

Soviet and Japanese Aerospace Literature

Throughout 1989 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 Aerodynamics from the USSR and Japan.

Support for assembling and publishing the selected abstracts has been provided by the Innovative Science and Technology Directorate of the Strategic Defense Initiative Organization (SDIO), with the sponsorship and technical management of the abstract service by the Office of Naval Research (ONR) under ONR Grant N0014-87-6-0137.

Abstracts in this listing have been taken from the semimonthly abstract journal International Aerospace Abstracts (IAA), published by the American Institute of Aeronautics and Astronautics (AIAA) in cooperation with the National Aeronautics and Space Administration (NASA) under Contract No. NASW-4112. Additional material can be obtained through searching the Aerospace Database – available online via DIALOG or NASA RECON.

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Soviet Aerospace Literature This month: Aerodynamics

A88-53971 Three-dimensional hypersonic viscous shock layer on blunt bodies in flow at angles of attack and sideslip (Giperzvukovoi prostranstvennyi viazkii udarnyi sloi na zatuplennykh telakh, obtekaemykh pod uglami ataki i skol'zheniia). A. I. BORODIN and S. V. PEIGIN, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 26, July-Aug. 1988, pp. 751-758. 12 Refs.

Hypersonic flow of a viscous heat-conducting gas past a smooth blunt body at angles of attack and sideslip is examined in the context of a model of a three-dimensional viscous shock layer. A numerical method of a high order of approximation with respect to the transverse coordinate is developed for integrating equations of a three-dimensional hypersonic viscous shock layer at moderately small Reynolds numbers in the absence of plane symmetry in the flow. The effect of the Reynolds number and angles of attack and sideslip on the shock wave behavior, surface friction and heat transfer coefficients, and flow structure in the shock layer is examined.

A88-32751 A method for measuring the lift coefficient in analog models of three-dimensional flow past a body (Ob odnom sposobе izmereniia koeffitsienta pod'emnoi sily v analogovykh modeliakh prostranstvennogo obtekaniiia tel). L. N. MAKAROV and I. N. RODIONOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), no. 3, 1987, pp. 92-94.

A simple and convenient method for determining the lift coefficient of a body from an analog of the induced velocity in the vortex wake of the body is proposed. Results of an experimental verification of the method proposed here using an analog model of circulation flow past a cylinder with a large aspect ratio are presented.

A88-52112 Aerodynamic heating of corrugated surfaces in a supersonic turbulent boundary layer (Aerodinamicheskoe nagrevanie volnistykh poverkhnostei v sverkhzvukovom turbulentnom pogranichnom sloe). V. V. BOGOLEPOV, V. N. BRAZHKO, L. V. DOZOROVA, G. I. MAIKAPAR, and V. IA. NEILAND, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 6, 1987, pp. 1-7. 9 Refs.

Heat transfer to a corrugated surface in a turbulent boundary layer, with both transverse and longitudinal flow past the surface, is investigated experimentally for Mach 4 and Re 2.9 x 10 to the 6th. In the case of transverse flow (separated or nonseparated), the maximum coefficients of heat transfer toward the corrugated surface are several times higher than those in the case of a flat surface. In the case of longitudinal flow, the maximum heat transfer coefficients are close for corrugated and flat

surfaces, while mean heat transfer toward a corrugated surface may be approximately 20 percent lower than that toward a flat surface.

A88-52047 Analysis of singularities in the solution of the problem of hypersonic flow around a low-aspect-ratio delta wing (Analiz osobennostei v reshenii zadachi giperzvukovogo obtekaniiia treugol'nogo kryla malogo udlineniia). A. I. GOLUBINSKII and V. N. GOLUBKIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 20-29. 14 Refs.

The solutions obtained by Golubinskii and Golubkin (1976) and Golubkin (1977) for the problem of hypersonic flow around a flat low-aspect-ratio delta wing contain singularities such as concentrated forces and breaks in the shock wave and in stream surfaces on a series of singular lines (sections). This paper analyzes the reasons of these singularities. It is shown that, in the field of continuous flow behind the bow shock, there exist narrow regions with elevated pressure and increased gradients of some characteristics. Under these conditions, these narrow regions are transformed into the peculiar sections.

A88-37653 Numerical separation models (Chislennye modeli sryva). O. M. BELOTSERKOVSKII, IN: *Problems of turbulent flows* (A88-37651 15-34). Moscow, *Izdatel'stvo Nauka*, 1987, pp. 32-56. 54 Refs.

Some current problems in aerodynamics are studied by direct numerical analysis using full models, without resorting to semiempirical theories. Emphasis is placed on separation (turbulent) flows in the case of 'limiting' regimes at large Reynolds numbers. New numerical models are developed for this class of flows, and numerical methods are proposed for computer implementation. Ordered structures typical of different classes of turbulent flows are shown.

A88-52093 Experimental study of the possibility of passive control of shock/boundary layer interaction (Eksperimental'noe issledovanie vozmozhnosti passivnogo upravleniia vzaimodeistviem skachka uplotneniia s pogranichnym sloem). S. A. KOVAL'NOGOV, V. M. FOMIN, and G. K. SHAPOVALOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 4, 1987, pp. 112-116. 7 Refs.

Results are presented from an experimental study on the passive control of shock/boundary layer interaction on an airfoil in transonic flow. A significant drag reduction was achieved by means of a perforated or two-slit surface above a cavity.

A88-52091 The study of the interference between lifting surfaces on an aircraft model in the canard configurations with sweptforward wing at low subsonic speeds (Issledovanie interferentsii mezhdu nesushchimi poverkhnostiami na modeli samoleta v skheme 'utka' s krylom obratnoi strelovidnosti pri mal'kikh dozvukovykh skorostiakh). E. P. VIZEL' and A. E. GONCHAR, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 4, 1987, pp. 103-106.

Results are presented from the study of the mutual influence of the lifting elements in a canard configuration model with sweptforward wings at low subsonic speeds. The total interference of the lifting elements is determined and the range of attack angles with positive and negative interference is identified.

A88-52090 A generalized dependence for lift-drag ratio (Obobshchennaia zavisimost' dlia aerodinamicheskogo kachestva). V. IA. ZAVERTAILO, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 4, 1987, pp. 97-102.

Generalized relationships for lift-drag ratio which are suitable for a wide range of flight vehicles are obtained. A technique for generalizing the $K = c_{sub} y/c_{sub} x$ relationship is examined.

A88-48312 Comparison of experimental and theoretical results concerning the effect of air suction on the aerodynamic characteristics of a wing (Sravnenie eksperimental'nykh i teoreticheskikh rezul'tatov vliianiia otsasyvaniia vozdukh na aerodinamicheskie kharakteristiki kryla). B. S. BAEV, *Samoletostroenie - Tekhnika Vozdushnogo Flota* (ISSN 0581-4634), no. 54, 1987, pp. 54-57.

Formulas are obtained for calculating the aerodynamic characteristics of aircraft with air-suction systems of boundary layer control. The proposed approach relies on the use of the theory of functions of complex variables and conformal mapping. Calculations are compared with experimental data, and good agreement is found.

A88-52075 Heat transfer in an annular recess in hypersonic flow in the presence and in the absence of gas injection (Teploobmen v kol'tsevoi vyemke v giperzvukovom potoke pri nalichii i otsutstvii vduva gaza). V. IA. BOROVOL, S. K. MARINICHENKO, and A. S. SKURATOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 3, 1987, pp. 125-130.

Heat transfer at the surface of a sharp cone with an annular recess in hypersonic flow is studied at a freestream Mach number of 6, and a freestream Reynolds number of 560,000. The distribution of the local heat transfer coefficient in and behind the recess is obtained. It is shown that, in the absence of gas injection, the value of the integral heat flux in the vicinity of the recess (including the mixing-layer attachment region) is close to that for a cone without a recess.

A88-52073 The experimental investigation of vortices shed from a wing strake (Eksperimental'noe issledovanie vikhrei, skhodiashchikh s naplyva kryla). V. A. PESETSKII, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 3, 1987, pp. 114-119. 15 Refs.

The results of experimental investigations of the velocity field in a vortex shed from a strake are presented for wings with low and medium aspect ratios. The measurements were carried out with a laser-Doppler velocimeter in a wind tunnel at small subsonic velocities. Consideration is given to vortex breakdown as well as to the effect of the rounding-off of the leading edge of the strake on the vortex velocity field.

A88-29971 Solution of ablation equations with slight asymmetry (Reshenie uravneniia obgara s maloi asimetriiei). V. V. LUNEV and E. A. SENKEVICH, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), Jan.-Feb. 1988, pp. 129-137. 5 Refs.

A semianalytical solution is proposed for nearly axisymmetric problems of ablation in a high-temperature gas flow using a simplified integro-local formulation of the three-dimensional ablation problem. Through linearization (used for method derivation only and not in the computational algorithm), the general problem is reduced to a set of isolated two-dimensional problems for each harmonic of the Fourier series along the circumferential variable. Examples are presented to show that the method is applicable over a finite region of problem asymmetry.

A88-52066 The nonstationary problem of combined heat transfer for blunt bodies in a supersonic flow (Nestatsionarnaia zadacha sopriazhennogo teploobmena dlia zatuplennykh tel v sverkhzvukovom potoke). V. A. BASHKIN and S. M. RESHET'KO, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 3, 1987, pp. 39-47. 8 Refs.

The nonstationary problem of combined heat transfer is studied for blunt bodies in a supersonic flow of an ideal gas at zero angle of attack. The gas flow in the boundary layer is assumed to be laminar. Numerical results are obtained for typical wind-tunnel thermal testing conditions. Features characterizing the behavior of the heat flux on the surface of the body as it is heated are elucidated; these are due to the nonisothermicity of the surface.

A88-52065 A method for calculating the flow past interfering bodies at supersonic velocities (Metod rascheta obtekanii interferiruiushchikh tel pri sverkhzvukovykh skorostiakh). V. V. KOVALENKO and A. N. KRAVTSOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 3, 1987, pp. 31-38. 13 Refs.

A method is developed for the calculation of the supersonic flow past aircraft elements with allowance for aerodynamic interference. The

calculations are carried out within the framework of a model using a set of Euler equations together with the second-order MacCormack two-step scheme in which the bow shocks are explicitly identified. The use of the present method to identify internal gasdynamic discontinuities is demonstrated.

A88-52062 The flow past a straight wing under stationary and quasi-stationary external conditions (Obtekanie priamogo kryla pri statsionarnykh i kvazistatsionarnykh vneshnikh usloviakh). M. A. GOLOVKIN, V. P. GORBAN', E. V. SIMUSEVA, and A. N. STRATONOVICH, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 3, 1987, pp. 1-12.

The aerodynamics of rectangular wings with an aspect ratio of 5 is studied at a Reynolds number of 0.6×10^6 to the 6th over a wide range of angles of attack. Included are weight measurements and flow visualization at the wing surfaces. At large angles of attack, in the absence of slip, substantial roll and yaw moments can arise due to the asymmetric structure of the flow relative to the wing's plane of symmetry.

A88-52060 Angular-motion dynamics of a flight-vehicle in the presence of aerodynamic hysteresis of the moment characteristics (Dinamika uglovogo dvizheniia letatel'nogo apparata pri nalichii aerodinamicheskogo gisteriezisa momentnoi kharakteristiki). S. S. BOGODISTOV and V. G. SITNIKOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 130-142. 6 Refs.

This paper considers the angular-motion dynamics of a flight vehicle (FV) in the angle-of-attack plane in the presence of aerodynamic hysteresis of the moment characteristics. The FV motion is described by a second-order dynamic system with a 'linear' approximation of the hysteresis loop. The results of the analysis can be used for evaluating qualitatively different motion types which can occur during planar vibrations of a FV that are characterized by aerodynamic hysteresis. The types of motion corresponding to structural stability of the system are derived.

A88-52056 Lift-drag ratio and balance of a wing with blunt edges in hypersonic flow (Aerodinamicheskoe kachestvo i balansirovka kryla s zatuplennymi kromkami v giperzvukovom potoke). V. S. NIKOLAEV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 104-111.

This paper presents an analysis of the aerodynamic characteristics of a wing in a hypersonic flow, investigating the effects of the degree of the lower-surface camber, the degree of bluntness, the design form, and the position of the mass center. Simple formulas are proposed for calculating the optimal balanced angle of attack and the position of the mass center needed for the optimal balance.

A88-52045 Flow in a local supersonic flow in the presence of a transonic flow around a wing profile (O techenii v mestnoi sverkhzvukovoi zone pri okolozvukovom obtekanii krylovogo profil'ia). V. A. PAN'ZHENSKII and A. S. PETROV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 1-8. 14 Refs.

This paper presents analytical relationships describing the velocity field in the local supersonic zone of a wing profile in the presence of the transonic flow of an ideal compressible gas around that wing section. The equations are validated by a comparison with available experimental and numerical data, and the results of the derived relationships are used to calculate the wave drag on the wing.

A88-52055 Application of Gauss-type quadrature formulas to the problem of the flow of an incompressible fluid past a thin airfoil (Primenenie kvadraturnykh formul Gaussova tipa v zadache ob obtekanii tonkogo profil'ia neszhimaemoi zhidkost'iu). V. E. BASKIN and V. S. KAPLAN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 100-103. 5 Refs.

This paper considers the use of two methods for solving the problem of a flow past a thin airfoil, the discrete vortex method and a method using Gauss-type of quadrature formulas. Quadrature formulas that correspond to the character of the flow past a given profile are examined. It is shown that, for cases in which the number of bound vortices is fixed and which require quadrature formulas, the choice of coordinate distribution and control-point distribution is important.

A88-52113 Generation of a suction force in flow past slender wings at large Reynolds numbers (O realizatsii podsasyvaiushchei sily pri obtekanii tonkikh kryl'ev pri bol'shikh chislakh Reinal'dsa). A. V. ZUBTSOV and G. G. SUDAKOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 6, 1987, pp. 8-13. 11 Refs.

The paper is concerned with the problem of determining conditions for the existence of nonseparated flow past the leading edge of a slender wing of finite aspect ratio with a deflectable tip. The method of matched asymptotic expansions is used to estimate the range of wing tip deflection angles (for a given angle of attack for the wing) corresponding to nonseparated flow, with the generation of a suction force. The estimates are made with allowance for the relative wing thickness and viscous effects.

A88-52044 A method for determining the geometrical parameters of a semirigid dynamically similar model equivalent to the original wing from flutter equation coefficients (Sposob opredeleniia geometricheskikh parametrov poluzhestkoi dinamicheskoi podobnoi modeli,

ekivalentnoi iskhodnomu krylu po koeffitsientam uravnenii flattera). V. M. FROLOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 1, 1987, pp. 140-144.

A method for determining the principal geometrical characteristics of a dynamically similar semirigid model is proposed which is based on the condition that the aerodynamic characteristics of the flutter equations of this model, obtained by using the steady-state hypothesis and the Galerkin method, correspond to similar coefficients for a full-scale elastic wing with arbitrary flutter-generating shapes of bending and torsional natural vibrations. The method proposed here is illustrated by numerical examples.

A88-52046 Numerical algorithm for calculating supersonic inviscid flow around wing-body combinations (Chislennyi algoritm rascheta sverkhzvukovogo neviazkogo obtekanii kombinatsii kryla s korpusom). I. I. LOBANSKII, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 9-19. 20 Refs.

This paper presents a technique for developing a numerical algorithm based on Euler equations, which can be used to calculate flow fields and integral aerodynamic characteristics for a basic glider design of ultrasonic and supersonic flight vehicles. The solutions obtained here are compared with available experimental data and with numerical results obtained by others.

A88-52026 Elimination of errors in aerodynamic force and moment coefficients obtained by the steady rotation method (Ustraneniye pogreshnostei v koeffitsientakh aerodinamicheskikh sil i momentov, poluchaemykh metodom ustanovivshegosia vrashcheniia). N. N. DOLZHENKO, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 1, 1987, pp. 1-8.

Aerodynamic force and moment coefficients and their increments resulting from the rotation of a flight vehicle model about the velocity vector are expanded in terms of even and odd components with respect to slip angle and angular velocity. It is then shown how these terms can be used to determine, with better accuracy, the aerodynamic derivatives and to eliminate or reduce some experimental errors. The errors in aerodynamic derivatives eliminated by this method are estimated.

A88-50777 Wing geometry: Methods and algorithms for designing lifting surfaces (Russian book) (Geometriia kryla: Metody i algoritmy proektirovaniia nesushchikh poverkhnostei). IURII VASIL'EVICH DAVYDOV and VIKTOR ALEKSANDROVICH ZLYGAREV, *Moscow, Izdatel'stvo Mashinostroyeniia*, 1987, 136 pp. 42 Refs.

Problems pertaining to the geometric simulation of aircraft wings are addressed. Methods for the mathematical description of planar contours and surfaces and for the calculation of geometric characteristics are presented. The formulation of algorithms for the solution of these tasks and the design of automated systems for their implementation are discussed.

A88-49415 Waveriders generated from flows behind parabolic shocks (Volnolety, postroennye na techeniakh za parabolicheskimi skachkami uplotneniia). V. I. VORONIN, V. F. ZAKHARCHENKO, and A. I. SHVETS, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May-June 1988, pp. 66-70. 11 Refs.

A numerical method is developed for calculating the flow parameters behind an arbitrary plane attached shock. Waveriders are generated whose compression surfaces are flow surface behind power-law-type shocks, and their aerodynamic characteristics are calculated.

A88-43996 Theory of flow past yawed and swept wings of large aspect ratios (Teoriia obtekanii skol'ziashchikh i strelivodnykh kryl'ev bol'shikh udlinenii). V. V. STRUMINSKII, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 300, no. 1, 1988, pp. 55-57. 7 Refs.

Some recently proposed methods for calculating swept wings of large aspect ratios, based on approximate assumptions, are briefly reviewed. The assumptions underlying these methods, such as the secondary flow assumption, are then critically examined, and three theorems are proposed which apply to yawed and swept wings of high aspect ratios in the path of a turbulent flow. A system of Reynolds equations for yawed and swept wings is written.

A88-52048 The characteristics of the interaction and separation of a transcritical boundary layer (Osobennosti vzaimodeistviia i otryva transkriticheskogo pogranichnogo sloia). V. IA. NEILAND, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 30-45. 20 Refs.

This paper presents an asymptotic theory describing the interactions of a hypersonic flow with a laminar boundary layer in flows with low temperature factors. A classification scheme for these flows is proposed, which includes the subcritical and supercritical flows reported in earlier studies. Special attention is given to transcritical flows, whose physical characteristics are analogous to those of inviscid transonic flows. Solutions are derived for flows around typical aerodynamic bodies.

A88-52035 Calculation of transonic flow past a fuselage-wing combination with allowance for the wing structure elasticity (Raschet okolozvukovogo obtekanii kombinatsii krylo-fuzelizhazh s uchetoм vliianiia uprugosti konstruktssii kryla). V. I. SAVITSKII, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 1, 1987, pp. 81-89. 7 Refs.

By using the method of influence coefficient in the context of the transonic theory of small perturbations and the method of sequential

relaxation, an iteration method is developed for considering the effect of wing structure elasticity on transonic flow past a fuselage-wing configuration. The convergence of the iteration procedure is investigated, and the optimal parameters of the procedure are determined. Results of calculations of the static aeroelasticity of the wing based on the method proposed here are presented.

A88-52028 Selection of an optimal shape for a supersonic flight vehicle (O vybore optimal'noi formy sverkhzvukovogo letatel'nogo apparata). G. I. MAIKAPAR, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 1, 1987, pp. 18-27. 6 Refs.

By considering a wave rider, treated as a schematized flight vehicle, the wave drag of a flight vehicle with specified lifting force and volume is determined under various constraints. The minimum-drag shape is shown to be dependent on several dimensionless parameters, and it is shown that the contour of the leading edge has a particularly strong effect on wave drag for a specified length. For specified lift, volume, length and width, the leading edge shape is a trapeze tending to a straight wedge with increasing dimensionless volume and decreasing lift.

A88-40311 Aerodynamics of supersonic shapes (Russian book) (Aerodinamika sverkhzvukovykh form). ALEKSANDR IVANOVICH SHVETS, *Moscow, Izdatel'stvo Moskovskogo Universiteta*, 1987, 208 pp. 197 Refs.

Problems in the aerodynamics of supersonic shapes are examined with reference to recent theoretical and experimental research related to minimum-drag bodies. In particular, attention is given to inverse problems in gas dynamics, methods for calculating flow past bodies of star-like configurations, and principles of the design of star-shaped structures. The discussion also covers wind tunnel test data, physical models of flows, and methods for calculating real structures with allowance for edge bluntness, friction, and heat transfer.

A88-44909 Aerodynamics of the Tu-134A-3(B-3) (Russian book) (Aerodinamika samoleta Tu-134A-3(B-3)). TEVEL' IOSIFOVICH LIGUM, *Moscow, Izdatel'stvo Transport*, 1987, 264 pp.

Aerodynamic data and performance characteristics are given for Tu-134A-3 and Tu-134B-3 with D-30 III series engines, modified versions of the standard Tu-134A and Tu-134B aircraft with D-30 II series engines. Particular attention is given to the aerodynamic basis for the recommended flight regimes under normal and special conditions. The discussion covers cruising flight, takeoff and landing, and climb characteristics; longitudinal and lateral stability, static stability, and controllability; characteristics of the aircraft at large angles of attack; characteristics of perturbed motion; and operation under extreme and emergency conditions.

A88-46914 Interaction between a compliant surface and the viscous sublayer of a turbulent boundary layer (O vzaimodeistvii podatlivoi poverkhnosti s viazkim podsloiem turbulentnogo pogranichnogo sloia). G. A. VOROPAEV and V. I. POPKOV, *Gidromekhanika* (ISSN 0367-4088), no. 57, 1988, pp. 32-35. 6 Refs.

The problem of the interaction between the compliant surface of a viscoelastic material and the viscous sublayer of a turbulent boundary layer is analyzed using an approach similar to that of Sternberg (1962), with allowance made for the effect of longitudinal motions of the surface. It is demonstrated that the longitudinal displacement of the surface of the viscoelastic material and of the viscous sublayer significantly affect Reynolds stresses in the turbulent boundary layer.

A88-48201 Methods of analogy in the aerodynamics of flight vehicles (Russian book) (Metody analogii v aerodinamike letatel'nykh apparatov). AL'BERT OSKAROVICH DITMAN, VIKTOR DMITRIYEVICH SAVCHUK, and IOSIF RAFAILOVICH IAKUBOV, *Moscow, Izdatel'stvo Mashinostroyeniia*, 1987, 152 pp.

The electromagnetic, electrohydrodynamic, and gas-hydraulic analogy methods are considered. Attention is given to the possibility of applying methods of four-dimensional geometrical physics to the aerodynamics of flight vehicles. Lorentz transformations are used to derive similarity relationships for subsonic and supersonic flow past bodies. The details of analog simulation are outlined, and the appropriate analog devices are described.

A88-32740 A minimum-wave-drag body of revolution of specified length with a bottom section of specified diameter in transonic gas flow (Telo vrashcheniia minimal'nogo volnovogo soprotivleniia s zadannoi dlinoi i diametrom donnogo secheniia v okolozvukovom potoke gaza). G. F. SIGALOV and M. A. KORCHAGINA, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), no. 3, 1987, pp. 59-64. 7 Refs.

A study is made of the optimal shape of a tapered body of revolution of specified length with a bottom section of specified diameter which has a minimum wave drag in transonic gas flow. The analysis is based on the asymptotic method of full approximation and the method of indeterminate Lagrange multipliers. The optimal body shape is determined as a function of the Mach number and body thickness. The optimal shape differs significantly from the Karman ogive in the transonic region for Mach numbers only slightly above unity.

A88-52049 An improvement in calculation techniques for three-dimensional boundary-layers (Usovershenstvovanie metodov rascheta

trekhmernogo pogranichnogo sloia). I. U. IA. GERASIMOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 2, 1987, pp. 46-53. 9 Refs.

This paper describes a method which makes it possible to reduce the computation time for three-dimensional boundary layers, by using a computational grid for the integration of the equations of motion which are described by an orthogonal coordinate system connected with outside stream lines. The computational grid is built on the basis of a nonorthogonal coordinate system connected with the body. It is shown that the application of this grid and the formulas derived reduce the time needed for the calculation of a three-dimensional compressible turbulent boundary layer along the wing by more than twice compared with a conventional integration method.

A88-52038 Using a solution to the inverse problem for aerodynamic surface design (Ispol'zovanie resheniia obratnoi zadachi dlia proektirovaniia aerodinamicheskoi poverkhnosti). L. A. POTAPOVA, I. U. N. SVIRIDENKO, and L. L. TEPERIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 1, 1987, pp. 106-109.

A method for solving the problem of the aerodynamic design of a lifting surface, with a specified pressure profile and a fixed wing planform, is proposed which allows for the effect of the fuselage, powerplant, and other components on the wing profile shapes. In the design problem for part of a wing, the specified pressure distribution represents a boundary condition for determining profile shapes for the surface being designed. The geometry of the remaining part of the wing and other components is assumed to be known and remains unchanged in the process of the solution.

A88-52094 Experimental study of flow in the core of a vortex structure (Eksperimental'noe issledovanie tekhnii v iadre vikhrevoi struktury). V. L. BAKULIN and A. M. GAIFULLIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 4, 1987, pp. 117-119.

The paper presents an experimental study of quasi-conical flow for a parabolically curved wing with a parabolic planform. Two closed recirculation regions not touching the wing were observed at the wing's leading edge. An analysis is made of the effect of nonself-similar factors on the structure of the quasi-conical flow.

A88-52068 The stability of the supercooled state of a flow in shaped wind-tunnel nozzles (Ob ustoiichivosti pereokhlazhdennoogo sostoiianiia potoka v profilirovannykh soplakh aerodinamicheskikh trub). A. V. CHIRIKHIN, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 3, 1987, pp. 57-68. 16 Refs.

Parametric calculations of the nonequilibrium condensation of nitrogen in shaped nozzles of different scales were used to establish stability criteria for the supercooled state (8-13 K) of the flow. A technique was developed to estimate the size of the stable-supercooling zone and to assess the effect of weak condensation on the gasdynamic properties in the uniform-flow region.

A88-39913 An error in the theory of conformal mappings of regions that are close to each other and in application to flow past airfoils (Ob odnoi oshibke v teorii konformnykh otobrazhenii blizkikh oblastei i v prilozhenii k obtekaniiu profilii). A. L. GONOR, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 52, Mar.-Apr. 1988, pp. 345-348.

The correct value of the boundary derivative for the conformal mapping of the outer periphery of regions that are close to each other is defined. This value is used in a formula for determining the velocity distribution on a contour close to a given airfoil. The correction is introduced in the formula, and examples of the calculation of the velocity distribution on an elliptical airfoil are considered.

A88-32755 Representation of a surface segment of an airfoil profile in Bezier form (Predstavlenie uchastka poverkhnosti aerodinamicheskogo profilii v forme bez'e). B. KH. PEREL'SHTEIN and S. S. SOLOV'EV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), no. 3, 1987, pp. 100-102. 5 Refs.

A formalism is developed for describing a segment of the surface of an airfoil profile of the kinematic kind. The approach used here is based on the use of a mathematical model of a surface in the form of the Bezier polyhedron, which makes it possible to use the coordinates of the Bezier polyhedron apex as the variable parameters in the shape optimization procedure. The method proposed here is designed for calculating optimal turbomachine profiles on the basis of three-dimensional gasdynamic models.

A88-37697 Separation of a supersonic boundary layer ahead of the base of a body (Otryv sverkhzvukovogo pogranichnogo sloia pered donnym srezom kontura tela). M. A. KRAVTSOVA and A. I. RUBAN, *Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki* (ISSN 0044-4669), Vol. 28, April 1988, pp. 580-590. 8 Refs.

The separation of supersonic flow near a corner point on a body is analyzed in the context of the asymptotic theory of the interaction between a laminar boundary layer and the external nonviscous part of flow. Particular attention is given to the transition stage of flow during which a pressure increase in the base region leads to the detachment of the separation point from the corner point and to the displacement of the separation point toward the leading edge of the body. Results of a numerical solution are presented.

A88-33903 Calculation of the diffusive combustion of a subsonic jet in a supersonic wake (K raschetu diffuzionnogo goreniia dozvukovoi strui v sputnom sverkhzvukovom potoke). I. S. BELOT-SERKOVETS and V. I. TIMOSHENKO, *PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), Jan.-Feb. 1988, pp. 91-95. 9 Refs.

An approximate method for calculating the parameters of a subsonic injected jet in a supersonic wake in the presence of diffusive combustion is developed on the basis of a model of strong viscous-nonviscous interaction through pressure. An algorithm is presented for integrating boundary layer equations across the viscous flow region in the presence of a flame front. The effect of the molecular weight of the injected jet and diffusive combustion of hydrogen on the pressure in the nonsymmetric near wake of a plate is estimated in relation to injection intensity and hydrogen concentration.

A88-46060 Asymptotic theory of separated flows (Russian book) (Asimptoticheskaia teoriia otryvnykh techenii). VLADIMIR VASIL'EVICH SYCHEV, ANATOLII IVANOVICH RUBAN, VIKTOR VLADIMIROVICH SYCHEV, GEORGII L'VOVICH KOROLEV, *Moscow, Izdatel'stvo Nauka*, 1987, 256 pp. 163 Refs.

Results of theoretical studies of separation flows of an incompressible fluid at large Reynolds numbers using asymptotic methods are examined. Particular attention is given to problems of self-induced separation in stationary and nonstationary flows, theory of local separations at the leading and trailing edges of thin airfoils, and investigations of the global field structure of flows in the wake of blunt bodies. Numerical methods for solving problems of the interaction between a boundary layer and a potential flow are discussed.

A88-52095 Calculation of noncirculating flow past arbitrary bodies (Raschet bestsirkulatsionnogo obtekaniiia proizvol'nykh tel). S. M. BELOT-SERKOVSKII, I. K. LIFANOV, and A. A. MIKHAILOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 5, 1987, pp. 1-10. 8 Refs.

The discrete vortex method is extended to a wide range of problems concerned with the calculation of noncirculating flow past bodies of arbitrary shape with corner points. The basic principles of a calculation method for plane problems are examined. The convergence of a numerical solution to the exact solution is demonstrated.

A88-52079 Numerical study of viscous swirling flows (Chislennoe issledovanie viazkikh zakruchennykh potokov). A. M. GAIFULLIN and V. F. MOLCHANOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3429), Vol. 18, no. 4, 1987, pp. 10-16. 8 Refs.

A method for the numerical analysis of the motion of viscous fluid in a swirling steady axisymmetric flow is presented. Examples are introduced, calculating this motion in the presence of recirculating regions near the central line of the vortex. The study is useful in understanding the anomaly known as a 'vortex explosion,' which sometimes occurs during subsonic flow along a wing in a vortex line.

A88-43632 Solution of a problem concerning flow past a finite-span wing (O reshenii zadachi obtekaniiia kryla konechnogo razmakha). Z. KH. NUGMANOV and V. M. ROMANOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), no. 1, 1988, pp. 108-110. 7 Refs.

The problem of flow past a finite-span wing is solved by using an approach representing a further development of the basis function method proposed in a previous study (Nugmanov, 1979). In contrast to the original method, the approach presented here involves solving singular integral equations. A significant saving in computational effort is achieved by transforming the kernels of the integral equations. Flow past a rectangular ring with a Zhukovskii profile is calculated as an example.

Japanese Aerospace Literature This month: Aerodynamics

A88-46048 Some thoughts on power-augmented-ram wing-in-ground (PAR-WIG) effect vehicle. SHIGENORI ANDO, *Japan Society for Aeronautical and Space Sciences Transactions* (ISSN 0549-3811), Vol. 31, May 1988, pp. 29-47. 13 Refs.

The PAR (Power-Augmented-Ram) WIG (Wing-in-Ground) effect vehicle is promising as an overwater commuter transport vehicle. Three important requirements, PAR effect, ability of off-ground effect flight, and ability of automatic IGE (in-ground effect) flight, are described. Many useful materials for designing WIG are presented. New concepts are proposed, which contain some new devices. Ability of 'stick-free' IGE flight is

especially desirable, hence the phugoid mode should be suppressed sufficiently.

A88-36698 Aeroelastic galloping of a square-section cylinder in the Reynolds-number range from 100 to 10,000. YOSHIMASA TOMONARI, *Japan Society for Aeronautical and Space Sciences Transactions* (ISSN 0549-3811), Vol. 30, Feb. 1988, pp. 234-242. 7 Refs.

The present study aims to make clearer the aerodynamic mechanism of high-speed, low-frequency galloping, starting spontaneously from rest in a cross-flow direction, to which the linear quasi-steady aerodynamic theory