Soviet and Japanese Aerospace Literature

Throughout 1989 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 Supersonics/Hypersonics from the USSR and Japan.

Support for assembling and publishing the selected abstracts has been provided by the Innovative Science and Technology Directorate of the Strategic Defense Initiative Organization (SDIO), with the sponsorship and technical management of the abstract service by the Office of Naval Research (ONR) under ONR Grant N0014-87-6-0137.

Abstracts in this listing have been taken from the semimonthly abstract journal International Aerospace Abstracts (IAA), published by the American Institute of Aeronautics and Astronautics (AIAA) in cooperation with the National Aeronautics and Space Administration (NASA) under Contract No. NASW-4373. Additional material can be obtained through searching the Aerospace Database – available online via DIALOG or NASA RECON.

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Soviet Aerospace Literature
This month: *Supersonics/Hypersonics*

A89-18671   Mathematical modeling of laminar and turbulent supersonic flow past convex-concave bodies (Matematicheskoe modelirovanie laminarnogo i turbulentnogo sverkhzvukovogo obtekaniia tel vypuklo-vognutoi formy). A. M. GRISHIN and O. I. POGORELOV, Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1988, pp. 138-145. 12 Refs.

Laminar and turbulent supersonic flow past two convex-concave bodies is analyzed on the basis of Navier-Stokes equations. For laminar flow, the effect of the Reynolds number on the shock layer structure, pressure distribution, and heat flux is investigated. For turbulent flow, the calculated results are compared with the calculations and experimental data of recent studies. It is shown that, in the separation region, the pressure distributions on the body and the position and shape of the shock wave based on the Navier-Stokes equations are found to be in better agreement with experimental data than results based on the Euler and viscous shock layer equations.

A89-18608   The competition between Stokes waves in a hypersonic phase conjugated mirror based on an oscillator-amplifier scheme under saturation conditions (Konkurentsiia stoksovykh voln v OVF-zerkale na giperzvuke po skheme generator - Usilitel' v rezhime nasyshcheniia). D. A. GLAZKOV, V. F. EFIMKOV, I. G. ZUBAREV, S. A. PASTUKHOV, and V. B. SOBOLEV, Kvantovaia Elektronika (ISSN 0368-7147), Vol. 15, Aug. 1988, pp. 1558-1563. 6 Refs.

Large gain increments in the four-wave mixing region result in signal energy transfer into a Stokes reference wave. This significantly reduces the signal reflection factor. It is shown that the intensity of the Stokes reference wave is always greater than the intensity of the Stokes signal. An increase in the degree of spatial inhomogeneity of the signal wave increases the signal reflection factor.

A89-12895   Numerical simulation of shock layer structure in a supersonic dusty gas flow past a blunted body. M. S. RAMM and A. A. SCHMIDT, IN: Shock tubes and waves; Proceedings of the Sixteenth International Symposium, Aachen, Federal Republic of Germany, July 26-31, 1987 (A89-12876 03-34). Weinheim, Federal Republic of Germany, VCH Verlagsgesellschaft mbH, 1988, pp. 251-259. 14 Refs.

A simulation of a supersonic dusty flow past a sphere is presented. It is shown that high-speed particle-body surface interaction is accompanied by the particle disintegration, which affects the density profiles across the shock layer. The model presented makes it possible to determine the major features of the flow and account for processes occurring in the particulate phase-flow boundary interaction.

A87-35911   Calculation of supersonic flow of a chemically nonequilibrium gas past three-dimensional blunt bodies (O raschete sverkhzvukovogo obtekaniia prostranstvennykh zatuplennykh tel khimicheski neravnovesnym potokom gaza). V. P. KOTENEV, V. I. SAKHAROV, and G. A. TIRSKII, Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), Vol. 27, March 1987, pp. 411-415. 7 Refs.

A numerical method is proposed for calculating supersonic flow of a viscous gas past blunt bodies in the subsonic region of the flow with allowance for chemical reactions. The system of equations describing such a flow is separated into a gasdynamic system and a relaxation system, which are solved consecutively. The gasdynamic equations are solved by using Godunov's finite difference scheme and an explicit finite difference scheme of second order of accuracy; the relaxation equations are integrated using an implicit scheme. Results of calculations for axisymmetric and three-dimensional flow of nonequilibrium air are presented.

A88-53970   Conditions of the induction-plasmatron modeling of the convective nonequilibrium heat transfer of bodies in hypersonic flow (Usloviia modelirovaniia konvektivnogo neravnovesnogo teploobmena tel s giperzvukovymi potokami na induktsionnykh plazmotronakh). A. F. KOLESNIKOV and M. I. IAKUSHIN, Teplofizika Vysokikh Temperatur (ISSN 0040-3644), Vol. 26, July-Aug. 1988, pp. 742-750. 29 Refs.

The possibility of the modeling of nonequilibrium heat transfer processes by using a 100-kW induction plasmatron with a 0.06-m-diameter discharge channel is investigated. Relations are established between the parameters of hypersonic flow past a smooth body and characteristics of subsonic jet flow past cylindrical models, and it is shown that these relations, when implemented in induction plasmatrons, provide full capabilities for the modeling of nonequilibrium heat transfer in a dissociated boundary layer near the critical point.

A89-18357   Calculation of hypersonic flow past the windward side of a low-aspect-ratio wing at high angles of attack (Raschet giperzvukovogo obtekaniia navetrennoi storony kryla malogo udlineniia pri bol'shikh uglakh ataki). V. N. GOLUBKIN and V. V. NEGODA, Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), Vol. 28, Oct. 1988, pp. 1586-1594. 12 Refs.

The paper presents a theoretical analysis of the hypersonic flow past a thin low-aspect-ratio wing at an angle of attack close to pi/2. An asymptotic method is used to study the two-layer structure of compressed-gas flow between the bow shock and the windward side of the wing.

A89-17742 **Variable-cycle engines for boosting-cruising vehicles.** N. IU. ROTMISTROV and M. M. TSKHOVREBOV, *IAF, 39th International Astronautical Congress*, Bangalore, India, Oct. 8-15, 1988. 15 pp. 5 Refs. (IAF Paper 88-249).

The present consideration of variable-cycle airbreathing booster vehicle engines for operation at Mach 5-6 gives attention to a variable-cycle engine with ramjet duct whose optimum energy transfer value into the duct is optimized. The thermodynamic and kinematic parameters of powerplant configurations of this type are presented; the boosting instantaneous overall efficiency is used to estimate these configurations' efficiencies at representative flight regimes.

A89-16620 **Vapor-phase combustion and heat and mass transfer during the interaction of a high-temperature gas flow with a solid (Parofaznoe gorenie i teplomassoobmen pri vzaimodeistvii vysokotemperaturnogo gazovogo potoka s tverdym telom).** V. N. PUSHKIN, G. S. SUKHOV, and L. P. IARIN, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 24, July-Aug. 1988, pp. 71-80. 6 Refs.

The problem of the combustion of a solid in incoming gas flow containing an oxidizer is solved by using an analytical model allowing for phase transitions and chemical transformations and assuming a quasi-equilibrium state on the free surface and diffusion combustion at the flame front. The hydrodynamic, temperature, and concentration fields are investigated for the case of flow past a body with a spherical nose. The principal combustion characteristics are determined as a function of the incoming flow intensity.

A89-13166 **Supersonic flow of an inhomogeneous viscous gas past a blunt body under conditions of surface injection (Sverkhzvukovoe obtekanie zatuplennogo tela neravnomernym potokom viazkogo gaza pri podache gaza s poverkhnosti).** I. G. EREMEITSEV, N. N. PILIUGIN, and S. A. IUNITSKII, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1988, pp. 122-129. 13 Refs.

Axisymmetric flow of an inhomogeneous viscous gas flow past smooth blunt bodies at large Mach numbers is investigated for the case of nonseparated flow. Equations of a thin viscous shock layer with generalized Rankine-Hugoniot conditions on the shock wave and boundary conditions on the body, allowing for surface gas injection, are solved numerically. The effect of surface gas injection on the conditions of nonseparated flow are analyzed as a function of the Reynolds number; critical values of the inhomogeneity parameter are obtained.

A88-49485 **A diffusion jet of atomized kerosene in comoving supersonic flow (Diffuzionnyi fakel raspylennogo kerosina v sputnom sverkhzvukovom potoke).** S. I. BARANOVSKII and M. N. MIKHAILOV, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 24, May-June 1988, pp. 35-38. 9 Refs.

The problem of a liquid kerosene jet injected into a comoving supersonic air stream is solved using a quasi-laminar formulation in the boundary layer approximation in the context of the hypothesis of Abramovich (1970). It is shown that an increase in the initial concentration and in the velocity ratio parameter leads to an increase in the jet length.

A88-49434 **An asymptotic solution to the problem of hypersonic flow past blunt axisymmetrical bodies in the separation zone of a limit shock layer (Asimptoticheskoe reshenie zadachi giperzvukovogo obtekaniia zatuplennykh osesimmetrichnykh tel v zone otryva predel'nogo udarnogo sloia).** A. A. SYTIKOV and V. N. ENGEL'GART, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), April 1988, pp. 68-71. 5 Refs.

The axisymmetric problem of hypersonic ideal gas flow past blunt bodies is examined for freestream, Mach numbers tending to infinity. The asymptotic solution is constructed near the zero stream line behind the separation of the limit shock layer where Lighthill's limit solution becomes incorrect.

A88-49414 **Measurements of density distributions in laminar thermal boundary layers by a shear interferometer (Izmereniia raspredelenii plotnosti v laminarnykh temperaturnykh pogranichnykh sloiakh sdvigovym interferometrom).** D. A. VAN, A. A. MASLOV, and A. L. RUDNITSKII, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May-June 1988, pp. 62-66. 6 Refs.

Density distributions in a convective boundary layer at the lower surface of a heated horizontal cylinder and near a cone in supersonic flow were measured using a focused-beam scanning shear interferometer with a spatial resolution of 30 microns and a sensitivity of 0.001 lambda. Measurements of radial distributions of the refractive index in a glass fiber with a spatial resolution of about 2 microns are presented to illustrate the method.

A88-49413 **The thermal-crisis effect in supersonic flows in the presence of a fixed heat source (K effektu teplovogo krizisa v sverkhzvukovykh potokakh pri nepodvizhnom istochnike nagreva).** B. P. GERASIMOV, S. A. SEMUSHIN, A. A. STEPANOV, and V. A. SHCHEGLOV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May-June 1988, pp. 59-62.

A mathematical model is developed for the steady upstream propagation of a shock wave arising in a supersonic flow due to a thermal crisis in the presence of a fixed heat source. An analytical solution is obtained, and attention is given to sources with mass and bulk heat relesase. (B.J.)

A88-49420 **Spatial self-similar problems concerning the penetration of blunt bodies into an ideal compressible fluid (The supersonic case) (Prostranstvennye avtomodel'nye zadachi pronikaniia zatuplennykh tel v ideal'nuiu szhimaemuiu zhidkost' /Sverkhzvukovoi sluchai/).** F. M. BORODICH, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May-June 1988, pp. 110-114. 7 Refs.

The paper presents a linear analysis of the spatial problems concerning the penetration of a blunt body into the half-space of an ideal slightly compressible fluid in the case when the expansion velocity of the wetted surface of the body is greater than the sound velocity in the fluid. It is shown that the problem considered is self-similar when the function defining the shape of the surface of the body is positive, smooth, and homogeneous.

A88-46913 **Calculation of supersonic flow past a cylindrical shell with allowance for aeroelastic deformation (Raschet sverkhzvukovogo obtekaniia tsilindricheskoi obolochki s uchetom aerouprugoi deformatsii).** N. N. BELIAEV and V. K. KHRUSHCH, *Gidromekhanika* (ISSN 0367-4088), no. 57, 1988, pp. 16-19.

The problem considered here is the coupled stationary aeroelasticity problem of transverse supersonic flow of a viscous ideal gas past a cylindrical shell. In particular, the effect of shell deformation on the drag is analyzed. Displacememts in the shell are determined for a pressure distribution corresponding to a rigid nondeformed cylinder and for the coupled problem where gas flow and shell deformation are calculated simultaneously. A numerical algorithm for solving the problem is developed which uses the method of flows to solve the Euler equations and the finite difference method to solve the Karman equations.

A88-43639 **Numerical study of a three-dimensional laminar boundary layer with allowance for coupled heat transfer (Chislennoe issledovanie prostranstvennogo laminarnogo pogranichnogo sloia s uchetom sopriazhennogo teploobmena).** V. I. ZINCHENKO and O. P. FEDOROVA, *PMFT—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.-Apr. 1988, pp. 34-42. 16 Refs.

A solution is presented for the problem of the heating of a spherically blunted cone in the path of a chemically equilibrium or supersonic air flow. The effect of the nonisothermality of the body surface on the characteristics of flow toward the body are analyzed for different angles of attack. Examples of body heating calculations are presented for a wide range of flight velocities. The applicability limits of some traditional approaches are analyzed.

A88-43088 **Supersonic flow past bodies in the presence of external heat sources (Sverkhzvukovoe obtekanie tel pri nalichii vneshnikh istochnikov teplovydeleniia).** P. IU. GEOGRIEVSKII and V. A. LEVIN, *Pis'ma v Zhurnal Tekhnicheskoi Fiziki* (ISSN 0320-0116), Vol. 14, April 26, 1988, pp. 684-687. 6 Refs.

The paper presents calculations on the supersonic flow past regions with heat sources and on the effect of these sources on the wave drag of axisymmetric blunt bodies of revolution located downstream. Flow past a sphere at a freestream Mach number of 3 is examined, and wave drag is shown to decrease substantially during the appearance of flow reversal. The sphere drag coefficient is evaluated as a function of the distance between the sphere and the hot spot for different intensities of heat delivery.

A88-52084 **Investigation of the working process of a low-pressure blowdown supersonic wind tunnel (Issledovanie protsessa raboty sverkhzvukovoi ballonno-vakuumnoi aerodinamicheskoi truby kratkovremennogo deistviia).** V. IA. BEZMENOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 4, 1987, pp. 50-58. 16 Refs.

The working process of a low-pressure blowdown supersonic wind tunnel is analyzed. It is shown that such characteristics as pressure reduction, the duration of the flow core in the working section, and overloads determined by universal dimensionless parameters.

A88-52083 **Calculation of supersonic flow past a pitot-static tube (Raschet sverkhzvukovogo obtekaniia priemnika vozdushnogo davleniia).** A. P. BAZZHIN, G. G. NERSESOV, and I. I. SHITIKOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 4, 1987, pp. 43-49.

Results of a numerical calculation of the flow past a pitot-static tube are presented. The calculations are made for the freestream Mach number range of 2 to 4 at zero angle of attack. The distribution of gasdynamic characteristics along the tube surface is presented. It is shown that changes in the front part of the pitot-static tube influence the distribution of static pressure.

A88-33971 **Spatial packet of instability waves in a supersonic boundary layer (Prostranstvennyi paket voln neustoichivosti v sverkhzvukovom pogranichnom sloe).** A. M. TUMIN, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002-3434), Feb. 1988, pp. 14-16. 5 Refs.

A spatial packet of instability waves in a supersonic boundary layer on a flate plate is calculated numerically. Results obtained for a boundary layer at Mach 2 and a perturbation frequency of 20 kHz are compared with experimental results obtained in a supersonic wind tunnel. Some differences between the experimental data and the calculations are briefly discussed.

A88-38850 **Effect of the condensation coefficient on vapor flow during subsonic and supersonic condensation (Vliianie koeffitsienta kondensatsii na techenie para pri kondensatsii s do- i sverkhzvukovymi skorostiami).** A. P. KRIUKOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Mar.-Apr. 1988, pp. 189-192. 5 Refs.

A method is proposed for calculating the process of one-dimensional stationary condensation with an arbitrary condensation coefficient. The method employs solutions obtained for the case of the complete absorption of molecules incident on an interface and a conversion rule proposed in an earlier study (Kogan & Makashev, 1971). An experiment with a supersonic air flow incident on a surface cooled by liquid helium is analyzed.

A88-29972 **Two-dimensional absolute instability of a supersonic boundary layer (Dvumernaia absoliutnaia neustoichivost' sverkhzvukovogo pogranichnogo sloia).** G. V. PETROV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1988, pp. 176-179.

Results obtained in previous studies of the stability of a partially viscous shock layer suggest that any plane-parallel flow may be absolutely unstable if more than one normal instability mode exists for such flow. Here, this hypothesis is verified for a supersonic boundary layer at infinitely high Reynolds numbers. Two types of absolute instabilities, corresponding to two known types of dispersion relation branching, are identified.

A88-29966 **A study of supersonic viscous flow past a sphere in the presence of subsonic and sonic injection (Issledovanie sverkhzvukovogo viazkogo obtekaniia sfery pri nalichii dozvukovogo i zvukovogo vduva).** A. M. GRISHIN, O. I. POGORELOV, and S. I. PYRKH, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1988, pp. 83-89. 11 Refs.

Supersonic flow past a sphere is investigated for a specified flow rate of the injected gas in the Reynolds number range 100-10000 at free-stream Mach 10. Qualitatively new features in flow structure and in the distribution of local supersonic flow characteristics along the sphere contour are identified at high subsonic and sonic injection velocities. Under conditions of sonic injection, changes in the flow structure are observed in the supersonic region only. Heat flux in the vicinity of the subsonic-sonic transition of injection flow has a local maximum whose absolute value does not exceed the heat flux in the absence of injection.

A89-14772 **Hypersonic flow of a viscous heat-conducting chemically reacting gas past bodies over a wide range of Reynolds numbers (Giperzvukovoe obtekanie tel viazkim teploprovodnym khimicheski reagiruiushchim gazom v shirokom diapazone chisel Reinol'dsa).** G. A. TIRSKII, *IN: Mechanics and scientific-technological progress. Volume 2* (A89-14764 03-34). Moscow, Izdatel'stvo Nauka, 1987, pp. 261-281. 35 Refs.

A fast and memory-efficient computer algorithm for solving two-dimensional problems of supersonic and hypersonic flow past bodies is described which involves solving full stationary equations of a viscous shock layer at Mach larger than 1 over a wide range of Reynolds numbers. The method is based on global iterations with relaxation of the pressure and head shock angle. Results are presented for hypersonic flow past spheres and blunt cones of large length (several hundred bluntness radii) at Reynolds numbers up to 10 to the eighth - 10 to the ninth.

A89-14769 **Asymptotic theory of boundary layer interaction and separation in supersonic gas flow (Asimptoticheskaia teoriia vzaimodeistviia i otryva pogranichnogo sloia v sverkhzvukovom potoke gaza).** V. IA. NEILAND, *IN: Mechanics and scientific-technological progress. Volume 2* (A89-14764 03-34). Moscow, Izdatel'stvo Nauka, 1987, pp. 128-145. 50 Refs.

The asymptotic approach to the solution of problems in the dynamics of supersonic flows of a viscous gas at large Reynolds numbers has made it possible to study a wide class of problems of theoretical and practical importance which are not necessarily reduced to a three-layer scheme and which are not described in terms of classical boundary layer theory. It is emphasized that the asymptotic approach is particularly important because of the difficulties associated with obtaining numerical solutions at large Reynolds numbers. Another advantage of the asymptotic approach is that it yields convenient approximate similarity laws.

A88-52101 **A method for determining the parameters of nonequilibrium air flow in hypersonic wind tunnels from T0, p0, and p0-prime measurements (T0 is equal to or less than 2000 K) (Metodika opredeleniia parametrov neravnovesnogo potoka vozdukha v giperzvukovykh aerodinamicheskikh ustanovkakh po dannym izmereniia T0, p0 i p0-prime /T0 less or equal 2000 K/).** V. N. KOMAROV and O. IU. POLIANSKII, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 5, 1987, pp. 48-56. 12 Refs.

A method is proposed for determining the velocity head, Mach number, pressure, density, and other gasdynamic parameters in the test section of hypersonic wind tunnels with allowance for nonequilibrium physicochemical processes in the working gas. The method uses measurements of T0, p0, and p0-prime (stagnation pressure behind a direct shock wave). For air, all the necessary expressions are presented for determining q, M, rho, and other parameters at stagnation temperatures up to 2000 K in the case where condensation is absent and the effect of molecular forces is negligible.

A88-52123 **Visualization of the laminar-turbulent boundary layer transition on a cone in supersonic flow (Vizualizatsiia perekhoda laminarnogo pogranichnogo sloia v turbulentnyi na konuse v sverkhzvukovom potoke).** B. IU. ZANIN and S. G. SHEVEL'KOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 6, 1987, pp. 98-100. 6 Refs.

A method is proposed whereby the location of the laminar-turbulent transition in a boundary layer at supersonic flow velocities is visualized by using sublimable coatings. Results of low visualization on a cone at Mach 2 and 4 are presented. The data obtained by the visualization technique proposed here are found to be in good agreement with data based on full pressure measurements.

A88-10300 **Necessary optimality conditions for three-dimensional bodies in supersonic gas flow (Neobkhodimye usloviia optimal'nosti prostranstvennykh tel v sverkhzvukovom potoke gaza).** I. E. MIKHAILOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 27, July 1987, pp. 1111-1114.

The problem of determining the optimal shape of a three-dimensional body in supersonic stationary flow of a gas is analyzed under the assumption that all the flow parameters are continuous in the determinacy region of the body. The necessary extreme conditions are derived by using the method of Lagrangian multipliers. The solvability of the conjugate boundary value problem is demonstrated.

A88-12068 **A study of three-dimensional hypersonic flow past blunt bodies using parabolized Navier-Stokes equations (Issledovanie giperzvukovogo prostranstvennogo obtekaniia zatuplennykh tel v ramkakh parabolizovannykh uravnenii Nav'e-Stoksa).** E. A. GERSH-BEIN and V. G. SHCHERBAK, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1987, pp. 134-142. 23 Refs.

Flow of a homogeneous gas in a three-dimensional hypersonic viscous shock layer including a shock wave structure is examined in terms of a parabolic approximation of the Navier-Stokes equations. The Navier-Stokes equations are simplified on the basis of an asymptotic analysis, written in Dorodnitsyn's variables, and solved by a method proposed in previous studies (Gershbein et al., 1980, 1984), which has been generalized to three-dimensional flows. Flow at zero angle of attack is calculated for elliptic paraboloids, two-cavity hyperboloids, and triaxial ellipsoids.

A88-12056 **Strong gas injection into supersonic flow with turbulent mixing (Sil'nyi vduv gaza v sverkhzvukovoi potok pri turbulentnom smeshenii).** I. I. VIGDOROVICH, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 51, July-Aug. 1987, pp. 600-610. 18 Refs.

Strong distributed injection of a gas through a porous plate into supersonic flow is analyzed for the case where the boundary layer is forced away from the plate and the injected gas is separated from the incoming flow by a turbulent mixing layer. A criterion for the detachment of the turbulent boundary layer during injection is formulated, as is a similarity rule reflecting the dependence of flow over the plate on the conditions at the end of the porous region. Pressure and injection layer thickness distribution curves are presented, and the force characteristics of the flow are calculated.

A87-50818 **Investigation of a hypersonic viscous shock layer near blunt bodies with nonuniform flow around them (Issledovanie giperzvukovogo viazkogo udarnogo sloia okolo zatuplennykh tel pri neravnomernom obtekanii).** I. G. EREMEITSEV, N. N. PILIUGIN, and S. A. IUNITSKII, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1987, pp. 154-159. 16 Refs.

Nonseparated viscous-gas flow around a blunt body is analyzed numerically on the basis of the theory of thin viscous shock layers. The equations of a hypersonic viscous shock layer with generalized Rankine-Hugoniot conditions on the shock wave are solved by a finite difference method in a wide range of Reynolds numbers, values of the temperature factor, and nonuniformity parameters. Calculation results are presented which characterize the effect of the nonuniformity of the oncoming flow on the velocity and temperature profiles across the shock layer, on the heat-transfer and friction coefficients, and on the separation of the shock wave. Critical values of the nonuniformity parameter are obtained in the case of which reverse-circulation zones arise on the front surface of the body depending on the Reynolds number.

A88-12071 **Oxygen recombination in a supersonic cooled flow (Rekombinatsiia kisloroda v sverkhzvukovom okhlazhdaiushchemsia potoke).** V. K. DUSHIN, I. E. ZABELINSKII, and O. P. SHATALOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1987, pp. 160-165. 10 Refs.

Oxygen recombination in supersonic cooled flows is investigated here by the following two methods: by measuring ultraviolet emission absorption by oxygen molecules forming in a supersonic nozzle and by measuring gas pressure inside the nozzle. For this particular problem, the absorption spectroscopy method is found to be much more sensitive, making it possible to measure the recombination rate constant for low degrees of initial oxygen dissociation and at lower temperatures (1000 K). The piezoelectric method makes it possible to conduct measurements at higher temperatures for much higher (by an order of magnitude) concentrations of recombining atoms. The results obtained are compared with data in the literature, and an expression for the oxygen atom recombination rate constant is proposed.

A88-28356   Thermodynamic nonequilibrium of a far hypersonic wake (O termodinamicheskoi neravnovesnosti dal'nego giperzvukovogo sleda). IU. P. SAVEL'EV and M. M. STEPANOV, *Zhurnal Tekhnicheskoi Fiziki* (ISSN 0044-4642), Vol. 57, Nov. 1987, pp. 2178-2183. 8 Refs.

The flow of a low-temperature plasma of a far hypersonic wake is studied theoretically with allowance for nonequilibrium chemical reactions as well as the possible absence of thermodynamic equilibrium. The investigation is based on a numerical analysis of simplified parabolic Navier-Stokes equations for a multicomponent mixture of reacting gases. Numerical results indicate the range of the greatest effect of thermodynamic nonequilibrium on the far-wake parameters.

A88-24622   Hypersonic three-dimensional viscous shock layer in an inhomogeneous gas flow near a critical point (Giperzvukovoi prostranstvennyi viazkii udarnui sloi v neravnomernom potoke gaza v okrestnosti kriticheskoi tochki). S. V. PEIGIN and S. V. TIMCHENKO, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Nov.-Dec. 1987, pp. 136-145. 11 Refs.

The paper is concerned with three-dimensional hypersonic flow of a viscous gas past smooth blunt bodies in the presence of injection and suction. By using flow from a supersonic spherical source and flow of the far wake type as examples, an analysis is made of the effect of the inhomogeneity of the incoming flow on shock wave detachment, wave structure, and friction and heat transfer coefficients. It is shown that this effect depends to a large degree on the Reynolds number, characteristics of the inhomogeneity, and body shape.

A88-23950   Stability of a supersonic boundary layer during the turning of a flow (Ustoichivost' sverkhzvukovogo pogranichnogo sloia pri povorote techeniia). S. A. GAPONOV and G. V. PETROV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002-3434), Oct. 1987, pp. 25-29. 8 Refs.

The development of perturbations in the region where supersonic flow turns around a convex surface is investigated by numerically integrating the boundary layer and stability equations and by using estimates based on the gradient Reynolds number. It is shown that flow acceleration in the region of the turn leads to intense flow stabilization. As the turn is completed and the flow reaches a flat plate, complete absorption of acoustic waves by the boundary layer is observed for certain frequencies. Solutions are also obtained which practically become acoustic waves in the external region.

A88-17737   A numerical study of the structure of nonequilibrium three-dimensional hypersonic flow past blunt bodies (Chislennoe issledovanie struktury neravnovesnogo techeniia okolo zatuplennykh tel pri giperzvukovom prostranstvennom obtekanii). V. G. SHCHERBAK, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.-Oct. 1987, pp. 143-150. 16 Refs.

Three-dimensional flow of a dissociating air around blunt bodies is investigated using parabolized Navier-Stokes equations. The analysis allows for multicomponent diffusion and homogeneous chemical reactions, including dissociation-recombination and exchange reactions. The boundary conditions are specified in the unperturbed flow and on the body surface, with allowance made for heterogeneous catalytic reactions and slip effects. The results obtained are compared with calculations based on a model of a thin viscous shock layer.

A88-21846   Hypersonic flow past axisymmetric rotating bodies in the presence of strong injection (Giperzvukovoe obtekanie osesimmetrichnykh vrashchaiushchikhsia tel pri nalichii sil'nogo vduva). V. A. LEVIN and N. A. KRASILOV, *Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika* (ISSN 0579-9368), Sept.-Oct. 1987, pp. 51-54. 6 Refs.

A solution is presented for the problem of hypersonic flow past an axisymmetric rotating body under conditions of high Reynolds numbers and strong injection. It is shown that, in the case of a rotating body, the separation of the contact discontinuity surface and shock wave from the body is smaller than in the case of a nonrotating body and that the longitudinal component of the velocity vector has a local minimum within the injected gas layer for a rotation parameter of the order of 1.

A88-17730   Effect of angle of attack on supersonic flow past axisymmetric blunt bodies in the presence of injection from the surface (Vliianie ugla ataki na sverkhzvukovoe obtekanie osesimmetrichnykh zatuplennykh tel pri nalichii vduva s poverkhnosti). V. A. ANTONOV, A. M. GRISHIN, and F. M. PAKHOMOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.-Oct. 1987, pp. 95-101. 9 Refs.

The effect of the angle of attack in the range 0-40 degrees on the flow pattern and aerodynamic characteristics of a power-law body under conditions of supersonic flow is investigated numerically for the case of strong localized subsonic injection from the surface and in the absence of injection. The problem is solved using Godunov's finite difference scheme. It is found that strong gas injection significantly reduces the aerodynamic drag of the body without any deterioration of its static stability.

A88-13759   An experimental study of the stability of a supersonic boundary layer on a cone (Eksperimental'noe issledovanie ustoichivosti sverkhzvukovogo pogranichnogo sloia na konuse). A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie 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.

A87-35823   Drag of a slender cone in supersonic flow of a rarefied gas (Soprotivlenie ostrogo konusa v sverkhzvukovom potoke razrezhennogo gaza). F. S. VORONIN and L. N. ZHDANOVA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1987, pp. 187-189. 14 Refs.

The paper reports the results of an experimental study of the drag of a slender cone for flow conditions approaching those of free molecular flow. The experiments were carried out in a wind tunnel at free-stream Mach 11.2 using cones with a half-angle of taper of 5, 10, and 15 deg and a base diameter of 5 and 10 mm. The experimentally determined drag coefficients are found to be close to the values calculated for free molecular flow.

Japanese Aerospace Literature
This month: *Supersonics/Hypersonics*

A89-20637   A note on the optimal hypersonic flight path. YOSHINORI WARIISHI and KANICHIRO KATO, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 36, no. 416, 1988, pp. 427-432.

Flight paths of a hypersonic plane are formulated as optimal control problems. Minimum-time, minimum-fuel and maximum-range solutions are shown with varying fuel-to-weight and thrust-to-weight ratios. One of the findings is that an initial path with a slight upward angle is usually advantageous because of the smaller drag (in higher altitude) when in high speed.

A88-19244   Stability of normal shock waves in diffusers. KAZUYASU MATSUO, HIROAKI MOCHIZUKI, and MINORU YAGA, *AIAA Journal* (ISSN 0001-1452), Vol. 25, Nov. 1987, pp. 1515-1517. 5 Refs.

The present analysis of the behavior of a shock wave in a diffuser in response to small-amplitude pressure disturbances indicates that shock wave stability depends not only on the Mach number immediately upstream of the shock, but also on diffuser efficiency for subsonic flow downstream of the shock wave. The neutral stability curve relating the diffuser efficiency to the Mach number is obtained. The maximum diffuser efficiency causing instability decreases as the Mach number increases from 1.0 to 1.48.

A88-13095   The scramjet - Toward Mach 4-25 flight. NOBUO CHINZEI and GORO MASUYA, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 35, no. 400, 1987, pp. 241-252. 51 Refs.

Technological problems in the development of the scramjet are characterized, and scramjet R&D in the United States and Japan is reviewed. Work from 1960 to 1975 is summarized, including the free-jet engine, the variable geometry engine, the component integration model, and the thermal compression engine. Also considered is work after 1975, including the airframe integrated engine and the dual combustor engine.

A89-15680   Numerical simulations of flow field around three-dimensional complex configurations. SATORU OGAWA, TOMIKO ISHIGURO, and YOKO TAKAKURA, *IN: 7th GAMM-Conference on Numerical Methods in Fluid Mechanics, Louvain-la-Neuve, Belgium, Sept. 9-11, 1987, Proceedings* (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.