

Japanese Aerospace Literature

This month: *Propulsion and Power—Propulsion, Propellants, Fluid Mechanics, and Computational Fluid Dynamics*

A88-50295 High temperature fuel cell with ceria-yttria solid electrolyte. HIDENORI YAHIRO, YOSHINOBU BABA, KOICHI EGUCHI, and HIROMICHI ARAI, *Electrochemical Society Journal* (ISSN 0013-4651), Vol. 135, Aug. 1988, pp. 2077-2080. 19 Refs.

The solid electrolyte of the system $\text{CeO}_2\text{-Y}_2\text{O}_3$ exhibited high ionic conductivity, as well as almost unity ionic transference number at 600-1000 C. High current density and electrical power can be obtained from a $(\text{CeO}_2)_0.9(\text{YO}_1.5)_0.1$ fuel cell at 600-800 C. $\text{La}_0.6\text{Sr}_0.4\text{CoO}_3$ was an excellent cathode as compared with Pt electrode. A thin film of stabilized zirconia coated by RF-sputtering is effective in protecting the anodic surface of ceria-yttria electrolyte from reduction with hydrogen. The open-circuit voltage of the fuel cell approached the theoretical value with this coating treatment.

A88-39207 Numerical integration of the Lagrangian renormalized approximation. TOSHIYUKI GOTOH, YUKIO KANEDA, and NAOAKI BEKKI, *Physical Society of Japan Journal* (ISSN 0031-9015), Vol. 57, March 1988, pp. 866-880. Research supported by Toyota Physical and Chemical Research Institute. 29 Refs.

The decay of two-dimensional and three-dimensional homogeneous isotropic turbulence at moderate and high Reynolds numbers is investigated analytically. The application of the Lagrangian renormalized approximations proposed by Kaneda (1981) is described in detail, and the results of numerical integration are presented in extensive graphs and compared with direct numerical simulations and published experimental data. Good agreement is demonstrated, and the performance of the modified Lagrange approximation is found to be similar to that of the TFM (Kraichnan, 1971).

A89-14863 Propagation of sound in axisymmetric shear flow. YASUJI TSUBAKISHITA, TAKAO YOSHIKAWA, and TOHRU TANAKA, *Japan Society for Aeronautical and Space Sciences Transactions* (ISSN 0549-3811), Vol. 31, Aug. 1988, pp. 94-103. 10 Refs.

The sound source radiation through the shear layer of an axisymmetric subsonic jet has been studied. The structure of the radiated field is numerically obtained for several velocity profiles of the shear layer and jet Mach numbers ranging from 0.2 to 0.8. The numerical simulations are conducted by solving a linearized unsteady Euler equation about mean flow states whose shear-layer velocities have continuous steep profiles, by means of a fourth-order-accurate finite-difference scheme. The interaction of the sound wave with the shear layer is discussed on the basis of a dispersion relation obtained from a linear stability theory.

A88-40571 An energetics experiment on a space platform. KY-OICHI KURIKI and HIROAKI OBARA, *Space Power* (ISSN 0951-5089), Vol. 7, no. 1, 1988, pp. 75-89. 5 Refs.

This paper discusses the Space Flyer Unit (SFU) free-flying platform and the on-board advanced-technology experiments planned for this system in relation to the Space Power Satellite (SPS) technology. Attention is given to the design of the SFU and payload integration, the energy-exploitation experiments, and to interactive experiments between SFU and SPS. Special consideration is given to the configuration and characteristics and the experimental objectives of a two-dimensionally deployable array and a high-voltage solar array and to electric propulsion experiment, microwave energy transmission experiment, and space experiment with particle accelerators. Design diagrams of the SFU and the various experiments designed for it are included.

A89-10568 Numerical experiments for separation flows around trapezoidal cylinders by a discrete vortex method. MASANORI HAYASHI, SHIGERU ASO, and TOMONORI TAGUCHI, *Kyushu University, Technology Reports* (ISSN 0023-2718), Vol. 61, June 1988, pp. 293-300. 5 Refs.

Separated flows around several trapezoidal cylinders are calculated by a discrete vortex method combined with a panel method. The potential flow around trapezoidal cylinders are expressed by vortex sheets and separated shear layers by discrete vortices. In the calculation five types of trapezoidal cylinders whose shape parameter b/h (b is a front body length normal to the freestream and h is rear body length normal to the freestream) are 0.0, 0.25, 0.5, 0.75, and 1.0, are used. The strength of a shed vortex is estimated using local velocity near a separation point. The strengths of shed vortices are changed remarkably with shape parameters. Those results agree with the previous results that the separation point moves from a rear corner to a front corner as the shape parameter, b/h , increases. Also modifications for the estimation of pressure coefficients around wing section are proposed. The results show good agreement with experiments.

A88-44639 SIR-B image calibration by a corner reflector array. MASAHARU FUJITA, HIDEYUKI NAITO, and NOBUYOSHI FUGONO, *International Journal of Remote Sensing* (ISSN 0143-1161), Vol. 9, May 1988, pp. 849-856. 9 Refs.

SIR-B image data taken over a corner reflector array are analyzed to calibrate the image and to estimate the 3 dB resolution. Square trihedral corner reflectors having different radar cross-sections (RCSs) are successfully used to relate an image data number to RCS. RCS of the background surface is estimated and its effect is also included in the above relation. The 3 dB resolutions are estimated by two independent techniques. The results obtained from the two techniques agree with each other within their relative difference by 5.6 percent except for one case. The estimated resolutions are larger than those predicted by the Jet Propulsion Laboratory. The estimates should be regarded as the image resolutions and do not represent the sensor characteristics.

A88-29718 Numerical simulation of vortex-induced flow fields in a turbine cascade. Numerische Simulation durch Wirbel zu bestimmender Strömungsfelder im Schaufelgitter. H. NISHIMURA, *Zeitschrift fuer angewandte Mathematik und Physik* (ISSN 0044-2275), Vol. 39, Jan. 1988, pp. 50-64. 7 Refs.

Vortex-induced flow fields in (1) a parallelogram-shaped zone enclosed by four nonporous walls; (2) a channel enclosed by upper and lower walls; and (3) a half-open region enclosed by upper, lower, and left-side walls are investigated by means of numerical simulations based on the potential-vortex model of Lakshminarayana (1970). The derivation of the governing equations is discussed, and the results are presented graphically and characterized in detail. The effectiveness of the present approach in describing secondary cascade flows with vortices is demonstrated.

A88-44522 Violent liquid sloshing in vertically excited cylindrical containers. HIROYUKI HASHIMOTO and SEIICHI SUDO, *Experimental Thermal and Fluid Science* (ISSN 0894-1777), Vol. 1, April 1988, pp. 159-169. 12 Refs.

The frequency characteristics of gas-liquid surface sloshing induced by the vertical vibration of cylindrical containers containing liquid were experimentally investigated using a vibration-testing system with an electrodynamic shaker. The results show that the resonance frequency of the liquid-container vibration system depends on the excitation acceleration, and that the acceleration distribution of the container wall was not axisymmetrical at higher excitation accelerations. Significant changes in liquid pressure, container wall acceleration, and amplitude of surface oscillation were noted following the formation of a bubble cluster.

A88-37188 Some topics of ASKA's flight test results and its future plan. TOSHIO BANDO, YOSHIO HAYASHI, OSAMU KOBAYASHI, and ISAO KAGEYAMA, IN: *Proceedings of International Powered Lift Conference and Exposition*, Santa Clara, CA, Dec. 7-10, 1987, Society of Automotive Engineers, Inc., Warrendale, PA, 1988, pp. 181-187. 11 Refs. (SAE Paper 872317)

The quiet STOL research airplane ('ASKA') was developed as a research aircraft that would provide high levels of STOL performance at low levels of community noise. The ASKA is a C-1 tactical transport, modified to incorporate an Upper Surface Blowing (USB) type propulsive-lift system. Attention is given to the major subjects in evaluation of a newly developed engine, the actual proof of the structure, confirmation of different avionics systems, and documenting of fundamental flying quality and performance.

A88-40424 Development of liquid apogee propulsion system for 2 ETS-VI. UICHI IMACHI, MASAKAZU SATO, KOICHI MIYOSHI, and YUICHI HAYASAKA, *Ishikawajima-Harima Engineering Review* (ISSN 0578-7904), Vol. 28, Jan. 1988, pp. 25-30.

ETS-VI (Engineering Test Satellite VI) the Japanese first two-ton-class stationary satellite is scheduled to be launched in 1992 by the H-II heavy launch vehicle. Under the contract with the National Space Development Agency, IHI conducts the apogee stage integration for the ETS-VI. Trade-off study on various possibilities resulted in stage configuration in separable blow-down type with storable propellant: i.e., NTO/N2H4 for the advantages of simplicity, lower program risks and shorter development period and christened LAPS (liquid apogee propulsion system). LAPS has a single 2000N-class engine and four thrusters and capabilities of on-orbit restarting, propellant settling and automatic engine shut-down with command from the satellite. The apogee engine has been fire tested over 500 times including sea-level fire testing with 3500 seconds of duration that simulated flight operation and the possibility of practical use as firmly convinced by the propulsion system.

A88-40354 SIR-B experiments in Japan. IV - Sensor calibration experiment. MASA HARU FUJITA, HIDEYUKI NAITO, and TADASHI ODA, *Radio Research Laboratory Journal* (ISSN 0033-8001), Vol. 35, March 1988, pp. 61-75. 11 Refs.

Among the test sites for the SIR-B calibration experiment, the Sarobetsu test site was successfully imaged twice on ascending and descending orbits. The SIR-B image data taken over the test site are analyzed to calibrate the image and to estimate the 3-dB resolution. Square trihedral corner reflectors with different radar cross sections (RCS) are used to relate the image data number to RCS. The RCS of the background surface is estimated and its effect is also included in these relations. The 3-dB resolutions are estimated by two independent techniques. The results of these two techniques agree with each other; however, the estimated resolutions are larger than those predicted by the Jet Propulsion Laboratory. The estimates should be regarded as the image resolutions rather than representing the sensor characteristics. Corner reflectors 50-m apart can be recognized on the image, while those 25-m apart seem a single target. The SIR-B image of targets 25 m or more apart is confirmed to be the sum of the individual target responses. The backscattering signal from a target does not correlate with another target over 25 m away.

A88-31191 A concept of CO₂-breathing propulsion engine for planet use. SABURO YUASA and HIROSHI ISODA, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 36, no. 409, 1988, pp. 16-22. 11 Refs.

The purpose of this paper is to assess the feasibility of a CO₂-breathing engine using metal fuels for planetary use. The heats of reactions between metals and CO₂ were reviewed. Equilibrium compositions and temperatures of the metal-CO₂ flames were calculated. It was confirmed experimentally that Al and Mg could burn in CO₂. Thermodynamic cycle calculations were carried out to evaluate the performance of a CO₂-breathing turbojet engine. With these results, it is concluded that metal-fueled CO₂-breathing turbojet engine with a practicable performance can be developed.

A88-49032 A transport study for resistive interchange mode turbulence based on a renormalized theory. HIDEO SUGAMA and MASAHIRO WAKATANI, *Physical Society of Japan Journal* (ISSN 0031-9015), Vol. 57, June 1988, pp. 2010-2025. 20 Refs.

A new formulation of renormalized theory for fluid-type turbulence to obtain wavenumber spectrum and turbulent diffusivity is presented. Applications to the resistive interchange mode turbulence are discussed. The turbulent diffusivity using the reduced MHD equations agrees with evaluations based on the mixing length argument or the scale invariance except a coefficient of about four. An extended model based on finite Larmor radius magnetohydrodynamics (FLR-MHD) including coupling between the resistive drift wave and the resistive interchange mode is analyzed by the renormalized theory. The diffusivity depends on the phase difference and the relative magnitude between the density fluctuation and the potential fluctuation, and role of density gradient becomes more significant than the reduced MHD result. However, the wavenumber spectrum does not change much by the extended model.

A88-40565 Laser propulsion with a magnetic nozzle. YOSHIHIRO ARAKAWA, and KIMITO YOSHIKAWA, *Space Power* (ISSN 0951-5089), Vol. 7, no. 1, 1988, pp. 17-25. 12 Refs.

This paper describes a relatively simple and low-cost experimental set up designed for laser propulsion (LP) research. A new propellant feed system was constructed for use of metal pellets as a propellant. In the experiment, metal pellets were injected one by one, their position and velocity were detected by photosensors, and high-temperature laser-induced plasma was generated. Magnetic nozzle was introduced to improve the performance and to protect the combustion chamber. Laser-induced plasmas were seen to expand in the magnetic nozzle, in which the conversion of radial to axial momentum was confirmed by probe measurements. The results obtained using this system were characterized by high accuracy, reproducibility, and flexibility under various experimental conditions.

A88-45225 Three-dimensional heat transfer and fluid flow analysis of arrays of square blocks encountered in electronic equipment. YUTAKA ASAKO and M. FAGHRI, *Numerical Heat Transfer* (ISSN 0149-5720), Vol. 13, June 1988, pp. 481-498. 11 Refs.

A numerical method developed for the analysis of the three-dimensional fluid flow and heat transfer characteristics of an array of heated square blocks deployed along one wall of a rectangular duct is presented. This configuration simulates the forced-convection cooling of printed circuit boards encountered in electronic equipment. Computations are carried out for a range of Reynolds numbers, for a Prandtl number of 0.7, and for several values of dimensionless geometric parameters characterizing the problem. The results indicate that there is a decrease in the friction factor and the Nusselt number when compared to the corresponding values obtained from a parallel-plate duct with the assumption of fully developed velocity and temperature profiles.

A88-39505 Melt phase decomposition of RDX and two nitrosamine derivatives. Y. OYUMI, *Propellants, Explosives, Pyrotechnics* (ISSN 0721-3115), Vol. 13, April 1988, pp. 42-47. 39 Refs.

Thermal decomposition of hexahydro-1,3,5-trinitroso-s-triazine (TRDX), C₃H₆N₃(NO)₃, and hexahydro-1,3-dinitro-5-nitroso-s-triazine (MRDX), C₃H₆N₃(NO)₂(NO), was studied by DTA and TGA in argon atmosphere, which was showing overall first-order kinetics. The results are compared with those for RDX in order to determine the effect of replacing NNO₂ group with NNO. The decomposition of the admixture of RDX/TRDX (50/50 by weight) was also tested. The kinetic parameters calculated are: for RDX, $\ln k = 43.1-47,900/RT$, for MRDX $\ln k = 34.3-37,200/RT$, for TRDX $\ln k = 29.4-30,500/RT$, while for the RDX/TRDX admixture, $\ln k = 37.0-39,700/RT$, where k is per sec. The melt-phase decomposition products of RDX, MRDX, and TRDX condensed on a NaCl plate which was placed 2 cm above the sample cell were almost exactly the same in IR measurements. RDX is soluble in liquefied TRDX and the decomposition of RDX is accelerated by its liquefaction.

A88-29275 On the Kolmogorov's spectrum for turbulence - A review of the statistical mechanical theory of turbulence. NORIO OHTOMO, TADASHI SEIDOU, and YUKIO TANAKA, *Hokkaido University, Faculty of Engineering, Bulletin* (ISSN 0385-602X), Feb. 1988, p. 69-75. 23 Refs.

Several contributions to the recent development of a statistical mechanical theory of turbulence are briefly reviewed. The first group of these is represented by Wyld's theory, which adopts a perturbation method for solving the Navier-Stokes equation, analogous to the perturbation theory using Feynman's diagrams of quantum field theory. The Kolmogorov '-5/3' spectrum is derived by Shut'ko on the basis of Wyld's theory. The next is Hopf's theory based on the functional formulation, in which the so-called Hopf equation is derived. The Hopf equation is formally identical to the Tomonaga-Schwinger equation of quantum field theory. The Kolmogorov '-5/3' spectrum is derived by Edwards and McComb using the maximum-entropy principle.

A88-28931 Mean-field magnetohydrodynamics associated with random Alfvén waves in a plasma with weak magnetic diffusion. HIROMITSU HAMABATA and TOMIKAZU NAMIKAWA, *Journal of Plasma Physics* (ISSN 0022-3778), Vol. 39, Feb. 1988, pp. 139-149. 7 Refs.

Using first-order smoothing theory, Fourier analysis and perturbation methods, a new equation is derived governing the evolution of the spectrum tensor (including the energy and helicity spectrum functions) of the random velocity field as well as the ponderomotive and mean electromotive forces generated by random Alfvén waves in a plasma with weak magnetic diffusion. The ponderomotive and mean electromotive forces are expressed as series involving spatial derivatives of mean magnetic and velocity fields whose coefficients are associated with the helicity spectrum function of the random velocity field. The effect of microscale random Alfvén waves, through ponderomotive and mean electromotive forces generated by them, on the propagation of large-scale Alfvén waves is also investigated by solving the mean-field equations, including the transport equation of the helicity spectrum function.

A88-36696 Numerical simulation of slightly underexpanded free jets. YASUJI TSUBAKISHITA, *Japan Society for Aeronautical and Space Sciences Transactions* (ISSN 0549-3811), Vol. 30, Feb. 1988, pp. 211-219. 9 Refs.

A numerical study of jets from a nozzle exhausting into ambient still air is presented with attention given to the effect of a jet pressure ratio on the jet structure. The free jet is slightly underexpanded with the pressure ratio ranging from 1.4 to 2.6. Numerical algorithm involves an extension of a bidiagonal implicit scheme by Casier et al. (1984) to axisymmetric Euler equation, with a time splitting procedure. The study demonstrates that an inviscid model of the jet flowfield exhibits good agreement with the available experimental data, including the primary wavelength. The computational results also confirm that the transition from a regular reflected shock to a Mach disk occurs at the experimentally observed pressure ratio.

A89-10545 Plasma jet ignition of lean hydrogen-air mixtures. SHINSUKE ONO, EIICHI MURASE, KUNIHICO HANADA, and SHOJI NAKAHARA, *Kyushu University, Faculty of Engineering, Memoires* (ISSN 0023-6160), Vol. 48, March 1988, pp. 1-15. 17 Refs.

In order to confirm the performance and characteristics of plasma jet ignition quantitatively, combustion tests of lean hydrogen-air mixtures are carried out with varying governing parameters of plasma jet igniter (plasma cavity size, orifice diameter, and discharge energy). From the series of tests, the combustion enhancement by the plasma jet ignition is revealed only in the initial stage of combustion. Then a comparing parameter of the performance of plasma jet ignition in its initial stage of combustion is proposed by comparing the pressure diagram of plasma jet ignition and that of conventional single-point center ignition. The performance and the characteristics of plasma jet ignition are revealed quantitatively by the comparing parameter.

A88-39206 Similarity transformations of compressible viscous flow in conservative force fields. I - Two-dimensional problem. TOSHIYUKI NISHITANI, *Physical Society of Japan Journal* (ISSN 0031-9015), Vol. 57, March 1988, pp. 844-855. 10 Refs.

The similarity transformation formulated by Lundgren (1982) and Kambe (1983) is applied to reduce the Navier-Stokes equations for the two-dimensional compressible viscous flow of a perfect gas in conservative force field to the equations for flow without an external force. The invariant transformation is explained; the flow in a centrifugal force field is analyzed as a test case; and the reduction from two dimensions to one is derived in detail.

A88-38345 Inertial guidance system for the H-I launch vehicle - NICE. NAOTERU NAGAO and SYOZO TANI, *Mitsubishi Heavy Industries Technical Review* (ISSN 0026-6817), Vol. 25, Feb. 1988, pp. 61-73.

This report gives an outline of the NICE (NASDA Inertial-guidance and Control Equipment) inertial guidance system developed for the NASDA H-I launch vehicle, and to proprietary participation in the NICE system's integration support, the development of the flight program, and the data-interface unit. This system provides for first and second stage attitude control, navigation and guidance, second stage tank pressurization control, and vehicle sequencing functions. The functions and performance of the NICE system were perfectly certified through the first flight of the H-I launch vehicle (Test flight #1 mission) on August 13, 1986.

A89-10542 A numerical solution of transonic flow using discontinuous shock relation. MASAYOSHI NAKAMURA, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 36, no. 414, 1988, pp. 333-342. 8 Refs.

The purpose of this study is to obtain solutions, which contain complete discontinuities of shock waves, of the potential equations for transonic airfoils using numerical techniques. For iterative calculations, the potential equations are transformed into a more convenient form of simultaneous equations with two variables of velocity potential and Mach number. The solutions with the complete discontinuities of shock waves satisfying Prandtl's relationship are obtained by the iterative calculations without divergencies or height frequencies under a grid system in the physical plane. Numerical results of the present techniques and of another

method for the transonic flow over an airfoil of NACA 0012 with shock wave are used as test cases for comparisons.

A89-12568 Direct energy conversion from a laser beam by using a relativistic electron beam. TAKASHI ABE, *Space Power* (ISSN 0951-5089), Vol. 7, no. 2, 1988, pp. 145-152. 5 Refs.

In space activity, the energy remotely transmitted by means of a laser beam is valuable for many purposes. This energy can be used as electric power through an energy converter. In this paper, a new energy converter is proposed, in which a relativistic electron beam is used. In this method, the operation of high power density is possible while maintaining a high efficiency, since the unconverted laser beam is transmitted rather than absorbed in the converter.

A88-36700 Addendum to the calculation of transonic potential flow through a two-dimensional cascade. KENJI INOUE and TAKASHI NAKAMURA, *Japan Society for Aeronautical and Space Sciences Transactions* (ISSN 0549-3811), Vol. 30, Feb. 1988, pp. 259-261.

A procedure proposed previously for calculating the transonic potential flow through a two-dimensional cascade is reviewed. This procedure is developed further by including a means of obtaining the solution in which a given point on a blade is a stagnation point; the downstream condition is not given. Consideration is also given to the relationship between the force acting on a blade, the pressure distribution on its surface, the circulation around it, and the upstream and downstream conditions.

A89-14862 A numerical simulation of plane turbulent shear layer. YUICHI MARUYAMA, *Japan Society for Aeronautical and Space Sciences Transactions* (ISSN 0549-3811), Vol. 31, Aug. 1988, pp. 79-93. 14 Refs.

A numerical simulation for a plane turbulent shear layer is worked out by means of the large-eddy simulation. Initial fields are assumed to be a superposition of the mean velocity (of error-function type) with isotropic or nonisotropic three-dimensional turbulence. The effects of the intensity as well as the nonisotropic property of the initial turbulence are examined along with various sizes of computational domain. The results are in reasonable agreement, at least qualitatively, with some of the experimental evidence for an appropriate choice of initial turbulence.

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