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Russian and Japanese Aerospace Literature

Throughout 1993 the *AIAA Journal* will carry selected abstracts on leading research topics from Russian 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 from Russia and Large Space Structures from Japan.

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Russian Aerospace Literature This month: *Supersonics*

A92-48986 Experimental investigation of liquid carbonhydrogen fuel combustion in channel at supersonic velocities. V. VINOGRADOV, S. KOBYZHSKII, and M. PETROV, 28th AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, Nashville, TN, July 6–8, 1992. 9 pp. (AIAA Paper 92-3429).

An experimental investigation of liquid hydrocarbon fuel ignition and combustion stabilization at supersonic velocities in the 2D channel was conducted to study the working process in a scramjet. The model was tested in CIAM's facility at freestream Mach number M of 6.0 and 1500 K temperature. Some variants of combustors with different kerosene injectors and flameholders were studied. Hydrogen was used for ignition and stabilization of kerosene burning. The conditions were found under what the kerosene combustion was successful in a combustor with constant area and expanding sections after the hygrogen stopped being injected. Distributions of aerothermodynamic parameters along the duct, data on stabilization, and joint inlet-combustor work are discussed. (Author)

A92-46519 Effect of a fan of rarefaction waves on the development of disturbances in a supersonic boundary layer (O vliianii veera voln razrezheniia na razvitie vozmushchenii v sverkhzvukovom pogranichnom sloe). S. A. GAPONOV, A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV, *PMTF—Prikladnaia Mekhanika i Tekhnicheskaia Fizika* (ISSN 0044-4626), No. 2, Mar.–Apr. 1992, pp. 52–55.

Experiments were conducted in a supersonic wind tunnel in order to study the boundary layer stability during its interaction with a fan of rarefaction waves. The results indicate that the nonuniformity generated by flow turning in the supersonic boundary layer is the cause of the disturbances. Acoustic waves in the nonuniform region that are external to the boundary layer generate vortex disturbances.

A92-31854 Analytical and experimental studies of the aerodynamic characteristics of a delta wing at a slip angle at high supersonic velocities (Raschetno-eksperimental'nye issledovaniia aerodinamicheskikh kharakterist ik treugol'nogo kryla pod uglom skol'zheniia pri bol'shikh sverkhzvukovykh skorostiakh). P. I. GORENBUKH and V. S. NIKOLAEV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 22, No. 1, 1991, pp. 32–38.

Analytical expressions are obtained for the coefficients of the aerodynamic forces and moments of a delta wing with cylindrical leading edges and plane lower and upper surfaces consisting of two plane halfs. The path stability characteristics and the possibility of slip angle nonlinearity are investigated. An experimental study is made of the lateral moment characteristics of a delta wing with flat leading edges.

A92-57499 Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem (Povyshenie tochnosti skhemy Godunova dlia rascheta statsionarnykh sverkhzvukovykh techenii gaza na osnove resheniia obobshchennoi zadachi Rimana). I. S. MEN'SHOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 32, No. 2, Feb. 1992, pp. 311–319.

The classical self-similar problem of interaction between two homogeneous steady-state supersonic gas flow is extended to inhomogeneous flows, i.e., to the case of an arbitrary variable distribution of the gasdynamic parameters. An explicit analytical solution is obtained in the vicinity of the flow-mixing line. This solution is then used to improve the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows.

A92-49194 Methods and means of heat transfer modeling for high-velocity heterogeneous flows (Metody i sredstva modelirovaniia teploobmena v vysokoskorostnykh geterogennykh potokakh). D. S. MIKHATULIN, IU. V. POLEZHAEV, and I. V. REPIN, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 30, No. 3, May–June 1992, pp. 573–579.

The paper is concerned with the possibility of using a gasdynamic wind tunnel to generate high-temperature supersonic heterogeneous flows (gas-solid particles) for modeling the thermal interaction between a heterogeneous medium and a body surface. The velocity and temperature inhomogeneities of the phases are analyzed. The experimental method and simulation of the thermal and dynamic loading of the models are discussed.

A92-42683 Aerodynamics of two-shock bodies derived by the gasdynamic design method (Aerodinamika dvukhskachkovykh tel, postroennykh metodom gazodinamicheskogo konstruirovaniia). I. I. MAZHUL' and I. I. IAKOVLEV, *Sibirskii Fiziko-Tekhnicheskii Zhurnal* (ISSN 0869-1339), No. 1, Jan.–Feb. 1992, pp. 61–65.

Results of a comparative aerodynamic analysis are presented for several configurations constructed by the gasdynamic design method using samples of supersonic plane flows for air intakes of hypersonic flight vehicles. The configurations considered include a plane two-shock air intake, a two-shock V-shaped wing, and two-shock convergent air intakes based on a spatial combination of elementary V-shaped wings. The results obtained in the Mach number range 4-15 suggest that configurations of this kind are characterized by a nonmonotonic dependence of the drag coefficient, an increase of the drag coefficient with the free-stream Mach number, and absence of stabilization with respect to free-stream Mach.

A92-30186 Calculation of the rolling moment for a wing with a supersonic leading edge in the presence of sideslip (Raschet momenta krena kryla so sverkhzvukovymi perednimi kromkami, dvizhushchegosia so skol'zheniem). T. M. PRITULO, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 21, No. 5, 1990, pp. 26–34.

A perturbation method developed in an earlier study (Pritulo, 1983) is extended to flow past wings with sideslip. Analytical expressions are obtained which make it possible to calculate, in explicit form, the rolling moment of a wing for different flow parameters. The rolling moment of an isolated delta wing is shown to change in an essentially nonlinear manner with the angle of attack and to decrease with the increasing free-stream Mach number.

A92-25997 An experimental study of supersonic H2 combustion and heat transfer in a circular duct (Eksperimental'noe issledovanie goreniia H2 i teplootvoda v kol'tsevom kanale pri sverkhzvukovoi skorosti). R. V. ALBEGOV, V. A. VINOGRADOV, G. G. ZHADAN, and S. A. KOBYZHSKII, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 27, Nov.–Dec. 1991, pp. 24–29.

Results of an experimental study of supersonic H2 combustion and heat transfer in a circular duct simulating the intake and the combustion chamber of a ramjet engine are reported. Stable operation regions for the intake and the combustion chamber are determined for various fuel distributions. The level of heat transfer to the duct walls and combustion efficiency are calculated as a function of the varying flow in the duct.

A92-18204 Existence of steady self-sustained regimes of combustion of porous fuels and fuels with channels (O sushchestvovanii statsionarnykh samopodderzhivaiushchikhsia rezhimov sgoraniia poristykh i kanal'nykh topliv). N. N. SMIRNOV and A. G. BERDIUGIN, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 27, July–Aug. 1991, pp. 18–24.

The existence of a steady self-sustained regime of convective flame front propagation in porous fuels and fuels with channels is demonstrated theoretically. The specific structure of the combustion zone gives rise to a qualitatively new propagation regime, subsonic with respect to the condensed phase and supersonic with respect to the gas phase ahead of the front. For constant average fuel density and heat conduticity, the wave velocity varies and can be controlled by selecting the size of individual channels.

A92-42682 A method for determining the internal force characteristics of a model in external supersonic flow (Metod opredeleniia vnutrennikh silovykh kharakteristik modeli v usloviiakh obduva ee vneshnim sverkhzvukovym potokom). A. V. LOKOTKO, *Sibirskii Fiziko-Tekhnicheskii Zhurnal* (ISSN 0869-1339), No. 1, Jan.–Feb. 1992, pp. 53–60.

A method for determining the internal force characteristics (e.g., thrust, lift force, and moment) of a nozzle in external supersonic flow is proposed which is based on the well-known doubling approach. The internal thrust of the model is determined from two consecutive measurements of the weight characteristics, with and without thrust, and calculation of the difference of the two measurements. The model used in such tests is a full configuration where the nozzle is an integral part of the model and is not weighed separately. A wind tunnel implementation of the method is described, and test results obtained for a supersonic passenger aircraft model are presented.

A92-40619 Pressure recovery coefficient (O koeffitsiente vosstanovleniia davleniia). N. A. SHUSHIN, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1991, pp. 88–93.

In engineering calculations using a one-dimensional representation of gas flow, various losses are accounted for by means of a pressure recovery coefficient. Here, the pressure recovery coefficient is related to the displaced boundary layer thickness. The resulting expressions provide a simple way to solve the problem of pressure increase in the boundary layer drain channel for supersonic external flow.

A92-36420 Structure of the separated flow region in a dihedral corner in front of an obstacle in supersonic flow (Struktura oblasti otryvnogo techeniia v dvugrannom ugle pered prepiatstviem, obtekaemym sverkhzvukovym potokom). A. I. ZUBKOV, B. E. LIAGUSHIN, and IU. A. PANOV, *Moskovskii Universitet, Vestnik, Seriia 1—Matematika, Mekhanika* (ISSN 0579-9368), No. 1, Jan.–Feb. 1992, pp. 107–110.

The paper is concerned with supersonic flow past an obstacle located at an inner side of a dihedral corner. In particular, wind tunnel test results are presented for a model in the form of a 90-deg dihedral angle formed by two tapered 170x300-mm plates, with a cylindrical obstacle introduced through a hole in one of the plates. The structure and size of the separated flow region are determined.

A92-31962 An exact solution to edge effect problem for a finite-span wing in supersonic flow (Ob odnom tochnom reshenii zadachi o kontsevom effekte kryla konechnogo razmakha v sverkhzvukovom potoke). N. F. VOROB'EV, *PMTF—Prikladnaia Mekhanika i Tekhnicheskaia Fizika* (ISSN 0044-4626), Jan.–Feb. 1992, pp. 65–70.

Formulas are presented for calculating the gasdynamic parameters of flow in the case where the velocity potential is determined in terms of the first and second derivatives in the basis plane. The solution proposed here provides for shedding at subsonic edges, which corresponds to separated flow over a finite-span wing.

A92-40605 Quick calculation of three-dimensional supersonic flow past nearly axisymmetric bodies (Operativnyi raschet prostranstvennogo sverkhzvukovogo obtekaniia tel, blizkikh k osesimmetrichnym). V. I. TIMOSHENKO and V. P. GALINSKII, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1991, pp. 22–27.

Results of calculations of three-dimensional supersonic flow past nearly axisymmetric bodies are presented to demonstrate the advantages of using a trigonometric approximation of the circumferential derivatives over the traditional finite difference methods. The computation times for the two approaches are compared in relation to meridional planes used in the calculation. It is shown that the approach proposed here makes it possible to significantly reduce the number of planes required and thus reduce the computation time by a factor of 5-6 for angles of attack less than 2 deg and by a factor of 3 for angles of attack 2-5 deg in comparsion with the finite difference method in the specific examples considered.

A92-31892 A study of flow of a fluid film on the surface of a plate in the case of slot injection (Issledovanie techenila zhidkoi plenki na poverkhnosti plastiny pri shchelevom vduve). P. E. BABIKOV, IU. N. ERMAK, and M. A. NAIDA, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 22, No. 3, 1991, pp. 51–60.

The problem of flow of a fluid film injected through a slot on the surface of a plate in the path of supersonic flow of a viscous thermally conducting gas is investigated analytically. The effect of the initial and boundary conditions on the length and shape of the film is determined. The initial-boundary value problem is formulated and solved numerically.

A92-31874 Computational studies of the aerodynamic characteristics of delta wings with a subsonic leading edge (Raschetnye issledovaniia aerodinamicheskikh kharakteristik treugol'nykh kryl'ev s dozvukovoi perednei kromkoi). R. A. BREUSOVA, V. V. KELDYSH, and V. V. KOVALENKO, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 22, No. 2, 1991, pp. 66–72.

The aerodynamic characteristics of delta wings at supersonic velocities as determined by solving the Euler equations and on the basis of linear theory are compared. Flow regimes with a subsonic leading edge are examined. It is shown that for wings with a nonplanar middle surface the wave drag in the vicinity of the flow regime with zero lift force as determined by the linear theory is significantly greater than that determined by solving the Euler equations.

A92-31873 The total drag of a body in the flow of a viscous heat-conducting gas (O polnom soprotivlenii tela v potoke viazkogo, teploprovodnogo gaza). A. S. PETROV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 22, No. 2, 1991, pp. 57–65.

The main term of the expression for the total drag of a body in aviscous heat-conducting gas at transonic and low supersonic velocities is obtained on the basis of the momentum theorem. The well-known expressions for profile, wave, and induced drag are derived as particular cases. The drag due to the heat transfer between the body and the surrounding medium is also investigated.

A92-31860 A parametric study of the lift-drag ratio of blunt cones (Parametricheskoe issledovanie aerodinamicheskogo kachestva zatuplennykh konusov). G. G. VORONOVA, A. V. LIMANSKII, and V. I. TIMOSHENKO, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 22, No. 1, 1991, pp. 77–81.

Results of a parametric study of the dependence of the lift-drag ratio of blunt cones on the principal geometric and physical parameters are reported. The results were obtained by solving the supersonic flow problem in the nonviscous and viscous gas approximations. Expressions are derived which relate the lift-drag ratio and the additional viscous terms to the aspect ratio and the half-angle of taper.

A92-23416 Mathematical modeling of supersonic flow over a convex-concave formed body based on the Euler and Navier-Stokes equations. V. A. ANTONOV, A. M. GRISHIN, and O. I. POGORELOV, *Russian Journal of Theoretical and Applied Mechanics* (ISSN 1051-8045), Vol. 1, Dec. 1991, pp. 395–406.

Solutions obtained on the basis of the Euler and Navier-Stokes equations for free-stream Mach 3, 4, and 6 and Re = 10 exp 4—10 exp 6 for three convex-concave bodies are compared. Both the local flow characteristics and the integral characteristics of the bodies are considered. Local differences in pressure distribution in the hollow region are shown to affect the resistance pressure coefficient. Heat flow and pressure distribution over the body profile are analyzed as a function of the Re number.

A92-23409 On the calculation of the compressible boundary layer on a nonplanar delta wing with supersonic leading edges. V. N. VETLUTSKII and T. V. POPLAVSKAIA, *Russian Journal of Theoretical and Applied Mechanics* (ISSN 1051-8045), Vol. 1, Dec. 1991, pp. 301–314.

An algorithm is developed for calculating a three-dimensional compressible boundary layer on a nonplanar delta wing in the case where a bow wave touches the leading edges. The conditions at the outer edge of the boundary layer are derived from calculations of the inviscid flow around the body. The problem is solved numerically using a two-layer implicit difference weighted scheme. The velocity and temperature profiles are calculated, and the results are used to determine the local skin-friction coefficients and Stanton numbers.

A92-31492 Numerical simulation of three-dimensional supersonic flow around aerodynamic configurations. P. I. CHUSHKIN and G. P. VOSKRESENSKII, (2nd International Association for Computational Mechanics, World Congress of Computational Mechanics, Stuttgart, Federal Republic of Germany, Aug. 27–31, 1990) *International Journal for Numerical Methods in Engineering* (ISSN 0029-5981), Vol. 34, March 30, 1992, pp. 485–506.

The present report deals with many applications of different numerical methods to calculations of three-dimensional stationary supersonic flows around aerodynamic configurations. Both an inviscid non-heat-conducting perfect gas and a real high-temperature gas with physical-chemical processes are considered. The results of some investigations carried out during recent years in the USSR are reviewed. A brief description of applicable numerical methods is presented. A number of results are discussed both for separate parts of a flying vehicle and for whole configurations. Some gasdynamic effects, and aerodynamic and thermal characteristics are analyzed. Among the aerodynamic elements considered are pointed and blunted nose parts of configurations, air intakes, wing, and stabilizers. Also more complicated cases are considered such as compound aerodynamic objects and configurations modeling different kinds of whole flying vehicles (missile, aircraft, spacecraft). (Author)

A92-30187 Transverse correlation of the spectral components of pressure fluctuations on a plate ahead of a step (Poperechnaia korreliatsiia spektral'nykh sostavliaiushchikh pul'satsii davleniia na plastine pered vystupom). V. N. BIBKO, B. M. EFIMTSOV, and V. G. KORKACH, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 21, No. 5, 1990, pp. 35–43.

Results of parametric experimental studies of the transverse correlation of pressure fluctuations in the case of two-dimensional supersonic flow past a straight step on a plate are presented. It is shown that the extent of the three-dimensional coupling of the pressure fluctuations along a coordinate orthogonal to the flow direction can be described in terms of dimensionless transverse correlation scales represented in the form of Strouhal number functions which are dependent on the Mach number, the dimensionless step height, and longitudinal coordinate as parameters. The effect of these parameters on the transverse correlation scales is estimated.

A92-30180 The effect of the angle-of-attack on laminar-turbulent boundary transition near the lower surface of triangular plates in a supersonic gas flow (Vliianie ugla ataki na perekhod laminarnogo pogranichnogo sloia v turbulentnyi na nizhnei poverkhnosti treugol'nykh plastin v sverkhzvukovom potoke gaza). N. A. KOVALEVA, N. P. KOLINA, and A. IA. IUSHIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 21, No. 4, 1990, pp. 92–95.

The laminar-turbulent boundary layer transition near the lower surface of a triangular plate with the leading-edge sweep angles chi between 65 and 75 deg was investigated in shock-tunnel experiments. Results are presented in the form of a single dependence of the Reynolds-number transition on the Mach number, the unit Reynolds number, and the angle of attack.

A91-28113 Instability of an entropic layer on a blunted plate in the path of supersonic gas flow (Neustoichivost' entropiinogo sloia na zatuplennoi plastine, obtekaemoi sverkhzvukovym potokom gaza). A. V. FEDOROV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Sept.–Oct. 1990, pp. 63–69.

Natural oscillations in an entropic layer on a plate in supersonic flow are analyzed in the context of linear theory. By using the method of matched expansions, well posed boundary conditions for the perturbations are obtained. It is shown that, in higher approximations, the entropic layer instability is described by nonviscous equations. The natural acoustic oscillations and the unstable mode are analyzed numerically and asymptotically.

A92-27537 A method for the optical measurement of surface friction in supersonic flow (K metodike izmereniia poverkhnostnogo treniia opticheskim metodom v sverkhzvukovom potoke). V. I. KORNILOV, A. A. PAVLOV, and S. I. SHPAK, *Sibirskii Fiziko-Tekhnicheskii Zhurnal* (ISSN 0869-1339), Nov.–Dec. 1991, pp. 47–51.

An attempt was made to use a single-beam optical scheme using a He-Ne laser for measuring surface friction in superosnic flow. The measurements were carried out on the side wall of the test section of a wind tunnel under conditions of essentially gradient-free flow at Mach 3.0 +/- 0.01 and Reynolds numbers of (1.16-3.92) x 10 exp 5. The results are found to agree with those obtained by the Spalding-Chi method to within 10 percent.

A92-16813 A discrete vortex study of stationary flow past three-dimensional lifting systems at subsonic and supersonic velocities (Issledovanie metodom diskretnykh vikhrei statsionarnogo obtekaniia prostranstvennykh nesushchikh sistem pri do- i sverkhzvukovykh skorostiakh potoka). A. M. VALUISKII, S. S. GRAS'KIN, and V. A. PODOBEDOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 4, 1990, pp. 48–50.

The discrete vortex method is applied to the analysis of stationary flow past three-dimensional lifting systems, such as multiple-airfoil wings, at subsonic and supersonic velocities. A unified mathematical model for the analysis of both subsonic and supersonic flow past wings of this type is developed. Examples of calculations are presented.

A92-27597 Characteristics of the mechanism of separated flow pulsation ahead of a spike-tipped cylinder in supersonic flow (Osobennosti mekhanizma pul'satsii otryvnogo techeniia pered tsilindrom s ostroi igloi pri sverkhzvukovom obtekanii). V. I. ZAPRIAGAEV and S. G. MIRONOV, *PMTF—Prikladnaia Mekhanika i Tekhnicheskaia Fizika* (ISSN 0044-4626), Nov.–Dec. 1991, pp. 101–108.

The mechanism and characteristics of separated flow pulsation ahead of a spike-tipped cylinder in supersonic flow are examined with reference to experimental data obtained by the schlieren photography method. An analysis of schlieren photographs shows that the relation between the position of the head shock wave and the pressure pulsation phase for aperiodic pulsations is generally similar to that observed in the case of developed self-oscillations. The onset of aperiodic pulsations is attributed to the fact that the small extension of the spike beyond the shock wave leads to stability loss in the oscillatory system while efficient feedback is not yet established. The impulse nature of the onset of intense pulsations at the boundary of the region of their existence provides evidence of the relaxation origin of the self-oscillations.

A92-27533 Radiant heat transfer in supersonic three-dimensional and axisymmetric flow of air past evaporating bodies (Luchistyi teploobmen pri sverkhzvukovom prostranstvennom i osesimmetrichnom obtekanii ispariaiushchikhsia tel vozdukhom). E. Z. APSHTEIN, V. I. SAKHAROV, and A. V. SHEVOROSHKIN, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 29, Nov.–Dec. 1991, pp. 1178–1183.

Supersonic flow of an ideal gas past bodies of various shapes (e.g., spheres, axisymmetric ellipsoids, and three-dimensional triaxial ellipsoids) is investigated numerically with allowance for injection from the surface. The effect of the screening by material vapors (modeled by air) on the distribution of relative radiant heat flows on the body surface is analyzed. It is shown that the distributions of relative radiant heat flows in the axisymmetric case are similar to the corresponding curves calculated without allowance for injection.

A92-24599 Effect of supersonic diffuser geometry on operation conditions. S. V. PUZACH, *Experimental Thermal and Fluid Science* (ISSN 0894-1777), Vol. 5, Jan. 1992, pp. 124–128.

Results are presented of experimental and theoretical studies of characteristics of start-up and stationary conditions of operation of a supersonic diffuser with variable geometry of the wall located in the track of a supersonic wind tunnel with Mach number M = 2 and 3 in the working region. The stationary and nonstationary turbulent boundary layers were computed in terms of the asymptotic theory of Kutateladze and Leontiev. The test data show an essential influence of supersonic diffuser geometry on the start-up ratio of pressures on the input and output from the wind tunnel and the flow velocity of the system of shock waves at a 'quasi-stationary' start-up. Theoretical integral characteristics and velocity profiles of a turbulent boundary layer in a supersonic diffuser are in good agreement with the experimental results. (Author)

A92-23481 Mechanical damage of solids by supersonic synergistic structures in gases (Mekhanicheskoe vozdeistvie na tverdye sredy sverkhzvukovykh sinergeticheskikh struktur v gazakh). IU. N. DENISOV and F. N. LIUBCHENKO, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 320, No. 5, 1991, pp. 1152–1155.

The excitation of ordered spatial-temporal synergistic structures at the macroscopic levels is observed in essentially homogeneous flows of gases and gas mixtures, both combustible and inert. In supersonic flows, the synergistic structures mechanically affect solid surfaces in direct contact with the gas. Here, experimental results are presented on the damage of solids in the case of plane detonation in the presence of cellular structures and in the case of the cylindrical reflection of a shock wave with gasdynamic fluctuations.

A92-15038 Some properties of subsonic flow in the wake of a shock wave generated in supersonic flow past bodies of finite thickness (O nekotorykh svoistvakh dozvukovogo techeniia za udarnoi volnoi, voznikaiushchei pri sverkhzvukovom obtekanii tel konechnoi tolshchiny). A. I. RYLOV, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 55, Sept.–Oct. 1991, pp. 780–786.

The paper is concerned with subsonic vortex flow in the wake of a separated or a reattached shock wave formed in plane supersonic flow past symmetrical bodies of finite thickness. In particular, attention is given to the relationship between subsonic regions of the body and the shock wave. It is shown that, when the wall angles are nonnegative, the velocity vector angles behind the shock wave are also nonnegative, and the shock wave angles do not exceed pi/2. Flow past a finite wedge with a bend in the generatrix is also analyzed.

A91-49402 Longitudinal vortex structures and heat transfer in the reattachment region of a supersonic turbulent boundary layer (Prodol'nye vikhrevye struktury i teploobmen v oblasti prisoedineniia sverkhzvukovogo turbulentnogo pogranichnogo sloia). E. G. ZAULICHNYI and V. M. TROFIMOV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.–Apr. 1991, pp. 66–72.

Results of an experimental study of the three-dimensional features of flow and heat transfer associated with Taylor-Goertler vortices are reported. A new second wall layer of longitudinal structures is discovered whose generation mechanism is not related to the Taylor-Goertler vortices. Details of the experimental procedure are described.

A92-21614 The laminar-turbulent boundary layer transition behind an irregularity at the attachment line of a swept cylinder in supersonic flow (Laminarno-turbulentnyi perekhod pogranichnogo sloia za nerovnost'iu na linii rastekaniia skol'ziashchego tsilindra v sverkhzvukovom potoke). A. S. SKURATOV and A. V. FEDOROV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Nov.–Dec. 1991, pp. 28–35.

The effect of a single two-dimensional irregularity and vortex generation on the laminar-turbulent boundary layer transition in supersonic flow past a swept cylinder was investigated experimentally for free-stream Mach 6. Characteristic flow regimes behind the irregularity are identified, and their boundaries are determined as a function of the Reynolds number and the ratio of the irregularity height to the boundary layer thickness. A qualitative comparison is made with flow regimes behind an irregularity at the attachment line in the case of flow of an incompressible fluid past a cylinder.

A92-13749 Experimental studies of the interaction of converging axisymmetric shock waves with sharp and blunt cones in supersonic flow (Eksperimental'nye issledovaniia vzaimodeistviia skhodiashchikhsia osesimmetrichnykh udarnykh voln s ostrym i prituplennym konusami v sverkhzvukovom potoke). A. V. KRASIL'NIKOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.–Oct. 1991, pp. 177–182.

Interactions of converging shock waves with sharp and blunt cones were investigated experimentally in a supersonic wind tunnel at a free-stream Mach of 4.67. Details of the experimental procedure and test results are discussed with emphasis on the effect of the taper angle of the converging shock wave, model shape, and its position relative to the shock wave configuration on flow structure and pressure distribution on the model surface.

A92-12169 Evolution of three-dimensional flows during the interaction between conical shock waves and a turbulent boundary layer (Razvitie prostranstvennykh techenii pri vzaimodeistvii konicheskikh skachkov uplotneniia s turbulentnym pogranichnym sloem). A. A. ZHELTOVODOV and A. I. MAKSIMOV, *Sibirskii Fiziko-Tekhnicheskii Zhurnal* (ISSN 0002-3434), Mar.–Apr. 1991, pp. 88–98.

Supersonic flow past half-cones located on a plate was investigated experimentally in a systematic manner in order to gain a better understanding of the evolution of three-dimensional turbulent flows and to compare some of the flow characteristics for different geometrical configurations. The experiments were carried out in a wind tunnel for an adiabatic model surface at free-stream Mach 2.27, 3, and 4. It is found, in particular, that, for moderate intensities of sliding shock waves, flow in the mixing region is characterized by predominantly horizontal deviations of the flow lines. A significant restructuring of the flow observed for high shock wave intensities suggests the formation of a three-dimensional separation.

A92-12166 Formation and evolution of turbulence in a strongly underexpanded supersonic jet (Vozniknovenie i razvitie turbulentnosti v sverkhzvukovoi sil'no nedorasshirennoi strue). S. A. NOVOPASHIN and A. L. PEREPELKIN, *Sibirskii Fiziko-Tekhnicheskii Zhurnal* (ISSN 0002-3434), Jan.–Feb. 1991, pp. 89–95.

Results of an experimental study of the evolution of flow at the boundary of a supersonic jet at Reynolds numbers corresponding to the laminar-turbulent transition are reported. Coherent structure associated with such flows are identified, and their evolution is discussed. The discussion also includes a description of the laser-based remote diagnostic equipment and methods used in the study.

A92-16679 Three-dimensional singularity of flow structure in an underexpanded supersonic jet (Trekhmernaia osobennost' struktury techeniia v sverkhzvukovoi nedorasshirennoi strue). V. I. ZAPRIAGAEV and A. V. SOLOTCHIN, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), July–Aug. 1991, pp. 42–47.

Structural inhomogeneities in underexpanded supersonic jets were investigated experimentally by using the photographic method and by measuring full and static pressures in the flow region between a suspended compression shock and the jet boundary in the compressed layer. The results obtained are found to be consistent with the hypothesis about the existence of formations of the Taylor-Goertler vortex type in the compressed layer of nonisobaric jets.

A91-33920 Effect of a single three-dimensional surface roughness on the transition in a supersonic boundary layer (Vliianie edinichnoi trekhmernoi sherokhovatosti na perekhod v sverkhzvukovom pogranichnom sloe). O. I. ZININ, A. A. MASLOV, V. E. NOVIKOV, and S. G. SHEVEL'KOV, *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002-3434), June 1990, pp. 47–53.

The effect of a single surface roughness in the form of a projecting cylinder (0.3 mm in diameter) on the laminar-turbulent transition in a boundary layer on a flat plate was investigated experimentally at M = 2.0 for various wind tunnel regimes. The transition was observed by means of flow visualization techniques and measured by using pressure transducers and hot-wire anemometry. The results are in agreement with the results of Van Drist and Blumer (1962) obtained for a cone with surface roughness in the form of spheres. The evolution of turbulence in the wake of the roughness is examined.

A91-39920 Experimental study of the supersonic boundary layer stability on the cone-cylinder model. A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV, *Laminar-turbulent transition; Proceedings of the IUTAM Symposium,* Toulouse, France, Sept. 11–15, 1989 (A91-39901 16-34). Berlin and New York, Springer-Verlag, 1990, pp. 239–249.

Results are presented from experimental studies of the supersonic laminar boundary layer instability of a cone-cylinder body, which elucidate the characteristics of unsteady plane waves in zero-pressure gradients on the conical portion of the boundary layer. Attention is given to the development of disturbances in the zone of interaction between the boundary layer and the expansion fan; both vortical and compressible mode disturbances are generated by a local source of artificial disturbances. A strong stabilizing influence on disturbances is noted for the negative pressure gradient. Three-dimensional vortical mode disturbances whose wave vector relative to the flow is of the order of 40–60 deg are found to be the least stable components of the cone region's boundary layer.

A90-39518 Wave structure of artificial perturbations in a supersonic boundary layer on a plate (Volnovaia struktura iskusstvennykh vozmushchenii v sverkhzvukovom pogranichnom sloe na plastine). A. D. KOSINOV, A. A. MASLOV, N. V. SEMENOV, and S. G. SHEVEL'KOV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.–Apr. 1990, pp. 95–98.

Artificially produced perturbations in a boundary layer on a plate were investigated experimentally in a supersonic wind tunnel with a test section of 200x200 mm at Mach 2. Perturbations were introduced either internally using a point source or externally using acoustic waves. The wave structures of perturbations produced by the two excitation methods are discussed and compared.

A91-29940 Effect of the separation zone length on the completeness of combustion in supersonic flow (Vliianie dliny otryvnoi zony na polnotu sgoraniia v sverkhzvukovom potoke). V. L. KRAINEV, *Molecular gas dynamics and the mechanics of inhomogeneous media* (A91-29927 11-34). Moscow, Izdatel'stvo Nauka, 1990, pp. 196–199.

The effect of the separation zone length on hydrogen combustion stabilized by the front separation zone ahead of a blunt body with a needle was investigated experimentally in a wind tunnel at M = 2. The model had the shape of a 30-mm-diameter cylinder with a stainless steel needle (external diameter, 6mm; internal diameter, 4 mm) along the cylinder axis for hydrogen injection in the direction opposite to the incoming flow; a solid fuel charge was used to ignite the hydrogen. Diagrams are presented which relate the completeness of hydrogen combustion in the separation zone to the hydrogen flow rate.

A91-22892 Experimental investigation of a 2-D dual mode scramjet with hydrogen fuel at Mach 4–6. V. A. VINOGRADOV, V. A. GRACHEV, M. D. PETROV, and IU. M. SHIKHMAN, *2nd AIAA, International Aerospace Planes Conference,* Orlando, FL, Oct. 29–31, 1990. 11 pp. (AIAA Paper 90-5269).

The paper presents the results of an experimental investigation of a working process in a model noncooled dual-mode scramjet with a two-dimensional inlet and combined combustor with hydrogen burning in subsonic and supersonic air flow. The investigation was conducted at freestream M = 5 and 6 and and also under conditions of connected duct, simulating the parameters at the combustor entry corresponding freestream M = 4. Distribution of gasthermodynamic parameters along the duct, efficiency of hydrogen-air mixture and combustion, special features of combustion stabilization, data on heat transfer and conditions of inlet and combustor interaction are discussed in this paper. (Author)

A91-22891 Gasdynamic features of supersonic kerosene combustion in a model combustion chamber. S. I. BARANOVSKII, V. M. LEVIN, and V. N. AVRASHKOV, *2nd AIAA, International Aerospace Planes Conference,* Orlando, FL, Oct. 29-31, 1990. 9 pp. (AIAA Paper 90-5268).

The article is devoted to the description of methods and analysis of the results of mixture-forming bubbling systems combined with tubular micropylons, and also to obtaining the self-ignition and supersonic burning of kerosene/air mixture. The burning was investigated in a cooled model combustion chamber of rectangular cross-section. The shape of combustion chamber channel was both of constant cross section and of expansion type. The assumption of the presence of gasdynamic burning stabilization on a shock wave dominant system is substantiated. Results obtained show the quantitative and qualitative relation between the stable kerosene/air mixture burning concentration limits and the combustion chamber shape. (Author)

A91-21962 Effect of the penetration depth of fuel jets on combustion in a supersonic combustion chamber (Vliianie glubiny proniknoveniia toplivnykh strui na gorenie v sverkhzvukovoi kamere sgoraniia). S. I. BARANOVSKII and I. V. KONOVALOV, *Fizika Goreniia i Vzryva* (ISSN 0430-6228), Vol. 26, July–Aug. 1990, pp. 66–68.

Experiments were carried out to investigate the effect of the relative penetration depth of hydrogen gas jets injected into supersonic cross-stream on self-ignition and combustion in a combustion chamber of constant cross section. The water-cooled experimental apparatus had a test section of 100x50 mm and a Mach 2.5 supersonic nozzle. It is found that the combustion efficiency of multiple-jet supersonic combustion chambers is largely determined by the ratio of the penetration depth to the boundary layer thickness at the point of injection.