Russian and Japanese Aerospace Literature

During 1995 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 Computational Fluid Dynamics from Russia and Titanium Alloys from Japan.

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Russian Aerospace Literature
This month: *Computational Fluid Dynamics*

A95-17523 Self-consistent shock capturing in finite difference calculations of gasdynamic flows (Samosoglasovannoe vydelenie razryvov pri skvoznykh raschetakh gazodinamicheskikh techenij). V. F. KAMENETSKIJ and A. YU. SEMENOV, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 34, No. 10, Oct. 1994, pp. 1489–1502. In Russian. 15 Refs. Documents available from Aeroplus Dispatch.

New self-consistent shock capturing algorithms are proposed which can be used in the numerical solution of one-dimensional and axisymmetric gasdynamic problems. The self-consistent shock capturing procedure proposed here employs special self-adjusting grids which automatically trace discontinuities formed in gasdynamic flow. The efficiency of the approach is illustrated by examples.

A95-15471 An implicit iterative scheme for calculating flows of a nonviscous incompressible fluid (Neyavnaya iteratsionnaya skhema dlya rascheta techenij vyazkoj neszhimaemoj zhidkosti). V. I. KOPCHENOV and D. A. NIKIFOROV, *Zhurnal Vychislitel'noj Mathematiki i Mathematicheskoj Fiziki* (ISSN 0044-4669), Vol. 34, No. 8–9, Sept. 1994, pp. 1335–1343. In Russian. 10 Refs. Documents available from Aeroplus Dispatch.

The compact approximation method is used to develop a higher-order implicit scheme employing the Gauss–Seidal iterative method. The advantages of this scheme over the approximate factorization algorithm are demonstrated. Calculations of flow in a square cavity up to Re 4000 are presented. The efficiency of the algorithm proposed here, when used with essentially nonuniform grids, is demonstrated.

A95-14901 The SUBMODELS Program—Gas dynamics (Programma podmodeli—Gazovaya dinamika). L. V. OVSYANIKOV, *Prikladnaya Matematika i Mekhanika* (ISSN 0032-8235), Vol. 58, No. 4, Aug. 1994, pp. 30–55, In Russian. 12 Refs. Documents available from Aeroplus Dispatch.

The fundamental principles and the implementation of the SUBMODELS program, aimed at the simplification of large mathematical models through maximum utilization of their inherent symmetry properties, are examined. The simplification is achieved through the transition to submodels describing classes of exact particular solutions which reduce the dimensionality of problems and make their analysis more accessible. A specific application example is included.

A95-14456 An analytical study of supersonic isentropic flow in a channel of constant cross section and in an adjoining Laval nozzle— A comparison with numerical and experimental results (Analiticheskoe issledovanie sverkhzvukovogo izoehntropicheskogo techeniya v kanale postoyannogo secheniya i v primykayushchem sople Lavalya— Sravnenie s chislennymi i ehksperimental'nymi rezul'tatami). U. G. PIRUMOV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 4, Aug. 1994, pp. 158–169. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

Plane supersonic isentropic flow is investigated analytically using Prandtl–Meyer invariants. Consideration is given to both flow in a channel, of constant cross section and flow in an adjoining Laval nozzle with a corner point. Experimental data are presented which are qualitatively consistent with analytical results obtained in the constant cross section channel and in the Laval nozzle.

A94-35328 Universal algebra of the symmetry operators of gasdynamic equations in terms of Euler and Lagrange variables (Obshchaya algebra operatorov simmetrii uravnenij gazovoj dinamiki v ehjlerovykh i lagranzhevykh peremennykh). N. A. DAR'IN, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 34, No. 5, May 1994, pp. 739–747. In Russian. 5 Refs. Documents available from Aeroplus Dispatch.

The paper focuses on the relation between equations of one-dimensional gas dynamics in Eulerian and Lagrangian coordinates. It is shown that, for the treatment of symmetry operators used here, the gasdynamic equations in Euler and Lagrange variables have the same algebra of symmetry operators.

A94-23855 Kinetic derivation of gas dynamic equations for multicomponent mixtures of light and heavy particles (O kineticheskom vyvode uravnenij gazodinamiki mnogokomponentnykh smesej legkikh i tyazhelykh chastits). V. S. GALKIN and N. K. MAKASHEV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 1, Feb. 1994, pp. 180–200. In Russian. 43 Refs. Documents available from Aeroplus Dispatch.

Gas dynamic equations for multicomponent mixtures of particles with largely different masses and frozen internal degrees of freedom are derived in the context of kinetic theory. The possibility of a one-velocity and two-temperature microscopic description is demonstrated. It is shown that a multiple-velocity solution of the Boltzmann equation must be used for the heavy components; a method of introducing the effective temperature is discussed. A modification of the generalized Chapman–Enskog method is presented.

A94-21688 Hyperbolic modification of Navier–Stokes equations (Giperbolicheskaya modifikatsiya uravnenij Nav'e–Stoksa). B. G. KUZNETSOV, *PMFT—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 34, No. 6, Dec. 1993, pp. 133–141. In Russian. 4 Refs. Documents available from Aeroplus Dispatch.

A comparison of the propagation velocities of perturbations determined from Euler and Navier–Stokes models leads to a paradox in the case of a viscous gas, where an infinite velocity is obtained. A hyperbolic modification of Navier–Stokes equations is proposed which makes it possible to resolve this paradox.

A94-21668 Determination of plane flow parameters for an incompressible fluid in the case of small variations of the profile shape (Opredelenie parametrov ploskogo techeniya neszhimaemoj zhidkosti prim maloj variatsii kontura profilya). A. L. GONOR, *Prikladnaya Matematika i Mekhanika* (ISSN 0032-8235), Vol. 57, No. 6, Dec. 1993, pp. 167–169. In Russian. 4 Refs. Documents available from Aeroplus Dispatch.

A corrected version of a formula for calculating flow of an incompressible fluid over a profile close to the specified shape is obtained. The validity of the formula is demonstrated using a test example.

A94-21665 Bifurcation of the upper arm of the neutral curve for a boundary layer on a plate in compressible flow (Bifurkatsiya verkhnej vetvi nejtral'noj krivoj dlya pogranichnogo sloya na plastine v szhimaemom potoke). V. I. ZHUK, *Zhurnal Vychislitel'noj Matematiki i*

Matematicheskoj Fiziki (ISSN 0044-4669), Vol. 34, No. 1, Jan. 1994, pp. 130–147. In Russian. 14 Refs. Documents available from Aeroplus Dispatch.

A Mach number limit is estimated above which the properties of the unstable mode of natural oscillations of the boundary layer become qualitatively different from those known in the incompressible case. An example is presented, in which the function describing the upper arm of the neutral curve becomes three-valued. For given conditions, four neutral values of the wave number correspond to a fixed Reynolds number, and the instability region is divided in two.

A94-19821   Transonic flow of a nonideal gas out of a vessel with plane walls (Transzvukovoe istechenie nesovershennogo gaza iz sosuda s ploskimi stenkami). O. M. KISELEV and SH. EH. MUKHAMETRAKHIMOV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 6, Dec. 1993, pp. 88–95. In Russian. 12 Refs. Documents available from Aeroplus Dispatch.

The problem of transonic flow of a gas out of a vessel with plane walls is investigated analytically for a real (thermally and calorically nonideal) gas. A method for solving this problem is described. Calculation results are presented which illustrate the effect of the angle between the walls and drag parameters on transonic flow of air.

A94-19440   Nearly conservative difference schemes for gas dynamics equations (Pochti konservativnye raznostnye skhemy dlya uravnenij gazovoj dinamiki). A. A. CHARAKHCH'YAN, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 33, No. 11, Nov. 1993, pp. 1681–1692. In Russian. 17 Refs. Documents available from Aeroplus Dispatch.

A method for modifying a wide class of schemes using arbitrary grids is proposed which makes it possible to obtain nearly conservative schemes that guarantee no loss of accuracy in internal energy calculations. The efficiency of the schemes proposed here in comparison with conservative schemes is demonstrated for the case of cumulative effect calculation using moving grids.

A94-18437   New approximate analytical solutions for gas dynamics equations (Novye priblizhennye analiticheskie resheniya uravnenij gazovoj dinamiki). G. I. NAZAROV, *Prikladnaya Matematika i Mekhanika* (ISSN 0032-8235), Vol. 57, No. 5, Oct. 1993, pp. 79–86. In Russian. 8 Refs. Documents available from Aeroplus Dispatch.

Approximate binomial solutions for gas dynamics equations in velocity hodograph variables are obtained without resorting to the method of approximations. The solutions are obtained for both subsonic flow, containing an arbitrary analytical function of a complex variable and a sonic (critical) point, and supersonic motion, which includes two arbitrary functions of characteristic variables and a sonic point. Two matching of these solutions at the sonic line during transonic motion is demonstrated by an example.

A94-13138   Calculation of flow induced by gas injection through the walls of a duct of finite length (Raschet techeniya, indutsiruemogo vduvom gaza cherez stenki kanala konechnoj dliny). A. P. KURYACHIJ, *Prikladnaya Matematika i Mekhanika* (ISSN 0032-8235), Vol. 57, No. 3, June 1993, pp. 50–56. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

A method is proposed for calculating gas flow in a narrow plane duct of finite length, with gas injected through the duct walls and outflowing from the duct at a specified pressure. The calculations are carried out in the Prandtl approximation. The method allows the determination of flow characteristics for different characteristic Mach number values based on the results of a single calculation for a fixed Reynolds number. The procedure for considering the ellipticity of the problem is substantially simplified.

A94-12800   Variational inverse boundary value problems in aerohydrodynamics for subsonic gas flow (Variatsionnye obratnye kraevye zadachi aehrogidrodinamiki dlya dozvukovogo techeniya gaza). A. M. ELIZAROV, E. V. FEDOROV, and D. A. FOKIN, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 33, No. 6, June 1993, pp. 958–968. In Russian. 10 Refs. Documents available from Aeroplus Dispatch.

Variational problems of determining the shape of nonporous wing profiles with a maximum lift-drag ratio in steady state subsonic flow of a viscous gas with large Reynolds numbers are solved numerically. The viscosity is considered in the boundary layer approximation, while gas compressibility is accounted for in the framework of Chaplygin's gas model. Examples of optimized profiles are presented, as are numerical calculations.

A94-12799   A finite element method for calculating the nonsteady state aerodynamic characteristics of a subsonic cascade of vibrating airfoils (Method konechnykh ehlementov dlya rascheta nestatsionarnykh aehrodinamicheskikh kharakteristik dozvukovoj reshetki vibriruyushchikh profilej). A. A. OSIPOV, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 33, No. 6, June 1993, pp. 919–935. In Russian. 29 Refs. Documents available from Aeroplus Dispatch.

A numerical method is developed for calculating the linear oscillations of subsonic flow of an ideal gas near a vibrating plane cascade of airfoils. Attention is given to harmonic vibrations of airfoils with a constant phase shift between any two adjacent airfoils in a cascade. The computational scheme is based on the finite element method used in conjunction with the variational principle. A modified formulation of the boundary value problem is used in order to reduce the errors associated with the large inhomogeneities of the main steady state flow near the leading and trailing edges of the airfoils.

A94-11042   A kinetic model of a gas-particle mixture and its validation. III-Validation (Kineticheskaya model' vzvesi i ee obosnovanie. III-Obosnovanie). V. A. TSIBAROV, *Sankt-Peterburgskij Universitet, Vestnik, Seriya 1—Matematika, Mekhanika, Astronomiya* (ISSN 0024-0850), No. 1, Jan. 1993, pp. 92–97. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

Kinetic equations of the gas and particle phases are derived using a version of a Liouville equation analog written for an ensemble consisting of gas molecules and solid particles. The particles move in a nonconservative field. The approach used here makes it possible to validate the kinetic equations obtained previously (Tsibarov, 1992).

A94-11040   Optimal aerodynamic shapes in rarefied gas (Ob optimal'nykh aehrodinamicheskikh formakh v razrezhennom gaze). R. N. MIROSHIN, *Sankt—Peterburgskij Universitet, Vestnik, Seriya 1—Matematika, Mekhanika, Astronomiya* (ISSN 0024-0850), No. 1, Jan. 1993, pp. 77–82. In Russian. 13 Refs. Documents available from Aeroplus Dispatch.

An isoperimetric problem concerned with the optimization of a convex body shape in rarefied gas is formulated. A two-stage procedure for solving the problem is presented. The solution is based on the theory of local interaction and employs the Chebyshev–Markov theorem.

A94-11012   Localized vortices and internal gravity waves in a stably stratified atmosphere (Lokalizovannye vikhri i vnutrennie gravitatsionnye volny v ustojchivo stratifitsirovannoj atmosfere). V. M. GRYANIK and A. A. DOBRITSYN (RAN, Inst. Fiziki Atmosfery, Moscow, Russia), *Rossijskaya Akademiya Nauk, Doklady* (ISSN 0869-5652), Vol. 331, No. 4, Aug. 1993, pp. 494–496. In Russian. 7 Refs. Documents available from Aeroplus Dispatch.

A mechanism of mixing in a stable boundary layer associated with localized vortices that are formed in the field of internal gravity waves is examined. In addition to vertical mixing, vorticity provides for horizontal mass, momentum, and heat transfer along the underlying surface in the direction normal to that of the main flow. The discussion covers the distribution of the vorticity-induced temperature field and the structure of the vorticity-induced flow, conditions for the existence of vortices, and the location of vortices in relation to the underlying surface and the wave field.

A94-10958   Possibility of the existence of weak contact discontinuities in a circular shock tube (Vozmozhnost' sushchestvovaniya slabykh kontaktnykh razryvov v krugloj udarnoj trube). V. D. SEROVA, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 3, June 1993, pp. 173–175. In Russian. 7 Refs. Documents available from Aeroplus Dispatch.

For the case of the interaction of a strong shock wave with a small obstacle at the axis of a round shock tube, the shock wave velocity and the Mach number in its wake are determined for which weak contact discontinuities cannot exist. Parameter ranges are determined for which weak contact discontinuities attenuate with time and for which they are transformed to strong contact discontinuities.

A94-10956   A numerical study of steady-state supersonic separated flow past three-dimensional lifting systems (Chislennoe issledovanie statsionarnogo otryvnogo obtekaniya prostranstvennykh nesushchikh sistem sverkhzvukovym potokom). S. S. GRAS'KIN, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 3, June 1993, pp. 142–148. In Russian. 10 Refs. Documents available from Aeroplus Dispatch.

A numerical method is proposed for studying supersonic flow past complex three-dimensional configurations. The method is an extension of well-known approaches that are commonly used for solving similar problems in subsonic aerodynamics. To illustrate the method, calculations of the aerodynamic characteristics of wings and three-dimensional lifting systems are performed.

A94-10955   Asymptotic theory of vortex breakdown (Asimptoticheskaya teoriya razrusheniya vikhrya). VIK. V. SYCHEV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 3, June 1993, pp. 78–90. In Russian. 31 Refs. Documents available from Aeroplus Dispatch.

The phenomenon of vortex breakdown is investigated by using an asymptotic analysis of a system of Navier–Stokes equations at large Reynolds numbers. A criterion for vortex breakdown is formulated; the flow structure is described as a whole and in the direct vicinity of the breakdown point. It is shown that vortex breakdown is a two stage process, and a description of each stage is provided.

A94-10954   A numerical study of the mixed three-dimensional boundary layers of flow past an ellipsoid at angles of attack (Chislennoe issledovanie techenij v smeshannykh prostranstvennykh pogranichnykh sloyakh ehllipsoida obtekaemogo s uglami ataki). YU. N. KARPEEV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 3, June 1993, pp. 69–77. In Russian. 9 Refs. Documents available from Aeroplus Dispatch.

Two cases of mixed flow in three-dimensional boundary layers on an ellipsoid of revolution are investigated numerically, for angles of attack of 10 and 5 deg, using a finite difference method. The closure equation for flows in the transition and turbulent regions is obtained by using the principle of superposition of viscous and turbulent stresses and the 'mixing path' model, extended to three dimensions. It is found that turbulent mixing significantly weakens three-dimensional effects, leading to the shifting of three-dimensional separation zones further downstream and to the reduction of their size.