

# Soviet and Japanese Aerospace Literature

Throughout 1990 the *AIAA Journal* will carry selected abstracts on leading research topics from the Soviet aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Wind Tunnel Flow Analysis from the USSR and Modeling of Hypersonic Flows from Japan.

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## Soviet Aerospace Literature This month: *Wind Tunnel Flow Analysis*

**A90-28996** Calculation of the Reynolds number of the laminar-turbulent boundary layer transition based on linear stability theory (Raschet chisel Reinol'dsa perekhoda laminarnogo pogranichnogo sloia v turbulentnyi na osnove lineinoy teorii ustoiichivosti). A. V. FEDOROV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 2, 1989, pp. 9-16. 15 Refs.

Methods for calculating the Reynolds numbers of the laminar-turbulent transition are examined from the standpoint of linear stability theory. A physical interpretation of the e(N)-method is presented. A simplified version of this method is used to process experimental data obtained for subsonic flow past plates, cones, and airfoils. The results of calculations are found to be in satisfactory agreement with experimental data.

**A90-28991** Aerodynamic quality of a plane delta wing with blunted edges at large supersonic flow velocities (Aerodinamicheskoe kachestvo ploskogo treugol'nogo kryla s zatuplennymi kromkami pri bol'shikh sverkhzvukovykh skorostiakh obtekaniia). P. I. GORENBUKH, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 1, 1989, pp. 108-112.

Experimental data on the aerodynamic quality of plane delta wings with blunted edges are reported for freestream Mach 9 and Reynolds numbers of  $1.2 \times 10^6$  to the 6th -  $4 \times 10^6$  to the 5th. The data are compared with results calculated by the method proposed by Nikolaev (1987). A unified analytical-experimental dependence is obtained for the relative aerodynamic quality near the maximum aerodynamic quality regime.

**A87-53544** Aerogas dynamics and its development at the Institute of Theoretical and Applied Mechanics of the Siberian Section of the Academy of Sciences of the USSR (Aerogazodinamika i ee razvitiie v ITPM SO AN SSSR). V. G. DULOV and V. M. FOMIN, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskie Nauki* (ISSN 0002-3434), June 1987, pp. 3-13. 28 Refs.

Developments in the field of aerogas dynamics for the past 30 years are reviewed with reference to the research carried out at the Institute of Theoretical and Applied Mechanics. The wind tunnel facilities of the Institute are briefly described, and results of some aerodynamic studies conducted by the Institute are discussed. These results cover the structure of three-dimensional supersonic gas flows in the interference region of intersecting surfaces; configurations of gasdynamic discontinuities; the structure of a three-dimensional boundary layer and its interaction with shock waves; and problems related to the properties of supersonic gas jets. Particular attention is given to mathematical modeling and the use of computers in aerogasdynamic research.

**A90-24147** A method for determining aileron efficiency and critical reversal and divergence rates at transonic velocities (Metod opredeleniia effektivnosti elerona i kriticheskikh skorostei reversa i divergentsii pri transzvukovykh skorostiakh). P. D. NUSHTAEV and I. U. P. NUSHTAEV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 19, No. 5, 1988, pp. 113-121. 6 Refs.

Results of numerical and experimental studies of aileron efficiency at transonic velocities are reported. The critical reversal and divergence rates of a wing are estimated on the basis of a wind tunnel experiment and calculations based on linear and nonlinear theories.

**A90-22421** Mean and pulse characteristics of supersonic flow in a wind tunnel with a honeycomb nozzle (Osrednennnye pul'satsionnye kharakteristiki sverkhzvukovogo potoka v aerodinamicheskoi trube s sotovym soplom). V. N. ZINOV'EV, M. G. KTALKHERMAN, V. A. LEBIGA, V. M. MAL'KOV, and N. A. RUBAN, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskie Nauki* (ISSN 0002-3434), Oct. 1989, pp. 37-42. 7 Refs.

The mean and pulse characteristics of supersonic flow at the outlet of honeycomb and plane nozzles were determined experimentally under identical conditions in a wind tunnel with a 40x40-mm test section. It is shown that, in the case of a dense honeycomb, sufficiently uniform supersonic flow is achieved, with Mach number variations within + or - 1.5 percent and a mass flow fluctuations of about 2 percent. The results of a parametric analysis of the fully mixed flow characteristics make it possible to select optimum honeycomb geometry for specific conditions.

**A89-42575** The nature of the K breakdown of the laminar boundary layer (Review). I - Formation of peakvalley structures and spikes from the spectral standpoint (Priroda K-razrusheniia laminarnogo pogranichnogo sloia /Obzor/. I - Obrazovanie struktury pikvpadina i vspleskov-shipov so spektral'noi tochki zreniia). I. U. S. KACHANOV, V. V. KOZLOV, V. IA. LEVCHENKO, and M. P. RAMAZANOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskie Nauki* (ISSN 0002-3434), April 1989, pp. 124-158. 31 Refs.

The available experimental data on the mechanisms of the K regime of laminar boundary layer breakdown are reviewed with emphasis on the initial, deterministic stage of perturbation evolution. Attention is given to details of the experimental procedures and equipment, initial perturbation profiles, pulsation oscillograms and spectra, and development of three-dimensional perturbations. The discussion then focuses on the evolution of the profiles and dispersion properties of frequency harmonics, analysis of the three-dimensional wave packets, and evolving flow stochasticity.

**A90-24123 The effect of longitudinal fins on turbulent friction drag (Vliianie prodol'nogo orebreniia na soprotivlenie turbulentnogo treniia).** G. V. ENIUTIN, I. U. A. LASHKOV, N. V. SAMOILOVA, I. V. FADEEV, and E. A. SHUMILKINA, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 19, No. 4, 1988, pp. 37-44. 6 Refs.

The effect of longitudinal fins on the turbulent friction drag on a flat plate was investigated in a low-turbulence wind tunnel. Eight different types of surfaces with small fins were investigated which differ in terms of fin shape and dimensions. It is shown that a range of parameters exists for each of these surfaces in which the turbulent friction drag is less than for a smooth plate. Here, the maximum reduction of the drag coefficient due to the fins depending on the fin geometry amounted to 4 to 8 percent.

**A90-24112 Aeroelastic deformation of a crescent-shaped rigid support in the diffuser chamber of a wind tunnel (Aeroprugaia deformatsiia serpovidnoi zhestkoi stoiki, raspolozhennoi v kamere stvorok diffuzora aerodinamicheskoi truby).** A. V. PILUGIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 19, no. 3, 1988, pp. 75-86.

The elastic interaction between a crescent-shaped rigid support in the diffuser chamber of a wind tunnel and subsonic aerodynamic flow is investigated analytically in the context of linear nonviscous flow theory. The approach used here, which is based on an exact analytical solution, allows quick and efficient multiparametric numerical analysis of the structural features of the mount with allowance for the interference of the adjacent sections of the wind tunnel. The method may be useful in developing wind tunnel experiments and in wind tunnel design.

**A90-24099 Effect of the design of a diffuser with tangential injection on the starting and separation ratios of pressures (Vliianie konstruktii diffuzora s tangentsial'nym vduvom na puskovye i sryvnye otnosheniia davlenii).** I. V. BABCHENKO and N. A. SHUSHIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 19, No. 2, 1988, pp. 57-64.

An analysis is made of the starting and separation ratios of pressures in a two-dimensional wind tunnel with tangential supersonic injection into the diffuser. The wedge-shaped injection nozzles used make it possible to obtain smaller pressure ratios than in the case of nozzles that form a step along the flow.

**A90-24076 Nonsymmetric vortex breakdown and aerodynamic hysteresis in flow past a low-aspect-ratio wing/fuselage configuration (Nesimmetrichnoe razrushenie vikhrei i aerodinamicheskii gisteriez pri obtekanii kryla malogo udlineniia s fiuzeliazhem).** M. G. GOMAN, A. I. ZADOROZHNI, and A. N. KHRABROV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 19, No. 1, 1988, pp. 1-7. 8 Refs.

Results of a windtunnel visualization study of separated flow past a model of a delta wing with a conical fuselage are reported. In particular, attention is given to nonsymmetric vortex breakdown, which is observed for zero slip angle at large angles of attack, and to aerodynamic hysteresis due to changes in the slip angle. The effect of flow perturbation on the characteristics of separated flow past a body is discussed.

**A90-12284 Hypersonic flow past blunt edges at low Reynolds numbers (Giperzvukovoe obtekanie zatuplennykh kromok pri mal'kikh chislakh Reinal'dsa).** A. V. BOTIN, V. N. GUSEV, and V. P. PROVOTOROV, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), July-Aug. 1989, pp. 161-168. 13 Refs.

Flow past the blunt edges and nose sections of a hypersonic flight vehicle is analyzed for small Reynolds numbers in the context of the theory of a thin viscous shock layer. Calculations are carried by the finite-difference method for flows of axial and plane symmetries over a wide range of similarity parameters. The use of cooling gas injection for reducing heat flows to the body is discussed. The results obtained are found to be in good agreement with experimental data.

**A90-12279 Pressure pulsation in a cavity in the path of subsonic and supersonic gas flow (Pul'satsii davleniia v vyemke, obtekaemoi dozvukovym ili sverkhzvukovym potokom gaza).** A. N. ANTONOV and K. N. FILIPPOV, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), July-Aug. 1989, pp. 84-89. 10 Refs.

Pressure pulsations generated in the case of subsonic and supersonic flow past an open cavity were investigated experimentally. The pressure pulsation spectrum includes continuous and discrete components. The effect of flow parameters on the levels of the continuous and discrete components of pressure pulsations in the cavity is determined.

**A89-50934 Boundary layer transition on the surface of a delta wing in supersonic flow (O perekhode pogranichnogo sloia na poverkhnostitireugol'nogo kryla pri sverkhzvukovom obtekanii).** V. N. BRAZHKO, N. A. KOVALEVA, L. A. KRYLOVA, and G. I. MAIKAPAR, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1989, pp. 87-92. 9 Refs.

The laminar-turbulent transition on the surface of a delta wing was investigated experimentally in a supersonic wind tunnel at Mach 3.5. It is found that, at Mach 3,  $Re_L = 6.5 \times 10^6$  to the 6th, and  $\alpha = -5.5$  deg, a wedge-shaped region of turbulent flow extends over most of the upper wing surface near the symmetry line. The heat fluxes in this region reach values equal to those of the heat transfer maxima due to separation flows and may exceed the turbulent level of heat fluxes at the windward wing surface. A change in the shape of the lower wing surface from planar to pyramidal is shown to accelerate the boundary layer transition.

**A89-50937 Characteristics of the spectra of pressure fluctuations in front of a step in supersonic transition flow (Osobennosti spektrov pul'satsii davleniia pered ustupom v sverkhzvukovom perekhodnom techenii).** V. N. BIBKO, B. M. EFIMTSOV, and V. B. KUZNETSOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1989, pp. 170-173. 6 Refs.

Results of an experimental study of wall pressure fluctuations in front of an axisymmetric step on an ogival cylinder are reported. A new phenomenon, which has not been previously observed in flows with a free separation line, is identified. The phenomenon involves the formation, evolution, and decay of well defined high-intensity peaks in the pressure fluctuation spectra with changes in Reynolds number corresponding to the separation of the transition boundary layer.

**A89-42572 Effect of gas dissociation and ionization on the transition of a supersonic boundary layer (Vliianie dissotsiatsii i ionizatsii gazov na perekhod sverkhzvukovogo pogranichnogo sloia).** V. I. LYSENKO, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seria Tekhnicheskii Nauki* (ISSN 0002-3434), April 1989, pp. 45-49. 21 Refs.

The effect of gas dissociation and ionization on the laminar-turbulent transition of the boundary layer was investigated experimentally in an impulse wind tunnel and a shock tube using air and nitrogen as the working gases. The freestream Mach number varied from 5 to 7; the flow stagnation temperature ranged from 1100 to 3600 K. It is found that, at moderate Mach numbers (about M 5), external flow dissociation lowers the Reynolds number of the turbulent transition. External flow ionization at Mach numbers equal to or greater than 8 does not reduce the Reynolds number of the boundary layer transition.

**A89-42461 A study of heat transfer in the pseudoshock region (Issledovanie teploobmena v oblasti psevdoskachka).** O. V. VOLOSHCHENKO, V. N. OSTRAS', and V. N. SERMANOV, *Pioneers of space and the present age* (A89-42451 18-99), Moscow, Izdatel'stvo Nauka, 1988, pp. 62-67. 6 Refs.

Heattransfer in the pseudoshock region formed in an uncooled cylindrical duct with high-enthalpy supersonic flow is investigated experimentally and analytically. Results of a wind tunnel study indicate that, in the presence of a pseudoshock, specific heat and temperature distributions on the duct wall are characterized by a maximum at a distance of 4-5 gauges from the beginning of the pseudoshock. Calculations based on a continuous separation-free dissipative model of flow in the pseudoshock are found to be in good agreement with the experimental results.

**A89-35624 A plane semiinfinite turbulent jet on a porous surface (Ploskaia turbulentnaia poluogranichennaia struia na pronitsaemoi poverkhnosti).** V. I. KOSENKO, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seria Tekhnicheskii Nauki* (ISSN 0002-3434), Feb. 1989, pp. 23-28. 19 Refs.

The effect of directional injection on the characteristics of a plane semiinfinite jet was investigated experimentally using an open-circuit wind tunnel. In particular, attention is given to the effect of injection angle and intensity on the integral characteristics of the dynamic and thermal layers of the jet. It is shown that injection in the flow direction at angles less than 90 deg is more efficient than injection at larger angles when the objective is to reduce gasdynamic losses or to prevent boundary layer separation, in addition to thermal protection.

**A89-30206 An experimental study of the formation and evolution of two-dimensional wave packets in a boundary layer (Eksperimental'noe issledovanie vozniknoveniia i razvitiia dvumernykh volnovykh paketov v pogranichnom sloe).** G. R. GREK, V. V. KOZLOV, and M. P. RAMAZANOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seria Tekhnicheskii Nauki* (ISSN 0002-3434), Dec. 1988, pp. 24-30. 14 Refs.

Experiments have been carried out in a subsonic wind tunnel to investigate the formation of two-dimensional wave packets in the vicinity of a perturbation source before the onset of the proper perturbations of the boundary layer. It is shown that the velocity of perturbation fronts propagating downstream decreases abruptly and stabilizes at a certain level. The region of the spatial evolution of the two-dimensional wave packets is investigated, and it is shown that the propagation velocities of the leading and trailing fronts of the packets in the longitudinal direction remain constant and are 0.43 and 0.30 of the mean velocity, respectively.

**A88-52058 Investigation of gas flow in the collectors (nozzles) of low subsonic and transonic wind tunnels (Issledovanie techeniia gaza v kollektorakh /soplakh/ aerodinamicheskikh trub mal'kikh dozvukovykh i okolozvukovykh skorostei).** A. P. BYRKIN, S. P. PONOMAREV, and L. I. KUDRIAVTSEVA, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, No. 2, 1987, pp. 117-124. 7 Refs.

Gas flow patterns in axisymmetric nozzles of subsonic and transonic wind tunnels were investigated numerically and experimentally, comparing two classes of nozzle contours: contours designed by the Witoszynski (1924) formula and those designed using a formula, derived on the basis of Mikhail's (1979) design equations, which makes it possible to represent the nozzle contour analytically. It is shown that, at the contraction and elongation values used in practice, the Witoszynski nozzle contour results in adverse negative values of the longitudinal velocity gradient at the wall near the nozzle entrance and might lead to boundary-layer separation. The new formula was used to define a nozzle with favorable features, and the calculated flows were compared to experimental results.

**A89-30205** Supersonic laminar boundary layer behind a fan of rarefaction waves (Sverkhzvukovoi laminarnyi pogranichnyi sloi za veerom voln razrezheniia). A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskii Nauki* (ISSN 0002-3434), Dec. 1988, pp. 18-23. 12 Refs.

A supersonic laminar boundary layer formed in the case of flow past an external blunt corner is investigated experimentally, with attention given to both mean flow parameters (longitudinal flow velocity profiles, Mach number at the outer boundary, and boundary layer thickness) and flow stability against natural perturbations. Results of tests conducted in a supersonic wind tunnel indicate that the turning of the supersonic laminar boundary layer over the blunt corner leads to flow stabilization, which is in qualitative agreement with the conclusions of a previous theoretical study (Gaponov and Petrov, 1987).

**A89-23685** Laminar-turbulent transition under conditions of increased turbulence of the incoming flow (Laminarno-turbulentnyi perekhod pri povyshennoi stepeni turbulentnosti nabegaiushchego potoka). G. R. GREK, V. V. KOZLOV, and M. P. RAMAZANOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Nov.-Dec. 1988, pp. 34-41. 14 Refs.

Results of a low-turbulence wind tunnel study of the laminar-turbulent transition under conditions of increased turbulence of the incoming flow are reported. It is shown that a Tollmien-Schlichting wave may form and affect the laminar-turbulent transition in the laminar regions of the boundary layer between turbulent spots. The principal characteristics of turbulent spot evolution are shown to be independent of the extent of incoming flow turbulence.

**A89-21581** Transition to turbulence on a wing in flight and in a wind tunnel at the same Reynolds numbers (Perekhod k turbulentnosti nakryle v polete i v aerodinamicheskoi trube pri odinakovykh chislakh Reinal'dsa). B. I. ZANIN, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskii Nauki* (ISSN 0002-3434), Oct. 1988, pp. 51-53.

The effect of external perturbations on the structure of the transition in a boundary layer on the same wing section in flight and in a wind tunnel is investigated experimentally. It is shown that, despite the relatively high levels of external perturbations, the turbulent transition in both cases involves the evolution of an instability wave packet in the boundary layer. The mean frequencies of the packets in flight and in a wind tunnel are found to be similar.

**A89-21575** Estimation of the effect of the principal design parameters of stagnation temperature transducers on measurement delay (Ob otsenke vlianiia osnovnykh konstruktivnykh parametrov datchikov temperatury tormozheniia na inertsionnost' izmereniia). A. M. SABIRZIANOV, R. KH. LATYPOV, and M. R. MUSIN, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 3, 1988, pp. 93-95.

A study is made of the effect of the design of the stagnation chamber, sensitive element, and intake and outlet devices of transverse-flow resistive temperature transducers in aviation gas turbines on the measurement delay. A formula is obtained which makes it possible to determine the effect of the design parameters of the temperature transducers on the measurement delay for a known dependence of the hydraulic drag of the transducer on the structural design and dimensions of the stagnation chamber, sensitive element, and intake and outlet devices. The validity of the method is verified by comparing the results with wind tunnel test data.

**A88-52112** Aerodynamic heating of corrugated surfaces in a supersonic turbulent boundary layer (Aerodinamicheskoe nagrevanie volnistykh poverkhnosti v sverkhzvukovom turbulentnom pogranichnom sloe). V. V. BOGOLEPOV, V. N. BRAZHKO, L. V. DOZOROVA, G. I. MAIKAPAR, and V. IA. NEILAND, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, No. 6, 1987, pp. 1-7. 9 Refs.

Heat transfer to a corrugated surface in a turbulent boundary layer, with both transverse and longitudinal flow past the surface, is investigated experimentally for Mach 4 and Re  $2.9 \times 10$  to the 6th. In the case of transverse flow (separated or nonseparated), the maximum coefficients of heat transfer toward the corrugated surface are several times higher than those in the case of a flat surface. In the case of longitudinal flow, the maximum heat transfer coefficients are close for corrugated and flat surfaces, while mean heat transfer toward a corrugated surface may be approximately 20 percent lower than that toward a flat surface.

**A88-13759** An experimental study of the stability of a supersonic boundary layer on a cone (Eksperimental'noe issledovanie ustoiichivosti sverkhzvukovogo pogranichnogo sloia na konuse). A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskii Nauki* (ISSN 0002-3434), Aug. 1987, pp. 64-69. 15 Refs.

An experimental study is made of the stability of a supersonic boundary layer on a cone against both natural and artificial perturbations. The spatial characteristics of the wave perturbation field of a supersonic boundary layer on a cone are determined, and it is shown that the evolution of perturbations on a cone is similar to the development of perturbations in a boundary layer on a flat plate. It is suggested that the difference in the Reynolds number of the transitions on a cone and on a plate may be due to both the lesser degree of the spatial amplification of perturbations on a cone and the difference in the nature of perturbation generation.

**A89-21566** Effectiveness of a gas curtain on a flat plate under conditions of flow laminarization (Effektivnost' gazovoi zavesy na ploskoi plastine v usloviakh laminarizatsii potoka). A. A. KHALATOV, V. S. MARUSENKO, and A. S. KOVALENKO, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 3, 1988, pp. 66-70.

In the presence of considerable negative pressure gradients characteristic of advanced gas turbines, conditions arise for the 'inverse' turbulent-laminar transition, which complicates the calculation of gas curtains since reliable recommendations are not available for this case. Here experimental results are presented on the effectiveness of a gas curtain on a flat plate for the case where the inverse transition occurs directly beyond the section where a gas curtain is formed.

**A89-18675** Determination of the perturbations of the flow fields of supersonic wind tunnels from measured aerodynamic coefficients (Opredelenie vozmushchenii poiei potokov sverkhzvukovykh aerodinamicheskikh trub po izmerennym znacheniam aerodinamicheskikh koefitsientov). V. V. EREMIN, I. M. LIPNITSKII, and S. E. FILIPPOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.-Oct. 1988, pp. 183-185.

A new approach is proposed for determining the perturbations of flow fields in supersonic wind tunnels, including the downwash. The approach is based on solving the inverse problem whereby the real values of these perturbations are reconstructed from the measured values of the integral aerodynamic characteristics of the model moving in the test section of the wind tunnel. The method is illustrated by a specific example.

**A89-14820** Consideration of unsteady state effects during air intake testing in a blowdown wind tunnel (Uchet effektivnost' nestatsionarnosti pri ispytaniakh vozdukhobabornikov v impul'snoi aerodinamicheskoi trube). V. I. ZVEGINTSEV and A. I. SEDEL'NIKOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskii Nauki* (ISSN 0002-3434), Aug. 1988, pp. 63-69. 10 Refs.

The possibility of accounting for unsteady flow in an air intake when measuring its flow rate characteristics in a blowdown wind tunnel is investigated. An algorithm is developed which makes it possible to determine the steady-state flow rate coefficient from the measurements of rapidly changing temperatures and pressures at the air intake outlet. Experimental data are differentiated numerically using an algorithm for constructing regularizing cubic splines. The possibilities of the method are illustrated by test calculations.

**A88-52096** Effect of the off-design work of the nose air intake on flow past a finite-span wing (Vlianie neraschetnoi raboty lobovogo vozdukhobabornika na obtekanie kryla konechnogo razmakha). V. M. SHURYGIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, No. 5, 1987, pp. 11-16. 5 Refs.

A linear theory is presented to account for the effect of the off-design work of the nose air intake (in the case of relatively thin nacelles) on flow past a finite-span wing at subsonic velocities of the incoming flow. Analytical results based on the theory proposed here are found to be in good agreement with wind tunnel test results obtained for a flow velocity of 40 m/s.

**A88-52078** Several features of wall flow in the wing-fuselage junction region (Nekotorye osobennosti pristennogo techeniia v oblasti sopriazheniia kryla i fiuzeliage). V. I. KORNILOV and A. M. KHARITONOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, No. 4, 1987, pp. 1-9. 13 Refs.

Results are presented from experimental studies of incompressible wall flow in the wing-fuselage junction region during subsonic flow across a schematized aircraft configuration at zero angle of attack. It is shown that the flow in this region has a complex spatial pattern with a dual-vortex structure and local zones, characterized by the separated flow and flow unsteadiness in the narrow regions adjacent to the line of the wing and fuselage junction.

**A88-52076** The experimental study of gas flow near the perforated walls of a transonic wind tunnel (Eksperimental'noe issledovanie techeniia gaza vblizi perforirovannykh stenok transzvukovoi aerodinamicheskoi truby). A. I. IVANOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, No. 3, 1987, pp. 131-135. 8 Refs.

The structure of the flow near the perforated wall of a wind tunnel is studied at transonic velocities for a wide range of Reynolds numbers. Experimental relationships between the parameters of the flow at the control surface, beyond the boundary layer, are obtained. The present work was carried out to establish a boundary condition on the perforations for the study of flowboundary induction.

**A88-52041** Consideration of the effect of a propeller jet on pressure distribution along the tunnel wall (Uchet vlianiia strui vinta na raspredelenie davleniia vdol' stenki truby). V. I. BABKIN and I. A. GORELOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, No. 1, 1987, pp. 121-125.

The testing of models with working propellers in a wind tunnel with nonperforated walls gives rise to an additional static pressure field at the tunnel wall. Here, the principal factors affecting the additional pressure are determined in relation to the relative propeller and tunnel dimensions, loading coefficient, and free-stream Mach number. Particular attention is given to the effect of air compressibility.

**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 obtekanii tsilindricheskogo tela vrashcheniia s zhidkim krylom). V. F. ZAKHARCHENKO, I. U. 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 usloviakh). 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  $0.6 \times 10^6$  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 I. U. 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, YOSHIKI 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  $O_2H_2$  (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. HIRO-TOSHI 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 input/output 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  $4.4 \times 10^6$  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).

A 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.