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Russian and Japanese Aerospace Literature

During 1996 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 Transonic Flows from Russia and Transonic Flows from Japan.

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Russian Aerospace Literature This month: *Transonic Flows*

A96-24297 Numerical simulation of transonic flow around a wing airfoil in a wind tunnel (Chislennoe modelirovanie transzvukovogo obtekaniya profilya kryla v aehrodinamicheskoj trube). S. A. VELICHKO, Y. B. LIFSHITS, V. M. NEJLAND, I. A. SOLNTSEV, and A. M. SOROKIN, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 35, No. 10, 1995, pp. 1518–1537. In Russian. 23 Refs. Documents available from Aeroplus Dispatch.

A method is developed for the numerical simulation of transonic flow of a viscous gas around an airfoil in the test section of a wind tunnel. The effect of viscosity is taken into account only in the boundary layer on the airfoil and in its wake, with potential flow assumed elsewhere. The solutions in the two regions are matched in the context of viscous-inviscid interaction. The inlet and outlet conditions for the test section, which would ensure the existence and uniqueness of a solution to the boundary value problem are discussed. The boundary value problem is solved numerically using the WINTUN program, specially developed for this purpose. At each iteration, the viscous-inviscid interaction problem in the internal region is solved by using the AIRFOIL code, developed previously for the numerical simulation of infinite flow of a viscous gas around an airfoil.

A96-20199 Nonclassical boundary value problem for a three-dimensional viscous transonic equation (Neklassicheskaya kraevaya zadacha dlya prostranstvennogo vyazkogo transzvukovogo uravneniya). Y. V. ZASORIN, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 35, Vo. 9, 1995, pp. 1401–1419. In Russian. 13 Refs. Documents available from Aeroplus Dispatch.

For a three-dimensional viscous transonic equation, a nonclassical boundary value problem is analyzed which has a system of boundary conditions of a special kind on a one-dimensional manifold. The solution is obtained in the form of a functional series of a special kind. The convergence of the series is investigated, and the solvability of the problem in a space of analytical functionals is proved.

A96-17938 An efficient method for calculating the wave drag of bodies of revolution in the transonic velocity range (Ehffektivnyj metod rascheta volnovogo soprotivleniya tel vrashcheniya v transzvukovom diapazone skorostej). M. A. NAJDA and A. S. FONAREV (TsAGI, Zhukovsky, Russia), *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 36, No. 3, 1995, pp. 60–68. In Russian. 13 Refs. Documents available from Aeroplus Dispatch.

An expression is obtained for the wave drag of bodies of revolution in stationary transonic flow, and an algorithm for computing transonic flow past bodies of revolution is developed, which represents an axisymmetric analog of the variable direction method with a monotone algorithm. Results of numerical calculations of the wave drag of several bodies of revolution are compared with experimental data. The drag of a complex three-dimensional flight vehicle configuration in the transonic velocity range is determined numerically using the transonic equivalence rule.

A95-45141 Shock wave formation in transonic flow with a local supersonic region (Formirovanie udarnykh voln v transzvukovom techenii s mestnoj sverkhzvukovoj oblast'yu). A. G. KUZ'MIN, *Sankt-Peterburgskij Universitet, Vestnik, Seriya 1—Matematika, Mekhanika, Astronomiya* (ISSN 0024-0850), No. 3, 1994, pp. 75–80. In Russian. 9 Refs. Documents available from Aeroplus Dispatch.

The paper is concerned with plane nonviscous flow of a gas in a channel with parallel walls and a small projection on the lower wall simulating an airfoil. The formation of shock waves is investigated numerically in the case of uniform deviations of the airfoil from the shock-free configuration over the entire supersonic region of its surface; the qualitative flow patterns are determined as a function of the deviation. The direct problem of flow over an airfoil of specified shape is solved via the decomposition of the region considered into subsonic and supersonic subregions using a fine grid, which makes it possible to identify the fine flow structure.

A95-39038 Investigation of transonic flow past thin bodies of 3-D configuration by a bounded gas flow (Issledovanie okolozvukovogo obtekaniya tonkikh tel prostranstvennoj konfiguratsii ogranichennym potokom gaza). K. G. SAYADYAN, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 2, 1995, pp. 149–158. In Russian. 5 Refs. Documents available from Aeroplus Dispatch.

A simultaneous solution of boundary value problems for the near and far flow fields is used to obtain the pressure coefficient distributions for the flow past a 'Khotol' type aircraft by a bounded gas stream for various transonic regimes in a pipe with a perforated throat. These distributions are compared with the pressure coefficient distribution in the case of unbounded flow past a body. An additional pressure coefficient induced by the walls is calculated for the subsonic flow past the aircraft in a large-radius cylindral pipe. Good agreement is found between the calculations and Malmuth's asymptotic theory for subsonic velocities.

A95-28384 Experimental studies of fluctuations structure in compressible flows. V. A. LEBIGA and V. N. ZINOV'EV (Russian Academy of Sciences, Inst. of Theoretical and Applied Mechanics, Novosibirsk, Russia), *PICAST'1 1993—Pacific International Conference on Aerospace Science and Technology*, National Cheng Kung Univ., Tainan, Taiwan, 1993, Proceedings. Vol. 2 (A95-28244 07-99), Tainan, Taiwan, National Cheng Kung Univ., 1993, pp. 988–995. 21 Refs. Documents available from Aeroplus Dispatch.

Some results of investigations of nonstationary processes in compressible flows (both subsonic and supersonic) carried out in the Institute of Theoretical and Applied Mechanics of the Siberian Division of the Russian Academy of Sciences are presented. Measurements of turbulent fluctuations behind nozzles of different types (Laval, screen, ventilated, etc.) in subsonic and supersonic flows are discussed. Examples of fluctuation measurements in boundary layers at supersonic velocities are given. A new approach to the interpretation of acoustic fluctuation measurements based on a mode diagram method has been used to study hot-wire data on the intensity, spectra, and mode composition of fluctuations in transonic flows in channels with different types of walls (rigid, perforated, slotted, with jets along the walls, etc.) for different typical sources of fluctuations. New information about the structure and sources of disturbances in test sections of wind tunnels is adduced. (Author)

A95-26229 AEROFOIL—A computer codes library for numerical analysis of viscous transonic flow around a wing section. Y. B. LIFSHITS and S. A. VELICHKO (TsAGI, Zhukovski, Russia), *La Recherche Aerospatiale*

(ISSN 0034-1223), No. 2, 1995, pp. 73–83. 25 Refs. Documents available from Aeroplus Dispatch.

The AEROFOIL codes library is intended for computational study of subsonic and transonic viscous gas flow around an airfoil at high Reynolds number. It includes several sections which allow the preparation of input information, computation of the flow, analysis of the results, and comparison of different flows. The library enables the numerical data to be saved in archives and supports rapid extraction of different results. The main functional part of the library contains the subroutines for flow simulation based on the interaction of the inviscid flow with viscous shear layers. A modified transonic potential theory is used in the outer domain, making it possible to obtain solutions including shock waves which are very close to those of the Euler equations. The outer solution is coupled with the viscous layer in such a way that the same number of iterations is required for attached or separated flow. Some examples presented for code validation show that the AEROFOIL results agree well with the experimental data and with solutions of the Navier–Stokes equations. Moreover, they can be obtained using much less computer time.

A95-22654 Transonic vortical gas flows (Book). E. G. SHIFRIN and O. M. BELOTSERKOVSKII (Russian Academy of Sciences, Inst. of Computer Aided Design, Moscow, Russia), Chichester, United Kingdom and New York, Wiley, 1994, p. 371. 160 Refs. Documents available from Aeroplus Dispatch.

The present volume discusses general properties of the transonic flow of an ideal gas. The flow in the vicinity of the point of orthogonality in the sonic line to the velocity vector is discussed. Problems and theoretical investigation, and numerical methods for solving profiling and direct problems of the Laval nozzle are presented. Attention is also given to the subcritical flow over a profile, supercritical subsonic flow over a profile, transonic flow over a corner point, transonic flow behind a detached shock wave in supersonic gas flow about a body, and secondary shocks.

A95-18921 Numerical study of low-frequency flow instability in an axial transonic compressor stage. V. I. GNESIN (National Academy of Sciences of Ukraine, Inst. for Problems in Machinery, Kharkov), *5th International Conference of Fluid Mechanics—ICFM5*, Cairo, Egypt, 1995, Proceedings. Vol. 1 (A95-18906 03-34), Giza, Egypt, Cairo Univ., 1995, pp. 257–267. 13 Refs. Documents available from Aeroplus Dispatch.

This paper presents the investigation of rotor/stator interaction and rotating stall in a complete stage of an axial compressor. The developed mathematical model assumes inviscid flow and uses fully three-dimensional Euler equations to analyze unsteady transonic flow in a stage with arbitrary pitch ratios, in which the unsteadiness is due to the relative blade row motion. This model is used as a basis for predicting the aerodynamic unsteady forces on compressor blades. It is shown that simultaneously with high-frequency nonstationarity caused by step nonuniformity of parameters distribution, there appears a low-frequency flow instability. This instability is accompanied by stall origin, its propagation in the circumferential direction and increased nonstationary loads on the blades. (Author)

A95-17524 Numerical solution of Navier–Stokes equations using iterative methods of the variational kind (Chislennoe reshenie uravnenij Nav'e-Stoksa s ispol'zovaniem iteratsionnykh metodov variatsionnogo tipa). I. Y. BABAEV, V. A. BASHKIN, and I. V. EGOROV, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 34, No. 11, 1994, pp. 1693–1703. In Russian. 8 Refs. Documents available from Aeroplus Dispatch.

An efficient numerical procedure is proposed for solving grid equations arising in the finite difference approximation of steady state Euler and Navier–Stokes equations by monotonic schemes. The procedure employs the Newton method, LU decomposition, and the generalized minimum-residual iterative method. Results of calculations of transonic flow of an ideal gas past a NACA 0012 airfoil are presented.

A95-17522 Exact solutions for some external problems described by unsteady viscous transonic equations (Tochnye resheniya nekotorykh vneshnikh zadach, opisyvaemykh nestatsionarnymi vyazkimi transzvukovymi uravneniyami). Y. V. ZASORIN, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 34, No. 10, 1994, pp. 1476–1488. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

Green's functions are obtained in explicit form for a series of initial-boundary value problems associated with unsteady viscous transonic equations. Some aspects of the correct solvability of the problems in Kipriyanov–Schwartz spaces are examined.

A95-13847 Discontinuous solutions for a viscous transonic equation (O razryvnykh resheniyakh vyazkogo transzvukovogo uravneniya). E. D. TERENT'EV, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 34, No. 6, 1994, pp. 1067–1081. In Russian. 12 Refs. Documents available from Aeroplus Dispatch.

The validity of the integral form of the mass, momentum, and energy conservation equations at possible discontinuities is postulated. After the transition to expressions for flows at discontinuities, the possibility of obtaining relationships for transonic velocities including derivatives for both sides of the discontinuity is investigated. It is shown that, for weak perturbations, relationships different from those of Rankine–Hugoniot are possible when an additional condition for the magnitude of the derivatives is satisfied. An illustrative example is presented.

A94-31811 Scale effect at transonic flow past a swept thick supercritical high-aspect-ratio wing. V. D. BOKSER (TsAGI, Zhukovsky, Russia), *ICAS, 19th Congress*, Anaheim, CA, 1994, Proceedings. Vol. 3 (A94-31534 10-01), Washington, DC, American Inst. of Aeronautics and Astronautics, Inc., 1994, pp. 2776–2786. 7 Refs. Documents available from Aeroplus Dispatch.

The aerodynamic features of the thick swept high-aspect-ratio wing incorporating supercritical second-generation airfoil sections in transonic flow regimes Reynolds numbers up to 32 $\times$ 10 exp 6 are studied on a large-scale semi-span wing-body model. The peculiarities of the pressure distribution, lifting capabilities of wing sections under both subcritical and supercritical flow conditions are examined. Also considered are distinctive features of developing local supersonic region on the supercritical wing incorporating thick supercritical second-generation airfoil sections. Attached and separated flow regimes as well as the effect of Reynolds number on suppressing flow separation in various wing sections are investigated. (Author)

A94-31542 Aerodynamic design transonic wing using CFD and optimization methods. J. R. STRESHINSKIJ and V. V. OVCHARENKO (ANTK Antonov, Kiev, Ukraine), *ICAS, 19th Congress*, Anaheim, CA, 1994, Proceedings. Vol. 1 (A94-31534 10-01), Washington, DC, American Inst. of Aeronautics and Astronautics, Inc., 1994, pp. 35–45. 9 Refs. Documents available from Aeroplus Dispatch.

Cases are presented which are illustrative of the geometrical and aerodynamic restrictions encountered in defining the sectional characteristics of transonic transport aircraft wings. An account is given of an optimization process which successively gives attention to the spanwise distribution of circulation, the wing central section shape, and spanwise twist. The specific case considered is that of the An-218 aircraft, which has demonstrated the present method's reduction of experimental effort required for wing optimization.