Soviet and Japanese Aerospace Literature

Throughout 1991 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 Supersonic Flow 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.

Paper copies and microfiche of the original documents cited are available from AIAA Library, Technical Information Service, American Institute of Aeronautics and Astronautics, Inc., 555 W. 57th St., New York, NY 10019 (212) 247-6500, ext. 231. Use the "A" number to identify material you want. Please be advised that most of the original documents are in the original language. Direct questions concerning this abstract section of the *AIAA Journal* to John Newbauer, AIAA Administrator, Technical Publications.

Soviet Aerospace Literature This month: *Supersonic Flow*

A91-13659 Non-Navier-Stokes models in problems of super- and hypersonic flow of a viscous gas past bodies (Nenav'e-stoksovskie modeli v zadachakh sverkh- i giperzvukovogo obtekaniia tel viazkim gazom). G. A. TIRSKII, *Contemporary mathematical problems of mechanics and their applications* (A91-13651 03-34). Moscow, Izdatel'stvo Nauka, 1989, pp. 74-84. 18 Refs.

The objective of the study was to evaluate errors associated with the modeling of super- and hypersonic flow problems using various types of simplified Navier-Stokes equations. In particular, a comparison is made between four approximate models derived from the full system of Navier-Stokes equations: parabolized Navier-Stokes equations, full equations of a viscous shock layer, equations of a thin (hypersonic) viscous shock layer, and equations of a thin viscous shock layer with a more accurately specified position of the head shock. The discussion covers applications of the equations, accuracy of the results, and simplicity of algorithms for calculating flows past spheres, hyperboloids, and blunt cones.

A91-13574 Finite-time stability theory for parametrically excited panels in gas flow (Tekhnicheskaia teoriia ustoichivosti parametricheski vozbuzhdaemykh panelei v gazovom potoke). K. S. MATVIICHUK, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), July-Aug. 1990, pp. 122-131. 27 Refs.

A study is made of the finite-time stability of parametrically excited two-dimensional panels interacting with supersonic flow. The load applied to the panel at its edges is time-dependent. Sufficient conditions are obtained for finite-time stability at finite and infinite time intervals and also for asymptotic finite-time stability using the comparison method combined with the second Liapunov method. Applications of the approach proposed here are discussed.

A91-13546 Possibility of modeling thermal and force loading of the lateral surface of a body in the path of a high-velocity gas flow (Kvozmozhnosti modelirovaniia teplosilovogo vozdeistviia na bokovuiu poverkhnost' tela, obtekaemogo vysokoskorostnym potokom gaza). N. M. GAVRILOVA, N. V. MEDVETSKAIA, and IU. V. POLEZHAEV, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 28, July-Aug. 1990, pp. 728-735. 11 Refs.

A new modeling-channel testing scheme is proposed which makes it possible to reproduce flow past the lateral surface of a body at supersonic Mach and high Reynolds numbers, corresponding to turbulent flow in a boundary layer. Supersonic channel profiles are calculated in such a way as to produce a specified flow parameter distribution on the body surface. Results of calculations are presented.

A90-46575 Gas dynamic characteristics of a plane or axisymmetric nozzle with a rectilinear generatrix of the supersonic section (Gazodinamicheskie kharakteristiki ploskogo ili osesimmetrichnogo sopla s priamolineinoi obrazuiushchei sverkhzvukovoi chasti). V. A. ALEKSEENKO, V. P. SAFONOV, and S. A. SHCHERBAKOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 6, 1989, pp. 100-104. 9 Refs.

Calculations of flow of an ideal gas in conical and plane nozzles using a modified Godunov scheme are reported. The integral and local characteristics of the nozzle are calculated as a function of the angle of taper of the supersonic section of the nozzle. Results of the numerical calculations are compared with analytical and the available experimental data.

A90-46550 Interference between a vortex filament and shock waves in free flow and in nonisobaric jets (Interferentsiia vikhrevogo shnura so skachkami uplotneniia v svobodnom potoke i neizobaricheskikh struiakh). G. F. GLOTOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 5, 1989, pp. 21-32. 15 Refs.

The interaction between a vortex filament generated by a wing cantilever at angles of attack of 5-20 deg and shock waves in free stream (Mach 1.8-3.5) in an underexpanded jet (Mach 1.0) was investigated experimentally in the relative pressure range 1.5-7. It is shown that the interaction between the vortex filament and a central shock wave in the jet leads to the formation of a freely suspended recirculation zone. Vortex breakdown limits are determined for a jet, a convergent nozzle, and supersonic flow at conical shock waves of maximum intensity.

A91-12019 Fluctuations of a shock wave generated by boundary layer separation (O kolebaniiakh skachka uplotneniia, indutsirovannogo otryvom pogranichnogo sloia). V. N. BIBKO, B. M. EFIMTSOV, V. G. KORKACH, and V. B. KUZNETSOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1990, pp. 168-170.

The mechanisms of shock wave fluctuations induced by separation in supersonic flow past a forward-facing step were investigated experimentally by measuring the spatial correlations of wall pressure pulsations in a low-noise wind tunnel for Mach 2.0 and 4.0. An analysis of the results obtained indicates that turbulent pulsations of the unperturbed boundary layer have little effect on the fluctuations of the separation-induced shock wave. From a more general standpoint, the experimental results provide additional evidence for the self-organization of separated flows, which is observed in this particular case as a certain behavior of the nonstationary flow characteristics.

A91-12014 An experimental study of the laminar-turbulent transition behind three-dimensional roughness in a boundary layer on a sharp cone (Eksperimental'noe issledovanie laminarno-turbulentnogo perekhoda za trekhmernoi nerovnost'iu v pogranichnom sloe na ostrom konuse). A. S. SKURATOV and A. V. FEDOROV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), July–Aug. 1990, pp. 60–66. 15 Refs.

The laminar-turbulent transitionbehind three-dimensional surface roughness in a nongradient boundary layer is investigated for a high supersonic velocity of the incoming flow with emphasis on the qualitative characteristics of the transition. Quantitative data on the heat transfer coefficient distribution near the roughness and in its wake are determined. Data on the position of the laminar-turbulent transition are compared against the correlations used in practice.

A90-46573 Calculation of three-dimensional flow past a plane supersonic air intake at angles of attack and side slip (Raschet prostranstvennogo obtekaniia ploskogo sverkhzvukovogo vozdukhozabornika pri nalichii uglov ataki i skol'zheniia). S. M. BOSNIAKOV, S. V. MIKHAILOV, and N. S. IATSKEVICH, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 6, 1989, pp. 89–95. 13 Refs.

Three-dimensional flow past a plane supersonic air intake with thick side walls at angles of attack and side slip is calculated using the algorithm proposed by Bosniakov et al. (1984, 1988, 1989). The algorithm allows for the displacing effect of the boundary layer; the bow shock is isolated explicitly. The results obtained are compared with experimental data and calculations by a different method.

A90-46562 Theoretical and experimental study of low-density supersonic flow past a sphere with allowance for surface condensation and vaporization (Teoreticheskoe i eksperimental'noe issledovanie obtekaniia sfery sverkhzvukovym potokom maloi plotnosti s uchetom kondensatsii i ispareniia s poverkhnosti). IU. V. NIKOL'SKII and IU. I. KHLOPKOV, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 5, 1989, pp. 118–122.

The effect of surface condensation and vaporization (ablation) on the aerodynamic drag of a sphere in supersonic flow of a rarefied gas (Re less than 50) is investigated theoretically and experimentally. The analysis is carried out using the direct statistical modeling approach; the experimental study is conducted for Mach 7.05 and stagnation temperatures of 294, 393, 493, and 572 K. The effect of a decrease in the aerodynamic drag coefficient of an ablating sphere is demonstrated.

A90-46546 An experimental study of a supersonic gas ejector (Eksperimental'noe issledovanie sverkhzvukovogo gazovogo ezhektora). V. A. MALANICHEV, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 4, 1989, pp. 119–122. 7 Refs.

The operation of a supersonic gas ejector was investigated in the critical regime. For the ejector investigated, expressions are obtained for the ejection coefficient as a function if the full pressure ratio and for the ejectior compression ratio as a function of the ejection coefficient. Expressions are also obtained which relate the low-pressure gas velocity and the ratio of the static pressures of the low- and high-pressure gases at the mixing chamber inlet to the full pressure ratio of the mixed gases. The results obtained suggest the existence of a previously unknown mechanism of the critical regime.

A90-44940 Flow in the vicinity of the stagnation line in the case of the supersonic motion of a blunt body through a region with elevated temperature and vibrational energy of the molecules (Techenie v okrestnosti linii tormozheniia pri sverkhzvukovom dvizhenii zatuplennogo tela cherez oblast' s povyshennoi temperaturoi i kolebatel'noi energiei molekul). V. L. BELOUSOV and IU. P. GOLOVACHEV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), May–June 1990, pp. 183–185. 8 Refs.

An analysis is made of unsteady flow in the vicinity of the stagnation streamline in front of a sphere that is moving at supersonic velocity through a two-dimensional layer of diatomic gas with elevated temperature and nonequilibrium-excited oscillations of the molecules. The problem is solved using a viscous shock layer model, the use of which makes it possible to take into account molecular-transport processes and to analyze unsteady heat transfer.

A90-30337 A multicomponent three-dimensional viscous shock layer flow over blunt bodies with a catalytic surface at angle of attack and grazing angles (Mnogokomponentnyi prostranstvennyi viazkii udarnyi sloi na zatuplennykh telakh s kataliticheskoi poverkhnost'iu, obtekaemykh pod uglami ataki i skol'zheniia). A. I. BORODIN, V. IU. KAZAKOV, and S. V. PEIGIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), Jan.–Feb. 1990, pp. 143–150. 23 Refs.

Three-dimensional supersonic flow of a nonequilibrium dissociating air past smooth blunt bodies with heterogeneous chemical reactions on their surface is investigated analytically in the context of the theory of a thin viscous shock layer. The governing equations are solved using an efficient numerical method which does not require the prior solution of the Stefan-Maxwell relations and makes it possible to calculate flows that do not a have a plane of symmetry. With flow past a triaxial ellipsoid used as an example, an analysis is made of the effect of the principal variables on the distributions of pressure, heat flux, and equilibrium temperature on the body surface.

A90-44939 Nonuniform supersonic flow past a trapezium-shaped profile (Obtekanie trapetsievidnogo profilia sverkhzvukovym neravnomernym potokom). L. V. GOGISH and S. G. DASHEVSKAIA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), May–June 1990, pp. 180–183.

The presence of temperature inhomogeneity can significantly alter the aerodynamic characteristics of a sharp-pointed body in a high-constant-velocity flow even in the absence of local subsonic and reverse flows. In the present work, it is demonstrated that such alterations are determined by the position of the body at the interface of media of different density. Numerical results are presented for steady two-dimensional supersonic flow past a trapezium-shaped body in the presence of a hot layer producing a nonuniform initial Mach-number profile.

A90-44931 Experimental investigation of turbulence in a supersonic flow (Eksperimental'noe issledovanie turbulentnosti v sverkhzvukovom potoke). V. A. LEBIGA, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), May–June 1990, pp. 119–124. 12 Refs.

A dc hot-wire anemometer was used to investigate the structure of disturbances introduced in the working part of a supersonic wind tunnel at a Mach number of 2. Disturbances in front of the critical nozzle section were generated by a circular-rod cascade. The disturbances in the working part of the tunnel consisted of uncorrelated vortex, entropy, and acoustic modes; the first two modes were generated by the cascade while the acoustic mode was generated by the boundary layer on the nozzle walls. Owing to the cascade-generated turbulence, the position of the laminar-to-turbulent transition in the boundary layer varied greatly.

A90-39465 Numerical solution of the problem of supersonic flow of a viscous gas past a concave conical wing (Chislennoe reshenie zadachi ob obtekanii vognutogo konicheskogo kryla sverkhzvukovym potokom viazkogo gaza). N. M. BELIAEV, V. L. BORSHCH, and V. V. KRAVETS, *Gidromekhanika* (ISSN 0367–4088), No. 60, 1989, pp. 31–37. 7 Refs.

Supersonic viscous flow past a concave conical wing at Mach 3 and angles of attack 0.5 and 10 deg is analyzed in the quasi-conical approximation for the Navier-Stokes equations using an explicit McCormack's scheme. It is shown that the approach used here provides sufficiently detailed information on the kinematic characteristics of flow past the wing and on the dynamics of formation, convergence, and coalescence of suspended shock waves on the concave side with an increase in angle of attack, making it possible to add new elements to the structural scheme of the flow.

A90-37811 The 'thermal needle' effect ahead of a blunt body in supersonic flow (Effekt 'teplovoi igly' pered zatuplennym telom v sverkhzvukovom potoke). V. I. ARTEM'EV, V. I. BERGEL'SON, I. V. NEMCHINOV, T. I. ORLOVA, V. A. SMIRNOV et al., *Akademiia Nauk SSSR, Doklady* (ISSN 0002–3264), Vol. 310, No. 1, 1990, pp. 47–50. 15 Refs.

The interaction of a separated compression shock with a viscous boundary layer localized near the surface of a needle leads to flow separation, separated flow formation ahead of the body, and changes in the head shock and aerodynamic body characteristics. Here, the nonviscous mechanism of interaction between a head shock and a local density perturbation is examined which leads to a similar change in supersonic flow past a blunt body in the absence of a needle. The difference between the viscous and nonviscous mechanisms of flow restructuring is briefly discussed.

A90-29184 Combined effect of viscosity and bluntness on the aerodynamic efficiency of a delta wing in flow with a high supersonic velocity (Sovmestnoe vliianie viazkosti i zatupleniia na aerodinamicheskoe kachestvo treugol'nogo kryla v potoke s bol'shoi sverkhzvukovoi skorost'iu). P. I. GORENBUKH and V. V. NOSOV, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 3, 1989, pp. 30–36. 7 Refs.

Supersonic flow past plane delta wings was investigated experimentally in the Reynolds number range 120,000–3,000. In the case of nonviscous flow, the maximum aerodynamic efficiency is shown to correlate with the sigma parameter. For sigma greater than 1/3, the effect of the bluntness of the leading edges of a highly swept wing is negligible, and its aerodynamic characteristics in the region of maximum aerodynamic efficiency are close to those of a wing with a sharp leading edge.

A90-23432 Transfer of the atomic ion energy of supersonic flow of a partially dissociated gas to a solid surface (O peredache energii atomarnykh ionov sverkhzvukovogo potoka chastichno dissotsirovannogo gaza poverkhnosti tverdogo tela). N. P. REZNICHENKO and V. A. SHUVALOV, *PMTF – Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044–4626), Nov.–Dec. 1989, pp. 11–19. 25 Refs.

Results of experimental studies of energy transfer between the atomic ions of supersonic gas flows and solid surfaces are reported. A method for determining recombination coefficients is proposed, and recombination coefficients are determined for the atomic ions of nitrogen, hydrogen, and oxygen on the surface of polycrystalline electrically conducting materials and alloys (e.g., Mo, Pt, Cu, Al, Ag, and steels 25 and 12Kh18N10T). Measurements of the transmission coefficients of different surfaces are presented.

A90-39519 The problem of supersonic flow past a thin wing of finite span with fully subsonic leading edges (K zadache obtekaniia sverkhzvukovym potokom tonkogo kryla konechnogo razmakha s polnost'iu dozvukovymi perednimi kromkami). N. F. VOROB'EV, PMTF—Zhurnal Prikladnoi Mekhaniki i TekhnicheskoiFiziki (ISSN 0044–4626), Mar.–Apr. 1990, pp. 105–111. 7 Refs.

The problem of supersonic flow past a slightly curved wing with fully subsonic leading edges is solved by assuming a zero perturbation potential on the basis plane outside the wing projection plane. The problem is reduced to an integral Volterra equation of the second kind, and the possibility of solving this equation by the method of successive approximations is demonstrated. The solution has the form of a series whose terms are multiple integrals of known functions.

A90-36068 Gas flow pulsations in cavieties under conditions of supersonic flow (Pul'satsii potoka gaza v kavernakh pri sverkhzvukovom obtekanii). N. L. ZAUGOL'NIKOV, M. A. KOVAL', and A. I. SHVETS, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), Mar.–Apr. 1990, pp. 121–127. 7 Refs.

Nonstationary flows in rectangular cavieties under conditions of supersonic external flow are calculated numerically using an ideal compressible gas model. The Euler equations are integrated using Godunov's finite difference scheme. Based on an analysis of the calculation results, a formula is proposed for determining the possible frequencies of flow rate fluctuations within the cavity as a function of the free-stream Mach number of the incoming flow and cavern geometry. The results obtained are compared with experimental data and analytical results in the literature.

A90-34672 A numerical method for calculating supersonic flows of a viscous gas (Chislennyi metod rascheta sverkhzvukovykh techenii viazkogo gaza). S. G. KARATAEV and V. N. KOTEROV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044–4669), Vol. 30, April 1990, pp. 586–600. 9 Refs.

A numerical method for calculating simplified stationary Navier-Stokes equations is proposed which employs the variables 'current function-orthogonal complement'. For solving a system of difference equations, a modified version of the global iteration method is proposed which significantly accelerates the convergence of the iteration process. Examples of calculations are presented, and the results are compared with the results of the asymptotic theory of local separated flows.

A90-34670 Numerical modeling of pulsed regimes in supersonic flow past a hollow cylinder (Chislennoe modelirovanie pul'satsionnykh rezhimov pri sverkhzvukovom obtekanii pologo tsilindra). A. N. ANTONOV, T. G. ELIZAROVA, B. N. CHETVERUSHKIN, and IU. V. SHERETOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044–4669), Vol. 30, April 1990, pp. 548–556. 16 Refs.

The problem of supersonic flow of a viscous compressible homogeneous gas is modeled numerically using kinetically consistent difference schemes. Pulsed flow regimes are obtained, which are observed experimentally. The calculation results are analyzed in qualitative and quantitative terms.

A90-32552 Entry of a flexible airfoil into a vertical gust (Vkhozhdenie gibkogo profilia v vertikal'nyi poryv). B. A. ERSHOV and R. M. RUBLEVSKAIA, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024–0850), Jan. 1990, pp. 58–63.

The problem of the stability of a flexible aileron in supersonic flow is investigated analytically. The aerodynamic forces are determined from a nonstationary velocity potential, which provides an additional number of summands generalizing the piston theory. The transition process associated with an entry into a gust of the singular shock type is defined.

A90-29194 Wall pressure fluctuation spectra in supersonic flow past a forward facing step (Spektry pristenochnykh pul'satsii davleniia pri sverkhzvukovom obtekanii perednego ustupa). B. M. EFIMTSOV and V. B. KUZNETSOV, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 3, 1989, pp. 111–118. 6 Refs.

The structure of pressure fluctuations in the separation region of a turbulent boundary layer ahead of a forward facing step is examined with reference to the available experimental data. Expressions are obtained which describe, in quantitative terms, the dependence of pressure fluctuation spectra on supersonic flow parameters. These relations make it possible to estimate pressure fluctuation spectra in front of a step and in the characteristic cross sections of the separation zone.

A90-24048 Some aspects of the numerical modeling of supersonic flow past flight vehicles. G. P. VOSKRESENSKII and A. V. ZABRODIN, *Uspekhi Mekhaniki Advances in Mechanics* (ISSN 0137–3722), Vol. 12, No. 2, 1989, pp. 99–119. 24 Refs.

Some problems associated with mathematical modeling in supersonic flow problems are briefly reviewed. In particular, attention is given to applications of mathematical modeling in aerodynamics; theoretical aspects of mathematical modeling and selection of a mathematical flow model; pressure data accuracy requirements in the analysis of aerodynamic characteristics; and mathematical problems involved in the development of computational algorithms. The discussion also covers estimation of the data volume and computational effort in problems of flow past flight vehicles.

A90-29182 Calculation of the drag of fuselage tail sections of different shapes in supersonic flow of a nonviscous gas (Raschet soprotivleniia khvostovykh chastei fiuzeliazhei razlichnykh form pri obtekanii sverkhzvukovym potokom neviazkogo gaza). S. A. SHCHENNIKOV and S. V. IAGUDIN, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 3, 1989, pp. 10–19. 9 Refs.

Calculation of supersonic flow past fuselage tail sections and engine nacelles of different shapes are presented. The three-dimensional flow of a nonviscous gas was calculated using McCormack's scheme; axisymmetric flow was calculated by the characteristic method. The drag coefficients of axisymmetric and plane tail sections of different cross sectional width/height ratios are compared assuming equal cross-sectional areas.

A90-28992 Laminar separated flow on a biconical body at high supersonic velocities (Laminarnoe otryvnoe techenie na bikonicheskom tele pri bol'shoi sverkhzvukovoi skorosti). A. P. KOSYKH, S. K. MARINICHENKO, G. G. NERSESOV, and A. S. SKURATOV, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 1, 1989, pp. 113–119. 12 Refs.

Experimental results are presented on gas flow and pressure distribution on the surface of a biconical body with half-angles of taper of 10 and 25 deg for Mach 6, angles of attack 0–9 deg, and Reynolds numbers of (0.36–4.24) x 10 to the 6th. The dependences of the length of the separation zone formed ahead of the rear zone and characteristic pressure in this zone on the Reynolds number and angle of attack are determined. Nonviscous flow past the biconical body is calculated for different angles of attack. A comparison of the analytical and experimental data demonstrates that the separation zone has a substantial effect on surface pressure distribution.

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 free-stream Mach 9 and Reynolds numbers of 1.2 x 10 to the 6th – 4 x 10 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.

A90-22422 Characteristics of turbulent separation flows on a porous surface under conditions of injection (Kharakteristiki turbulentnykh otryvnykh techenii na poristoi poverkhnosti v usloviiakh vduva). A. I. LEONT'EV, V. M. EPIFANOV, A. M. PAVLIUCHENKO, and A. V. PASHUTOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002–3434), Oct. 1989, pp. 50–56. 12 Refs.

The structure of supersonic turbulent separation flows formed on a flat porous plate in the presence of injection was investigated experimentally in the case of flow around a step and in the case of an oblique external compression shock for Mach up to 3.0 and flow intensities up to 0.3 percent. It is shown that porous injection is an effective method of controlling the dynamic characteristics of supersonic turbulent separation flows. In the presence of injection, the velocity field is deformedto a considerable extent, the return flow region expands, and the separation zone shifts upstream by up to 25 percent in comparison with the case where injection is absent.

A90-22421 Mean and pulse characteristics of supersonic flow in a wind tunnel with a honeycomb nozzle (Osrednennye 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, Seriia 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.

A90-17220 The rotational nonequilibrium of isotopic molecules in a supersonic flow of vibrationally excited carbon dioxide (Effekt vrashchatel'noi neravnovesnosti izotopicheskikh molekul v sverkhzvukovom potoke kolebatel'no vozbuzhdennogo uglekislogo gaza). G. S. BARONOV, D. K. BRONNIKOV, A. E. VARFOLOMEEV, I. I. ZASAVITSKII, V. D. RUSANOV et al., *Akademiia Nauk SSSR, Doklady* (ISSN 0002–3264), Vol. 308, No. 6, 1989, pp. 1390–1393. 11 Refs.

Experimental results are presented on the rotational nonequilibrium of the distribution of isotopic molecules in a supersonic flow of CO2.It is shown that nonresonant VV-prime exchange, forming the vibrational distribution of CO2 molecules, can lead to a considerable divergence of the rotational distribution function from the Boltzmann function during the redistribution of rotational energy.

A90-22396 Comparison of thin and full viscous shock layer models in the problem of supersonic flow of a viscous gas past blunt cones (Sravnenie modelei tonkogo i polnogo viazkogo udarnogo sloia v zadache sverkhzvukovogo obtekaniia prituplennykh konusov viazkim gazom). G. A. TIRSKII and S. V. UTIUZHNIKOV, *Prikladnaia Matematika i Mekhanika* (ISSN0032–8235), Vol. 53, Nov.Dec. 1989, pp. 963–969. 16 Refs.

Solutions for the equations of a thin (hypersonic) viscous shock layer with a specified shock wave configuration are compared with solutions for the full equations of a viscous layer using supersonic flow of a viscous gas past blunt cones as an example. It is shown that the appropriate specification of the shock wave configuration makes it possible to obtain a solution far downstream and to achieve much better accuracy in comparison with the commonly used asymptotic approach whereby the shock wave configuration is assumed to be equidistant with respect to the bodyshape.

A90-17109 Equilibrium of an elastic porous shell in supersonic gas flow (O ravnovesii gibkoi pronitsaemoi obolochki v sverkhzvukovom potoke gaza). S. V. GUVERNIUK and K. G. SAVINOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), Sept.–Oct. 1989, pp. 152–158.

Stationary plane flow past a uniaxial perfectly elastic open porous shell supported in a fixed position in uniform supersonic flow of an ideal gas is investigated numerically. The effect of angle of attack and of the degree of porosity distribution nonuniformity on the aerodynamic characteristics and equilibrium mode of the shell are determined for different shell support conditions. Approximate relations are formulated which describe the distributed load on a concave porous screen as a function of the screen porosity and incoming flow parameters. The application of these relations to three-dimensional problems of porous shell equilibrium in supersonic flow is illustrated by an example.

A90-17108 Changes in supersonic flow past an obstacle due to the formation of a thin rarefaction channel ahead of the obstacle (Izmenenie rezhima sverkhzvukovogo obtekaniia prepiatstviia pri vozniknovenii pered nim tonkogo razrezhennogo kanala). V. I. ARTEM'EV, V. I. BERGEL'SON, I. V. NEMCHINOV, T. I. ORLOVA, V. A. SMIRNOV et al., *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), Sept.–Oct. 1989, pp. 146–151. 10 Refs.

The effect of a rarefaction channel on supersonic flow past an obstacle is investigated numerically and experimentally. Results of the numerical analysis are examined for the case of flow of an ideal gas (Mach 3.07, adiabatic exponent gamma 1.08) past a cylinder end. The results obtained indicate a restructuring of supersonic flow ahead of the body with the formation of a thin rarefaction channel. The numerical results are found to be in good agreement with experimental data.

A90-12281 Lee-side heating of a delta wing in supersonic flow (O nagrevanii podvetrennoi storony treugol'nogo kryla pri sverkhzvukovom obtekanii). V. N. BRAZHKO, N. A. KOVALEVA, L. A. KRYLOVA, and G. I. MAIKAPAR, *PMTF – Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044–4626), July–Aug. 1989, pp. 106–112. 14 Refs.

Results of several earlier studies of the flow structure and heat transfer on the upper surface of a delta wing are briefly reviewed.Results of an experimental investigation of the lee-side heating of a delta wing in supersonic flow (M = 3, 4, and 5) are then reported. In particular, attention is given to criteria for the existence of specific types of separated flow, effect of flow scheme on heat transfer, and effect of Mach and Reynolds numbers and wing surface configurations on the lee-side aerodynamic heating of the wing.

A89-54625 Optimal permeability of wind tunnel walls at low supersonic velocities (Optimal'naia pronitsaemost' stenok aerodinamicheskoi truby pri malykh sverkhzvukovykh skorostiakh). V. M. NEILAND, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568–5281), July–Aug. 1989, pp. 187–189.

The interaction of oblique shock and rarefaction waves at freestream Mach of 1 or greater with the porous walls of a wind tunnel is investigated theoretically. Conditions are determined under which these perturbations are not reflected from the tunnel walls and therefore do not affect flow around the model. The theoretical conclusions reached here are supported by experimental data.

A89-50934 Boundary layer transition on the surface of a delta wing in supersonic flow (O perekhode pogranichnogo sloia na poverkhnosti treugol'nogo kryla pri sverkhzvukovom obtekanii). V. N. BRAZHKO, N. A. KOVALEVA, A. KRYLOVA,L. 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, ReL = 6.5 x 10 to the 6th, and alpha = –5.5 deg, a wedgeshaped 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.

A90-29009 Effect of gas injection on flow past a biconical body at a high supersonic velocity (Vliianie vduva gaza na obtekanie bikonicheskogo tela potokom s bol'shoi sverkhzvukovoi skorost'iu). S. K. MARINICHENKO and A. S. SKURATOV, *TsAGI, Uchenye Zapiski* (ISSN 0321–3439), Vol. 20, No. 2, 1989, pp. 92–97. 6 Refs.

The paper reports the results of an experimental studyof flow past a biconical body at a high supersonic velocity, with air injected through the porous surface of the front cone. Pressure distribution measurements and optical tests show that injection leads to changes in flow structure. The effect of injection on the wave drag coefficient of the biconical body is examined.

A90-19237 Supersonic nonuniform flow of a gas past oblong axisymmetric bodies (Obtekanie udlinennykh osesimmetrichnykh tel sverkhzvukovym neravnomernym potokom gaza). S. V. PEIGIN and S. V. TIMCHENKO, *PMTF – Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044–4626), Sept.–Oct. 1989, pp. 60–65. 13 Refs.

Equations of a thin viscous shock layer near oblong hyperboloids of revolution are solved numerically for the case of nonuniform gas flow at zero angle of attack. Attention is given to two particular cases of such flows: far-wake flow and flow from a supersonic spherical source. The effect of the nonuniformity type and intensity, Reynolds number, body shape, and body surface temperature on the flow structure in a viscous shock layer and surface friction and heat transfer coefficients is analyzed.

A90-12282 An experimental study of fluctuations in the front separation zone at supersonic flow velocities (Eksperimental'noe issledovanie pul'satsii v perednei otryvnoi zone pri sverkhzvukovoi skorosti potoka). V. I. ZAPRIAGAEV and S. G. MIRONOV, *PMTF– Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044–4626), July–Aug. 1989, pp. 116–124. 23 Refs.

Experimental data are presented on pressure fluctuations and discrete tone frequencies for a model with variable geometry of the front separation zone. The results of a combined analysis of the motion of shock waves ahead of a spike-tipped cylinder and pressure fluctuations at the cylinder end are presented, and the mechanism of the fluctuations is discussed. A criterion is obtained for the relative mass transfer in the case of fluctuations in the separation region.

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.

A89-52852 A second-order finite-difference scheme for calculating three-dimensional supersonic flows of an ideal gas (Konechno-raznostnaia skhema vtorogo poriadka dlia rascheta trekh ykh sverkhzvukovykh techenii ideal'nogo gaza). M. K. AUKIN and R. K. TAGIROV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044–4669), Vol. 29, July 1989, pp. 1057–1066. 13 Refs.

An explicit second-order finite-difference scheme for calculating three-dimensional stationary supersonic flows of an inviscid gas is proposed, and some methodological features of the scheme are discussed. Results of calculations for conical flows and a submerged jet are found to be in good agreement with the results obtained by using some well-known second-order schemes. Examples of calculations for complex three-dimensional supersonic flows are presented.

A89-50937 Characteristics of the spectra of pressure fluctuations in front of a step in supersonic transition flow (Osobennosti spektrov pul'satsiidavleniia 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.

A89-48007 Effect of a bend in the contour of the Laval nozzle of a gas turbine engine on flow in the supersonic section (Vliianie izloma kontura sopla Lavalia GTD na techenie v sverzvukovoi chasti). IU. I. TSYBIZOV, *Aviatsionnaia Tekhnika* (ISSN 0579–2975), No. 2, 1989, pp. 73–75.

Results of experimental studies of a series of plane and axisymmetric Laval nozzles (subsonic convergence angle, 0–40 deg; supersonic convergence angle 30–10 deg) are generalized and discussed with particular reference to the adjustable nozzles of aircraft gas turbine engines. Three characteristic regions are identified on the curve describing wall pressure distribution in the supersonic section; flow characteristics in each of these regions are briefly examined.