momentum, and mass between the surface and the atmosphere.
2. The study aims to improve the prediction of surface exchange fluxes and boundary layer characteristics.
3. The methodologies involve observational approaches and modeling techniques.

Methodology:
- **Observational Approaches:**
  - Use of lidar and radar data to detect atmospheric structures.
  - In situ measurements from aircraft and balloons.
- **Modeling Techniques:**
  - Numerical models to simulate ABL dynamics.
  - Integration of observational data into models for validation.

Results:
- Enhanced understanding of the ABL properties and their variability.
- Improved model accuracy for predicting surface exchange processes.

Future Work:
- Further development of observational techniques.
- Collaboration between different research groups.

Conclusions:
- The atmospheric boundary layer is a critical component of the Earth's energy balance.
- Improved models can lead to better predictions of climate and weather conditions.

Acknowledgments:
- Thanks to the contributors for their invaluable insights and data.
- Support from various funding agencies is gratefully acknowledged.

This paper summarizes and discusses the fuel cell system results of Phase I of the Energy Conversion Alternatives Study (ECAS). Ten advanced electric power systems for central-station baseload generation using coal were studied by NASA in ECAS. Three types of low-temperature fuel cells (solid polymer electrolyte, SPE, aqueous alkaline, and phosphoric acid) and two types of high-temperature fuel cells (molten carbonate, MC, and zirconia solid electrolyte, SE) were studied. The results indicate that (1) overall efficiency increases with fuel cell temperature, and (2) scale-up in powerplant size can produce a significant reduction in cost of electricity (COE) only when it is accompanied by utilization of waste fuel cell heat through a steam bottoming cycle and/or integration with a gasifier. For low-temperature fuel cell systems, the use of hydrogen results in the highest efficiency and lowest COE. In spite of higher efficiencies, the use of higher fuel cell replacement costs integrated SE systems have higher projected COEs than do integrated MC systems. Present data indicate that life can be projected to over 30,000 hr for MC fuel cells, but data are not yet sufficient for similarly projecting SE fuel cell life expectancy.


A pure thermochemical cycle is a system of linked regenerative chemical reactions which accepts only water and heat and produces hydrogen. Thermochemical cycles are potentially more efficient and cheaper means of producing hydrogen from water than is the generation of electricity followed by electrolysis. The Energy Storage Systems Division of the Department of Energy is currently funding a national program on thermochemical hydrogen production. The National Aeronautics and Space Administration is responsible for the technical management of this program. The goal is to develop a cycle which can potentially operate with an efficiency greater than 40% using a heat source providing a maximum available temperature of 1150 K. A closed bench scale demonstration of such a cycle would follow. This cycle would be labeled a ‘reference cycle’ and would serve as a baseline against which future cycles would be compared.


Energy consumption for the developed and non-developed world is expressed as a function of GNP. An almost straight-line graph results when energy consumption is treated in this manner. The richest countries consume the most energy, and the poorest countries the least. It therefore follows that greater energy production in the developing countries (leading to greater energy consumption) will contribute to their economic growth. Energy resources in the developing countries are compared, including: solid fossil fuels, crude oil, natural gas, oil shale, and uranium. Mention is also made of the potential of renewable energy resources, such as solar, wind, and hydroelectric power, in the underdeveloped world; and it is these resources which offer the greatest possibilities for economic development of the money is forthcoming, i.e., from the world bank, to fund the necessary technology. D.M.W.


The investigation of the Thermoelectronic Laser Energy Converter (TELEC) concept at the Lewis Research Center (LeRC) began with a feasibility study of a 1 megawatt size TELEC system. The TELEC was to use either cesium vapor or hydrogen as the plasma medium. The cesium vapor TELEC appears to be the more practical device studied with an overall calculated conversion efficiency of greater than 48%. This study of TELEC was fabricated and demonstrated the conversion of a small amount of solar power to electrical power. The cell developed a short circuit current of 0.7 amperes and an open circuit voltage, as extrapolated from the curves, of about 1.5 volts. Work is now in progress to construct and test a cesium vapor TELEC capable of absorbing 20% of an incident 10 kW, 10.6 micron beam, and converting 30% of this power to electrical power.


Seven computer codes for analyzing performance and loads in large, horizontal-axis wind turbines were used to calculate blade bending moment loads for two operational conditions of the 100 kW Mod-O wind turbine. Results are compared with test data on the basis of cycle loads, peak loads, and harmonic contents. Four of the seven codes include rotor-tower interaction and three are limited to rotor analysis. With few exceptions, all calculated loads were within 25% of nominal test data.


Materials for solar cell module construction have been studied on the basis of limited real time outdoor exposure evaluations. The materials tested included transmission samples, sub-modules, and...
actual solar cells. The results suggest that glass, fluorinated ethylene propylene, and perfluoroalkoxy are good materials for the covering or encapsulation of solar-cell modules. In all cases, dirt accumulation and cleanliness are important factors.

S.C.S.


An outline is presented of changes in measurement procedures concerning solar cells. Outdoor measurements of cell performance based on pyranometer or pyrheliometer determination of intensity are discouraged. The absolute scale of irradiance is to be adopted as soon as possible. The standard atmosphere conditions are 1000 W/m² irradiance, temperature 28°C, air mass 1.5, and precipitable water vapor content of 2 cm. The allowable light sources for solar simulation are short arc xenon lamps, pulsed xenon lamps, and dichroic filtered tungsten lamps. Key considerations in the design of a reference cell are considered and approaches for the matching of a reference cell to a test cell or modules are discussed. G.R.


The ERDA LeRC Photovoltaic Systems Test Facility (STF) provides a vital support function to the overall ERDA National Solar Photovoltaic Program. It allows preliminary investigation and checkout of components, subsystems, and complete photovoltaic systems before installation in actual service. The STF can also be used to determine optimum system configurations and operating modes. A facility description is presented, taking into account the solar cell array, the energy storage equipment, the power conditioning equipment, electric utility distribution network and loads, and instrumentation and data acquisition systems. Safety procedures which have been set up for maintenance and inspection of the solar array are discussed. Attention is also given to a number of investigations regarding the effect of environmental factors on solar cell array operation. G.R.


Wind turbine configurations that would lead to generation of electrical power in a cost effective manner were considered. All possible overall system configurations, operating modes, and subsystem concepts were evaluated for both technical feasibility and compatibility with utility networks, as well as for economic attractiveness. A design optimization computer code was developed to determine the cost sensitivity of the various design features, and thus establish the configuration and design conditions that would minimize the generated energy costs. The preliminary designs of both a 500 kW unit and a 1500 kW unit operating in a 12 mph and 18 mph median wind speed respectively, were developed. The rationale employed and the key findings are summarized. Author


Topics include surface studies (laser surface treatments, basic surface experiments, and activation chamber experiments); plasma studies (converter theory and enhanced mode conversion experiments); and component development (low temperature conversion experiments, high efficiency conversion experiments, and heat shield development).


The use of thermal energy storage (TES) in the latent heat of molten salts as a means of conserving fossil fuels and lowering the cost of electric power was evaluated. Public utility systems provided electric power on demand. This demand is generally maximum during late weekday afternoons with considerably lower overnight and weekend loads. Typically, the average demand is only 60% to 80% of peak load. As peak load increases, the present practice is to purchase power from other grid facilities or to bring older less efficient fossil-fuel plants on line which increase the cost of electric power. The widespread use of oil-fired boilers, gas turbine and diesel equipment to meet peak loads depletes our oil based energy resources. Heat exchangers utilizing molten salts can be used to level the energy consumption curve. The study begins with a demand analysis and the consideration of several existing modern fossil-fuel and nuclear power plants for use as models. Salts are evaluated for thermodynamic, economic, corrosive, and safety characteristics. Heat exchanger concepts are explored and heat exchanger designs are conceived. Finally, the economics of TES conversions in existing plants and new construction is analyzed. The study concluded that TES is feasible in electric power generation. Substantial data are presented for TES design, and reference material for further investigation of techniques is included. Author


Several procedures are presented for latent heat thermal energy storage systems that can be used for electric utility off-peak energy storage, solar power plants and other preliminary design applications. Author


All possible overall system configurations, operating modes, and subsystem concepts for a wind turbine configuration for cost effective generation of electrical power were evaluated for both technical feasibility and compatibility with utility networks. Author
as well as for economic attractiveness. A design optimization computer code was developed to determine the cost sensitivity of the various design features, and thus establish the configuration and design conditions that would minimize the generated energy costs. The preliminary design of both a 500 kW unit and a 1800 kW unit, operating in a 12 mph and 18 mph medium wind speed respectively, were developed. The various design features and components evaluated are described, and the rationale employed to select the final design configuration is given. All pertinent technical performance data and component cost data are included. The costs of all major subassemblies are estimated and the resultant energy costs for both the 500 kW and 1500 kW units are calculated. Author


Additional design and analysis data are provided to supplement the results of the two parallel design study efforts. The key results of the three supplementary tasks are: (1) The velocity duration profile has a significant effect in determining the optimum wind turbine design parameters and the energy generation cost (2) Modest increases in capacity factor can be achieved with small increases in energy generation costs and capital costs. (3) Reinforced concrete towers that are aesthetically attractive can be designed and built at a cost comparable to those for steel truss towers. The approach used, method of analysis, assumptions made, design requirements, and the results for each task are discussed in detail. Author


The objective of NAS 3 20138 was the development and evaluation of improved anion selective membranes useful as efficient separators in a recirculating power storage cell system being constructed. The program was divided into three parts, (a) optimization of the selected candidate membrane systems, (b) investigation of alternative membranes/polymer systems, and (c) characterization of candidate membranes. The major synthesis effort was aimed at improving and optimizing as far as possible each candidate system with respect to three critical membrane properties essential for good redox cell performance. Substantial improvements were made in 5 candidate membrane systems. The critical synthesis variables of cross-link density, monomer ratio, and solvent composition were examined over a wide range. In addition eight alternative polymer systems were investigated, two of which attained candidate status. Three other alternatives showed potential but required further research and development. Each candidate system was optimized for selectivity. Author


An analytical representation of a wind turbine generator is presented which employs blade pitch angle feedback control. A mathematical model was formulated with the functioning MOD 0 wind turbine serving as a practical case study. Results of computer simulations of the model as applied to the problem of dynamic stability at rated load are also presented. The effect of the tower shadow was included in the input to the system. Different configurations of the drive train and, optimal values of the tie line reactance were used in the simulations. Computer results revealed that a static excitation control system coupled with optimal values of the tie line reactance would effectively reduce oscillations of the power output, without the use of a slip clutch. Author


A three part technical study was conducted whereby parametric technical and economic feasibility data were developed on several power conversion systems suitable for the generation of central station electric power through the combustion of hydrogen and its use as the resulting heat energy in turbogenerator equipment. The study assessed potential applications of hydrogen-fueled power conversion systems and identified the three most promising candidates. (1) Ericsson Cycle, (2) gas turbine, and (3) direct steam injection system for fossil fuel as well as nuclear powerplants. A technology development strategy for the implementation on the three systems from which the direct injection system (fossil fuel only) was selected for a preliminary conceptual design of an integrated hydrogen-fueled power conversion system. Author


Preliminary designs of low power (50 to 500 kW) and high power (1500 to 3000 kW) wind generator systems (WGS) for electric utility applications were developed. These designs provide the bases for detailed design, fabrication, and experimental demonstration testing of these units at selected utility sites. Several feasible WGS configurations were evaluated, and the concept offering the lowest energy cost potential and minimum technical risk for utility applications was selected. The selected concept was optimized utilizing a parametric computer program prepared for this purpose. The utility requirement evaluation task examined the economic operational and institutional factors affecting the WGS in a utility environment, and provided additional guidance for the conceptual design task. The conceptual design task indicated that a rotor operating at constant speed driving an AC generator through a gear transmission is the most cost effective WGS configuration. Author


In the conceptual design task, several feasible wind generator systems (WGS) configurations were evaluated, and the concept offering the lowest energy cost potential and minimum technical risk for utility applications was selected. In the optimization task, the selected concept was optimized utilizing a parametric computer program prepared for this purpose. In the preliminary design task, the optimized selected concept was sized and analyzed in detail. The utility requirement evaluation task examined the economic operational and institutional factors affecting the WGS in a utility environment and provided additional guidance for the preliminary design effort. Results of the conceptual design task indicated that a rotor operating at constant speed driving an AC generator through a gear transmission is the most cost effective WGS configuration. Author
task indicated that a rotor operating at constant speed, driving an AC generator through a gear transmission is the most cost effective WGS configuration. The optimization task results led to the selection of a 500 kWe rating for the low power WGS and a 1500 kWe rating for the high power WGS. 

Author

N78-24874*/ Thermo Electron Corp., Waltham, Mass.
ERDA/NASA ADVANCED THERMIONIC TECHNOLOGY PROGRAM Progress Report May 1977 24 p refs (Contracts NAS3-20302, EY-78-C-02-3698) (NASA CR-157117; PR-23, TE-4217/4220-140-77; COO-3056-28) Avail. NTIS HC AO2/MF AO1 CSCL 10A Research progress is outlined in the areas of surface studies (basic experiments and direct beam chamber, plasma studies, converter development, component development (low-temperature and high-temperature converter experiments), and component hardware (hot shell development). 

ERA

ERDA/NASA ADVANCED THERMIONIC TECHNOLOGY PROGRAM Program Report Aug 1977 16 p refs (Contracts NAS3-20969, EY-78-C-02-3068) (NASA CR-157222, PR-26, TE-4220/4233-29-78; COO-3056-28) Avail. NTIS HC AO2/MF AO1 CSCL 10B Research is summarized on surface studies (work functions of different LaB6 surfaces, plasma studies, converter development (tungsten emitter, nickel collector and tungsten emitter La B6 collector), and hot shell development for using thermionic converters in the topping cycle of fossil-fuel plants. Author (ERA)

EVALUATION OF GLASS RESIN COATINGS FOR SOLAR CELL APPLICATIONS Final Report M S Beed Apr 1978 38 p (Contracts NAS3-20968) (NASA CR 159392) Avail. NTIS HC A03/MF AO1 CSCL 10A Using a variety of non vacuum deposition techniques, coatings were implemented on silicon solar cells and arrays of cells interconnected on Kaption substrates. The coatings provide both antireflection optical matching and environmental protection. Reflectance minima near 2% was achieved at a single wavelength in the visible. Reflectance averaging below 5% across the useful collection range was demonstrated. The coatings and methods of deposition were (1) Ta2O5 spun on or sprayed, (2) Ta2O5 SnO2 spun on or sprayed, (3) SnO sprayed on the surface, (4) Cr2O3 spun on or sprayed, (5) Al spun on the surface. The thicknesses were in the range of 18 microns to 25 microns. The coatings and processes are compatible with single cells or cells mounted on Kaption substrates. 

G.Y

N78-27562*/ Thermo Electron Corp., Waltham, Mass.
ERDA NASA ADVANCED THERMIONIC TECHNOLOGY PROGRAM Progress Report Sep 1977 11 p (Contracts NAS3-20959, EY-78-C-02-3056) (NASA CR 1524/4; 14270/4/223/44 78; COO 3056-29 PR 2/5) Avail. NTIS HC AO2/MF AO1 CSCL 10A Research progress is briefly outlined in the areas of activation experiments, enhanced mode conversion experiments, converter development (tungsten emitter, lanthanum hexaboride collection and hot shell development. Author (ERA)

PRELIMINARY DESIGN STUDY OF AN ALTERNATE HEAT SOURCE ASSEMBLY FOR A BRAYTON ISOTOPIC POWER SYSTEM Final Report Oct 1977 - Apr 1978 Hal J. Stumpf May 1978 112 p refs Prepared for JPL (Contract NAS3-20618) (NASA CR-135428; AirResearch-78-15171) Avail. NTIS HC AO5/MF AO1 CSCL 10A Results are presented for a study of the preliminary design of an alternate heat source assembly (HSA) intended for use in the Brayton isotopic power system (BIPS). The BIPS converts thermal energy emitted by a radioactive heat source into electrical energy by means of a closed Brayton cycle. A heat source heat exchanger configuration was selected and optimized. The design consists of an 8 turn helically wound Hastelloy tube. Thermal analyses were performed for various operating conditions to ensure that post impact containment shell (PICS) temperatures remain within specified limits. These limits are essentially satisfied for all modes of operation except for the emergency cooling system for which the PICS temperatures are too high. Neon was found to be the best choice for a fill gas for auxiliary cooling system operation. Low cycle fatigue life, natural frequency, and dynamic loading requirements can be met with minor modification to the existing HSA. 

B.B

AMION PERMESELECTIVE MEMBRANE S S Alexander and R B Hodgdon Jan 1978 77 p (Contracts NAS3-20108, E40-28-1002) (NASA CR-135316, CON5/O101) Avail. NTIS HC AO5/MF AO1 CSCL 10A Experimental amion permeselective membranes were improved and characterized for use as separators in a chemical redox power storage cell being developed at the NASA Lewis Research Center. The goal of minimal Fe(3) ion transfer was achieved for each candidate membrane system. Membrane resistivity was demonstrated by reduction of film thickness using synthetic backing materials but usefulness of thin membranes was limited by the scarcity of compatible fabrics. The most durable and useful backing fabrics were modacrylics. One membrane, a copolymer of 4 vinylpyridine and vinyl benzylchloride was outstanding in overall electrochemical and physical properties. Long term (1000 hour) test of the membrane chemical and thermal durability in redox environment was shown by three candidate polymers and two membranes. The remainder had good durability at ambient temperature. Manufacturing capability was demonstrated for large scale production of membrane sheets 5.5 sq ft in area for two candidate systems. 

Author

N78-29664*/ Rohr Industries, Inc. Chula Vista, Calif.
PRELIMINARY POWER TRAIN DESIGN FOR A STATE-OF-THE-ART ELECTRIC VEHICLE Final Report James A. Ross and Gerald A. Wooldridge Apr 1978 222 p refs (Contracts NAS3-20682, EC-77-A-31-1044) (NASA CR 136540, RHR-78-026, DQ2/NASA/0592-78/1) Avail. NTIS HC AO10/MF AO1 CSCL 10A The state-of-the-art (SOTA) of electrical vehicles built since 1965 was reviewed to establish a base for the preliminary design of a power train for a SOTA electric vehicle. The performance of existing electric vehicles were evaluated to establish preliminary specifications for a power train design using state-of-the-art technology and commercially available components. Power train components were evaluated and selected using a computer simulation of the SAE J227a Schedule D driving cycle. Predicted range was determined for a number of motor and controller combinations in conjunction with the mechanical elements of power train and a battery pack of two 60 ampere-hour, 4717 kg at 0.033 MJ/kg (1104 lbs at 117 Wh/lb) on the basis of maximum range and overall system efficiency using the Schedule D cycle. An induction motor and 3 phase inverter/ controller was selected as the optimum combination when used with a two speed transaxle and steel belted radial tires. The predicted Schedule D range is 904.5 km (562 mi). Four near term improvements in the SOTA were identified: evaluated, and predicted to increase range approximately 7%.

F.D.S

Several uses of thick-film technology in solar cell fabrication are discussed. Wrap-around contacts are obtained by first printing and firing a dielectric over the edge and subsequently applying a low-firing temperature conductor. Interconnection of cells into arrays can be achieved by printing and co-firing thick-film pastes, sintering, or with heat-treating conductive oxides on low-cost substrates. Despite ongoing research, printed (thick) film wires and conductive coatings do not yet offer sufficient optical uniformity and transparency for use on silicon. Ohmic contacts on n- and p-type silicon are considered.

M.L.


Reduction of the ionization and scattering losses associated with ignited mode cesium diodes is essential for high thermal-to-electrical conversion efficiency. Use of an auxiliary electrode in conjunction with a noble gas in the interelectrode space should permit more efficient ion generation for space charge neutralization. The characteristics of a thermionic triode utilizing a ring electrode and a dispersive cathode, in which the anode has been studied as a function of anode pressure, cesium reservoir temperature, spacing, electrode temperature and pulse parameters (potential, density and repetition rate) applied to the auxiliary electrode. Pulse operation significantly enhanced output power with uniform discharges appearing to be sustained at emitter-collector spacings as low as 0.6 mm. (Author)


A pulse charger which uses water cooled 1000 amp transistor switches has been developed to determine empirically the best methods of rapidly charging large cells in the one to two volt range. The pulse charger is capable of delivering a positive current from 0 to 1000 amp, and a negative current from 0 to 1000 amp. The charger can supply a 1000 amp DC charge or can switch 1000 amps at a rate of 1000 Hz. Special attention is given to problems associated with rapid switching of high currents through use of transistors. (Author)


The Open-Cycle Gas Turbine/Steam Turbine Combined Cycle can be an effective energy conversion system for converting coal to electricity. The intermediate step in this energy conversion process is to convert the coal into a fuel acceptable to a gas turbine. This can be accomplished by producing a synthetic gas or liquid, and by removing, in the fuel conversion step, the elements in the fuel that would be harmful to the environment if combusted. In this paper, two open cycle gas turbine combined systems are evaluated: one employing an integrated low-Btu gasifier, and one utilizing a semi-clean liquid fuel. A consistent technical/economic information base is developed for these two systems, and compared with a reference steam plant burning coal directly in a conventional furnace. (Author)


The desire to establish an efficient Energy Conversion System to utilize the fossil fuel of the future coal has produced many candidate systems. A composite technical economic evaluation was performed on the seven most attractive advanced energy conversion systems. The evaluation maintains a cycle to cycle consistency in both performance and economic projections. The technical information base can be employed to make program decisions regarding the most attractive concept. A reference steam power plant was analyzed to the same detail and, under the same ground rules, was used as a comparison base. The power plants were all designed to utilize coal or coal derived fuels and were targeted to meet an environmental standard. The systems evaluated were two advanced steam systems, a potassium looping cycle, a closed cycle helium system, two open cycle gas turbine combined cycles, and an open cycle HED system. (Author)


The dendritic web process for growing long thin ribbon crystals of silicon and other semiconductors is described. Growth is initiated from a thin amorphous dendirite seed which is blown into contact with the melt surface. Initially, the seed grows laterally to form a button at the melt surface, when the seed is withdrawn new-like dendrites propagate from each end of the button into the melt, and the web portion of the crystal is formed by the solidification of the liquid film supported by the button and the bounding dendrites. Application used for dendritic web growth, material characteristics, and the two distinctly different mechanisms involved in the growth of a single crystal are examined. The performance of solar cells fabricated from dendritic web material is indistinguishable from the performance of cells fabricated from Czochralski grown material. D. J. P. L. M.

A78-33827H Honeywell, Inc., Minneapolis, Minn.

DEVELOPMENT OF FLAT-PLATE SOLAR COLLECTORS FOR THE HEATING AND COOLING OF BUILDINGS: EXECUTIVE SUMMARY

A78-33827H (Contract NAS3-17982)

(NASA CR-134804) Aided: NTIS HC A02/MF A01 CSCL 10A

An efficient, low cost, flat-plate solar collector was developed. Computer aided mathematical models of the heat process in the collector were used in defining absorber panel configurations; determining insulation thickness; and in selecting the number, spacing, and material of the covers. Prototypes were built and performance tested. Data from simulated operation of the collector are compared with predicted loads from a number of locations to determine the degree of solar utilization. S.B.S.

A description is given of the NASA Global Atmospheric Sampling Program (GASP), taking into account the onboard system which collects atmospheric data automatically, the extensive atmospheric measurement capability, and the data handling and distribution procedure. GASP was implemented to assess the environmental impact of aircraft exhaust emissions in the upper troposphere and lower stratosphere. Global air quality data are to be obtained for a period of five to ten years. Measurements of pollutants not related to aircraft exhaust emissions, such as chlorofluoromethanes, are now included. GASP systems are operating on a United Airlines 747, two Pan Am 747s, and a Qantas Airways of Australia 747. Real-time, in situ measurements are conducted of ozone, water vapor, carbon monoxide, and oxides of nitrogen. Chlorofluoromethanes are measured by laboratory analysis. Typical GASP data show significant changes in ozone, carbon monoxide, and water vapor related to crossings of the tropopause. G.R.
46 GEOPHYSICS

Includes aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism.

For space radiation see 93 Space Radiation.


Atmospheric ozone in the upper troposphere and lower stratosphere north of the equator has been measured aboard two commercial B-747 aircraft during the Spring of 1976. This monitoring is part of a much broader and continuing project developed by NASA and known as the Global Atmospheric Sampling Project (GASP). Additional flight and meteorological conditions have also been automatically recorded on board concurrent with the ozone measurements. Independently derived tropopause pressure information was available from NMC data archives and was used to identify stratospheric and tropospheric flight. The composite ozone, flight and meteorological data are reported for selected dates in March, April, and May. Attention is drawn particularly to the vertical profiles of atmospheric ozone mixing ratios as a function of both distance from the tropopause and curvature of the streamlines. The GASP observations suggest that ozone levels typical of the lower atmosphere are often embedded in the upper troposphere, principally during occasions when cycloidal wind curvatures were noted.

Author


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Author
theoretical approaches. The measured experimental fluxes have been combined with recent quantum yield data to calculate the OD(10) photoproduction rate for various albedo values. This rate is larger than that used in models by about a factor of 2 for reasonable values of assumed albedo.

(Investigation)


With the development of a large magnetized plasma source it has become possible to investigate space plasma physics problems in the laboratory. First, the nonlinear effects associated with the excitation of a large amplitude whistler wave have been explored. It is found that the radiation pressure of the wave and thermal effects give rise to a field-aligned density depression in which the wave becomes completely trapped. Hyperfine filaments with diameters small compared with the parallel wavelength are observed. Second, the stability of oblique whistler waves in the presence of an electron beam has been studied. A broadband whistler instability is observed and identified as a Cherenkov interaction between beam electrons and whistlers propagating near the resonance cone. These observations confirm the present model for the generation of VLF hiss in the aurora.

(Author)
47 METEOROLOGY AND CLIMATOLOGY

Includes weather forecasting and modification.

N75-17688* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AUTOMATED METEOROLOGICAL DATA FROM COMMERCIAL AIRCRAFT VIA SATELLITE: PRESENT EXPERIENCE AND FUTURE IMPLICATIONS

A low cost communications system to provide meteorological data from commercial aircraft in near real-time, on a fully automated basis, has been developed. The complete system including low profile antenna and all installation hardware weighs 34 kg. The prototype system was installed on a Boeing 747 aircraft and provided meteorological data (wind angle and velocity, temperature, altitude and position as a function of time) on a fully automated basis. The results were exceptional. This concept is expected to have important implications for operational meteorology and airline route forecasting.

Author

N75-19710* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PHOTOVOLTAIC REMOTE INSTRUMENT APPLICATIONS: ASSESSMENT OF THE NEAR-TERM MARKET

A preliminary assessment of the near-term market for photovoltaic remote instrument applications is presented. Among the potential users, two market sectors are considered: government and private. However, the majority of the remote systems studied are operated by or for the federal, state, or local governments. Environmental monitoring and surveillance remote instrument systems are discussed. Based on information obtained in this preliminary market survey, a domestic civilian market of at least 1.3 MW sub pk is forecast for remote instrument systems. This estimate is exclusive of several potentially large-scale markets for remote instruments which are identified but for which no hard data is available.

Author


A fractoelastic, adiabatic model is used to study the growth of random vortices in an atmosphere with buoyant instability and vertical wind shear, taking account of the effects of axial drag, heat transfer, and precipitation-induced downdrafts. It is found that downdrafts of tornadic magnitude may occur in negatively buoyant columns. The radial inflow velocity required to maintain a given maximum tangential velocity in a tornado is determined by using a turbulent vortex model. A toroidal model which involves a rotating parent cloud as well as buoyancy and precipitation effects is also discussed.

B. J.
51 LIFE SCIENCES (GENERAL)

Includes genetics.

N78-32918* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
THE USE OF AN ION-BEAM SOURCE TO ALTER THE SURFACE MORPHOLOGY OF BIOLOGICAL IMPLANT MATERIALS
Conf., San Antonio, 29 Apr. - 2 May 1976
(NASA-TM-78851: E-9873) Avail: NTIS HC A03/MF A01
CSCI 06C

An electron bombardment ion thruster was used as a neutralized ion beam sputtering source to texture the surfaces of biological implant materials. Scanning electron microscopy was used to determine surface morphology changes of all materials after ion-texturing. Electron spectroscopy for chemical analysis was used to determine the effects of ion texturing on the surface chemical composition of some polymers. Liquid contact angle data were obtained for ion textured and untreated polymer samples. Results of tensile and fatigue tests of ion-textured metal alloys are presented. Preliminary data of tissue response to ion textured surfaces of some metals, polytetrafluoroethylene, alumina, and segmented polyurethane were obtained.

Author

N78-31880* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
DIGITAL ENHANCEMENT OF COMPUTERIZED AXIAL TOMOGRAMS
1978: cosponsored by IEEE, NIH, and Stanford Univ. School of Med
(NASA-TM-78974: E-9748) Avail: NTIS HC A02/MF A01
CSCI 05E

A systematic evaluation was conducted of certain digital image enhancement techniques performed in image space. Three types of images were used, computer generated phantoms, tomograms of a synthetic phantom, and axial tomograms of human anatomy containing images of lesions, artificially introduced into the tomograms. Several types of smoothing, sharpening, and histogram modification were explored. It was concluded that the most useful enhancement techniques are a selective smoothing of singular picture elements, combined with contrast manipulation. The most useful tool in applying these techniques is the gray-scale histogram.

L.S.

N78-18672* Case Western Reserve Univ., Cleveland, Ohio.
Dept. of Biomedical Engineering.
EFFECT OF SURFACE TEXTURE BY ION BEAM SPUTTERING ON IMPLANT BIOMCOMPATIBILITY AND SOFT TISSUE ATTACHMENT Annual Report
Donald F. Gebbons Dec. 1977 15 p refs
(Grant No: 3128)
(NASA-CR-135311: AR-1) Avail: NTIS HC A02/MF A01
CSCI 06C

The objectives in this report were to use the ion beam sputtering technique to produce surface textures on polymers, metals, and ceramics. The morphology of the texture was altered by varying both the width and depth of the square pits which were formed by ion beam erosion. The width of the rib separating the pits were defined by the mask used to produce the texture. The area of the surface containing pits varies as the width was changed. The biological parameters used to evaluate the biological response to the texture were: (1) fibrous capsule and inflammatory response in subcutaneous soft tissue; (2) strength of the mechanical attachment of the textured surface by the soft tissue, and (3) morphology of the epidermal layer interfacing the textured surface of percutaneous connectors. Because the sputter yield on teflon ribs was approximately an order of magnitude larger than any other material the majority of the measurements presented in the report were obtained with teflon.

Author
A surgical tissue macerating and removal tool is described which has a rotating rod with a cutting member at one end and which is disposed in a tube which is then contained in an extension of the tool handle. A frusto-conical member extends into the extension at the cutter member end of the rotating rod with its small end engaging the tube. The portion of the frusto-conical member outside of the extension forms a tissue engaging member and may be cut-off at an angle to the axis of the rod to form a tissue engaging edge. Apertures are provided in the extension adjacent the frusto-conical member so that treatment fluid supplied in the annular space between the tube and the extension may flow to the operative site. An aperture is provided in the frusto-conical member between the extension and the tube so that fluid may also flow into the tube where it mixes with macerated tissue being directed through an aperture in the tube to a passageway which may have suction applied to help remove macerated material.

Official Gazette of the U.S. Patent Office

A toxicity profile is provided, of 187 toxic substances procured by NASA Lewis Research Center during a 3 1/2 year period, including 27 known or suspected carcinogens. The goal of the program is to ensure that the center's health and safety personnel are aware of the procurement and use of toxic substances and to alert and inform the users of these materials as to the toxic characteristics and the control measures needed to ensure their safe use. The program also provides a continuing record of the toxic substances procured, who procured them, what other toxic substances the user has obtained in the past, and where similar materials have been used elsewhere at the center.

Author
54 MAN/SYSTEM TECHNOLOGY
AND LIFE SUPPORT

Includes human engineering, biotechnology, and space suits and protective clothing.

NTS-24807* National Aeronautics and Space Administration,
Lewis Research Center, Cleveland, Ohio.
ESCORT: A DATA ACQUISITION AND DISPLAY SYSTEM
TO SUPPORT RESEARCH TESTING
Robert L. Miller 1978 10 p Presented at Electro 1978,
Boston, 23-25 May 1978; sponsored by IEEE
(NASA-TM-78909; E-8544) Avail: NTIS HC AO1/MF AO1
CSCL 088

Primarily designed to acquire data at steady state test conditions, the system can also monitor slow transients such as those generated in moving to a new test condition. The system configuration makes use of a microcomputer at the test site which acts as a communications multiplexer between the measurement and display devices and a centrally located minicomputer. A variety of measurement and display devices are supported using a modular approach. This allows each system to be configured with the proper combination of devices to meet the specific test requirements, while still leaving the option to add special interfaces when needed. Centralization of the minicomputer improves utilization through sharing. The creation of a pool of minis to provide data acquisition and display services to a variable number of running tests also offers other important advantages.

Author
60 COMPUTER OPERATIONS
AND HARDWARE

Includes computer graphics and data processing.
For components see 33 Electronics and Electrical Engineering.

N78-23781g National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

A DATA ACQUISITION AND HANDLING SYSTEM FOR THE
MEASUREMENT OF RADIAL PLASMA TRANSPORT
RATES
W. M. Krasewicz, C. E. Boyd (Texas Univer. Austin), J. Y. Hong
(Texas Univer. Austin), and E. J. Powers (Texas Univer. Austin) 1977
Res. Knoxville, Tenn. 25-28 Oct 1977
(NASA-TM-78649), AAI: NTIS HC AO5/MI A01 CSCL 098

A system which allows the transfer of experimental data
from one or more transient recorders to a digital computer, the
entry of calibration data and the entry of archival data is described.
The overall approach is discussed and illustrated in detail.

Author

A78-37685 J. # Escott: A data acquisition and display system
to support research testing. R. L. Miller (NASA, Lewis Research
Center, Cleveland, Ohio). Institute of Electrical and Electronics
Engineers ELECTRO '78 Conference, Boston, Mass., May 23-25,

A combination of a central minicomputer and test-site micro-
computers has been adopted to provide on-line data acquisition and
display service for a large number of different research programs. By
integrating the data acquisition and recording functions in the
minicomputer/microcomputer system, rapidly updated displays of
selected data in terms of engineering units may be obtained. The
system described here is primarily designed for steady-state test
conditions, but may also provide data on slow transients associated
with changing experimental conditions. Application of the system to
full-scale jet engine tests, ion thruster assessments and anechoic
chamber analyses are mentioned.

J. M. B.
61 COMPUTER PROGRAMMING AND SOFTWARE

Includes computer programs, routines, and algorithms.

N78-10749‡ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
USER'S GUIDE FOR SFTRAN/380
(NASA-TP-1008; E-9264) Avail: NTIS HC AO4/MF AO1 CSL 089
An extension and improvements made to SFTRAN, a structured-programming language are discussed. This improved language is implemented as a precompiler that translates from SFTRAN to FORTRAN. The SFTRAN language and its use are described. Time-Sharing System (TSS) command procedures were implemented that eliminate the complications of dealing with extra files and processing steps which the use of a precompiler would otherwise require. These command procedures are described and their use is illustrated by examples.

N78-10735‡ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
AN AUTOMATED PROCEDURE FOR CALCULATING SYSTEM MATRICES FROM PERTURBATION DATA GENERATED BY AN EAI PACEr AND 100 HYBRID COMPUTER SYSTEM
(NASA-TM-73869; E-8465) Avail: NTIS HC AO3/MF AO1 CSL 089
Techniques are presented for determining the elements of the A, B, C, and D state variable matrices for systems simulated on an EAI Pacer 100 hybrid computer. An automated procedure systematically generates disturbance data necessary to linearize the simulation model and stores these data on a floppy disk. A separate digital program verifies this data, calculates the elements of the system matrices, and prints these matrices appropriately labeled. The program automates form, the elements of the state variable matrices are approximated by finite difference calculations.

N78-17724‡ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
COMPUTER PROGRAM FOR CALCULATION OF COMPLEX CHEMICAL EQUILIBRIUM COMPOSITIONS, ROCKET PERFORMANCE, INCIDENT AND REFLECTED SHOCKS, AND CHAPMAN-JOUQUET DETONATIONS
(NASA-SP-273) Avail: NTIS HC AO7/MF AO1 CSL 089
A detailed description of the equations and computer program for computations involving chemical equilibrium in complex systems is given. A free-energy minimization technique is used. The program permits calculations such as (1) chemical equilibrium for assigned thermodynamic states (T,P), (H,P), (S,P), (T,V), (U,V), or (S,V), (2) theoretical rocket performance for both equilibrium and frozen compositions during expansion, (3) incident and reflected shock properties, and (4) Chapman-Jouquet detonation properties. The program considers condensed species as well as gaseous species.

N78-51791‡ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
FLOWNET: A COMPUTER PROGRAM FOR CALCULATING SECONDARY FLOW CONDITIONS IN A NETWORK OF TURBOMACHINERY
(NASA-TM-73774; E-8579) Avail: NTIS HC AO4/MF AO1 CSL 089
The program requires the network parameters, the flow component parameters, the reservoir conditions, and the gas properties as input. It will then calculate all unknown pressures and the mass flow rates in each flow component in the network. The program can treat networks containing up to fifty flow components and twenty-five unknown network pressures. The types of flow components that can be treated are face seals, narrow slots, and pipes. The program is written in both structured FORTRAN (SFTRAN) and FORTRAN 4. The program must be run in an interactive (conversational) mode.

N78-30802‡ Boeing Computer Services, Inc., Seattle, Wash.
Energy Technology Applications Div.
A SIMULATION MODEL FOR WIND ENERGY STORAGE SYSTEMS, VOLUME 1: TECHNICAL REPORT
Final Report
(Contracts NAS3-20385. E-149-281-1028)
(NASA-CR-135283; BCS-40180-1-Vol-1: CONS-038-S-1) Avail: NTIS HC AO8/MF AO1 CSL 089
A comprehensive computer program for the modeling of wind energy and storage systems utilizing any combination of five types of storage (pumped hydro, battery, thermal, flywheel and pneumatic) was developed. The level of detail of Simulation Model for Wind Energy Storage (SIMWEST) is consistent with a role of evaluating the economic feasibility as well as the general performance of wind energy systems. The software package consists of two basic programs and a library of system, environmental, and load components. The first program is a precompiler which generates computer models (in FORTRAN) of complex wind source storage application system from user specifications using the respective library components. The second program provides the techno-economic system analysis with the respective I/O, the integration of systems, dynamic, and the iteration for conveyance of variables. SIMWEST program, as described, runs on the UNIVAC 1100 series computers.

N78-10769‡ National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
USER'S GUIDE FOR SFTRAN/1100
(NASA-TP-1200; E-9445) Avail: NTIS HC AO3/MF AO1 CSL 089
Extensions and improvements were made to SFTRAN, a structured programming language. This language was implemented as a precompiler that translates from SFTRAN to FORTRAN. It was available to batch and conversational users of the UNIVAC 1100 computer system. The SFTRAN language and its use are described. In addition, conversational time-sharing system command subroutines were implemented that eliminated the complications of dealing with extra files and processing steps that the use of a precompiler would otherwise require. These command subroutines are reported, and their use is illustrated by examples.
A comprehensive computer program (SIMWEST) developed for the modeling of wind energy/storage systems utilizing any combination of five types of storage (pumped hydro, battery, thermal, flywheel, and pneumatic) is described. Features of the program include: 1) a precompiler which generates computer models in FORTRAN of complex wind source/storage/application systems, from user specifications using the respective library components, 2) a program which provides the techno-economic system analysis with the respective I/O the integration of system dynamics, and the iteration for conveyance of variables, and capability to evaluate economic feasibility as well as general performance of wind energy systems. The SIMWEST operation manual is presented and the usage of the SIMWEST program and the design of the library components are described. A number of example simulations intended to familiarize the user with the program's operation is given along with a listing of each SIMWEST library subroutine.

Author
A new algorithm is presented for solution of dynamic optimization problems which are nonlinear in the state variables and linear in the control variables. It is shown that the optimal control is bang-bang. A nominal bang-bang solution is found which satisfies the system equations and constraints, and influence functions are generated which check the optimality of the solution. Nonlinear optimization (gradient search) techniques are used to find the optimal solution. The algorithm is used to find a minimum time acceleration for a turbospan engine. (Author)

A new approach to the design of multivariable control systems using the inverse Nyquist array method is proposed. The technique utilizes a conjugate direction function minimization algorithm to achieve dominance over a specified frequency range by minimizing the ratio of the modulus of the off-diagonal terms to the modulus of the diagonal term of the inverse open loop transfer function matrix. The technique is easily implemented in either a batch or interactive computer mode and will yield diagonalization when previously suggested methods fail. The proposed method has been successfully applied to design a control system for a sixteenth order state model of the F-100 turbofan engine with three inputs.
65 STATISTICS AND PROBABILITY

Includes data sampling and smoothing; Monte Carlo method; and stochastic processes.

N75-18738*J National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CHAIN POOLING MODELING SELECTION AS DEVELOPED FOR THE STATISTICAL ANALYSIS OF A ROTOR BURST PROTECTION EXPERIMENT


(NASA TM 73874. E 9478) Avail. NTIS HC A04/ MF A01 CSCL 12A

As many as three iterated statistical model deletion procedures were considered for an experiment. Population model coefficients were chosen to simulate a saturated 2 to the 4th power experiment having an unfavorable distribution of parameter values. Using random number studies, three model selection strategies were developed, namely, (1) a strategy to be used in anticipation of large coefficients of variation, approximately 65 percent. (2) a strategy to be used in anticipation of small coefficients of variation, 4 percent or less. and (3) a strategy to be used in the absence of such prior knowledge. Author


A statistical decision procedure called chain pooling had been developed for model selection in fitting the results of a two-level fixed-effects full or fractional factorial experiment not having replication. The basic strategy included the use of one nominal level of significance for a preliminary test and a second nominal level of significance for the final test. The subject has been reexamined from the point of view of using as many as three successive statistical model deletion procedures in fitting the results of a single experiment. The investigation consisted of random number studies intended to simulate the results of a proposed aircraft turbine-engine rotor-burst protection experiment. As a conservative approach, population model coefficients were chosen to represent a saturated 2 to the 4th power experiment with a distribution of parameter values unfavorable to the decision procedures. Three model selection strategies were developed. (Author)
66 SYSTEMS ANALYSIS

Includes mathematical modeling, network analysis, and operations research.

NTIS-28596®. National Aeronautics and Space Administration.
Lewis Research Center, Cleveland Ohio.

PROCEDURES FOR GENERATION AND REDUCTION OF LINEAR MODELS OF A TURBOFAN ENGINE

(NASA-TP-1251. E-9480) Avail: NTIS RC A03/MF A01 CSCI
128

A real time hybrid simulation of the Pratt & Whitney F100-PW-F100 turbofan engine was used for linear-model generation. The linear models were used to analyze the effect of disturbances about an operating point on the dynamic performance of the engine. A procedure that disturbs, samples, and records the state and control variables was developed. For large systems, such as the F100 engine, the state vector is large and may contain high-frequency information not required for control. Thus, reducing the full-state to a reduced-order model may be a practicable approach to simplifying the control design. A reduction technique was developed to generate reduced-order models. Selected linear and nonlinear output responses to exhaust-nozzle area and main-burner fuel flow disturbances are presented for comparison.

Author
70 PHYSICS (GENERAL)

For geophysics see 46 Geophysics. For astrophysics see 80 Astrophysics. For solar physics see 82 Solar Physics.

N78-138649# National Aeronautics and Space Administration
Optical and electrical properties of ion beam textured kapton and teflon
Michael J. Mirin and James S. Berry 1977 16 p. refs
Presented at 24th Natl Vacuum Symp., Boston, 8-11 Nov. 1977.
sponsored by Am. Vacuum Soc.
(NASA-TM 73778, E-83291) Avail NTIS NC A02/MF A01
CSCI 11G
An electron bombardment argon ion source was used to
ion etch polyimide (Kapton) and fluorinated ethylene, FEP (Teflon).
Samples of polyimide and FEP were exposed to 100-1.0 kV
Ar ions at an current density of (10-1-8) mA/sq cm for
various exposure times. Changes in the optical and electrical
properties of the samples were used to characterize the
exposure. Spectral reflectance and transmittance measurements
were made between 0.33 and 2.16 micron m using an integrating
sphere after each exposure. From these measurements, values
of solar absorptance were obtained. Total emittance measurements
were also recorded for some samples. Surface resistivity was
used to determine changes in the electrical conductivity of the
etched samples. A scanning electron microscope recorded surface
structure after exposure. Spectral optical data, resistivity
measurements, and solar absorptance data were presented.

N78-235989# Suntech, Inc. Marcus Hook, Pa
Study of dynamic emission spectra from lubricating fluids
Using Fourier transform spectroscopy
J. L. Lauer (Rensselaer Polytechnic Inst., Troy, N.Y.) 28 Aug
1978 128 p. refs
(Contact NAS3 1975B)
(NASA CR 158418) Avail NTIS NC A02/MF A01 CSCI 20K
Infrared emission spectra were obtained through a diamond
window from lubricating fluids in an operating sliding velocity
hydrodynamic contact and analyzed by computer. Emission
spectra for similar pressures. Different loads, shear
rates and temperatures were used. Most of the spectra
exhibited polarization characteristics indicating directional
alignment of the lubricant in the EHD contact. Among the fluids
studied were a traction fluid, an advanced ester, and their
mixtures, a synthetic paraffin, a naphthenic, a reference fluid (TMT)
both neat and containing 1 percent of p-terphenyl phosphoric acid
as an anti wear additive and a C ether. Traction properties were
found to be nearly proportional to mixture composition for traction
fluid and ester mixtures. The anti wear additive reduced traction
and fluid temperature under low loads, but increased them under
higher loads, giving rise to formation of a friction polymer. GRA
71 ACOUSTICS

Includes sound generation, transmission, and attenuation. For noise pollution see 45 Environment Pollution.


Future STOL aircraft may utilize engine-over-the-wing installations in which the exhaust nozzles are located above and separated from the upper surface of the wing. An external jet flow deflector can be used with such installations to provide flow attachment to the wing/flare surfaces for lift augmentation. Deflector noise in the flowper plane measured with several model-scale nozzle/deflector/wing configurations is examined. The deflector-associated noise is correlated in terms of velocity and geometry parameters. The data also indicate that the effective overall sound pressure level of the deflector-associated noise peaks in the forward quadrant near 40 deg from the inlet axis.

Author

N78-13884* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. A PARAMETRIC INVESTIGATION OF AN EXISTING SUPersonic RELATIVE TIP SPEED PROPULSER NOISE MODEL James H. Dittmer Nov. 1977 25 p. refs (NASA-TM-73818; E-9405) Avail: NTIS HC A02/MF A01 CSDL 20A

A tip speed turbojet is being considered as a future energy conservative airplane. The high tip speed of the propeller combined with the cruise speed of the airplane may result in supersonic relative flow on the propeller tips. These supersonic blade sections could generate noise that is a cabin environment problem. An existing supersonic propeller noise model was parametrically investigated to identify and evaluate the noise reduction variables. Both independent and interdependent parameter variables (constant propeller thrust) were performed. The noise reductions indicated by the independent investigation was varied from a model in the case of reducing Mach number to minimal for adjusting the thickness and loading distributions. The noise reduction possibilities of decreasing relative Mach number were further investigated during the interdependent investigation. The independent investigation indicated that significant noise reductions could be achieved by increasing the propeller diameter and/or increasing the number of propeller blades while maintaining a constant propeller thrust.

Author


Approximate equations for the far field acoustic radiation patterns in the forward quadrant from a flanged circular duct were compared with exact equations for both single and multimodal radiation. The single mode comparison showed good agreement between the exact and approximate equations for the principal lobes of higher radial order modes. For lower and especially for zero radial order modes, there was some error in the angular location and decibel level of principal lobe peak pressure obtained from the approximate equation. Some agreement of sidelobes was also observed although the approximate equation was not intended to simulate the sidelobes.

multimodal approximate summation equations consisting only of a simple function of directivity angle and an acoustic power biasing function were checked against the exact equations for several distributions of modal power and showed excellent agreement with exact equations for all cases. Although many modes contribute to the final level and shape of the directivity curve, the major contributions appear to come from the higher radial order modes.

Author


A hemispherical inlet flow control device was tested on a 50.8 cm (20-in) diameter fan stage in the NASA-Leaves anechoic chamber. The control device used honeycomb and was mesh to reduce turbulence intensities entering the fan. Far field acoustic power level results show about a 5 db reduction in blade passing noise and about 10 db reduction in pure tone sound power at 90% design fan speed with the inlet device in place. Hot film cross probes were inserted in the inlet to obtain data for two components of the turbulence at 65 and 90% design fan speed. Without the flow control device, the axial intensities were below 1.0%, while the circumferential intensities were almost twice this value. The inflow control device significantly reduced the circumferential turbulence intensities and also reduced the axial length scale.

Author


Acoustic tests were conducted at model scale to determine the noise produced in the flow of and sideline planes at reduced separation distances between the nozzle exhaust plane and the flags of an under-the-wing externally blown flap configuration. The tests were made to determine the noise suppression effectiveness of two types of passive devices which were located on the jet impingement surfaces of the configuration. Additional static aerodynamic performance data were obtained to evaluate the penalties produced by these suppression devices.

Author


A correlating equation relating the optimum acoustic impedance for the wall lining of a circular duct to the acoustic mode cut-off ratio, is presented. The optimum impedance was correlated with cut-off ratio because the cut-off ratio appears to be the fundamental parameter governing the propagation of sound in the duct. Modes with similar cut-off ratios respond in a similar way to the acoustic liner. The correlation is a semi-empirical expression derived from an empirical modification of an equation originally derived from theory in a thin boundary layer. The correlating equation represents a part of a simplified linear design method based upon modal cut-off ratio, for multimodal noise propagation.

Author
SMEAR CROCA~ON


NASA-TM-73828. E-9203) Avail. NTIS HC A02/MF A01 CSCL 20A

Closed form solutions are presented for sound propagation from a line source in or near a shear layer. The analysis was exact for all frequencies and was developed assuming a linear velocity profile in the shear layer. This assumption allowed the solution to be expressed in terms of parabolic cylinder functions. The solution is presented for a line monopole source first embedded in the uniform flow and then in the shear layer. Solutions are also discussed for certain types of dipole and quadrupole asymptotic expansions of the exact solutions for various large values of Strouhal number gave expansions which correspond to solutions previously obtained for these limiting cases. Author

REDUCTION OF FAN NOISE IN AN ANECHOIC CHAMBER BY REDUCING CHAMBER WALL INJECTED INLET FLOW DISTURBANCES


NASA-TM-78854: E-9580) Avail. NTIS HC A02/MF A01 CSCL 20A

The difference between the flight and ground static noise of turbofan engines presents a significant problem in engine noise testing. The additional noise for static testing has been attributed to nonturbulent fluctuations in the inlet flow characteristics. In an attempt to determine a possible source of these fluctuations, a test was conducted in the Lewis Research Center anechoic chamber. The inlet flow was used to determine potential flow characteristics. These potential flow calculations indicated that there was substantial flow over the wall directly behind the fan inlet that could produce significant insect disturbances. Fan noise tests were run with various extensions added to the fan inlet to move the inlet away from the back wall and thereby reduce the nonturbulent flow disturbances. Significant noise reductions were observed with increased inlet length. Over 5 db reduction of the blade passage tone sound power level was observed between the shortest and longest inlets at 90% fan speed and the first overtone was reduced 9 db. High frequency broadband noise was also reduced. Author

ACOUSTIC EVALUATION OF A NOVEL SWEPT-ROTOR FAN


Inlet noise and aerodynamic performance are presented for a high tip speed fan designed with rotor blade leading edge sweep that gave a subsonic component of inlet Mach number normal to the edge at all radii. The intent of the design was to minimize the generation of rotor leading edge shock waves thereby minimizing multiple pure tone noise. Sound power level and spectral comparisons are made with several high speed fans of conventional design. Results show multiple pure tone noise at levels below those of some of the other fans and this noise was observed at a higher tip speed. Aerodynamic performance of the fan did not meet design goals for this first build which applied conventional design procedures to the swept fan geometry. Author

VARIATION OF FAN TONE STABILITY FOR SEVERAL INFLOW CONDITIONS


An amplitude probability density function analysis technique for quantifying the degree of fan noise tone steadiness has been applied to data from a fan tested under a variety of inflow conditions. The test conditions included typical stetic operation, inflow control by a honeycomb/screen device and forward velocity in a wind tunnel simulating flight. The ratio of mean square sinusoidal-to-random signal content in the fundamental and second harmonic tones was found to vary by more than an order-of-magnitude. Some implications of these results concerning the nature of fan noise generation mechanisms are discussed. Author

PRELIMINARY STUDY OF THE EFFECT OF THE TURBULENT FLOW FIELD AROUND COMPLEX SURFACES ON THEIR ACOUSTIC CHARACTERISTICS


Fundamental theories for noise generated by flow over surfaces exist for only a few simple configurations. The role of turbulence in noise generation by complex surfaces should be examined in the same way as for simple configurations. Examination of simple surface theories indicates that the spatial distribution of the mean velocity and turbulence properties are sufficient to define the noise emission. Measurements of these flow properties were made for a number of simple and complex surfaces. The configurations were selected because of their acoustic characteristics. The spatial distribution of the turbulent flow properties around the complex surfaces and approximate theory are used to locate and describe the noise sources, and to quantitatively explain the varied acoustic characteristics. L.S.

A correlation equation relating the optimum acoustic impedance for the wall lining of a circular duct to the acoustic mode cut-off ratio is presented and compared to exact calculations. The optimum impedance was correlated with cut-off ratio because of the cut-off ratio appears to be the fundamental parameter governing the propagation of sound in ducts. Modes with similar cut-off ratios respond in a similar way to the acoustic liner. The correlation equation is useful for the design of suppressors for aircraft engine inlets having a steadily mean flow with a boundary layer and spinning mode noise source excitation. The correlation is a semi-empirical expression developed from an empirical modification of an equation originally derived from sound propagation theory in a thin boundary layer. Exact calculations of the optimum wall impedance were made over a wide range of frequency, parameter, boundary layer thickness and flow Mach numbers to develop and verify the correlation. The correlation equation represents a part of a simplified liner design method, based upon model cut-off ratio, for multimodal noise propagation.

(Author)


Closed form solutions are presented for sound propagation from a line source in or near a shear layer. The analysis is exact for all frequencies and is developed assuming a linear velocity profile in the shear layer. This assumption allows the solution to be expressed in terms of parabolic cylinder functions. The solutions presented for a line monopole source first embedded in the uniform layer and then in the shear layer. Solutions are also discussed for certain types of dipole and quadrupole sources. Asymptotic expansions of the exact solutions for small and large values of Strouhal number give expressions which correspond to solutions previously obtained for these limiting cases.

(Author)


Acoustic tests were conducted at model scale to determine the noise produced in the flyover and sideline planes at reduced separation distances between the nozzle exhaust plane and the flaps of an under-the-wing (UTW) externally blown flap (EBF) configuration in its approach attitude. Tests were also made to determine the noise suppression effectiveness of two types of passive devices which were located on the jet impingement surfaces of the configuration. In addition, static aerodynamic performance data were obtained to evaluate the penalties produced by these suppression devices. Broadband low frequency noise reductions were achieved by reducing the separation distance between the nozzle and flaps. However, mid and high frequency noise was produced which exceeded that of the reference configuration. Two passive noise suppression devices located on the flaps produced moderate to large noise reductions at reduced separation distances. Consideration of the static aerodynamic performance data obtained for the configurations tested suggests that specific broadband noise suppression characteristics may be obtained through a trade-off with aerodynamic performance penalties by the careful selection of suppression devices.

(Author)


A comparison is made between approximate equations for far-field acoustic radiation patterns and exact equations for single and multimodal excitations in order to determine the validity range for the approximate approach. It is found that for single-mode cases: (1) the gross behavior of the primary lobes is adequately described by the approximate equations, (2) some error is found for lower and zero radial order modes, and (3) some agreement is yielded between exact and approximate side lobes, although the approximate equation was not intended to simulate side lobes. Multimodal approximate equations are compared to exact equations for various distributions of mental power; for all cases excellent agreement is found. For multimodal patterns it is noted that many modes influence the final level and shape of the directivity curve, although the major contributions are from the higher radial order modes.

S.C.S.


Jet noise is modeled by particle attached quadrupolar sources convected with the velocity of the actual fluid but positioned near a hypothetical instability free vortex sheet. The strength of each quadrupole is Lighthill's stress tensor per unit mass. The work of Mann (1976) has shown that this type of model agrees well with experiment, and the present work establishes some of the equivalent sources needed for an exact analogy. The instability waves of the shear layer, as they grow into turbulence, are heard as sound that builds up as a precursor of the main turbulence-driven field. The circular compact jet is examined in some detail, and it is found that when the jet is very light it can provide a waveguide in which the
effects of source activity persist for some time but eventually leak out as sound. This interaction greatly distorts the free field characteristics of the turbulent sources, so that Reynolds-stress induced waves have an intensity that scales with the fourth power of jet velocity.

P.T.H.


The difference between the flight and ground static noise of turboprop engines has been identified as a significant problem in engine noise testing. The additional noise for static testing has been attributed to inlet flow disturbances or turbulence interacting with the fan rotor. In an attempt to determine a possible source of inflow disturbances entering fans tested in the Lewis Research Center anechoic chamber the inflow field was studied using potential flow analysis. These potential flow calculations indicated that there was substantial flow over the wall directly behind the fan inlet that could produce significant inflow disturbances. Fan noise tests were run with various extensions added to the fan inlet to move the inlet away from this backwall and thereby reduce the inflow disturbances. Significant noise reductions were observed with increased inlet length. Ongoing reduction of blade passage tone sound power level was observed between the shortest and longest inlets at 90% fan speed and the first overtone was reduced 9 dB. High frequency broadband noise was also reduced. (Author)


A numerical method is developed that could predict the pressure distribution of a ducted source from far field pressure inputs. Using an initial value formulation, the two-dimensional homogeneous Helmholtz wave equation (no steady flow) is solved using explicit marching techniques. The Von Neumann method is used to develop relationships which describe how sound frequency and grid spacing affect numerical stability. At the present time, stability considerations limit the approach to high frequency sound. Sample calculations for both hard and soft wall ducts compare favorably to known boundary value solutions. In addition, assuming that reflections in the duct are small, this initial value approach is successfully used to determine the attenuation of a straight soft wall duct. Compared to conventional finite difference or finite element boundary value approaches, the numerical marching techniques are orders of magnitude shorter in computation time and required computer storage and can be easily employed in problems involving high frequency sound. (Author)


An amplitude probability density function analysis technique for approximating the degree of fan noise tone steadiness has been applied to data from a fan tested under a variety of inflow conditions. The test conditions included typical static operation, inflow control by a horizontal center device and forward velocity in a wind tunnel simulation test. The ratio of mean square normalized to unsteady signal content in the horizontal and vertical harmonic flows was found to vary by more than an order of magnitude. Some implications of these results concerning the nature of fan noise generation mechanisms are discussed. (Author)


A theoretical analysis of pure tone fan noise generated by inflow distortion-rotor interaction is carried out with the aid of the three-dimensional unsteady lifting surface theory developed by Namba (1977, 1974). Particular attention is given to a study of the accuracy of available two-dimensional theory for the prediction of pure tone fan noise due to the interaction of inflow distortion with a subsonic annular blade row. The theoretical model considered consists of a single three-dimensional annular cascade rotating at constant angular velocity in an annular rigid-walled duct of infinite axial extent. Attention is given to the fluctuating pressure induced by a rotor blade row, the fluctuating velocity induced by it, an inflow distortion with only an axial velocity component, the determination of acoustic dipole distribution, the pure tone acoustic power, and two-dimensional theory and quasithree-dimensional theory. (G.R.


Inlet noise and aerodynamic performance are presented for a high tip speed fan designed with rotor blade leading edge sweep that gives a sonic component of inlet Mach number normal to the edge at all radii. The intent of the design was to minimize the generation of rotor leading edge shock waves thereby minimizing multiple pure tone noise. Sound pressure level and spectral comparisons are made with several high-speed fans of conventional design. Results showed multiple pure tone noise at levels below those of some of the other fans and this noise was initiated at a higher tip speed. Aerodynamic performance of the fan did not meet design goals for this first build which applied conventional design procedures to the swept fan geometry. (Author)


Early extensive measurements have been conducted of the turbulent flow around various surfaces as a basis for a study of the acoustic characteristics involved. In the experiments the flow from a nozzle was directed upon various two-dimensional surface configurations such as the three-fin model. A turbulent flow field description is given and an estimate of the acoustic characteristics is provided. The development equations are based upon fundamental theories for simple configurations having simple flows. Qualitative estimates are obtained regarding the radiation patterns and the velocity phase lag. The effect of geometry and turbulent flow distribution on the acoustic emission from simple configurations are discussed. (G.R.

A78-20920* United Technologies Research Center, East Hartford, Conn. A METHOD FOR CALCULATING EXTERNALLY BLOWN FLAP NOISE Final Report Martin R. Fink, May 1978, 130 p. refs (Contract NASD 17863) (NASA CR 2854; R77-91739-17) Available NTIS HC A07/MT A01 CSCI 20A

Several basic noise components were described. These components are: (1) compact lift dipoles associated with the wing and flaps; (2) trailing edge noise associated with the last trailing edge; and (3) quadrupole noise associated with the undeflected exhaust jet and the free jet located downstream of
the trailing edge. These noise components were combined to allow prediction of directivity and spectra for under the wing (UTW) slotted flaps with conventional or muser nozzles, UTW slotted flaps, upper surface blowing (USB) slotted flaps, and engine in front of the wing slotted flaps. A digital computer program listing was given for this calculation method. Directivities and spectra calculated by method were compared with free field data for UTW and USB configurations. The UTRC method best predicted the details of the measured noise emission, but the ANOP method best estimated the noise levels directly below these configurations. 

Author

N78-25821*  United Technologies Research Center, East Hartford, Conn.


Portions of a four-year analytical and experimental investigation relative to noise radiation from engine internal components in turbulent flow are summarized. Spectra measured for such airfoils over a range of chord, thickness ratio, flow velocity, and turbulence level were compared with predictions made by an available rigorous thin-airfoil analytical method. This analysis included the effects of flow compressibility and source noncompactness. Generally good agreement was obtained. This noise calculation method for isolated airfoils in turbulent flow was combined with a method for calculating transmission of sound through a subsonic exit duct and with an empirical far-field directivity shape. These three elements were checked separately and were individually shown to give close agreement with data. This combination provides a method for predicting engine internally generated aft-radiated noise from radial struts and stators, and annular splitter rings. Calculated sound power spectra, directivity, and acoustic pressure spectra were compared with the best available data. These were for noise caused by a fan exit duct annular splitter ring, larger-chord stator blades, and turbine exit struts. 

Author

N78-25827*  Avco Lycoming Div., Stratford, Conn.


The combustion chamber from a YF 102 gas turbine engine was instrumented with semi-infinite acoustic wave guide probes and installed in a test rig to complement the combustor noise test. These combustor rig tests are described and the recorded data are listed. Internal dynamic pressure level measurements were made at the same locations and at the same operating conditions of the NASA YF 102 test. In addition, the combustor was operated at various off-design points where one parameter at a time was varied. Background noise recordings were made to determine the magnitude of facility or test rig noise present. 

Author

N78-25829*  Avco Lycoming Div., Stratford, Conn.


For abstract, see N78-25827.

N78-25829†  Avco Lycoming Div., Stratford, Conn.


For abstract, see N78-25827.

N78-25867†  Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.


Jet noise spectra obtained at static conditions from an acoustic wind tunnel and an outdoor facility are compared. Data curves are presented for (1) the effect of relative velocity on GASPFL directivity (all configurations); (2) the effect of relative velocity on noise spectra (all configurations); (3) the effect of velocity on PN5 directivity (coannular nozzle configurations); (4) nozzle exhaust plume velocity profiles; and (5) the effect of relative velocity on aerodynamic performance. 

A.R.H.

N78-25888†  Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.


Data from the acoustic tests of the convergent reference nozzle and the 0.75 area ratio coannular nozzle are presented in tables. Data processing routines used to scale the acoustic data and to correct the data for atmospheric attenuation are included. 

A.R.H.

N78-25889†  Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.


Acoustic data from tests of the 0.75 area ratio coannular nozzle with an ejector and the 1.2 area ratio coannular are presented in tables. Aerodynamic data acquired for the four test configurations are included. 

A.R.H.

Jet mixing noise data at different measurement distances are compared with values calculated from the Lockheed prediction method. Although the method does not include any acoustic near-field effects, the measured and predicted results agree well where the measured data deviates from the inverse square law. It is therefore suggested that departures from the inverse square law are primarily the result of (1) the non-negligible distance between the nozzle exit plane and the true axial source location and (2) the jet mixing noise directivity, as modeled in the prediction method. Allowing for these effects, jet noise data at 8 and 96 diameters over a wide range of frequencies, angles and jet conditions are shown to collapse with reasonable accuracy. (Author)
72 ATOMIC AND MOLECULAR PHYSICS

Includes atomic structure and molecular spectra.


Metastable states of rare gas crystallites containing \( N \) atoms are investigated for \( N = 5,6,7, \) and 8. In particular, the stability, structures, structural transformation, and binding energy versus temperature are determined using a Monte Carlo method. The square pyramid isomer for \( N = 5 \) is found to be unstable at any finite temperature. The other metastable isomers are all found to make spontaneous transitions to the ground state if the temperature is greater than about one half that of melting. Comparisons with previous work are also made.

Author

A78-18063* Colorado State Univ., Fort Collins. Dept. of Physics


Plasma probe surveys were conducted in a 30-cm source to verify that the uniformity in the ion beam is the result of a corresponding uniformity in the discharge-chamber plasma. A 15 cm permanent magnet multipole ion source was designed, fabricated, and demonstrated. Procedures were investigated for testing a variety of seed and surface materials for controlling secondary electron emission, increasing electron absorption of light, and improved attachment of biological tissue for medical implants using argon and tetrafluoroethane as the working gases. The cross section for argon-argon elastic collisions in the ion-beam energy range was calculated from interaction potentials and permits calculation of beam interaction effects that can determine system pumping requirements. The data also indicate that different optimizations of ion-beam machines will be advantageous for long- and short-run, with 1 mA/hr/cm being the rough dividing line for run length. The capacity to simultaneously optimize components in an ion-beam machine for a single application, a capacity that is not evident in competitive approaches such as diode sputtering is emphasized.

Author
73 NUCLEAR AND HIGH-ENERGY PHYSICS

Includes elementary and nuclear particles; and reactor theory.
For space radiation see 53 Space Radiation.

NASA-TM-73892 National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.

OPTIMIZE OUT-OF-CORE THERMIonic ENERGY CONVER-
SION FOR NUCLEAR ELECTRIC PROPULSION

James F. Morris Sep. 1977 15 p. refs Proposed for presentation
at Intern. Conf. on Plasma Sci., Monterey, Calif., 15-17 May
1978; sponsored by IEEE
(NASA-TM-73892) Avail. NTIS : HC A02/MF A01 CSCL 1BE

Current designs for out of core thermionic energy conversion
(TEC) to power nuclear electric propulsion (NEP) were evaluated.
Approaches to improve out of core TEC are emphasized and
probabilities for success are indicated. TEC gains are available
with higher emitter temperatures and greater power densities.
Good potentialities for accommodating external high tempera-
ture, high power density TEC with heat pipe cooled reactors
exist.
75 PLASMA PHYSICS

Includes magnetohydrodynamics and plasma fusion.
For ionospheric plasma, see Geophysics. For space plasmas see Astrophysics.

N78-10831*
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
INWARD TRANSPORT OF A TOROIDALLY CONFINED PLASMA SUBJECT TO STRONG RADIAL ELECTRIC FIELDS

Digitally implemented spectral analysis techniques were used to investigate the frequency-dependent fluctuation-induced particle transport across a toroidal magnetic field. When the electric field pointed radially inward, the transport was inward and of significant enhancement of the plasma density and confinement time resulted.

Author

N78-10834*
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
A MODEL FOR PARTICLE CONFINEMENT IN A TOROIDAL PLASMA Subject to STRONG RADIAL ELECTRIC FIELDS

A toroidal plasma is confined and heated by the simultaneous application of strong d.c. magnetic fields and electric fields. Strong radially inward electric fields (about 1 kilovolt per centimeter) are imposed by biasing the plasma with up to 12 heat pipes, significantly reduced reactor and shield-related weights, many fewer converters and associated current-carrying bus bars, lower power conditioning, and lower transmission losses. Integration of these effects should yield considerably reduced NEP specific weights.

Author

N78-10875*
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
PROBE STUDIES IN A MODIFIED PENNING DISCHARGE

The axial and radial floating potential distribution in a modified Penning discharge were studied at different values of the background pressure, discharge voltage, and magnetic field. An array of small disc probes arranged radially with their planes perpendicular to the magnetic field and movable along the axial direction was inserted in the plasma through one open end of the magnetic mirror system. Results show that depending on the operating conditions, the discharge can undergo different mode transitions in which the plasma can sustain different floating potentials in the radial as well as in the axial directions. Preliminary results of measurement, using RF probes in the modified Penning discharge plasma are also discussed.

Author

N78-10879*
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
LOWER HYBRID EMISSION DIAGNOSTICS ON THE NASA LEWIS BUMPY TORUS

The feasibility of using RF emission near the lower hybrid frequency of the NASA Lewis Bumpy Torus plasma diagnostic purposes is examined. The emission is detected using a spectrum analyzer and a 50 ohm matched coaxial antenna that is sensitive to the polarization of the incoming signal. The frequency shift of the lower hybrid emission peak is monitored as a function of the background pressure, electrode voltage, electrode ring configuration and the strength of the toroidal d.c. magnetic field. Simultaneous measurements of the average plasma density are made with a polarization diplexing microwave interferometer. Data derived from the experiment are discussed with reference to the following: (1) the strength of the d.c. magnetic field limiting region; (2) comparison of the lower hybrid plasma density with the average plasma density; and (3) validity of the cold plasma lower hybrid resonance formula in the high density operating regime of the bumpy torus plasma.

Author

N78-12380*
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
HIGH-TEMPERATURE, HIGH-POWER-DENSITY THERMIONIC ENERGY CONVERSION FOR SPACE

Theoretical converter outputs and efficiencies indicate the need to consider thermionic energy conversion (TEC) with greater power densities and higher temperatures within reasonable limits for space missions. Conversion-dicted power density, voltage, and efficiency as functions of current density were determined for 1400 to 2000 K emitters with 725 to 1000 K collectors. The results encourage utilization of TEC with hotter-than-16500 K emitters and greater-than-58 W/cm² output to attain better efficiencies, greater voltages, and higher waste-heat-rejection temperatures for multihundred kilowatt space power applications. For 1800 K, 5 A/cm² case should allow much lower radiation weights, substantially fewer and/or smaller emitter

Author

N78-20968*
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio
TEMPERATURE DISTRIBUTIONS OF A CESEINI-BEUDED HYDROGEN-OXYGEN SUPERBIONIC FEE JET

The hydrogen oxygen plasma was generated at combustion chamber pressures ranging from 0.5 to 2.0 megapascals and for various seed ratios (1 to 10 percent). The plasma was observed as the atmospheric exhaust from a Mach 2 rocket test facility. Transverse profiles of the absolute integrated intensity were measured with the optically thin cell lines (0.5664 and 0.5636 microns) at a range of axial positions downstream of the 5-cm-diameter combustor nozzle exit. Radial profiles of the emission coefficients were obtained from the measured transverse profiles of intensity by Abel inversion. Temperatures were then determined from the emission coefficients for conditions of local thermodynamic equilibrium using particle density generated by a two-dimensional free jet computer program. Temperature results show the inherent effects of compression and expansion pressure waves characteristic of a free jet exiting from a supersonic nozzle.

Author
Further hot-ion plasma experiments were conducted in the SUMMA superconducting magnetic mirror facility. A steady-state EsB plasma was formed by applying a strongly inward dc electric field between cylindrical anodes and hollow cathodes located near the magnetic mirror maxima. Extending the use of water cooling to the hollow cathodes, in addition to the anodes, resulted in higher maximum power input to the plasma. Steady-state hydrogen plasmas with ion kinetic temperatures as high as 0.3 eV were produced. Functional relations were obtained empirically among the plasma current, voltage, magnetic flux density, ion temperature, and relative ion density. The functional relations were deduced by using two multiple correlation analysis. Data were obtained for midplane magnetic fields from 0.5 to 3.37 tesla and input power up to 45 kW. Also, initial absolute electron density measurements are reported from a 90 deg Thomson scattering laser system.

A. R. H.

The approach adopted in the NASA Lewis Bumpy Torus experiment is to confine and heat a toroidal plasma by the simultaneous application of strong radial electric fields and magnetic fields. Strong radial electric fields (about 1 kV/cm) are imposed by biasing the plasma with up to 12 negative electrode rings which surround its minor circumference. The plasma containment is consistent with a balance of two processes: a radial diffusion of ions in those sectors not containing electrode rings, resulting from the radially inward electric fields, and ion loss to the electron heating, each of which acts as a sink and draws ions out of the plasma in the manner of a Langmuir probe in the ion saturation regime. The highest density on axis which has been observed so far in this steady-state plasma is 8.2 trillion particles per cm3, for which the particle confinement time is 3.5 min. The electron ion kinetic temperature for these conditions was in the range of 360 to 520 eV. (Author)


The axial and radial floating potential distribution in a modified Penning discharge have been studies at different values of the background pressure, discharge voltage, and magnetic field. An array of small disc probes arranged radially with their planes perpendicular to the magnetic field and movable along the axial direction was inserted in the plasma through one open end of the magnetic mirror system. Results show that depending on the operating conditions, the discharge can undergo different mode transitions in which the plasma can sustain different floating potentials in the radial as well as in the axial directions. Preliminary results of measurement using RF probes in the modified Penning discharge plasma are also discussed. (Author)


The feasibility of using RF radiation near the lower hybrid frequency of the NASA Lewis Bumpy Torus plasma for diagnostic purposes is examined. The emission is detected using a spectrum analyzer and a 50-cm-diameter coaxial antenna that is sensitive to the polarization of the incoming signal. The frequency shift of the lower hybrid emission peak is monitored as a function of the background pressure, electrode voltage, and magnetic field configuration, and the strength of the axial dc magnetic field. Simultaneous measurements of the average plasma density are made with a polarization phase-sensitive interferometer. The experimental results extend previous work to include negative electrode voltages and plasma densities up to 1 trillion per cm3. The information derived from the experiment is discussed with reference to: (1) the strength of the dc magnetic field in the emitting region, (2) the comparison of the lower hybrid plasma density with the average plasma density, and (3) the variation of the cold plasma lower hybrid resonance formula in the high-density operating regime of the bumpy-torus plasma. (Author)


A preliminary experiment was performed to investigate conversion of 10-6 watt laser energy to electrical energy via a laser-sustained argon plasma. Short-circuit currents of 0.7 A were measured between a thoriated tungsten emitter and collector electrodes immersed in the laser-sustained argon plasma. Open-circuit voltages of about 1.8 V were inferred from the current voltage load characteristics. The dominant mechanism of laser energy conversion is uncertain at this time. Much higher output powers appear possible. (Author)


The influence of applied dc radial electric fields on particle transport in a bumpy torus plasma is studied. The plasma, magnetic field, and ion heating mechanism are operated in steady state. Ion kinetic temperature is more than a factor of ten higher than electron temperature. The electric fields near the ions to energies on the order of kilovolts and then point radially inward or outward. Plasma number density profiles are flat or triangular across the plasma diameter. It is suggested that the radial transport processes are non-diffusional and dominated by strong radial electric fields. These characteristics are caused by the absence of a second derivative in the density profile and the flat electron temperature profiles. If the electric field acts on the minor radius of the toroidal plasma points inward, plasma number density and confinement time are increased. (Author)


Further hot ion plasma experiments were conducted in the SUMMA superconducting magnetic mirror facility. A steady state plasma with mutually perpendicular magnetic and electric fields was formed by applying a strong radially inward dc electric field between cylindrical anodes and hollow cathodes located near the magnetic mirror maxima. Extending the use of water cooling to the hollow cathodes, in addition to the anodes, resulted in higher maximum power input to the plasma. Steady-state hydrogen plasmas with ion kinetic temperatures as high as 830 eV were produced. Functional relations were obtained empirically among the plasma current, voltage, magnetic flux density, ion temperature, and relative ion density. The functional relations were derived by use of a multiple correlation analysis. Data were obtained for multiple magnetic fields from 0.5 to 3.37 tesla and input power up to 45 kW. Also, initial absolute electron density measurements are reported from a 10 deg Thomson scattering laser system. (Author)


High current density ion sources have been used to heat plasmas in controlled thermonuclear reaction experiments. High beam currents imply relatively high emission currents from cathodes which have generally taken the form of tungsten filaments. This paper describes a hydrogen ion source which was primarily developed to assist the mission current capability and design requirements for hollow cathodes for application in neutral beam injection devices. The hydrogen source produced ions by electron bombardment via a single hollow cathode. Source design followed Mercury ion thruster technology, using a weak magnetic field to enhance ionization efficiency. A 1.3 cm diam hollow cathode using a low work function material discharges satisfactorily over a discharge current range of 10-0 A. Cylindrical probe measurements taken with ion extraction indicate maximum ion number densities on the order of 10 trillion/cm3. Discharge durations spanned from 30 sec to
continuous operation. Tests with beam extraction at 2.6 keV and 30 A/cm² show a discharge current yield average ion beam current density of 0.1 A/cm² over a 5-cm extraction diameter. Results of this study can be used to supply the baseline information needed to scale hollow cathodes for operation at discharge currents of hundreds of amperes using distributed cathodes.


A plasma model, previously developed to interpret neutral-particle analyzer measurements on E × B heating devices, is adapted to analyze Doppler broadened charge-exchange neutral lines measured by an optical monochromator. Comparison of theoretical with experimental results indicates that azimuthal drift as well as cyclotron motion are quite influential in determining line shapes and widths, and thus important in determination, even when the monochromator line of sight is intersecting the plasma axis of symmetry. At this central viewing position, however, results are quite insensitive to radial ion density distribution when time lag between the charge-exchange excitation events and emission is neglected. Line shapes and widths obtained by sighting across chords of plasma at various distances from the plasma axis of symmetry indicate a strong dependence on time lag.


The paper presents 20 plasma confinement schemes each representing an alternative to the tokamak fusion reactor: Attention is given to: (1) tokamak-like devices (TORMAC, tokolation, and the Extrapp concept); (2) stellarator-like devices (Toruman and twisted coil stellarators); (3) mirror machines (Astrom and reversed field devices, the 7KIII B experiment, laser-heated bolometers, the LITE experiment, the Kaktus-Sumac concept); (4) bumpy torus (bumpy torus with electron bumpiness, toroidal minimum B configurations); (5) electromagnetically assisted confinement (electromagnetically stuffed cusps and mirrors, electromagnetically assisted toroidal confinement); (6) the Migma concept, and (7) wall-confined plasmas. The plasma parameters of the devices are presented and the advantages and disadvantages of each are listed.


A 2000 MWe MHD steam plant for central station applications has been designed and costed as part of the Energy Conversion Alternatives Study (ECAS). This plant is fueled by Illinois No. 6 coal, rejects heat through mechanical draft wet cooling towers, and includes coal processing equipment, seed reprocessing, electrical inversion of the MHD generator output, and emission controls to current EPA standards. It yields an estimated overall efficiency of 0.4808 (7064 Btu/kWe/hr), a capital cost of $718 per kWe (1975 dollars), and a cost of electricity at 85% capacity factor of 32 mills per kWe/hr. If the assumed life and reliability could be achieved with these performance parameters, the MHD system should prove attractive.
76 SOLID-STATE PHYSICS

Includes superconductivity.
For related information see also 33 Electronics and Electrical Engineering and 36 Lasers and Waves.

A78-13616* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRYSTAL FIELD AND MAGNETIC PROPERTIES

C6CL 208

Magnetizaton and magnetic susceptibility measurements have been made in the temperature range 1.3 to 4.2 K on powdered samples of ErH3. The susceptibility exhibits Curie-Weiss behavior from 4.2 to 2 K, and intercepts the negative temperature axis there at 0.05 ± 0.05 K, indicating that the material is antiferromagnetic. The low field effective moment is 1.06 μB = 0.27 Bohr magnetons per iron. The magnetization exhibits a temperature independent contribution, the slope of which is 5 nearly 12 x 10 to the 8th Weber m/kg Tesla. The saturation moment is 3.84 ± 1.15 Bohr magnetons per iron.

The results can be qualitatively explained by the effects of crystal fields on the magnetic ions. The definitive assignment of a crystal field ground state can be given, nor can a clear choice be made between cubically or hexagonally symmetric crystal fields be made. For hexagonal symmetry, the first excited state is estimated to be 80 to 100 K above the ground state. For cubic symmetry, the splitting is the order of 160 to 180 K.

Author


The electrical resistivity of silicon bronze and phosphor bronze was measured in magnetic fields from 0 to 14 T and at temperatures between 2 and 300 K. At any fixed temperature, the change in resistivity to 14 T was less than a few percent in 100,000. Thus, these bronze are excellent for use in high magnetic fields where constant resistance is required. Wrinkling leads to the sample was found to be effective for soldering. The soldered contacts were subject to spurious resistance changes that resulted from superconducting transitions in the solder.

Author


Magnetization and magnetic susceptibility measurements have been made in the temperature range 1.3 to 4.2 K on powdered samples of ErH3. The susceptibility exhibits Curie-Weiss behavior from 4.2 to 2 K, and intercepts the negative temperature axis there at 0.05 ± 0.05 K, indicating that the material is antiferromagnetic. The low field effective moment is 1.06 μB = 0.27 Bohr magnetons per iron. The magnetization exhibits a temperature independent contribution, the slope of which is 5 nearly 12 x 10 to the 8th Weber m/kg Tesla. The saturation moment is 3.84 ± 1.15 Bohr magnetons per iron. The results can be qualitatively explained by the effects of crystal fields on the magnetic ions. The definitive assignment of a crystal field ground state can be given, nor can a clear choice be made between cubically or hexagonally symmetric crystal fields be made. For hexagonal symmetry, the first excited state is estimated to be 80 to 100 K above the ground state. For cubic symmetry, the splitting is the order of 160 to 180 K.

Author


An investigation is made of the physics and chemistry of MoS2 intercalation compounds. These compounds may be separated into two groups according to their stoichiometry, structure and superconducting properties. The first group consists of Na, Ca, and Sr intercalates, and the second group consists of K, Rb, and Cs intercalates. Particular attention is given to the structure of the electronic energy band and to the normal state and superconducting properties of these compounds.

S.C.S.


Critical currents in sputtered Chou-Chao-phase lead molybdenum sulfide have been measured at several temperatures as a function of applied magnetic field up to 10 T. A critical current density of approximately 50 million A/m² was obtained at 15 T and 1.8 K, and the effective upper critical field was estimated to be 30 T. The pinning force at low fields was found to be dependent on the amount of free lead.

Author


Grant No. NAG 3103.


The upper critical field of sputtered and sputtered copper molybdenum sulfide CuAlMoS8S8 was measured and found to exceed the Werthaus, Heelfand, and Hubert (1966) value for a type II superconductor characterized by dirty limit, weak intergrain electron phonon coupling, and no paramagnetic limiting. It is suggested that the enhancement results from amorphity or clean limit or both. Other ternary molybdenum sulfides appear to show similar anomalies.

M.L.


Superconducting Nb3Ge tape conductors 5 to 10 m long were fabricated by chemical vapor deposition. Such tapes could be used in high field magnet applications. Average tape properties are the high current performance limit of a magnet at 27 tesla (4.2 K). Magnetic critical current densities obtained in thin and layered films set the upper performance limit at 20 tesla (4.2 K).

Author
ADMINISTRATION AND MANAGEMENT

Includes management planning and research.

NDT-139397 National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE MINER PROJECT: MINORITY INVOLVEMENT IN NASA ENGINEERING
(NASA-TM-73811, E-8397) Avail. NTIS HC AQ2/MF AQ1 CBCL 05A

The Miner Project developed by Lewis Research Center (LRC) along with Tennessee State University and Tuskegee Institute, is described. The project calls for LRC to assemble on-going NASA university affairs programs aimed at benefiting the school, its faculty, and its student body. The schools receive grants to pursue research and technology projects that are relevant to NASA's missions. Upon request from the universities, LRC furnishes instructors and lecturers. The schools have use of surplus government equipment and access to NASA research facilities for certain projects. Both the faculty and students of the universities are eligible for summer employment at LRC through special programs. The Miner Project is designed to establish a continuing active relationship of 3 to 5 years between NASA and the universities, and well afford LRC with an opportunity to increase its recruitment of minority and women employees.

Author
82 DOCUMENTATION AND INFORMATION SCIENCE

Includes information storage and retrieval technology; micrography; and library science.

For computer documentation see 61 Computer Programming and Software.

N78-17929* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL CONTRIBUTIONS ANNOUNCED IN 1976
(NASA-TM-73850; E-9449) Avail: NTIS HC A09 CSCL 068
Abstracts of L's authored publications and publications resulting from Lewis managed contracts which were announced in the 1976 issues of STAR (Scientific and Technical Aerospace Reports) and IAA (International Aerospace Abstracts) are presented. Research reports, journal articles, conference presentations, patents and patent applications, and theses are included. The arrangement is by NASA subject category. Citations indicate report literature (identified by their N-numbers) and the journal and conference presentations (identified by their A-numbers). A grouping of indexes helps locate specific publications by author (including contractor authors), contractor, organization, contract number, and report number.

Author

N78-28996* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1977
(NASA-TM-78918; E-9449-2) Avail: NTIS 4C A15/MF A01 CSCL 068
This compilation of abstracts describes and indexes over 780 technical reports resulting from the scientific and engineering work performed and managed by the Lewis Research Center in 1977. All the publications were announced in the 1977 issues of STAR (Scientific and Technical Aerospace Reports) and/or IAA (International Aerospace Abstracts). Documents cited include research reports, journal articles, conference presentations, patents and patent applications, and theses.

A.R.H.
85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation. For related information see 02 Air Transportation and Safety, 16 Space Transportation, and 44 Energy Production and Conversion.

N7B-18828* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.
BASELINE TESTS OF THE C. M. WATERMAN RENAULT 6 ELECTRIC PASSENGER VEHICLE
Noel B. Sargent, Edward F. McNab, and Ralph Slepic, Oct. 1977, 58 p refs
(Contract EC-77-A-31-1011)

The Waterman vehicle, a four passenger Renault GTL performance test results are presented and characterized the state-of-the-art of electric vehicles. It was powered by sixteen 6-volt traction batteries through a two-step converter controller actuated by a foot throttle to change the voltage applied to the 6.7-kilowatt motor. The motor output shaft was connected to a front-wheel drive transaxle that contains a four-speed manual transmission and clutch. The braking system was a conventional hydraulic braking system. Author

N7B-17833* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.
BASELINE TESTS OF THE AM GENERAL DJ-5E ELECTRUCK ELECTRIC DELIVERY VAN
Miller D. Dustin, Henry B. Tryon, and Noel B. Sargent. Oct. 1977, 45 p refs
(Contract EC-77-A-31-1011)

An electric quarter ton truck designed for use as a postal delivery vehicle was tested to characterize the state of the art of electric vehicles. Vehicle performance test results are presented. It is powered by a single 60 volt industrial battery through a silicon controlled rectifier continuously adjustable controller with regenerative braking applied to a direct current compound wound motor. Author

N7B-17834* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.
BASELINE TESTS OF THE ZAGATO ELCAR ELECTRIC PASSENGER VEHICLE
(Contract EC-77-A-31-1011)

The Ecar vehicle performance test results are presented. The Elcar Model 2000 is a two passenger vehicle with a reinforced fiberglass body. It is powered by eight 12-volt batteries. The batteries are connected to the motor through an arrangement of contactors operating from a foot pedal in conjunction with a hand-operated switch. These contactors change the voltage applied to the 2-kilowatt motor. Acceleration tests, operating characteristics, and instrumentation are described. Author

N7B-17835* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.
PHTOVOLTAIC HIGHWAY APPLICATIONS: ASSESSMENT OF THE NEAR-TERM MARKET
(Contract E149-26-1022)

A preliminary assessment of the near-term market for photovoltaic highway applications is presented. Among the potential uses, two market sectors are considered: government and commercial. Within these sectors, two possible application areas, signs and motorway aids, are discussed. Based on judgemental information, obtained by a brief survey of representatives of the two user sectors, the government sector appears more amenable to the introduction of photovoltaic power sources for highway applications in the near-term. However, considerable interest and potential opportunities were also found to exist in the commercial sector. Further studies to quantify the market for highway applications appear warranted. Author

N7B-17836* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.
TEST AND EVALUATION OF 23 ELECTRIC VEHICLES FOR STATE-OF-THE-ART ASSESSMENT
(Contract EC-77-A-31-1011)

Eleven of the electric vehicles were passenger cars and 12 were commercial vans. Tests were conducted in accordance with an ERDS test procedure which is based on the SAE J227a Test Procedure. Tests included range, acceleration, coast-down, and braking. The results of the tests are presented, and comments on reliability are made. Author

N7B-17837* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.
BASELINE TESTS OF THE EVA CHANGE-OF-PACE COUPE ELECTRIC PASSENGER VEHICLE
John M. Bozek, Edward A. Maslowsky, and Miles O. Dustin. Nov. 1977, 13 p refs
(Contract EC-77-A-31-1011)

The EVA Change-of-Pace Coupe, an electric passenger vehicle, is described. It is an electric passenger vehicle to characterize the state-of-the-art of electric vehicles. The EVA Change-of-Pace Coupe is a four passenger sedan that has been adapted to an electric vehicle. It is powered by twenty 6-volt traction batteries through a silicon controlled rectifier/ chopper controller actuated by a foot throttle to change the voltage applied to the series-wound direct current motor. Braking is accomplished with a vacuum assist hydraulic braking system. Regenerative braking is also provided. Author
is a converted four-passenger DAF 46 sedan. It is powered by sixteen 6-volt traction batteries through a three-step contactor 
controlled by a foot throttle to change the voltage applied to 
the 6.7 kw motor. The braking system is a conventional 
hydraulic braking system.

**R78-18040** National Aeronautics and Space Administration. 
Lewis Research Center, Cleveland, Ohio. 
STATE-OF-THE-ART ASSESSMENT OF ELECTRIC VEHICLES AND HYBRID VEHICLES

(NASA-TM-73715; CONS/1011-1: E-9308) Avail: NTIS 
HC A25/MF A01 CSSL 13F

The Electric and Hybrid Vehicle Research, Development, and 
Demonstration Act of 1976 (PL 84-413) requires that data be 
developed to characterize the state of the art of vehicles powered 
by an electric motor and those propelled by a combination of 
an electric motor and an internal combustion engine or other 
power sources. Data obtained from controlled tests of a 
representative number of sample vehicles, from information 
supplied by manufacturers, or contained in the literature, and 
from surveys of fleet operators of individual owners of electric 
vehicles is discussed. The results of track and dynamometer 
tests conducted by NASA on 22 electric, 2 hybrid, and 
6 conventional vehicles, as well as on 5 spark-ignition-engine 
powered vehicles, the conventional counterparts of 5 of 
the vehicles, are presented. Author
RESPONSE OF LEAD-ACID BATTERIES TO CHOPPER-
CONTROLLED DISCHARGE: PRELIMINARY RESULTS
Robert L. Cataldo Feb. 1978 9 p refs
(Contract EC-77-31-1044)
The preliminary results of simulated electric vehicle, chopper,
speed controller discharge of a battery show energy output losses
up to 25 percent compared to constant current discharges at the
same average discharge current of 100 amperes. These energy
losses are manifested as temperature rises during discharge,
amounting to a two-fold increase for a 400-ampere pulse
compared to the constant current case. Because of the potentially
large energy inefficiency, the results suggest that electric vehicle
battery/speed controller interaction must be carefully considered
in vehicle design.

A CYCLE TIMER FOR TESTING ELECTRIC VEHICLES
Richard F. Soltis 1978 11 p Proposed for presentation at the
sponsored by the Elec. Vehicle Council
(Contract EC-77-A-31-1011)
A cycle timer was developed to assist the driver of an electric
vehicle in more accurately following and repeating SAE driving
schedules. These schedules require operating an electric vehicle
in a selected stop-and-go driving cycle and repeating this cycle
pattern until the vehicle ceases to meet the requirements of the
cycle. The heart of the system is a programmable read-only
memory (PROM) that has the required test profiles permanently
recorded on plug in cards, one card for each different driving
schedule. The PROM generates a direct current analog signal
that drives a speedometer displayed on one scale of a dual
motion meter. The second scale of the dual motion meter
displays the actual speed of the vehicle as recorded by the
wheel. The vehicle operator controls vehicle speed to match the
desired profile speed. The PROM controls the recycle start time
as well as the buzzer activation. The cycle programmer is powered
by the vehicle's 12-volt accessory battery, through a 5-volt
regulator and a 12-volt dc-to-dc converter.

STATE-OF-THE-ART ASSESSMENT OF ELECTRIC AND
HYBRID VEHICLES Jan. 1978 598 p refs
(Contract EX-76-A-31-1011)
Data are presented that were obtained from the electric and
hybrid vehicles tested, information collected from users of
electric vehicles, and data and information on electric and hybrid
vehicles obtained on a worldwide basis from manufacturers and
available literature. The data given include: (1) information and
data base (electric and hybrid vehicle systems descriptions, sources
of vehicle data and information, and sources of component data);
(2) electric vehicles (theoretical background, electric vehicle track
tests, user experience, iteration data, electric vehicle status); (3)
electric vehicle components (tires, differentials, transmissions, traction motors, controllers, batteries, battery
chargers, and component summary); and (4) hybrid vehicles
(types of hybrid vehicles, operating modes, hybrid vehicles
components, and hybrid vehicles performance characteristics).

A STIRLING ENGINE COMPUTER MODEL FOR PERFORMANCE
(Contract EC-77-31-1011)
To support the development of a Stirling engine as a possible
alternative to the automobile spark-ignition engine, the thermody-
namic characteristics of the Stirling engine were analyzed and
modeled on a computer. The modeling techniques used are
presented. The performance of an existing, rhombic-drive Stirling
engine was simulated by use of this computer program, and
some typical results are presented. Engine tests are planned in
order to evaluate this model.

In many cases it has been found that advances made in one technical field can contribute to other fields. An investigation is in this connection conducted concerning subjects from contemporary NASA programs and projects which might have relevance and potential usefulness to the automotive industry. Examples regarding aerospace developments which have been utilized by the automotive industry are related to electronic design, computer systems, quality control experience, a NASA combustion scanner and television display, exhaust gas analyzers, and a device for suppressing noise propagated through ducts. Projects undertaken by NASA’s center for propulsion and power research are examined with respect to their value for the automotive industry. As a result of some of these projects, a gas turbine engine and a Stirling engine might each become a possible alternative to the conventional spark ignition engine.

G.R.


Data developed by ERDA used to evaluate the performance parameters of modern electric vehicles is presented with reference to range, acceleration, cost-down, and braking. Eight of the tested vehicles had some type of regenerative braking system, which provided range increases from 1 to 31 percent. In comparison with conventional vehicles, performance was found to be lower, and reliability poorer. Energy consumption was the same, but electric power is less damaging to the environment than hydrocarbon fuels, and does not use up an increasing scarce resource.

D.M.W.


The Ford/DOE automotive Stirling engine development program is directed towards establishing the technological and developmental base that would enable a decision on whether or not an engineering program should be directed at Stirling engine production. The on-going evaluation assessment aims to achieve, with a high degree of confidence, the ERDA proposal estimate of 200 MPG (gasoline) for the Scavenger engine package for a 4.5 liter car. This current M-H fuel economy projection for the 170 HP Stirling engine is 15.7 MPG. The confidence level for this projection is 32%. A confidence level of 29% is projected for a 22.1 MPG estimate if all of the planned analyses and test work is accomplished at the end of the one year effort, and the projected improvements are substantiated. The confidence levels would rise to 59% for the 20.6 MPG projection and 54% for the 22.1 MPG projection. Progress achieved thus far during the fuel economy assessment is discussed.

Author

and working through cycles analyses. Analysis methodologies are classified as first, second or third order depending upon degree of complexity and probable application; first order for preliminary engine studies, second order for performance prediction and engine optimization, and third order for detailed hardware evaluation and engine research. A few comparisons between theory and experiment are made. A second order design procedure is documented step by step with calculation sheets and a worked out example to follow. Current high power engines are briefly described and a directory of companies and individuals who are active in Stirling engine development is included. Much remains to be done - some of the more complicated and potentially very useful a priori procedures are now only referred to. Future support will enable a more thorough job of comparing all available design procedures against experimental data which should soon be available.

Author


Ceramic regenerator cores are considered that can be used in passenger car gas turbine engines, Stirling engines, and industrial/truck gas turbine engines. Improved materials and design concepts aimed at reducing or eliminating chemical attack were placed on durability test in Ford 707 industrial gas turbine engine. The results of 19.500 hours of turbine engine durability testing are described. Two materials, aluminum silicate and magnesium aluminum silicate continue to show promise toward achieving the durability objectives of this program. A regenerator core made from aluminum silicate showed minimal evidence of chemical attack damage after 6935 hours of engine test at 800 C and another showed little distress after 3510 hours at 982 C. Results obtained in ceramic material screening tests, aerothermodynamic performance tests, stress analysis, cost studies, and material specifications are also included.

Author


Ceramic regenerator cores are considered that can be used in passenger car gas turbine engines, Stirling engines, and industrial/truck gas turbine engines. Improved materials and design concepts aimed at reducing or eliminating chemical attack were placed on durability tests in industrial gas turbine engines. A regenerator core made from aluminum silicate shows minimal evidence of chemical attack damage after 7804 hours of engine test at 800 C and another showed little distress after 4983 hours at 982 C. The results obtained in ceramic material screening tests, aerothermodynamic performance tests, stress analysis, cost studies, and material specifications are also included.

G.G.
PRELIMINARY POWER TRAIN DESIGN FOR A STATE-OF-THE-ART ELECTRIC VEHICLE Final Report
Philip Megdolh and William F. Hahn Apr 1978 144 p refs
(Contracts NAS3-20698, EC-77-A-31-1044)
(NASA-CR-135341, DOE/NASA/0695-78/1) Avail: NTIS
HC A07/MF A01 CSCL 13F

Power train designs which can be implemented within the current state-of-the art were identified by means of a review of existing electric vehicles and suitable off-the-shelf components. The effect of various motor/transmission combinations on vehicle range over the SAE J227a schedule D cycle was evaluated. The selected state-of-the-art power train employs a dc series wound motor, SCR controller, variable speed transmission, regenerative braking, drum brakes and radial ply tires. Vehicle range over the SAE cycle can be extended by approximately 20% by the further development of separately excited, shunt wound DC motors and electrical controllers. Approaches which could improve overall power train efficiency, such as AC motor systems, are identified. However, future emphasis should remain on batteries, tires and lightweight structures if substantial range improvements are to be achieved. Author
SPACEx SCIENCES (GENERAL)

878-32914 9 National Aeronautics and Space Administration,
Lewis Research Center, Cleveland, Ohio,
SPACExCRAFT CHARGING CONTROL: THERMAL FIELD
EMISSION WITH LANTHANUM-HExABORIDE EMITTERS
James F. Norris Aug. 1978 28 p refe
NASA-TN-72060. E-9773 Avail: NTIS HC A03/MF A01
CSECL 228
Thermal field emitters of lanthanum (or perhaps cerium) hexaboride (LaB6) with temperature variability up to about 1500 K are suggested for spacecraft charging control. Such emitters operate at much lower voltages with considerably more control and add plasma-diagnostic versatility. These gains should outweigh the additional complexity of providing heat for the LaB6 thermal, field emitter.
L.S.
Includes solar activity, solar flares, solar radiation and sunspots.

70-2m. National Aeronautics and Space Administration.
Lewis Research Center Cleveland, Ohio.
EVALUATION OF MODELS TO PREDICT INSOLATION ON TILTED SURFACES
Thomas M. Klucher Mar. 1978 30 p ref
(Contract E(48-26)-1022)
(NASA-TM-78842. E-9556) Avail: NTIS HC A03/MF A01 CSCL 10A
An empirical study was performed to evaluate the validity of various insolation models which employ either an isotropic or an anisotropic distribution approximation for sky light when predicting insolation on tilted surfaces. Data sets of measured hourly insolation values were obtained over a six-month period using pyranometers which received diffuse and total solar radiation on a horizontal plane and total radiation on surfaces tilted toward the equator at 37 deg and 60 deg angles above the horizon.
Data on the horizontal surfaces were used in the insolation models to predict insolation on the tilted surface; comparisons of measured versus calculated insolation on the tilted surface were examined to test the validity of the sky light approximations.
It was found that the Liu-Jordan isotropic distribution model provides a good fit to empirical data under overcast skies but underestimates the amount of solar radiation incident on tilted surface under clear and partly cloudy conditions. The anisotropic-clear-sky distribution model by Tempa and Coulson provides a good prediction for clear skies but overestimates the solar radiation when used for cloudy days. An anisotropic-all-sky model was formulated in this effort which provided excellent agreement between measured and predicted insolation throughout the six-month period.

Author
DESIGN AND PERFORMANCE OF HEART ASSIST OR ARTIFICIAL HEART CONTROL SYSTEMS


The factors leading to the design of a controlled driving system for either a heart assist pump or artificial heart are discussed. The system provides square pressure waveform to drive a pneumatic-type blood pump. For assist usage the system uses an R-wave detector circuit that can detect the R-wave of the electrocardiogram in the presence of electrical disturbances. This circuit provides a signal useful for synchronizing an assist pump with the natural heart. It synchronizes a square waveform circuit, the output of which is converted into square waveforms of pneumatic pressure suitable for driving both assist device and artificial heart. The pressure levels of the driving waveforms are controlled by means of feedback channels to maintain physiological regulation of the artificial heart's output flow. A more compact system that could achieve similar regulatory characteristics is also discussed.

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**ABSORPTION SPECTRA**

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4 Noise reduction

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Sound absorption probes for flowing duct noise measurements -- jet engine diagnosis

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OPTICAL FILTERS

Optical interference filters with extended transmission bands at 0.6, 0.7, and 0.8 microns. These filters are designed for use in various optical systems requiring high selectivity and narrow bandwidth.

OPTICAL SPECTROMETRY

Development of an efficient spectrometry system for precise analysis of optical spectra. The system incorporates advanced optical components and signal processing algorithms to enhance spectral resolution and detection limits.

LASER DIESEL EXCITATION

Laser diesel excitation technology for improved engine performance and emissions reduction. The system utilizes high-intensity laser light to excite diesel droplets, facilitating better mixing and combustion efficiency.

OPTICAL SENSORS

A comprehensive range of optical sensors, including photodiodes, photomultipliers, and fiber optics, for various applications such as detection, measurement, and control.

OPTICAL AND ELECTRONIC COMPONENTS

A wide selection of optical and electronic components, including lenses, mirrors, and semiconductors, for use in optical systems and electronic devices. The components are designed to withstand harsh environmental conditions.

OPTICAL COMPONENTS

A variety of optical components, such as prisms, gratings, and filters, for optical system design and optimization.

OPTICAL MEASUREMENTS

Optical measurements and imaging systems for various applications, including medical diagnostics, industrial inspection, and environmental monitoring.

OPTICAL ENGINEERING

Optical engineering solutions for project development, analysis, and system integration. Services include optical design, simulation, and integration of optical components and systems.

OPTICAL DESIGN SOFTWARE

Software tools for optical design, simulation, and analysis, enabling rapid prototyping and optimization of optical systems.

OPTICAL COMPONENTS

A range of optical components, such as lenses, mirrors, and filters, for use in various optical systems and applications.

OPTICAL MATERIALS

Optical materials for use in optical systems, including glasses, plastics, and crystals, with properties such as high optical clarity, thermal stability, and chemical resistance.

OPTICAL FIBERS

A selection of optical fibers for use in various applications, including telecommunications, sensing, and medical imaging.

OPTICAL WAVEGUIDES

Optical waveguides for guiding light in optical fibers and integrated optical devices. The waveguides are designed for low loss and high efficiency.

OPTICAL COATING PROCESSING

A process for depositing optical coatings on optical surfaces for various applications, including antireflection, high transmittance, and high reflectance coatings.

OPTICAL COATING TECHNOLOGY

Optical coating technology for the deposition of thin film layers on optical components. The technology offers precise control over coating properties and thickness.

OPTICAL COATING MATERIALS

Materials for optical coatings, including thin-film optical materials and dyes, for use in various applications, such as antireflection coatings and color filters.

OPTICAL COATING SYSTEMS

Optical coating systems for the deposition of thin film layers on optical surfaces. The systems are designed for high accuracy and repeatability.

OPTICAL COATING SERVICES

Services for the deposition of optical coatings on optical components, including custom coating services and turnkey solutions.

OPTICAL COATING INSTRUMENTATION

Instrumentation for the characterization and analysis of optical coatings, including profilometry, reflectometry, and transmittance measurement.

OPTICAL COATING QUALITY CONTROL

Quality control methods and procedures for the production of optical coatings, ensuring high performance and reliability.

OPTICAL COATING APPLICATIONS

Applications of optical coatings, such as antireflection coatings, high transmittance coatings, and high reflectance coatings, in various fields, including telecommunications, aerospace, and medical imaging.
A parametric investigation of an existing supersonic relative tip speed propeller nozzle -- turbojet aircraft

A parametric investigation of an existing supersonic relative tip speed propeller nozzle -- turbojet aircraft

A parametric investigation of an existing supersonic relative tip speed propeller nozzle -- turbojet aircraft
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AERODYNAMIC

Aero3dynamic
The effect of high electric fields on aircraft engine performance and design.

- Utilizing new materials and coatings for improved performance.
- Analysis of the impact of electric fields on acoustic design and engine efficiency.
- Research on the relationship between electric fields and aircraft noise reduction.

Studies include:
- Effects of applied electric fields on particle transport in a complex flow environment.
- Acoustic design and noise reduction in high-performance aircraft engines.
- Investigation of electric field interactions with mechanical components of aircraft engines.

Key references:

This research is supported by the National Aeronautics and Space Administration (NASA) and other federal agencies.
Steady-state imbalance response of a three-disk flexible rotor on flexible, damped supports [NASA-TH-29136]

Concepts for the development of light-weight composite structures for rotor bearing containment [NASA-TH-50052]

Stability of numerical integration techniques for transient dynamics [NASA-TH-12682]

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Effect of vibration on retention characteristics of acoustic acquisition systems -- for surface tension, propellant acquisition [AIAA Paper 78-1030]

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7 SPACE SHRIEK ORBITERS

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- Silicon Solar Cells
- Single-Crystal Silicon
- Single-Crystal Silicon Carbide
- Contact deformation of single-crystal silicon carbide in sliding contact with various metals
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**Note:** The table above represents the measurements and weights of various items, possibly parts or components, with dimensions given in millimeters and weights in kilograms.
<p>| ASA-TH-7384 |          | p014 | 787-1306292 | ASA-TH-7383 |          | p001 | 787-2116897 |
| ASA-TH-7385 |          | p018 | 787-1737990 | ASA-TH-7384 |          | p005 | 787-2231396 |
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| ASA-TH-7387 |          | p006 | 787-1520496 | ASA-TH-7386 |          | p009 | 787-2473594 |
| ASA-TH-7388 |          | p009 | 787-1769094 | ASA-TH-7387 |          | p013 | 787-2267194 |
| ASA-TH-7389 |          | p015 | 787-3065692 | ASA-TH-7388 |          | p003 | 787-2099396 |
| ASA-TH-7390 |          | p013 | 787-1915397 | ASA-TH-7389 |          | p004 | 787-2129999 |
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| ASA-TH-7392 |          | p013 | 787-2073592 | ASA-TH-7391 |          | p019 | 787-2209496 |
| ASA-TH-7393 |          | p015 | 787-1748992 | ASA-TH-7392 |          | p103 | 787-3336992 |
| ASA-TH-7394 |          | p015 | 787-1748992 | ASA-TH-7393 |          | p103 | 787-3336992 |
| ASA-TH-7395 |          | p015 | 787-1748992 | ASA-TH-7394 |          | p103 | 787-3336992 |
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