Soviet and Japanese Aerospace Literature

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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*

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, Seriia Tekhnicheskie 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 free-stream 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.

A89-42567 Effect of the adiabatic exponent on the stability and turbulent transition of a supersonic laminar boundary layer (Vliianie pokazatelia adiabaty na ustoichivost' i perekhod sverkhzvukovogo laminarnogo pogranichnogo sloia v turbulentnyi). V. I. LYSENKO, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Mar.-Apr. 1989, pp. 179-183. 11 Refs.

The effect of the adiabatic exponent on the laminar-turbulent transition of a boundary layer is investigated analytically and experimentally for a supersonic flow of a compressible heat-conducting gas in a two-dimensional boundary layer. It is shown that a decrease in the adiabatic exponent leads to a substantial decrease in the Reynolds number of the laminar-turbulent transition.

A89-42563 A three-dimensional thin viscous shock layer in the absence of symmetry planes in the flow (Prostranstvennyi tonkii viazkii udarnyi sloi pri otsutstvii v techenii ploskostei simmetrii). A. I. BORODIN and S. V. PEIGIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Mar.-Apr. 1989, pp. 150-158. 16 Refs.

The principal characteristics of flow of a homogeneous viscous gas past smooth blunt bodies with a porous surface at high supersonic velocities are examined on the basis of a thin viscous shock layer model. An efficient numerical model for solving the shock layer equations is proposed which makes it possible to consider cases of flow at angles of attack and slip where planes of symmetry are absent. Results obtained for flow past a triaxial ellipsoid (10:7:3) at angles of attack 0-45 deg and slip angles of 0-45 deg over a wide Reynolds number range are presented as an example.

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.

Heat transfer 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.

A89-42460 Supersonic flow stagnation in a duct during combustion (O tormozhenii sverkhzvukovogo potoka v kanale pri gorenii). S. I. ROZHITSKII and V. N. STROKIN, *Pioneers of space and the present age* (A89-42451 18-99). Moscow, Izdatel'stvo Nauka, 1988, pp. 57-61. 6 Refs.

During combustion in supersonic air flow in a duct, the separation of the boundary layer at the walls may lead to the formation of an extended stagnation zone propagating from the heat release region in the direction opposite to that of the flow. The objective of the experimental study reported here, in which various amounts of a gaseous fuel (hydrogen) were burned in supersonic air flow (M 2.6) in a water-cooled duct simulating a simple combustion chamber, was to investigate the relationship between the dimensions of the stagnation zone and heat release within the duct. The possibility of calculating the maximum possible heat removal based on the the duct length is demonstrated.

A89-35479 Asymptotic analysis of nonviscous perturbations in a supersonic boundary layer (Asimptoticheskii analiz neviazkikh vozmushchenii v sverkhzvukovom pogranichnom sloe). V. R. GUSHCHIN and A. V. FEDOROV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Jan.-Feb. 1989, pp. 69-75. 8 Refs.

Nonviscous perturbations in a supersonic boundary layer are analyzed asymptotically using the short-wave approximation. The dispersion relation and eigenfunctions are determined for high-number neutral modes. Stability characteristics for the four first modes in a plane parallel boundary layer are calculated numerically for Mach 8. Directly determined neutral solutions are found to be in good agreement with asymptotic theory for third and higher modes.

A89-35481 Supersonic flow past caret wings and elements of star-shaped bodies at angles of attack and bank (Sverkhzvukovoe obtekanie Lambda-kryl'ev i elementov zvezdoobraznykh tel pri uglakh ataki i krena). O. N. IVANOV and A. I. SHVETS, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Jan.-Feb. 1989, pp. 81-87. 12 Refs.

Experimental results are reported on supersonic flow past caret wings at angles of attack and bank. The results cover flow characteristics for a wide range of anhedral angles (the caret angle between the windward planes of the wing), with both a curved shock wave and a system of shocks between the wings, corresponding to Mach and regular interactions. For large anhedral angles (150-180 deg), the flow schemes studied correspond to nonsymmetric flow past aircraft with caret wings; for small anhedral angles (less than 90 deg), they correspond to flow past an element of a star-shaped body.

A89-35477 Boundary conditions at a shock wave in supersonic flow (O granichnykh usloviiakh na udarnoi volne pri sverkhzvukovom obtekanii). V. G. SHCHERBAK, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Jan.-Feb. 1989, pp. 49-56. 13 Refs.

The validity of a two-layer model with a frozen wave front describing supersonic shock layer flow in the presence of chemical reactions is examined analytically with emphasis on the effect of chemical reactions in the shock wave on flow characteristics. It is shown that the assumption of frozen chemical reactions in the shock wave leads to a lesser error in concentration, heat flux, and friction coefficients than the failure to account for the effects of barodiffusion. When determining heat flux and friction coefficients, chemical reactions in the shock wave can be justifiably neglected in the case of gliding-path motion (maximum error in heat flux is estimated at 1 percent).

A89-35435 Thin axisymmetric caverns in supersonic flow (Tonkie osesimmetrichnye kaverny v sverkhzvukovom potoke). A. D. VASIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1989, pp. 179-181. 10 Refs.

An integro-differential equation for the profile of a cavern in supersonic flow is obtained in the context of thin body theory. An analytical expression is obtained which relates cavern elongation to the cavitation and Mach numbers. As the cavitation number decreases, the effect of compressibility on cavern elongation becomes insignificant.

A89-35430 A combined method for calculating supersonic flow of an ideal gas past a wing with a supersonic blunt leading edge (Kombinirovannyi metod rascheta sverkhzvukovogo obtekaniia kryla so sverkhzvukovoi zatuplennoi perednei kromkoi ideal'nym gazom). N. V. VOEVODENKO and I. M. PANTELEEV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1989, pp. 159-164. 5 Refs.

A combined numerical method based on the consecutive calculation of flows near the blunt leading edge of a wing and at its center is proposed for calculating supersonic flow of an ideal gas past a wing with a supersonic blunt leading edge. Flow parameters near the center of the wing are calculated on the basis of the plane flow law. Equations of motion for both regions are integrated numerically using Godunov's method. The results obtained are analyzed to evaluate the applicability of the combined method.

A89-34133 Thermal control on a porous spherical nose in supersonic flow with allowance for coupled heat transfer (Upravlenie teplovym rezhimom na pronitsaemom sfericheskom noske v sverkhzvukovom potoke s uchetom sopriazhennogo teploobmena). K. G., GARAEV, A. N. KUSIUMOV, and V. G. PAVLOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), no. 4, 1988, pp. 30-34. 8 Refs.

The paper is concerned with the problem of maintaining a specified temperature on the surface of a porous spherical shell, with gas flow rate and variable wall thickness used as the controls. The analysis accounts for two additional factors: coupled heat transfer and the Darcy's filtering law. By using the method of generalized integral relations, the problem is reduced to that of solving the Cauchy problem for a system of ordinary differential equations. Calculations are carried out for a porous shell of a corrosion-resistant steel.

A89-13165 Effect of the diffusive separation of chemical elements on a catalytic surface (for supersonic aerodynamics) (Effekt diffuzionnogo razdeleniia khimicheskikh elementov na kataliticheskoi poverkhnosti). V. L. KOVALEV and O. N. SUSLOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1988, pp. 115-121. 5 Refs.

Asymptotic expansion, at large Schmidt numbers, of a solution to a system of equations of a chemically nonequilibrium multicomponent boundary layer near the catalytic surface of a blunt body is used to obtain formulas for the diffusion flows of reaction products, chemical elements, and heat fluxes. It is shown that, in the case of supersonic flow of air past a body, the extent of the diffusive separation of oxygen is largely determined by the concentration of atoms at the outside edge of the boundary layer and characteristics of the homogeneous and heterogeneous catalytic reactions.

A89-34121 A simple one-dimensional model for the effect of air pollution on supersonic combustion (Prostaia odnomernaia model' vliianiia zagriaznennosti vozdukha na sverkhzvukovoe goreniie). S. I. BARANOVSKII, A. S. NADVORSKII, and D. D. ROMASHKOVA, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 24, Nov.-Dec. 1988, pp. 42-51. 18 Refs.

An attempt is made to develop a numerical model describing the effect of the type of heating on the combustion of a hydrogen-air mixture in supersonic flow. It is shown, in particular that the enrichment of the mixture with oxygen is a necessary but not sufficient condition for the correct modeling of supersonic combustion using flame heating. Flame heating using a hydrocarbon fuel is shown to be preferable to heating with a hydrogen fuel.

A89-32197 Gasdynamic structure of the quasi-steady separated flow of different gases in a plane supersonic nozzle (O gazodinamicheskoi strukture kvazistatsionarnogo otryvnogo techeniia razlichnykh gazov v ploskom sverkhzvukovom sople). B. M. DOBRYNIN, V. G. MASLENNIKOV, and V. A. SAKHAROV, *Zhurnal Tekhnicheskoi Fiziki* (ISSN 0044-4642), Vol. 58, Dec. 1988, pp. 2390-2392.

A shock-tube study of quasi-steady separated flows of different gases in supersonic wedge-shaped nozzles was carried out. Based on the experimental results, a simplified model of separated flow in a wedge-shaped nozzle is proposed. The dependence of Mach number at the separation point on the pressure ratio is evaluated.

A89-30111 Numerical simulation of supersonic flow past a sphere in a gas with variable density (Chislennoe modelirovanie sverkhzvukovogo obtekaniia sfery v gaze s izmeniaiushcheisia plotnost'iu). IU. P. GOLOVACHEV and N. V. LEONT'EVA, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, Jan. 1989, pp. 148-151. 7 Refs.

A viscous-shock-layer model is used to investigate unsteady processes accompanying the supersonic motion of a spherically blunt body upon entry into an infinite region with the same pressure as the antecedent region but with different gas density and temperature. The flow in the shock layer is described by simplified Navier-Stokes equations, which are integrated using an implicit difference scheme. Calculation results are presented which illustrate the features of the shock-layer structure and heat transfer on the surface of the body.

A89-30110 Three-dimensional supersonic flows past blunt bodies with allowance for interference (O sverkhzvukovom prostranstvennom obtekanii zatuplennykh tel s uchetom interferentsii). A. A. ANDREEV and A. S. KHOLODOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, Jan. 1989, pp. 142-147. 5 Refs.

Attention is given to the numerical solution of the problem of the supersonic three-dimensional flow of an inviscid non-heat-conducting gas past a blunt body. A grid/characteristics method is used to solve the gasdynamic equations. Calculations results are presented for flow past spherical bodies.

A89-27388 Engineering stability of the motion of a panel in gas flow (O tekhnicheskoi ustoichivosti dvizheniia paneli v gazovom potoke). K. S. MATVIICHUK, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Nov.-Dec. 1988, pp. 93-99. 26 Refs.

Sufficient conditions are obtained for the finite- and infinite-time engineering stability and asymptotic engineering stability of a two-dimensional panel loaded by a constant force in supersonic gas flow. The regions of the engineering stability of the system are related, via the Mach number, to the positive determinacy conditions of the Liapunov functional, the small positive parameter, and solution regularity conditions for the corresponding Cauchy scalar comparison problem. Conditions leading to instability are identified.

A89-27385 Stability of a high-velocity boundary layer (Ustoichivost' vysokoskorostnogo pogranichnogo sloia). V. I. LYSENKO, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Nov.-Dec. 1988, pp. 76-79. 11 Refs.

The stability of a boundary layer at high supersonic velocities is investigated theoretically and experimentally using a nitrogen wind tunnel. It is found that, in accordance with calculations for the second perturbation mode, an increase in the Mach number has a stabilizing effect on a high-velocity boundary layer, whereas cooling has a destabilizing effect. Details of the experimental procedure are presented.

A89-27384 Evolution of perturbations near a surface in supersonic flow (Razvitie vozmushchenii vblizi poverkhnosti, obtekaemoi sverkhzvukovym potokom). S. A. GAPONOV and V. I. LYSENKO, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Nov.-Dec. 1988, pp. 70-76. 12 Refs.

The stability of a supersonic boundary layer near a surface is investigated analytically. It is found that, for different flow parameters, such as longitudinal velocity, temperature, and pressure, the perturbation growth rates are different and that these relations are strongly dependent on the Mach number. The results are compared with experimental data obtained by using hot-wire anemometers on the surface of models.

A89-26011 Unsteady separation wave in a supersonic boundary layer (Nestatsionarnaia volna otryva v pogranichnom sloe pri sverkhzvukovom obtekanii). V. I. ZHUK and S. P. POPOV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 303, no. 4, 1988, pp. 822-824. 9 Refs.

Theoretical results are presented on a number of unsteady inviscid flows characterized by the presence of separation zones with closed streamlines propagating upstream along the boundary layer. A numerical solution is obtained to the Burgers equation with inhomogenous terms. It is shown that a shock wave incident on the boundary layer or steady injection creates favorable conditions for the appearance of broad separation zones propagating upstream.

A89-22227 The role of mixing and kinetics in heat release decrease in the supersonic combustion of unmixed gases in expanding ducts (Rol' smesheniia i kinetiki v umen'shenii teplovydeleniia pri sverkhzvukovom gorenii neperemeshannykh gazov v rasshiriaiushchikhsia kanalakh). E. A. MESHCHERIAKOV and V. A. SABEL'NIKOV, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 24, Sept.-Oct. 1988, pp. 23-32. 25 Refs.

The factors responsible for the retardation of the supersonic combustion of unmixed gases in slightly expanding ducts are investigated analytically. By using Zeldovich's theory and numerical integration of the conservation equations of a multicomponent reacting gas mixture in turbulent flow, it is shown that, for the practically important range of chamber inlet conditions, the retardation of combustion is due to the intense mixing of components. Possible methods of overcoming this effect are examined.

A89-18675 Determination of the perturbations of the flow fields of supersonic wind tunnels from measured aerodynamic coefficients (Opredelenie vozmushchenii polei potokov sverkhzvukovykh aerodinamicheskikh trub po izmerennym znacheniiam aerodinamicheskikh koeffitsientov). V. V. EREMIN, IU. 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.

A89-13166 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.

A89-13160 A study of supersonic isobaric submerged turbulent jets (Issledovanie sverkhzvukovykh izobaricheskikh zatoplennykh turbulentnykh strui). V. S. KRASOTKIN, A. I. MYSHANOV, S. P. SHALAEV, N. N. SHIROKOV, and M. IA. IUDELOVICH, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1988, pp. 56-62. 11 Refs.

Supersonic submerged turbulent air jets are investigated experimentally in the Mach range 1.5-3.4, with the ratio of the full enthalpy of the ambient medium to that of the jet varying from 0.01 to 1. A study is also made of oxygen-hydrogen jets issuing from a nozzle at Mach 1 and 2.4 and oxidizer excess ratios of 0.3-5. It is proposed that the jet be divided into two sections: the initial one and the main one. It is shown that, in the main section of the jet, the dimensionless velocity and temperature at the jet axis vary in inverse proportion to distance and are independent of the flow characteristics determining the length of the initial section.

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.

A87-35813 Structure and pulsation characteristics of a compressible turbulent boundary layer behind a fan of rarefaction waves (Struktura i pul'satsionnye kharakteristiki szhimaemogo turbulentnogo pogranichnogo sloia za veerom voln razrezheniia). M. A. GOLDFELD, V. N. ZINOVEV, and V. A. LEBIGA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1987, pp. 48-53. 12 Refs.

The development of an axisymmetric turbulent boundary layer following its interaction with a fan of rarefaction waves is investigated experimentally for $M \approx 3$, a unit Reynolds number of 36 x 10 to the 6th per m, and a flow turn angle of 15 deg. It is shown that, due to a large negative pressure gradient, the fullness of the mean velocity profile directly behind the fan of rarefaction waves increases (with a simultaneous decrease in mass flow pulsation) and then decreases rapidly downstream to equilibrium at a distance of approximately 50 times the boundary layer thickness from the contour bend. A comparison is made with results obtained for plane flow.

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.

A87-50822 Interaction of a liquid jet with an oncoming gas stream (Vzaimodeistvie strui zhidkosti so vstrechnym potokom gaza). M. A. KOVAL' and A. I. SHVETS, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), May-June 1987, pp. 178-181.

Wind-tunnel tests were carried out to study the interaction between water jets issuing from various types of nozzles (including cylindrical) and subsonic and supersonic air streams with Mach numbers from 0.3 to 3 and Reynolds numbers from 1 x 10 to the 6th to 3 x 10 to the 7th. The following interaction structure was observed: (1) at moderate outflow velocities, the liquid jet has an extended region, which subsequently expands abruptly as a spherical or mushroom-shaped drop; (2) this drop is atomized in the peripheral region and is carried away as a gas-liquid mixture; (3) a shock wave is formed in front of the jet in the oncoming supersonic stream; and (4) a separated flow region is present in the vicinity of the cylindrical nozzle section.

A87-46093 Convergent flows and air intakes of simple and compact-channel designs (Konvergentnye techeniia i vozdukhozaborniki, prosteishie i s predel'no kompaktnym kanalom). B. I. GUTOV and V. V. ZATOLOKA, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.-Apr. 1987, pp. 57-62. 7 Refs.

A class of supersonic flows and air intakes is considered in which transverse jet flows are compressed along convergent intersecting directions. These intakes differ from conventional ones (plane and divergent) by the small area of the channel walls and essential three-dimensionality. Air intakes of this type are first specified by simple combinations of two-dimensional flows using gasdynamic design methods. A very simple method (cutting along flow surfaces) is then used to obtain a large number of configurations, including air intakes with an extremely compact channel. Tables for calculating and designing convergent flows and air intakes are given.

A89-13163 Analysis of optimal nonsymmetric plane nozzles with allowance for moment characteristics (K analizu optimal'nykh nesimmetrichnykh ploskikh sopel s uchetom momentnykh kharakteristik). A. I. RYLOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1988, pp. 103-108. 10 Refs.

The characteristics of flow in nonsymmetric plane nozzles in which maximum moment is achieved with respect to a specified point are examined. The conditions for maximum moment are derived from an analysis of the second variation. A numerical analysis is carried out for nozzles with a relatively short lower wall, which are considered for possible application in advanced powerplants.

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, *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.

A87-50826 Rotational inequilibrium in supersonic flows (Vrashchatel'naia neravnovesnost' v sverkhzvukovykh potokakh). IU. S. KUSNER, *Zhurnal Tekhnicheskoi Fiziki* (ISSN 0044-4642), Vol. 57, May 1987, pp. 849-853. 16 Refs.

Rotational level populations measured by the electron beam method in a free supersonic nitrogen jet are found to be significantly distorted during diagnostics. An analysis of experimental data and theoretical models of rotational relaxation show that, at low translational temperatures, the populations of upper rotational levels with energies higher than the thermal energy for a given temperature are not related to rotational relaxation processes, and therefore experimental results cannot be used for computing the kinetic coefficients of rotational relaxation. At translational temperatures below 10 K, the measured intensities in the rotational spectrum can be successfully used for computing the matrix elements of excitation coefficients.

A87-51663 Interaction of bodies with a nonuniform supersonic flow (Vzaimodeistvie tel s neodnorodnym sverkhzvukovym potokom). F. V. KAMENETSKII and L. I. TURCHAK, *Numerical modeling in aerohydrodynamics* (A87-51651 23-02). Moscow, Izdatel'stvo Nauka, 1986, pp. 104-115. 17 Refs.

The grid-characteristic scheme (a difference scheme based on characteristic relationships) is applied to the numerical solution of problems of supersonic aerodynamics. Attention is given to flow past bodies of variable shape as well as to the effect of body-velocity or flow-velocity changes on the flow pattern. Wake flows past bodies and two-dimensional separated flows past steps are modeled by introducing a nonuniformity into the oncoming flow. The motion of a body at supersonic velocity in an ideal gas in the presence of various types of discontinuities is examined. Particular consideration is given to transition flows during the interaction between a body and a plane shock wave and during the motion of a body in a point-explosion region.

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.

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.

A88-33903 Calculation of the diffusive combustion of a subsonic jet in a supersonic wake (K raschetu diffuzionnogo goreniia dozvukovoi strui v sputnom sverkhzvukovom potoke). I. S. BELOTSERKOVETS and V. I. TIMOSHENKO, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Jan.-Feb. 1988, pp. 91-95. 9 Refs.

An approximate method for calculating the parameters of a subsonic injected jet in a supersonic wake in the presence of diffusive combustion is developed on the basis of a model of strong viscous-nonviscous interaction through pressure. An algorithm is presented for integrating boundary layer equations across the viscous flow region in the presence of a flame front. The effect of the molecular weight of the injected jet and diffusive combustion of hydrogen on the pressure in the nonsymmetric near wake of a plate is estimated in relation to injection intensity and hydrogen concentration.

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.

A88-49485 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.

A88-33971 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.

A88-37697 Separation of a supersonic boundary layer ahead of the base of a body (Otryv sverkhzvukovogo pogranichnogo sloia pered donnym srezom kontura tela). M. A. KRAVTSOVA and A. I. RUBAN, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 28, April 1988, pp. 580-590. 8 Refs.

The separation of supersonic flow near a corner point on a body is analyzed in the context of the asymptotic theory of the interaction between a laminar boundary layer and the external nonviscous part of flow. Particular attention is given to the transition stage of flow during which a pressure increase in the base region leads to the detachment of the separation point from the corner point and to the displacement of the separation point toward the leading edge of the body. Results of a numerical solution are presented.

A88-45009 Flow in the free interaction region near a permeable wall section (O techenii v oblasti svobodnogo vzaimodeistviia okolo pronitsaemogo uchastka stenki). V. I. ZHUK, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 28, June 1988, pp. 941-945. 14 Refs.

Asymptotic equations of the theory of the free interaction of a boundary layer with external supersonic flow are integrated numerically for problems concerning gas injection through a slot. Flow patterns are presented for the case of stationary injection and for periodic injection-suction through a permeable wall section. Solutions are obtained which illustrate the effect of localized suction on the separation bubble for a plate with a surface bend.

A88-49522 Effect of nozzle type on the characteristics of a diffuser with tangential injection (Vliianie tipa soplovogo bloka na kharakteristiki diffuzora s tangentsial'nym vduvom). I. V. BABCHENKO and N. A. SHUSHIN, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), no. 2, 1988, pp. 82-84.

The starting and operating pressure ratios of channels with a conventional mononozzle and a cellular nozzle unit with injection along the narrow sides of the supersonic diffusor were investigated in a wind tunnel. It is shown that the channel with the mononozzle performs better than the channel with the cellular nozzle unit in the range of intense injection in long diffusors.

A89-13158 Numerical study of axisymmetric flows in the wake of blunt bodies in the path of supersonic flow of a viscous gas (Chislennoe issledovanie osesimmetrichnykh techenii v slede za zatuplennymi telami, obtekaemymi sverkhzvukovym potokom viazkogo gaza). O. N. BELOVA, N. S. KOKOSHINSKAIA, and V. N. PASKONOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1988, pp. 42-47. 6 Refs.

Axisymmetric flow in the near wake of spherically blunted cones in the path of a supersonic flow of a viscous perfectly heat-conducting gas is investigated numerically using full Navier-Stokes equations. Flow structure in the near wake is described in detail, and the effect of the Mach (2, 3, and 4) and Reynolds numbers on the base pressure, full body resistance, and geometric characteristics of the wake is analyzed. The results obtained are compared against experimental data.

A88-49417 Experimental investigation of supersonic three-dimensional jets (Eksperimental'noe issledovanie sverkhzvukovykh prostranstvennykh strui). G. M. ZHINZHIKOV and N. O. PAVLOVA, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May-June 1988, pp. 75-80. 11 Refs.

Schlieren visualization and total-head measurements were used to study the shock-wave structure and distribution of parameters in supersonic underexpanded jets of cold air flowing into the atmosphere from rectangular sonic nozzles. Empirical relationships are obtained for determining the position of the central shock in three-dimensional jets and the Mach-number distribution on the axis.