Soviet and Japanese Aerospace Literature

Throughout 1991 the *AIAA Journal* will carry selected abstracts on leading research topics from the Soviet aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Computational Fluid Dynamics from the USSR and Japan.

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Soviet Aerospace Literature This month: *Computational Fluid Dynamics*

A91-27365 Numerical prediction of turbulent flow in centrifugal compressor stage. K. P. SELEZNEV, Y. I. BIBA, B. N. SAVIN, and A. M. SIMONOV, *Archiwum Mechaniki Stosowanej* (ISSN 0373-2029), Vol. 41, No. 5, 1989, pp. 735–746. 9 Refs.

The calculation procedure of centrifugal compressor internal flow and losses based on the quasi-three-dimensional turbulent model is considered. The procedure includes the prediction of hub-to-shroud and blade-toblade flows with tip-clearance flow, surface curvature, rotation and secondary flows being taken into account. A comparison of calculated results with experimental data is presented. Satisfactory agreement of local and energy parameters is achieved.

A91-24484 Convergence acceleration and wave drag determination in transonic airfoil calculations. S. V. LIAPUNOV, *Proceedings of the 17th ICAS, Congress,* Stockholm, Sweden, Sept. 9–14, 1990, Vol. 2 (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.

A91-17179 Increasing the stability of a counterflow implicit scheme with three-point scalar factorization for the Euler equation (Povyshenie ustoichivosti protivopotochnoi neiavnoi skhemy s trekhtochechnymi skaliarnymi progonkami 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.

A91-17104 Numerical modeling of viscous effects in the analysis of three-dimensional flow in turbomachine cascades (Chislennoe modelirovanie effektov viazkosti pri raschete prostranstvennogo techeniia v reshetkakh turbomashin). M. L. UGRIUMOV and IU. A. SKOB, *Samoletostroenie—Tekhnika Vozdushnogo Flota* (ISSN 0581-4634), No. 56, 1989, pp. 20–25. 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 calculation 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.

A91-13548 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.

A90-25756 Numerical simulation of the unsteady separated fluid flows in wide range of Reynolds numbers. V. A. GUSHCHIN and V. N. KONSHIN, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 257–262. 15 Refs.

A hybrid finite-difference scheme possessing second-order accuracy, minimal scheme dissipation, and applicability over a wide range of Reynolds numbers is used in the present treatment of the flow about a cylinder. The critical total drag coefficient and rapid increase in Stouhal number are numerically simulated for critical Reynolds numbers in the vicinity of 400,000. The present calculations, which are based on the modeling of the large-scale vortex structures that arise from the unsteady separated flows around finite bodies, are also applicable to the simulation of transitional fluid flows.

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, sviazannye s postanovkoi granichnykh uslovii natverdoi poverkhnosti). M. N. ZAKHARENKOV, *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.

A91-11356 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 multirow 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, ampliude 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.

A90-44922 Numerical modeling of transverse flow past a cylinder using Euler equations (Chislennoe modelirovanie poperechnogo obtekaniia tsilindra na osnove uravnenii Eilera). IU. M. BELETSKII, P. A. VOINOVICH, IU. 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.

A89-38443 Numerical modeling of gasdynamic flow in a cylindrical chamber generated by a high-power heat source (Chislennoe modelirovanie gazodinamicheskogo techeniia v tsilindricheskoi kamere, voznikaiushchego pod deistviem moshchnogo istochnika teplovydeleniia). B. V. ALEKSEEV, G. V. NESTEROV, and S. A. USTIUGOV, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 27, Mar.–Apr. 1989, pp. 287–291. 19 Refs.

The restructuring of the gasdynamic front in a closed cylindrical chamber under the effect of a high-power near-axial continuous heat source is modeled numerically for the case of two-dimensional axisymmetric nonstationary flow in a gravitational field. The gasdynamic equations are solved by using Godunov's finite element scheme, assuming an optically transparent medium. The process is shown to consist of several stages, including a sharp rise in pressure in the heat release zone, free expansion in the heated region, nonlinear wave interaction, and transition to the quasi-stationary state.

A90-37816 The use of contact transformations of the inhomogeneous Monge Ampere equation in one-dimensional gas dynamics (Primenenie kontaktnykh preobrazovanii 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 Monger-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.

A90-37190 Advancement of the method of direct numerical solving of the Boltzmann equation. F. G. CHEREMISIN, *Technical Papers of the 16th International Symposium, Rarefied gas dynamics: Theoretical and computational techniques,* Pasadena, CA, July 10-16, 1988, (A90-37169 16-77). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1989, pp. 343–358. 12 Refs.

Progress in the development and applications of the direct numerical method for solving the fundamental kinetic equation for gases is reviewed. The results of investigations aimed at the improvement of the computational efficiency of the method are discussed, with emphasis on such gas flow parameters as small Knudsen numbers, changes in density or concentration among components of gas mixtures, and high Mach numbers. The interpretation of numerical algorithms considered indicates their relation with the direct simulation method as well as with a discrete velocities approach. It is shown that the numerical algorithms of the proposed approach could be considered as a realization of a discrete model for rarefied gas composed of 'phase particles' of finite sizes.

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

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

A90-29181 Effect of a jet on transonic flow past an airfoil (Vliianie strui na okolozvukovoe obtekanie profilia). N. B. VORONTSOVA and S. V. LIAPUNOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 3, 1989, pp. 1–9. 6 Refs.

A method is proposed for calculating transonic flow of a jet past an airfoil. The method involves using the relaxation method to calculate the jet and external flows, which are characterized by different Mach numbers, and then splicing the solutions by means of successive approximations. Difference grids in these regions are constructed using the conformal mapping method. Examples of calculations are presented.

A90-28980 Numerical solution of the problem of supersonic flow of an ideal gas past a trapezoidal wedge (Chislennoe reshenie zadachi obtekaniia trapetsievidnogo klina sverkhzvukovym potokom ideal'nogo gaza). S. M. BOSNIAKOV, V. V. KOVALENKO, S. V. MIKHAILOV, and N. KH. REMEEV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 1, 1989, pp. 29–39. 17 Refs.

The problem of supersonic flow of an ideal gas past a trapezoidal wedge is solved using a first-order finite difference scheme. The results are compared with results obtained by using a second-order scheme and experimental data. It is shown that the first-order scheme makes it possible to calculate the integral flow characteristics to within 1.5-2 percent, which is sufficient for practical applications.

A90-25791 The problem on small local Knudsen numbers in computational rarefied gas dynamics. EVGENII SHAKHOV, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 519–524. 5 Refs.

The two-dimensional problem of stagnation point flow over a blunt body is considered. The role of the nonlinear Knudsen layer is analyzed. Methods of treating flows with small local Knudsen numbers are discussed.

A89-38437 Nonstationary supersonic flow past a body (O nestatsionarnom sverkhzvukovom obtekanii tela). V. I. BOGATKO and G. A. KOLTON, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), Jan. 1989, pp. 104–106. 6 Refs.

A computational model based on a modified coarse-particle method is applied to the analysis of the restructuring of supersonic flow past bodies of revolution with a front separation zone at a small angle of attack. Details of the numerical solution are presented for a circular cylinder and an axisymmetric disk-cylinder configuration in the path of supersonic flow at a small angle of attack.

A90-25855 Use of Euler and Navier-Stokes models for simulation of largescale vortex structures in jet and near wakes. A. V. BABAKOV, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 944–949. 7 Refs.

One of the most important problems in computational aerodynamics is the investigation of steady and unsteady gas flows at subsonic and transonic regimes. Here, the simulation of viscous gas flows near a cylinder and of unsteady vortex structures in near wake and jet are discussed. The resulting large-scale structures are shown and described.

A90-25763 The third order compact approximation in algorithms for incompressible flows. A. I. TOLSTYKH, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 311–316. 7 Refs.

A third-order-accurate compact upwind differencing scheme designated 'CUD-3', which has been developed for the approximation of connective terms, is presently applied in different forms of hydrodynamic equations. Its 'CUD-5' extention is also presented. It is shown that there is no limitation on cell Reynolds number with CUD-3. Illustrative applications of the method are in the computation of vorticity isolines at successive moments in a Prandtl vortex-pair problem, and in the unsteady viscous flow about a circular cylinder.

A90-25755 Numerical simulation of turbulent flows in channels andpipes—Methods, results, and prospects. B. L. ROZHDESTVENSKII, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 251–256. 10 Refs.

An evaluation is made of the development status of methods for the treatment of turbulent flows in channels and pipes by means of the direct numerical integration of the Navier-Stokes equations. Attention is given to the dependence of three-dimensional turbulence simulation on the periods X and Y, as the values of these variables approach infinity. The choice of the appropriate time-step and time of integration is noted to be of great importance; the time-step choice is often controlled by reproduction in numerical results of the growth (or damping) rate of some eigenfunctions of the Orr-Sommerfeld equation.

A90-25745 Numerical algorithms of solving the Navier-Stokes equations of a compressible gas. V. M. KOVENIA, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 189–196. 28 Refs.

The construction of efficient numerical algorithms for compressible gas behavior has led to the development of concepts of geometrical and analytical splitting which permit the construction of algorithms for different classes of problems in a way which proceeds from the unified positions. In the construction of difference schemes for the solution of aerodynamics problems, a further splitting has been devised in which each one-dimensional problem is represented in the form of the sum total of problems describing the elementary processes of convective transfer, pressure effects, and dissipative effects.

A90-25743 Direct numerical modelling of free induced shear layer turbulence. OLEG M. BELOTSERKOVSKII, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 177–182. 6 Refs.

A scheme is formulated for the organization of the computational process in a direct numerical simulation of wake flows with free induced-shear turbulence. The present consideration of this overall scheme is split into two related problems: (1) the calculation of the nonstationary motion of ordered and large-scale turbulent structures, and (2) the numerical simulation of the stochastic component of a turbulent shear flow (small-scale turbulence). Computations using the smoothed equations with the present dissipative mechanism are conducted over time spans sufficiently long to reach the formation of stable ordered structures.

A90-25724 About solving the PNS equations by marching method. V. V. RUSANOV, O. N. BELOVA, and V. A. KARLIN, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 34–39. 5 Refs.

The axisymmetric viscous supersonic flow on the midbody of a blunt vehicle is investigated analytically, solving the parabolized Navier-Stokes equations with the marching scheme described by Belova and Karlin (1988) and Rusanov et al. (1988). The derivation for the simple initial-value problem (IVP) is outlined; the close correspondence of the IVP solution and that of the corresponding boundary-value problem is pointed out; and numerical results for the case of a hemisphere-cylinder body are presented in graphs. Good agreement with the full Navier-Stokes solutions is demonstrated.

A90-25729 Flow about a spherically blunted body in supersonic wake. IU. P. GOLOVACHEV, *ISCFD Nagoya 1989—Technical Papers of the 3rd International Symposium on Computational Fluid Dynamics,* Nagoya, Japan, Aug. 28–31, 1989, (A90-25720 10-34). Nagoya, Japan, Japan Society of Computational Fluid Dynamics, 1989, pp. 74–79. 7 Refs.

Stationary flows past the nose of a spherically blunted body in the supersonic wake-type nonuniform stream are investigated. Numerical solutions of Navier-Stokes equations at Reynolds number 100-5000 are presented. The solutions are obtained by means of the time-asymptotic technique with implicit constant-direction finite-difference schemes. The validity of reduced Navier-Stokes and Euler equations for the flows under study is discussed.

A90-19236 Numerical modeling of a viscous separated flow in the near wake (Chislennoe modelirovanie viazkogo otryvnogo techeniia v blizhnem slede). V. M. KOVENIA and A. S. LEBEDEV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Sept.–Oct. 1989, pp. 53–59. 20 Refs.

Laminar flow in the near wake of a blunt body of small aspect ratio is analyzed. The geometrical characteristics of the wake, relative base pressure, and its contribution to the integral body drag are determined as a function of the Mach and Reynolds numbers of the incoming flow. Examples are presented which illustrate the effect of the body shape and its surface heat characteristics on the base pressure. For certain parameters of the incoming flow, the formation of small-scale vortices near the separation point is shown to be possible; a local supersonic zone may be formed at the axis of symmetry in the reverse flow.

A90-15623 Compact third-order approximations in algorithms for incompressible fluids (Kompaktnye approksimatsii tret'ego poriadka v algoritmakh dlia neszhimaemoi zhidkosti). A. I. TOLSTYKH, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, Oct. 1989, pp. 1514–1529. 20 Refs.

Difference algorithms for the numerical modeling of flows of incompressible fluids are described which use compact third-order approximations for different forms of incompressible fluid equations. In particular, attention is given to algorithms for vortex-current function variables; implicit methods with pressure correction for velocity-pressure variables; schemes based on the artificial compressibility method; and marching algorithms.

A89-54536 Demonstration of a scheme for the direct modeling of rarefied gas flows (K obosnovaniiu skhemy priamogo modelirovaniia techenii razrezhennykh gazov). V. V. NEKRUTKIN and N. I. TUR, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, Sept. 1989, pp. 1380–1392. 23 Refs.

The validity of a chaos propagation hypothesis is proved for a generalized version of the regularized inhomogeneous Boltzmann equation with boundary conditions of the reflection type and an interaction law corresponding to a pseudo-Maxwellian gas (in the case of power law potentials). The root mean square convergence rate and the bias are evaluated for Monte Carlo estimates of the linear functional of the solution to the Boltzmann equation.

A89-52854 Numerical analysis of nonstationary self-similar problems for a boundary layer with a separation zone (Chislennoe issledovanie nestatsionarnykh avtomodel'nykh zadach pogranichnogo sloia s zonoi otryva). A. IU. DEM'IANOV, IU. A. DEM'IANOV, and SH. A. KASYMOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, July 1989, pp. 1093–1098. 17 Refs.

An efficient numerical method is proposed for solving self-similar nonstationary boundary layer problems, including problems for boundary layers with separation zones. The method is used to carryout a systematic study of a boundary layer on a plate (including flows with back currents) moving in a quiescent medium in accordance with a power law with respect to time.

A89-49205 A study of nonstationary loads during the accelerated and abrupt motion of bodies of various shapes (Issledovanie nestatsionarnykh nagruzok pri uskorennom i vnezapnom dvizhenii tel razlichnoi formy). V. V. PODLUBNYI and A. S. FONAREV, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May–June 1989, pp. 83–88. 21 Refs.

The system of divergent Navier-Stokes equations for curvilinear coordinate systems is solved using a steady implicit high-accuracy Godunov difference scheme. A procedure involving the breakdown of arbitrary discontinuity and piecewise-parabolic parameter distribution over cells of the difference grid, which satisfies the monotonicity conditions, serves as the basis of the scheme.

A89-45353 Computational models in plasma dynamics. K. V. BRUSHLINSKY, *Proceedings of the 11th International Conference on Numerical Methods in Fluid Dynamics,* Williamsburg, VA, June 27–July 1, 1988, (A89-45351 19-34). Berlin and New York, Springer-Verlag, 1989, pp. 21–30. 25 Refs.

The application of CFD techniques to the physics of dense plasmas is considered in an analytical review, with an emphasis on recent Soviet research. Particular attention is given to the derivations of the model equations for plasma flows in different magnetic-field configurations, simulating astrophysical and laboratory plasmas. Typical numerical results are presented in graphs and discussed in detail.

A89-45418 Accuracy of the marching method for parabolized Navier-Stokes equations. V. V. RUSANOV, O. N. BELOVA, and V. A. KARLIN, *Proceedings of the 11th International Conference on Numerical Methods in Fluid Dynamics,* Williamsburg, VA, June 27–July 1, 1988, (A89-45351 19-34). Berlin and New York, Springer-Verlag, 1989, pp. 512–517. 7 Refs.

The accuracy of viscous flow computations in the mixed steady parabolized Navier-Stokes (PNS) problem is studied, and the results are presented. The mixed steady PNS problem corresponding to a supersonic two-dimensional flow problem is formulated, and the effects of upstream propagation of perturbations and its regularization on the accuracy of the numerical solution is examined in detail.

A89-42561 Quasi-one-dimensional approximation in two-dimensional problems of gas dynamics (Kvaziodnomernoe priblizhenie v dvumernykh zadachakh gazovoi dinamiki). I. S. MEN'SHOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Mar.–Apr. 1989, pp. 136–143. 9 Refs.

The possibility of extending the quasi-one-dimensional approach to the analysis of two-dimensional gasdynamic processes is investigated. The quasi-one-dimensional model proposed here is applied to several problems in gas dynamics, including flow past a cone, flow past a blunt body, and jet flows. The results obtained are compared with solutions to the corresponding two-dimensional problems.

A89-42519 Calculation of stationary subsonic and transonic nonpotential flows of an ideal gas in axisymmetric channels (Raschet statsionarnykh do- i transzvukovykh nepotentsial'nykh techenii ideal'nogo gaza v osesimmetrichnykh kanalakh). IU. S. KOSOLAPOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, May 1989, pp. 765–774. 11 Refs.

A generalization of a method for calculating stationary subsonic and transonic nonpotential flows of an ideal gas is proposed. The method is based on the numerical solution of a current function equation written in arbitrary coordinates. To determine density in transonic flow calculations, a marching procedure is proposed for solving one of the Euler equation projections. Results of calculations are presented.

A89-38420 Properties of the solvability of the unsteady Euler equations in terms of H, psi (Svoistva razreshimosti nestatsionarnykh uravnenii Eilera v terminakh H, psi). V. M. SOLOPENKO, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 305, No. 3, 1989, pp. 567–570. 6 Refs.

An analysis is made of the solvability properties of the Euler equations in terms of H (total pressure head), psi (stream function), which are the main physically measurable quantities of the flow problem considered. A nonlinear operator equation of the first kind is derived whose solvabilty in the case of arbitrary initial data requires additional smoothness conditions.

A89-35450 A method for calculating potential transonic flows in turbomachinery cascades (Metod rascheta potentsial'nykh transzvukovykh techenii v reshetkakh turbomashin). P. M. BYVAL'TSEV and M. IA. IVANOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, March 1989, pp. 447–459. 25 Refs.

A fast method has been developed for calculating stationary subsonic, transonic, and supersonic potential flows in plane cascades and in cascades located on a rotation surface in a variable-thickness layer. The method implements a version of the approximate factorization method which retains second-order accuracy in the supersonic regions of the flow. The method is based on the numerical integration of the complete equation for the velocity potential written in divergent form in arbitrary curvilinear coordinates. The advantages of this approach over the commonly used versions of the approach that uses the method of artificial compressibility in the supersonic regions are demonstrated.

A89-34043 Energy dissipation rate for a viscous fluid with a tangential stress condition at the boundary flow line (Skorost' dissipatsii energii viazkoi zhidkosti s usloviem dlia kasatel'nogo napriazheniia na granichnoi linii toka). A. G. PETROV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 304, No. 5, 1989, pp. 1082–1086. 8 Refs.

The Helmholtz theorem yields an exact lower bound on the dissipation rate of flow for fluids of different viscosities with the same velocity at the boundary. It is shown here that, for the same tangential stress at the boundary, it is possible to obtain an exact upper bound on the dissipation rate for fluids of different viscosities. A proof for the corresponding theorem is presented, and flow of a viscous fluid inside a spherical drop in the path of viscous gas flow is considered as an example.

A89-32281 Entry of a free expanding gas jet into a round opening in a transverse obstacle (Vkhod svobodno rasshiriaiushcheisia gazovoi strui v krugovoe otverstie v poperechnoi pregrade). A. M. BISHAEV, E. F. LIMAR, S. P. POPOV, and E. M. SHAKHOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, Feb. 1989, pp. 277–285. 6 Refs.

Results of a numerical solution are presented for an axisymmetric problem concerning the impingement of a free expanding jet of a monoatomic gas on a plane transverse obstacle separating the gas jet from a vacuum and having a circular opening at the jet axis. The obstacle may be either infinitely thin or have a finite thickness. The problem is solved on the basis of Euler equations and a model kinetic equation. In the limit of a continuum, a steady oscillation regime is observed for moderate distances between the obstacle and the nozzle exit section.

A89-30108 Vortex generation in computational aerodynamics (O vikhreobrazovanii v vychislitel'noi aerodinamike). A. A. GLADKOV, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 29, Jan. 1989, pp. 135–137. 14 Refs.

Three implicit difference schemes of splitting type are used to calculate the unsteady flows of a viscous heat-conducting gas with highly inhomogeneous regions (boundary layer, shock wave, or mixing zone). A numerical solution is obtained to the problem of an arbitrary discontinuity near a limiting plane. The results obtained demonstrate the effectiveness of the proposed approach.

A89-40501 Numerical modeling of separated flows near the boundaries (Chisel'ne modeliuvannia vidrivnikh techii poblizu granits' potoku). I. M. GORBAN', V. O. GORBAN', and M. V. SALTANOV, *Akademiia Nauk Ukrains'koi RSR, Dopovidi, Seriia A—FizikoMatematichni ta Tekhnichni Nauki* (ISSN 0002-3531), Feb. 1989, pp. 26–30. In Ukrainian. 7 Refs.

A numerical algorithm for modeling separated flows near the boundaries is proposed which combines the discrete-vortex approach with the conformal mapping method. The problem of the formation of a separation zone in flow past a step is analyzed, and the importance of considering vorticity dissipation is demonstrated. Results of calculations of vortex bunch formation in the case of a jet issuing into transverse flow are presented. It is shown that the parameters of vortex structures formed at the jet boundary are significantly affected by small jet flow rate fluctuations.

A89-35495 Potential models of transonic flows (O potentsial'nykh modeliakh transzvukovykh techenii). IU. B. LIFSHITS and A. A. SHAGAEV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 304, No. 6, 1989, pp. 1315–1319. 6 Refs.

The paper considers the development of potential models for transonic flows, where the Zhukovskii-Chaplygin condition guarantees uniqueness of the solution. The proposed method is used to calculate transonic flow past wing profiles. In particular, the pressure-coefficient distribution is shown for the NACA 0012 profile at a freestream Mach number of 0.8 and an angle of attack of 1.25 deg.

Japanese Aerospace Literature
This month: *Computational Fluid Dynamics*

A91-28830 An upwind finite element scheme for high-Reynolds-number flows. MASAHISA TABATA and SHOICHI FUJIMA, *International Journal for Numerical Methods in Fluids* (ISSN 0271-2091), Vol. 12, Feb. 20, 1991, pp. 305–322. 28 Refs.

A new upwind finite element scheme for the incompressible Navier-Stokes equations at high Reynolds number is presented. The idea of the upwind technique is based on the choice of upwind and downwind points. This scheme can approximate the convection term to third-order accuracy when these points are located at suitable positions. From the practical viewpoint of computation, the algorithm of the pressure Poisson equation procedure is adopted in the framework of the finite element method. Numerical results of flow problems in a cavity and past a circular cylinder show excellent dependence of the solutions on the Reynolds number. The influence of rounding errors causing Karman vortex shedding is also discussed in the latter problem.

A91-24729 A Chebyshev collocation method for the compressible Navier-Stokes equations in generalized coordinates. JIAN PING WANG, YOSHIAKI NAKAMURA, and MICHIRU YASUHARA, *Japan Society for Aeronautical and Space Sciences, Transactions* (ISSN 0549-3811), Vol. 33, Nov. 1990, pp. 120–134. 13 Refs.

A new Chebyshev spectral collocation scheme was developed for the compressible Navier-Stokes equations transformed from the Cartesian coordinates to generalized ones. Both the spatial derivatives of variables and the metrics of coordinate transformation were calculated by the spectral collocation method (SCM). An explicit integration scheme was used for time-marching. The supersonic flow around a two-dimensional cylinder was solved as a test problem. Comparisons between the SCM code and a finite difference method code showed the superiority of the SCM in accuracy, though more CPU time was needed. Good agreement was also obtained between the numerical results and the experimental data.