A88-25617 Comparison of the aerodynamic characteristics of annular and elliptic wings (Sravnenie aerodinamicheskikh kharakteristik kol'tsevykh i ellipticheskikh kryl'ev). M. D. ZHURAVLEV and S. A. MATVEENKO, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1987, pp. 29-31. 5 Refs.

Results of experimental studies of annular and elliptic wings of varying sweep are reported for low subsonic flow velocities. The experimental data cover several different configurations based on wings of these types. The advantages of sweptforward wings and of the canard configuration are demonstrated.

A88-17731 Force and moment characteristics of supersonic flow past a cylindrical body of revolution with a fluid wing (Silovye i momentnye kharakteristiki sverkhzvukovogo obtekaniia tsilindricheskogo tela vrashcheniia s zhidkim krylom). V. F. ZAKHARCHENKO, IU. KH. KARDANOV, and P. V. SIDOROV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.-Oct. 1987, pp. 102-106. 5 Refs.

Jet interaction in a 'fluidwing' injection scheme is examined with reference to results of wind tunnel studies. Particular attention is given to the contribution of the surface areas of the body behind the injected jets to the generation of controlling and stabilizing forces and moments. Results of approximate calculations of the force and moment characteristics of flow past a cylindrical body of revolution with a 'fluid wing' are also presented.

A88-52062 The flow past a straight wing under stationary and quasistationary external conditions (Obtekanie priamogo kryla pri statsionarnykh i kvazistatsionarnykh vneshnikh usloviiakh). M. A. GOLOVKIN, V. P. GORBAN', E. V. SIMUSEVA, and A. N. STRATONOVICH, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, No. 3, 1987, pp. 1-12.

The aerodynamics of rectangular wings with an aspect ratio of 5 is studied at a Reynolds number of 0.6 x 10 to the 6th over a wide range of angles of attack. Included are weight measurements and flow visualization at the wing surfaces. At large angles of attack, in the absence of slip, substantial roll and yaw moments can arise due to the asymmetric structure of the flow relative the wing's plane of symmetry.

A87-41846 The effect of contraction on the level of flow turbulence (Vliianie konfuzornosti techeniia na uroven' turbulentnosti potoka). G. I. DERBUNOVICH, A. S. ZEMSKAIA, E. U. REPIK, and IU. P. SOSEDKO, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Mar.-Apr. 1987, pp. 146-152. 12 Refs.

Results of an experimental study of the effect of contraction in the convergent nozzle of a subsonic wind tunnel on the level of flow turbulence are reported. It is shown that the effect of the nozzle contraction ratio on the level of turbulence is not as strong as predicted by the linear theory of Batchelor and Proudman (1954). Details of the experimental procedure and data processing are given.

Japanese Aerospace Literature
This month: *Modeling of Hypersonic Flows*

A90-25883 Several improvements of spectral method in compressible flow calculation. JIAN-PING WANG, YOSHIAKI NAKAMURA, and MICHIRU YASUHARA, 3rd ISCFD Nagoya 1989 - International Symposium on Computational Fluid Dynamics, Nagoya, Japan, Aug. 28-31, 1989, Technical Papers (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 1210-1215. 7 Refs.

Supersonic and hypersonic flows around a sphere are simulated by the spectral collocation method. The resolution for different grids, the Reynolds number effect, the Mach number effect, and the isothermal boundary conditions are taken into account. Highly accurate results are obtained in the boundary layer.

A89-43215 Numerical simulation of hypersonic viscous perfect gas flow for the aerothermodynamic design of space planes at low angles of attack. YUKIMITSU YAMAMOTO, HARUHIKO ARAKAWA, and RYUJI YOSHIDA, 24th AIAA, Thermophysics Conference, Buffalo, NY, June 12-14, 1989. 22 pp. 21 Refs. (AIAA Paper 89-1699).

In the present numerical simulation of hypersonic aerothermodynamic heating along the wing leading edge of a reentry-glide spacecraft, with a view to preliminary aerothermal structural design that must be conditioned by localized heating due to recompression or shock impingement at low angles-of-attack, attention is given to this phenomenon in three different vehicle configurations proposed by Japan's NAL. These three designs differ with respect to wing leading-edge sweep angles. The numerical computations were conducted at Mach 7 and Reynolds number of 4.4 million, at zero, 10, and 20 deg angles-of-attack; the results obtained are compared with experimental heattransfer measurements.

A89-38386 Standing oblique detonation held by a wedge (in supersonic combustion ramjet engines). AKIKO MATSUO, *Proceedings of the 16th International Symposium on Space Technology and Science,* Sapporo, Japan, May 22-27, 1988, Vol. 2 (A89-38031 16-12). Tokyo, AGNE Publishing, Inc., 1988, pp. 2589-2594. 6 Refs.

The feasibility of generating a standing oblique detonation wave (SODW) on a blunt two-dimensional wedge is investigated by means of numerical simulations based on the Euler equations for an exothermally reacting gas. The derivation of the model and its numerical implementation via a fully implicit TVD finitedifference scheme are outlined, and results are presented graphically for premixed stoichiometric O2H2 (diluted in 70 percent Ar/He) passing over a circularly blunted wedge of apex half-angle 30 deg at inlet Mach numbers 6 and 10. At Mach 6, increasing the radius of the blunting circle changes the SODW from detached (between the bow shock and the reaction front) to attached and unsteady. At Mach 10, however, the SODW remains steady and attached. The applicability of the present results to the design of scramjet engines is indicated.

A89-38150 Estimation of the heat transfer of SSTO model. HIROTOSHI KUBOTA, KIYOSHI YAMAMOTO, MASAYOSHI NAKAMURA, NORIHIKO ITODA, MASASHI OKADA et al., *Proceedings of the 16th International Symposium on Space Technology and Science,* Sapporo, Japan, May 22-27, 1988, Vol. 1 (A89-38031 16-12). Tokyo, AGNE Publishing, Inc., 1988, pp. 935-938. 6 Refs.

A simple technique is presented for estimating the aerodynamic heating of the first-phase concept design of a SSTO. The technique determines the surface inviscid streamlines on the SSTO model and predicts the heat flux into the body using DeJarnette's (1973) method. Comparisons with experimental data and other calculations confirm the validity of the technique.

A90-24950 'HYREFS series codes' users' manual. VISWANATH K. REDDY and TOSHI FUJIWARA, *Nagoya University, Faculty of Engineering, Memoirs* (ISSN 0027-7657), Vol. 41, No. 1, 1989, pp. 39-92. 14 Refs.

The basic theoretical principles and application procedures of HYREFS, a set of computer programs for the numerical simulation of hypersonic reacting flows, are presented in a manual for potential users. The formulations of the governing equations and the solution algorithm are outlined; the FORTRAN 77 numerical implementation is explained; and the subroutine code structures and inputoutput procedures are examined in detail. Graphs, flow charts, tables of numerical data, and sample HYREFS graphics are included.

A89-25230 Numerical simulation of hypersonic flow around a space plane at high angles of attack using implicit TVD Navier-Stokes code. YUKIMITSU YAMAMOTO and SHIN KUBO, 27th AIAA, Aerospace Sciences Meeting, Reno, NV, Jan. 9-12, 1989. 16 pp. 17 Refs. (AIAA Paper 89-0273).

Flux-split upwind TVD scheme has been applied to the hypersonic flow around a space plane proposed by National Aerospace Laboratory (NAL). Thin-layer Navier-Stokes equations in a finite volume formulation are solved by using an implicit approximately factored ADI algorithm. Numerical computations are performed for the conditions of Mach number of 7.0 and Reynolds number of 4.4 x 10 to the 6th at angles of attack up to 50 degrees. Numerical results are compared with experimental data obtained from the hypersonic wind tunnel tests at NAL. Through these comparisons, it is demonstrated that the present TVD Navier-Stokes code has the excellent capabilities for evaluating total aerodynamic performance and investigating the aerodynamic heating, which are of great significance in the design of a space plane configuration.

A89-15680 Numerical simulations of flow field around three-dimensional complex configurations. SATORU OGAWA, TOMIKO ISHIGURO, and YOKO TAKAKURA, *Proceedings of the 7th GAMM Conference on Numerical Methods in Fluid Mechanics,* Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, (A89-15651 04-34). Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, pp. 256-267. 18 Refs.

Numerical simulations of flow around three-dimensional complex configurations are performed by solving both the Euler equations and the Navier-Stokes equations. Recent TVD schemes are used for two problems: (1) transonic and supersonic flow around Shuttle Orbiter, and (2) hypersonic flow in scramjet inlet.

A88-43703 Computation of three-dimensional chemically reacting viscous flow around rocket body. K. V. REDDY, T. FUJIWARA, T. OGAWA, and K. ARASHI, AIAA Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 22 pp. MOESC supported research. 21 Refs. (AIAA Paper 88-2616).

An hybrid scheme that treats the strong peripheral shock as sharp shock is developed to compute the hypersonic, viscous and chemically reacting three-dimensional flow around a rocket body. A multicomponent mixture of thermally perfect but calorically imperfect gas is used. Diffusion velocities at all grid points are computed by solving multicomponent diffusion equations. All the molecular diffusion transport terms are retained. The governing equations in conservation law form are solved using a noniterative, approximately factored implicit finitedifference scheme. Both fully catalytic and noncatalytic walls are treated. Laminar flowfields over a rocket nose configuration are generated for different gas models and boundary conditions.

A90-25866 Thermo-chemically nonequilibrium hypersonic flow around an axisymmetric blunt body. VISWANATH K. REDDY, TOSHI FUJIWARA, and TOSHI MURAYAMA, 3rd ISCFD Nagoya 1989 - International Symposium on Computational Fluid Dynamics, Nagoya, Japan, Aug. 28-31, 1989, Technical Papers (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 1079-1084.

This work deals with a flow arounda reentry hypersonic vehicle at flight speeds Mach = 15 and 25 under a thermally and chemically nonequilibrium concept. As a thermally nonequilibrium model, Park's (1985) two-temperature one is adopted: translational and vibrational temperatures of the molecule, where all the reaction rates depend on both temperatures. Under this concept the reaction front is significantly separated from the shock front; the reaction delay time is accurately given by the present shock-fitting method.

A90-25828 Numerical simulation of hypersonic viscous flow for the design of Japanese H-II Orbiting Plane (Hope) - Investigation of lateral and directional aerodynamic characteristics. YUKIMITSU YAMAMOTO, NAOYUKI SUZUKI, and KATSUMI MORI, 3rd ISCFD Nagoya 1989 - International Symposium on Computational Fluid Dynamics, Nagoya, Japan, Aug. 28-31, 1989, Technical Papers (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 785-790.
9 Refs.

A flux-split-type TVD computation scheme for the Navier-Stokes equations (Yamamoto, 1988) is used to investigate the lateral and directional aerodynamics of three different versions of the proposed Japanese space plane Hope. Results from simulations at freestream Mach number 7.0, Reynolds number 2.5 x 10 to the 6th, angle of attack up to 40 deg, and yaw angle 5 deg are presented in extensive graphs and discussed in detail. The predicted heat-transfer distributions and aerodynamic coefficients are found to be in good agreement with wind-tunnel measurement data.

A90-21427 A comparison among three DSMC methods (Direct Simulation Monte-Carlo method). JUNICHI TANAKA, YOSHIAKI NAKAMURA, and MICHIRU YASUHARA, *Japan Society for Aeronautical and Space Sciences, Transactions* (ISSN 0549-3811), Vol. 32, Nov. 1989, pp. 116-128.9 Refs.

Three methods in the direct simulation Monte Carlo technique are compared: Bird's (1976) time counter, a modified Nanbu (1986) technique, and Koura's (1986) null collision Poisson method. When the values of simulation parameters are carefully determined, the three methods yield almost the same results for the flat rate problem. However, when the number of particles per cell is insufficient in hypersonic flow, the time counter method cannot correctly count the collision number. As a result, the null collision method is found to be the most useful of the three methods considered.

A90-21377 Numerical simulations of axisymmetric flows in astrophysics and their visualization by a video movie. TAKUYA MATSUDA, HIROSHI KOIDE, YUZO FUJIMOTO, NOBUHIRO SEKINO, KEISUKE SAWADA et al., *Kyoto University, Faculty of Engineering, Memoirs* (ISSN 0023-6063), Vol. 51, July 1989, pp. 198-205. Research supported by the Yamada Science Foundation. 10 Refs.

Numerical simulations of axisymmetric flow in four different astrophysical situations are performed, and their results are visualized by using a video movie. The situations considered are (1) an accretion flow on to a gravitating compact object allowing maximum accretion; (2) a jet formation in a flow past a gravitating rigid sphere; (3) an interaction between a supersonic wind from a central object and a uniform supersonic incident flow; and (4) a wind bubble formed by spherical supersonic wind.

A90-19838 Numerical simulation of hypersonic viscous flow for the design of H-II Orbiting Plane (HOPE) - Investigation of lateral and directional aerodynamic characteristics. YUKIMITSU YAMAMOTO, TOSHIO AKIMOTO, and NAOYUKI SUZUKI, 28th AIAA, Aerospace Sciences Meeting, Reno, NV, Jan. 8-11, 1990. 16 pp. 11 Refs. (AIAA Paper 90-0416).

Results are presented from hypersonic CFD analyses performed for configurations of the Japanese H-II Orbiting Plane (HOPE). The analyses were conducted to study the lateral and direction aerodynamic characteristics of the plane. For four HOPE models, numerical computations were performed at a freestream Mach number of 7.0, Reynolds number of 2,500,000 at various angles of attack. The results are compared with experimental wind tunnel data, showing that the numerical code is successful in predicting lateral and directional aerodynamic characteristics.

A90-15227 Recent Navier/Stokes calculations in applications. H. YOSHIHARA, *Aeronautical Society of India Journal* (ISSN 0001-9267), Vol. 40, Nov.–Dec. 1988, pp. 221-227.

The capabilities and limitations of current Navier-Stokes codes for fluid-dynamics simulations are reviewed on the basis of sample computations. Results for (1) transonic flow with shock-induced separation on a swept wing, (2) high-lift supersonic flow over a delta wing, and (3) and hypersonic flow on the wing/fuselage of an aerospace plane in cruise are presented in graphs and diagrams and discussed in detail. The need for better modeling techniques to treat incipient and developed turbulence, hypersonic turbulence, and highly swept shocks is stressed.

A90-19941 Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). YUKIMITSU YAMAMOTO, TOSHIO AKIMOTO, and NAOYUKI SUZUKI, 28th AIAA, Aerospace Sciences Meeting, Reno, NV, Jan. 8-11, 1990. 16 pp. 12 Refs. (AIAA Paper 90-0601).

The H-II orbiting plane (HOPE) is an unmanned winged vehicle for space transportation whose current baseline configuration is that of a double delta wing with tip fins. Hypersonic CFD analysis is performed for the four types of proposed HOPE configurations, and aerodynamic and aerothermodynamic characteristics are investigated. Numerical computations are carried out for the HOPE 62A, 62B, and 62C models at Mach 7, Reynolds number 2.5 x 10 to the 6, and at angles of attack from 0-40 degrees. The aerodynamic characteristics are compared with experiments performed in a hypersonic wind tunnel. For the HOPE 63 model, calculations are made at the above conditions at angles of attack up to 50 degrees. In addition, Reynolds and Mach number effects are also analyzed for this model. Numerical results of heat transfer distributions are compared with experimental data obtained by the phase change paint methods.

A90-12840 New method for measurement of surface pressure using magnetic tape. TAKEYOSHI KIMURA and MASATOMI NISHIO, *AIAA Journal* (ISSN 0001-1452), Vol. 27, Nov. 1989, pp. 1579-1583. 8 Refs.

A new method of surface pressure measurement has been developed using magnetic tape as a sensor, instead of the usual strain gage, piezogage or semiconductor, within a diaphragm-type pressure transducer. The method is based on the idea that a pressure value applied to the diaphragm is related to the deflection of the diaphragm, and the deflection can be related to the value of magnetization strength sensed in the tape. The merit of the new method is that it can be easily applied for measurement of pressure distributions on model surfaces because many pressure transducers are contained in a single sheet only about 1-mm thickness. The proposed method can be used in the high-temperature, short-duration measurement conditions, and so it is well suited to hypersonic wind-tunnel use. The sheet can be bonded onto a model surface. In this study, experiments using the new pressure sensor were performed in a hypersonic gun tunnel at a Mach number of 10 for a duration time of 0.01 s. Pressure distributions around two models in hypersonic flow were measured successfully.

A89-49754 Hypersonic rarefied flows around a circular disk perpendicular to the stream. KENICHI NANBU, SABURO IGARASHI, and YASUO WATANABE, *Aerodynamics in relation to an aeroassisted orbit transfer vehicle* (A89-49751 22-02). Tokyo, Institute of Space and Astronautical Science, 1988, pp. 27-37. Research supported by the Institute of Space and Astronautical Science. 7 Refs.

Rarefied gas flows around a circular disk in a hypersonic stream are analyzed by the direct simulation Monte Carlo method. The domain of calculation is fully three-dimensional. The rarefaction effect upon the flow field, the drag and heat transfer coefficients, and the recovery temperature is shown for Kn = 0.1 - 20 at the wall to stagnation temperature ratios of 0.5 and 1. The drag coefficient is in good agreement with the experimental data for argon by Legge (1973). The cell network proposed here can easily be applied to more general lifting flows.

A89-45432 Numerical calculation of hypersonic flow by the spectral method. MICHIRU YASUHARA, YOSIAKI NAKAMURA, and JIAN-PING WANG, *Proceedings of the 11th International Conference on Numerical Methods in Fluid Dynamics,* Williamsburg, VA, June 27July 1, 1988, (A89-45351 19-34). Berlin and New York, Springer-Verlag,1989, pp. 607-611.

The collocation spectral method is applied to three-dimensional flow inthe hypersonic flow regime, and results are presented for Mach numbers four and eight. The generalized coordinate code for a three-dimensional body is developed and applied to the forebody of a Shuttle-like body. The viscous flow is calculated assuming asymmetry. Results obtained using the Euler equations show good agreement with experimental results for a bow shock wave shape. Finally, the multidomain method is applied to a hemispherecylinder flow problem.

A89-44972 Experimental study on aerodynamic characteristics of hypersonic transport configuration. NORIKAZU SUDANI, SHIGEAKI NOMURA, KOICHI HOZUMI, AKIRA MURAKAMI, and YASUHIKO AIHARA, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 37, No. 423, 1989, pp. 178-185. 17 Refs.

An experimental study has been carried out on aerodynamics of a cruising type hypersonic transport (HST) configuration, assuming to cruise at a height of 30 km at Mach number 7. The hypersonic flow over the double-delta wing, which is a basic wing shape of HST, has been investigated. The results of the flow visualization and the quantitative measurements (static pressure and heat transfer) show that the vortices of the leeward side of the double-delta wing influence aerodynamic forces, and that they are associated with the intense local heating along the center line. From the wind tunnel test of the HST model at Mach number 7, it is confirmed that the geometry of the model almost satisfies the requirements of aerodynamic characteristics under hypersonic cruising. In parallel with the experiments, a basic study on aerothermodynamic control of the performance has been performed. The results show that the static pressure rises with heat addition to the stream beneath the afterbody of the HST, and suggest possibility of improving lift-to-drag ratio.