

Russian and Japanese Aerospace Literature

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Russian Aerospace Literature This month: *Computational Fluid Dynamics*

A92-21602 Optimization of the three-dimensional shape of lifting bodies of small aspect ratio at hypersonic velocities (Optimizatsiia prostranstvennoi formy nesushchikh tel malogo udlineniia pri giperzvukovykh skorostiakh). V. N. GOLUBKIN and V. V. NEGODA, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 31, Dec. 1991, pp. 1858-1870. 11 Refs.

Problems of the partial (for a specified shape of the shock wave) and full optimization of hypersonic lifting bodies of small aspect ratio are formulated in the context of the theory of a thin shock layer with a view to achieving maximum lift-drag ratio for a given lift force. The partial optimization problem is solved analytically. In the case of the full problem, an approximate solution is obtained numerically using the direct optimization method.

A92-15493 Lagrangian turbulence and anomalous transport. G. M. ZASLAVSKII, *Fluid Dynamics Research* (ISSN 0169-5983), Vol. 8, Oct. 1991, pp. 127-133. 19 Refs.

The motion of a passive particle in a given velocity field can be considered from the viewpoint of dynamic systems theory. A two-dimensional time-dependent field and a three-dimensional field generate chaotic behavior of liquid particles. The diffusion process of liquid particles is considered as a random walk process in the fractal space and time. This leads to anomalous transport properties of the particles. The notion of stochastic jets is introduced. A complete analysis is given for a special form of Beltrami flows—so-called Q-flows with symmetry of the order of Q.

A91-24484 Convergence acceleration and wave drag determination in transonic airfoil calculations. S. V. LIAPUNOV, *Proceedings of the 17th ICAS, Congress, Volume 2*, Stockholm, Sweden, Sept. 9-14, 1990, (A91-24301 09-01). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, pp. 1819-1825. 15 Refs.

It is shown that one of the reasons for a relatively slow iteration process convergence during transonic potential flow calculations by relaxation methods is the calculation in the vicinity of the infinity point. The exclusion of this domain from the calculation region and using of the Dirichlet type condition on its boundary leads to an appreciable convergence acceleration and computational time reduction. The analogous method can be utilized for the calculations of axisymmetrical bodies and wings. The second question involved deals with the determination of the wave drag in the potential airfoil flow calculations. The drag values were corrected for the nonconservativity of the finite-difference scheme and potential model errors and the result agrees well with the Euler equation solutions.

A92-16686 Solution of parabolized Navier-Stokes equations by the pressure gradient iteration method (Reshenie parabolizovannykh uravnenii Nav'e-Stoksa metodom iteratsii po gradienty davleniia). I. U. V. GLAZKOV and V. G. SHCHERBAK, *Moskovskii Universitet, Vestnik, Seriya 1—Matematika, Mekhanika* (ISSN 0579-9368), July-Aug. 1991, pp. 52-57. 13 Refs.

A numerical method is proposed for solving parabolized Navier-Stokes equations using global iterations. Each iteration involves solving the boundary value problem by the marching method. This approach makes it possible to calculate supersonic flow past a blunt body with allowance for the shock wave structure. Seven to ten global iterations are required for determining the pressure, heat flow, and friction on a body to within 0.1 percent.

A91-55253 Supersonic laminar flow past the windward side of infinite-span swept wings over a wide range of Reynolds numbers (Sverkhzvukovoe laminarnoe obtekanie navetrennoi chasti skol'zishchikh kryl'ev beskonrechnogo razmakha v shirokom diapazone chisel Reinol'dsa). I. V. VERSHININ, G. A. TIRSKII, and S. V. UTIYZHNIKOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July-Aug. 1991, pp. 40-44. 13 Refs.

The problem of supersonic flow past swept wings over a wide range of Reynolds numbers (from small Re corresponding to the onset of continuous flow to large Re corresponding to the theory of an asymptotically thin boundary layer) is analyzed using a model based on full equations of a viscous shock layer. The numerical calculations are performed using independent variables and a difference scheme. Results of calculations are presented and compared with experimental data in the literature.

A91-35788 Calculation of steady-state three-dimensional flows of viscous gases and chemically reacting gas mixtures (Raschet statsionarnykh trekhmernykh techenii viazki kh gazov i khimicheskii reagiuiushchikh gazovykh smesei). A. E. KUZNETSOV, M. KH. STRELETS, and M. L. SHUR, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 31, Feb. 1991, pp. 300-316. 30 Refs.

In an earlier study (Strelets and Shur, 1988), a method, referred to as the compressibility scaling method, has been developed for the numerical modeling of two-dimensional steady-state compressible flows for arbitrary freestream Mach numbers. Here, the method is extended to the case of three-dimensional steady-state flows of viscous gases and multicomponent gas mixtures in the presence of chemical reactions. The capabilities of the finite difference algorithm proposed here are illustrated by two examples.

A92-20150 Soviet CFD—An international perspective. V. A. SO-SUNOV and M. IA. IVANOV, *Aerospace America* (ISSN 0740-722X), Vol. 30, Jan. 1992, pp. 48–51.

An overview is presented of Soviet CFD development and the organizations that have had experience using moderately powerful computers to solve practical problems encountered in aerospace design methods. Highly accurate monotonic difference methods that follow the local flow structure, have been developed and now form the basis for constructing effective algorithms and codes that solve practical external and internal aerodynamics problems. Consideration is given to a potential area for international CFD cooperation that would involve solving problems connected with the design of scramjets for the aerospace plane.

A92-12805 Calculation of the cross-sectional shape of a jet in a cross flow (Raschet formy poperechnogo secheniia strui v snosishchem bokovom potoke). E. V. BRUIATSKII and V. G. KUZ'MENKO, *Gidromekhanika* (ISSN 0367-4088), No. 63, 1991, pp. 15–20. Refs.

A vortex model of the evolution of the cross section of a jet flowing into a cross stream is examined. The jet is modeled by a system of discrete vortices which move along the jet-stream interface. A closed system of equations describing the vortex paths is obtained and solved numerically. The jet cross section calculations are found to be in good agreement with experimental data.

A91-55256 A study of the expansion of a plane wall jet over a step (Issledovanie rasprostraneniia nad ustupom ploskoi pristenochnoi strui). E. G. ZAITSEV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July–Aug. 1991, pp. 61–66. 12 Refs.

The flow of a sonic underexpanded jet over a plane step is investigated experimentally in the case where the jet issues from a nozzle along a horizontal surface. In particular, attention is given to the effect of the full pressure in the jet and step height on the separation of the jet from the wall and its attachment to the wall. The principal characteristics of the jet, such as the bottom pressure, circulation zone length, and jet path, are determined, and hysteresis phenomena are discussed.

A91-51295 Computation of a transonic airfoil flow considering viscous effects and thin separated regions. V. E. KOVALEV and O. V. KARAS, *La Recherche Aerospaciale* (English Edition) (ISSN 0379-380X), No. 1, 1991, pp. 1–15. 20 Refs.

A direct-inverse method is proposed for computing a laminar or turbulent compressible 3D boundary layer that uses a finite-difference type technique of the predictor-corrector type, according to the Kellerscheme. A method is then presented for calculating a transonic flow around a wing, including viscous effects and thin separated regions, based on semi inverse coupling. Examples of applications are discussed, including cases where the flow separates on the upper surface near the trailing edge, or near the shock root.

A91-45773 Turbulent heat and momentum transfer in boundary layers under strong pressure gradient conditions—Analysis of experimental data and numerical prediction. E. V. SHISHOV, *Experimental Thermal and Fluid Science* (ISSN 0894-1777), Vol. 4, July 1991, pp. 389–398. 19 Refs.

The results of experimental investigation of the structure, including correlations containing pressure fluctuations, and the processes of turbulent transfer of heat and momentum in strongly accelerated and retarded turbulent boundary layers are presented. Based on the analysis of the data obtained, a modified algebraic 'K-epsilon' model, capable of predicting local friction and heat transfer in boundary layers developing under strong positive and negative pressure gradients, is proposed.

A91-34221 Numerical calculation of stationary subsonic gas dynamics problems. IU. I. SHOKIN and G. S. KHAKIMZIANOV, *Proceedings of the 8th GAMM-Conference on Numerical Methods in Fluid Mechanics*, Delft, Netherlands, Sept. 27–29, 1989, (A91-34176 13-34). Wiesbaden, Federal Republic of Germany/Hauppauge, NY, Friedr. Vieweg & Sohn/Bal-len Books, 1990, pp. 513–521. 8 Refs.

The paper concentrates on the algorithm of a numerical solution of the problem of two-dimensional ideal-gas subsonic flows in complex-shape channels with the inlet, outlet, and impermeable parts on the boundary. Two existing approaches are outlined, and a proposed method based on splitting the system of stationary equations of gas dynamics into elliptic and hyperbolic parts is presented. The method is based on an iteration process, every step of which is a successive solution of relatively simple boundary-value problems on an irregular rectangular grid. A case of an arbitrary curvilinear grid covering a flow region is considered.

A91-17023 Hypersonic flow past delta wings with blunted edges (Giperzvukovoe obtekanie treugol'nykh kryl'ev s zatuplennymi kromkami). S. A. GOROKHOV, V. V. EREMIN, and A. M. POLIAKOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.–Oct. 1990, pp. 175–179. 11 Refs.

A method is proposed which makes it possible to calculate hypersonic flow of an ideal gas past delta wings with blunted edges over the aspect ratio range 100–200. Systematic calculations are carried out for delta wings for free-stream Mach 6–20, angles of attack 0–20 deg, and sweeps 60–80 deg, and the results are processed using hypersonic similarity parameters. The results confirm numerically the effect of flow spreading in the plane of symmetry of delta wings with blunted edges.

A91-35787 An approach to the numerical solution of two-dimensional Navier-Stokes equations by a finite difference method (Ob odnom podkhode k chislennomu resheniu dvumernykh uravnenii Nav'e-Stoksa metodom skvoznogo scheta). I. V. EGOROV and O. L. ZAITSEV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 31, Feb. 1991, pp. 286–299. 16 Refs.

A finite difference method based on an implicit second-order conservative scheme is used to obtain a numerical solution for the Navier-Stokes equations. The convective terms of the Navier-Stokes equations are approximated by using a monotonic scheme; the diffusion terms are approximated by using a central difference scheme. The problem of steady-state supersonic flow of a gas past a cylinder is examined as an example.

A91-23776 Determination of relaxation scales in turbulent and quasi-turbulent boundary layers on a plate (Opredelenie relaksatsionnykh mashtabov v turbulentnom i kvaziturbulentnom pogranichnykh sloiakh plastiny). E. P. DYBAN and E. A. FRIDMAN, *Promyshlennaia Teploekhnika* (ISSN 0204-3602), Vol. 12, No. 6, 1990, pp. 17–23. 11 Refs.

A method for calculating turbulent and quasi-turbulent boundary layers is proposed which is based on the numerical solution of a system of equations for the mean flow, which is closed by using an equation of Reynolds stress transfer. Calculations of the velocity profiles and characteristics of turbulent and quasi-turbulent boundary layers on a plate are compared against the available experimental data. The distribution of tangent stresses, upper layer thickness, and distributions of longitudinal and transverse relaxation scales in the turbulent and quasi-turbulent layers are calculated.

A91-21876 A method of developing a computation algorithm for incompressible viscous flows (Ob odnom sposobe postroeniia algoritma rascheta techenii viazkoii neshhimaemol' zhidkosti). D. B. GUROV and T. G. ELIZAROVA, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 30, Nov. 1990, pp. 1719–1727. 10 Refs.

A method is proposed for the regularization of difference schemes for solving Navier-Stokes equations for flows of viscous incompressible fluids. The method is based on the formal generalization of kinetically matched difference schemes that have been previously developed for the calculation of viscous gas flows. The modeling of an isothermal liquid in a plane cavern is examined as an example.

A91-20936 Calculation of three-dimensional compressible boundary layers on slender bodies (Berechnung dreidimensionaler kompressibler Grenzsichten an spitzen Koerpern). V. N. VETLUTSKII and E. KRAUSE, *Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen* (ISSN 0172-3898), No. 30, 1990, pp. 60–63. 10 Refs.

A numerical technique for the characterization of three-dimensional compressible supersonic boundary-layer flows on slender bodies is described. The forebody (assumed to be conical) is analyzed using the similarity method of Veltusky and Ganimedov (1982), and the general solution is obtained using the difference method of Veltusky (1981). The method is applied to smooth bodies with double-ellipse and ogival body cross sections and circular-cone nose sections at freestream Mach numbers 2–4 and angles of attack 4.2–10 deg, incorporating several different mixing-path models for the turbulent boundary layers. Results are expressed in terms of Stanton-number distribution, velocity and temperature profiles, and drag coefficients and compared with published experimental data. Good general agreement is demonstrated; for the turbulent boundary layers, best agreement is obtained using the Baldwin-Lomax (1978) model with $C_{(cp)}$ varied from 3.6 to 1.6.

A91-17170 A version of the method of splitting and implicit implementation of boundary conditions for solving Navier-Stokes equations in curvilinear coordinates (Ob odnom variante metoda rasshchepleniia i neiavnoi realizatsii granichnykh uslovii dlia resheniia uravnenii Nav'e-Stoksa vkrivolineinoi sisteme koordinat). A. S. VOINOVSKII, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 30, Sept. 1990, pp. 1372–1380. 13 Refs.

An approach to the numerical integration of Navier-Stokes equations in curvilinear orthogonal coordinates is presented which is based on a version of an implicit splitting scheme in terms of physical processes and coordinates which has a second order of accuracy with respect to spatial variables and a first order of accuracy with respect to time. For this scheme, an absolutely stable algorithm is proposed for the implicit implementation of the boundary conditions. Results of calculations are presented.

A91-17020 A generalized similarity method in calculations of the internal subregion of a turbulent boundary layer (Metod obobshchennogo podobiiia v raschetakh vnutrennei podoblasti turbulentnogo pogranichnogo sloia). L. G. LOITSIANSKII, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Sept.–Oct. 1990, pp. 25–34. 14 Refs.

An attempt is made to extend to turbulent flows the generalized similarity method, which has been successfully used in the case of laminar flows (Loitsianskii, 1987). A comparison of calculations with experimental results obtained for the internal subregion of a turbulent boundary layer suggests that the generalized similarity method may be applicable to the turbulent boundary layer in the whole.

A91-13548 Using the finite element method in the numerical modeling of convection-diffusion transfer processes in axisymmetric regions (Primenenie metoda konechnykh elementov pri chislennom modelirovanii protsessov konvektivno-diffuzionnogo perenosa v osesimmetrichnykh oblastiakh). A. A. KOCHUBEI, S. E. MEL'NIK, and A. A. RIADNO, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 28, July-Aug. 1990, pp. 742-746. 9 Refs.

An algorithm is proposed for calculating and approximating the unknown functions on triangular elements for solving problems in convection-diffusion transfer in axisymmetric regions. The finite element method is implemented using the control volume principle. It is shown that the allowance for source terms and function approximation on the elements has a stabilizing effect on the solution.

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 (K vozmozhnosti modelirovaniia teplosilovogo vozdeistviia na bokovuiu poverkhnost' tela, obtekaemogo vysokoskorostnym potokom gaza). N. M. GAVRILOVA, N. V. MEDVETSKAIA, and I. 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.

A91-12048 Solution of the problem of axisymmetric gas flow in a turbomachine blade row (Reshenie zadachi ob osesimmetrichnom techenii gaza v ventse turbomashiny). I. S. KOSOLAPOV and E. I. PROTSENKO, *Akademiia Nauk SSSR, Izvestiia, Energetika i Transport* (ISSN 0002-3310), July-Aug. 1990, pp. 105-113. 14 Refs.

Equations describing flow in an infinitely dense cascade with thin blades are reduced to a current function equation. The system of finite difference equations resulting from the approximation of the second-order current function equation are solved in explicit form using the variable direction method. Examples of calculations of subsonic gas flows in the rotor of axial-flow and centrifugal compressors are presented, and the results are compared with experimental data and computation results in the literature.

A91-11967 Properties of difference schemes for solving two-dimensional Navier-Stokes equations associated with boundary conditions prescribed on a solid surface (Osobennosti raznostnykh skhem resheniia dvumernykh uravnenii Nav'e-Stoksa, svyazannye s postanovkoi granichnykh uslovii na tverdoi poverkhnosti). M. N. ZAKHARENKO, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 30, Aug. 1990, pp. 1224-1236. 21 Refs.

Different methods of implementing boundary conditions on a solid surface in the numerical solution of two-dimensional Navier-Stokes equations are examined. In particular, attention is given to an approach whereby the system equations are solved separately. In this case, with two-dimensional Navier-Stokes equations for an incompressible viscous fluid written in velocity-pressure, velocity-vortex, and vortex-current function variables, the method of boundary condition implementation is shown to be algorithmically universal and can be based on a two-parameter formula proposed previously for the approximation of wall vorticity.

A91-11909 A three-dimensional boundary layer on bodies with a slight cross-sectional asymmetry at small angles of attack (Prostranstvennyi pogrannichnyi sloi na telakh s maloi asimmetriiei poperechnogo secheniia pri nebol'shikh uglakh ataki). A. D. KHON'KIN and V. I. SHALAEV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 313, No. 5, 1990, pp. 1067-1071. 9 Refs.

Equations of a three-dimensional boundary layer are analyzed asymptotically in a rigorous manner, including linear (with respect to cross-sectional asymmetry and angles of attack) effects. It is shown that, in this case, the problem is reduced to that of solving a set of two-dimensional problems. Singular solutions are obtained for the equations of flow which are valid in the vicinity of sharp and blunt apices. The results of the study make it possible to significantly simplify the calculation of the boundary layer on the fuselage under cruising flight conditions.

A91-11356 Numerical modeling of nonstationary separated flows of an incompressible fluid on the basis of fifth-order compact approximations (O chislennom modelirovanii nestatsionarnykh otryvnykh techenii neszhimaemoi zhidkosti na osnove kompaktnykh approksimatsii piatogo poriadka). V. A. GARANZHA and A. I. TOLSTYKH, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 312, No. 2, 1990, pp. 311-314. 7 Refs.

Results obtained by using fifth-order compact approximations as the basis of numerical algorithms for modeling separated nonstationary flows of a viscous incompressible fluid are presented. In particular, the approximations have been used to develop a numerical algorithm for Navier-Stokes equations in the variables vortex-flow function. The algorithm has been used for the analysis of flow past a circular cylinder and nonsymmetric periodic regimes of the Karman vortex street type. The advantages of using an implicit rather than an explicit scheme are demonstrated.

A90-49460 Numerical simulation of transonic flow through oscillating and multi-row two-dimensional airfoil cascades. A. B. ARKAD'EV, V. A. VANIN, and S. V. ERSHOV, *Proceedings of the Fifth International Symposium, Unsteady aerodynamics and aeroelasticity of turbomachines and propellers*, Beijing, People's Republic of China, Sept. 18-21, 1989 (A90-49451 22-07). Beijing/Oxford, England and New York, International Academic Publishers/Pergamon Press, 1990, pp. 93-107. 13 Refs.

The problems of aerodynamic interaction of two and three reciprocally moving blade rows, as well as the unsteady flow about isolated oscillating airfoils in cascade are considered. The solution of the problems under review can be achieved through the set of algorithms which have been devised using the numerical integration of Euler equations by Godunov's difference scheme and its high resolution modifications. A computational analysis of turbine and compressor cascades has been made. An effect of flow regime, as well as mode, frequency, amplitude and phase shift of oscillating airfoils on the performance of cascades air damping has been investigated. The analysis of local parameters has enabled to get a deeper insight into the mechanisms of flutter origin. The influence of Strouhal number, ratio of blade-numbers and axial spacing on the unsteady forces has been examined for the aerodynamic interaction of two blade-rows. Effects of wake segments splitting have been achieved numerically as a result of the wake/rotor interaction. In the case of three blade-rows the influence of axial spacing and moving and static cascades blade-numbers ratios on unsteady loads has been in changing the relating tangential stator rows shift.

A90-48248 Calculation of the shock wave structure using high-accuracy hydrodynamics equations (Raschet struktury udarnoi volny s pomoshch'iu uravnenii gidrodinamiki povyshennoi tochnosti). B. V. ALEKSEEV and V. V. POLEV, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 28, May-June 1990, pp. 614-616. 7 Refs.

A novel approach to the analysis of various flow regimes, including those for moderate Knudsen numbers, is proposed which is based on solving hydrodynamics equations obtained in an earlier study (Aleksseev, 1987). The method is demonstrated for the problem of the shock wave structure, which is reduced to a boundary value problem for a system of ordinary differential equations. The method has been implemented in software which can be run on a personal computer.

A90-44922 Numerical modeling of transverse flow past a cylinder using Euler equations (Chislennoe modelirovanie poperechnogo obtekaniiia tsilindra na osnove uravnenii Eйлера). I. M. BELETSKII, P. A. VOINOVICH, I. P. GOLOVACHEV, and E. V. TIMOFEEV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 30, June 1990, pp. 933-940. 12 Refs.

The paper reports results of calculations of transverse nonviscous flow past a circular cylinder made by using a quasi-monotonic TVD scheme. The effect of scheme factors on the results of the numerical solution of Euler equations is investigated for subsonic, transonic, and supersonic velocities. The regimes considered include nonseparated flow, stationary flow with symmetric recirculation regions in the near wake and nonstationary separated flow.

A90-40270 Turbulent gas flow heat transfer and friction in channels of different cross-sections. A. I. LEONT'EV, B. B. PETRIKEVICH, and O. G. VYRODOV, *International Journal of Heat and Mass Transfer* (ISSN 0017-9310), Vol. 33, June 1990, pp. 1047-1055. 11 Refs.

Consideration is given to gas flow in channels of circular, annular and plane cross-sections. A mathematical model is suggested which uses an integral approach for describing momentum and energy transfer in a turbulent boundary layer. It is assumed that dynamic and thermal boundary layers start to develop on the channel walls simultaneously and subsequently converge.

A90-30424 Effect of the formation of vibrationally excited nitrogen molecules on heat transfer during the recombination of atoms in a boundary layer (Vliianie na teploperedachu obrazovaniia kolebatel'no-vozbuzhdennykh molekul azota pri rekombinatsii atomov v pogrannichnom sloe). V. M. DOROSHENKO, N. N. KUDRIAVTSEV, S. S. NOVIKOV, and V. V. SMETANIN, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 28, Jan.-Feb. 1990, pp. 82-89. 15 Refs.

The combined system of boundary layer equations and equations of level-by-level relaxation kinetics of vibrationally excited nitrogen molecules formed during the gas-phase recombination of atoms near a blunt body is solved numerically. It is shown that the consideration of the finite time of relaxation of vibrationally excited nitrogen molecules leads to a significant (up to 30 percent) decrease in the calculated heat flow toward the body surface, which is consistent with experimental data. The distribution of the molecules by the vibrational levels is essentially of the non-Boltzmann kind.

A92-21631 Heat wake of a body (Teplovoi sled obtekaemogo tela). N. I. IAROVSKII, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 55, Nov.-Dec. 1991, pp. 941-948. 11 Refs.

The stationary problem of the heat wake of a body in the path of uniform flow of a viscous incompressible fluid is analyzed using a full heat conduction equation. The solution for the corresponding hydrodynamic problem is assumed to be known. Conditions leading to the shape memory effect in the turbulent thermal wake are determined, and some applications are examined.

A90-39515 A self-similar solution to boundary layer equations (Ob odnom avtomodel'nom reshenii uravnenii pogranichnogo sloia). G. I. BURDE, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.–Apr. 1990, pp. 71–75. 7 Refs.

The Falkner-Skan equation and its analog for axisymmetric boundary layers formed on thin bodies of revolution in longitudinal flow are examined. In particular, a case is considered in which the Falkner-Skan equation and its axisymmetric analog can be solved in closed form.

A91-37195 A rapidly converging method for solving Euler equations (Bystroshkodiashchiisa metod resheniia uravnenii Eilera). I. L. SOFRONOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 31, April 1991, pp. 575–591. 13 Refs.

A new method is proposed for improving the convergence of numerical schemes for solving problems of steady state nonviscous flow. A two-dimensional Lax-Wendroff difference scheme and its modification, corresponding to the proposed method, are developed. Test problems are solved for different flow regimes.

A91-17179 Increasing the stability of a counterflow implicit scheme with three-point scalar factorization for the Euler equation (Povyshenie ustoychivosti protivopotochnoi neiavnoi skhemy s trekhtochechnymi skaliarnymi progonomkami dlia uravnenii Eilera). V. E. KOZLOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 30, Oct. 1990, pp. 1596–1599. 7 Refs.

A method is proposed whereby the stability of calculations in counterflow implicit schemes with three-point factorization is improved by modifying the calculation steps that involve the consideration of the local directions of perturbation propagation. The modification proposed here does not lead to an increase in the required memory and in the number of arithmetic operations per one time step. A calculation example is presented.

A90-39519 The problem of supersonic flow past a thin wing of finite span with fully subsonic leading edges (K zadache obtekania sverkhzvukovym potokom tonkogo kryla konechnogo razmakha s polnost'iu dozvukovymi perednimi kromkami). N. F. VOROB'EV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (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.

A90-37816 The use of contact transformations of the inhomogeneous Monge-Ampere equation in one-dimensional gas dynamics (Primenenie kontaktnykh preobrazovaniy neodnorodnogo uravneniia Monzha-Ampera v odnomernoi gazodinamike). S. V. KHABIROV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 310, No. 2, 1990, pp. 333–336. 6 Refs.

An approach to solving equations of one-dimensional gas dynamics is proposed which provides an alternative to the use of Euler and Lagrange coordinates. The approach uses Martin's substitution, which leads to the inhomogeneous Monge-Ampere equation. In this case, there are equations of state for which the contact symmetries of the equation form an infinite pseudogroup. The approach makes it possible to obtain solutions that are dependent on arbitrary functions and to write an infinite number of new conservation laws.

A90-42992 New solutions for two-dimensional stationary Euler equations (Novye resheniia dvumernykh statsionarnykh uravnenii Eilera). O. V. KAPTSOV, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 54, May–June 1990, pp. 409–415. 10 Refs.

A generalized variable separation method is used to obtain new particular solutions for the current function describing two-dimensional stationary motions of an ideal fluid. Flow line patterns are presented. The proof of the stability of some of the solutions is based on Arnold's (1966) theorem.

A91-55252 Discontinuous flow past a step whose height is much greater than the thickness of the lower sublayer of the interaction region (Otryvnoe obtekanie ustupa, vysota kotorogo mnogo bol'she tolshchiny nizhnego podsloia oblasti vzaimodeistviia). S. I. CHERNYSHENKO, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), July–Aug. 1991, pp. 25–30. 8 Refs.

Flow past a small step is investigated analytically in the context of the theory of boundary layer interaction with supersonic flow. The height of the step is assumed to be much greater than the lower sublayer thickness but much less than the boundary layer thickness. It is shown that such a flow can be calculated with sufficient accuracy using the Batchelor model.

A91-15434 Velocity calculation in the discrete vortex method (O vychislenii skorostei v metode diskretnykh vikhrei). I. K. LIFANOV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 313, No. 6, 1990, pp. 1399–1402.

The mathematical aspects of the calculation of velocities at the sites of discrete vortices in the discrete vortex method are examined. In particular, it is shown that the use of the discrete radius alone in the calculation of the tangential component produces an error when a free discrete vortex (or the point at which the velocity is calculated) is located very close to the vortex layer location curve relative to the discrete step. A model is proposed for the construction of vortex sheets of free vortices shed by an airfoil using the discrete vortex method.

A90-39514 Boundary layer stability in the case of transonic external flow (Ob ustoychivosti pogranichnogo sloia pri tranzvukovykh skorostiakh vneshnego potoka). O. S. RYZHOV and I. V. SAVENKOV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Mar.–Apr. 1990, pp. 65–71. 15 Refs.

The classical theory of free interaction predicts the stability of direct waves propagating in the incoming flow direction in the case of supersonic flow velocities. The available equations for the transonic range, however, are not applicable to stability problems for viscous flows, although they do predict correctly flow separation. Here, an additional analysis of the initial system of Navier-Stokes equations is carried out in order to preserve the terms determining the loss of boundary layer stability in the transonic region.

A90-34672 A numerical method for calculating supersonic flows of a viscous gas (Chislennyi metod rascheta sverkhzvukovykh techenii viazkoogo 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.

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A92-12423 A numerical simulation of separated flows around bodies. SHIGERU ASO and ATSUHIRO SAKAMOTO, *Kyushu University, Technology Reports* (ISSN 0023-2718), Vol. 64, Aug. 1991, pp. 249–255. 12 Refs.

Dynamic stall phenomena have been investigated numerically by solving incompressible Navier-Stokes equations by a third-order upwind-scheme in order to reveal the flow structure and mechanism of dynamic stall. At first, in order to examine the validity of the calculations separated flows around circular cylinder are calculated. The results show excellent agreements with the experiments. Also, separated flows around a wing section at fixed attack angle are calculated and the results show excellent agreements with experiments which are conducted by the present authors. Finally, separated flows around oscillating airfoil in pitch are calculated by using moving mesh system. The flow conditions are selected from the experiments. The calculated separated region is small in pitching-up process and it becomes large in a pitching-down process. Quite different characteristics of flow patterns between a pitching-up and pitching-down processes are obtained.

A92-11701 Numerical simulations of axisymmetric accretion flows. HIROSHI KOIDE, TAKUYA MATSUDA, and EIJI SHIMA, *Royal Astronomical Society, Monthly Notices* (ISSN 0035-8711), Vol. 252, Oct. 15, 1991, pp. 473–481. 25 Refs.

Properties of axisymmetric accretion flow on to a gravitating compact object from a uniform flow are studied by performing pure hydrodynamic calculations. At first a comparison is made between a numerical solution and an analytic solution based on a ballistic orbit theory, and it is found that the analytic solution is an extremely good approximation even for Mach numbers as low as 1.4. Next, results are presented for Mach numbers of 0.6, 1.4, 2.4, 5, and 10, and for a ratio of specific heats of 5/3. The accretion rate, the stand-off distance of the bow shock, and the stagnation point on the rear axis are computed based on various boundary conditions. An empirical formula for the accretion rate is proposed. It is found that the flow is not completely in steady state but a dome-like shock is formed quasi-periodically in front of the compact object for higher Mach number cases. It is argued that this shock perturbs the flow, leading to the destruction of axisymmetry of the flow eventually.