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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 Turbulent Boundary Layers from Russia and Turbulent Boundary Layers from Japan.

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Russian Aerospace Literature
This month: *Turbulent Boundary Layers*

A96-24298 Calculations of viscous gas flows using compact third-order schemes (Raschety techenij vyazkogo gaza na osnove kompaktnykh skhem tret'ego poryadka). A. D. SAVEL'EV, *Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki* (ISSN 0044-4669), Vol. 35, No. 10, 1995, pp. 1538–1551. In Russian. 14 Refs. Documents available from Aeroplus Dispatch.

An algorithm for solving viscous gas flow problems on curvilinear grids is presented which is based on the approximation of the Navier–Stokes equations by means of compact third-order schemes. Results of calculations of shock-induced turbulent boundary layer separation and viscous gas flows past an airfoil and turbine cascades are presented.

A96-23738 Effects of riblets on vortex development in the wake behind a single roughness element in the laminar boundary layer on a flat plate. G. R. GREK, V. V. KOZLOV, and S. V. TITARENKO (Russian Academy of Sciences, Inst. of Theoretical and Applied Mechanics, Novosibirsk, Russia), *La Recherche Aerospatiale* (ISSN 0034-1223), No. 1, 1996, pp. 1–9. 13 Refs. Documents available from Aeroplus Dispatch.

The experimental results of the effect of riblets on vortex development in the wake behind a single roughness element (a small cylinder) in the laminar boundary layer on a flat plate are presented. The investigation showed that riblets could substantially affect the way vortices develop in the wake behind a single roughness element (so-called 'vortex street'). A triangular riblet located lengthwise in the flow approximately halved the height and span of the vortex street by comparison with the height and span of the vortex street on a smooth surface of the flat plate. Furthermore, the riblet steadied the flow inside the vortex street, resulting in delay of the turbulence. According to hot-wire measurements, this large influence of riblets on the vortex street behavior was related to changes in the inner vortex structure. (Author)

A96-19612 On 3-D boundary layer receptivity. V. Y. LEVCHENKO and V. A. SHCHERBAKOV (Russian Academy of Sciences, Inst. of Theoretical and Applied Mechanics, Novosibirsk, Russia), *Laminar-turbulent transition; IUTAM Symposium*, Sendai, Japan, 1994, Proceedings (A96-19558 04-34), Berlin, Germany, Springer–Verlag, 1995, pp. 525–532. 12 Refs. Documents available from Aeroplus Dispatch.

Experimental data on the receptivity of three-dimensional boundary layer to freestream turbulence and sound are presented. The model was a flat plate with a relatively sharp, 45-deg, swept leading edge. The flow above the plate had a negative pressure gradient. Traveling waves were the object of this investigation. They were generated in the vicinity of the leading edge. The vibration of the leading edge under the influence of the external turbulence and sound was a generator of traveling waves. (Author)

A96-19586 Experimental study of secondary instability and breakdown in a swept wing boundary layer. A. V. BOJKO, V. V. KOZLOV, V. V. SYZRANTSEV, and V. A. SHCHERBAKOV (Russian Academy of Sciences, Inst. of Theoretical and Applied Mechanics, Novosibirsk, Russia), *Laminar-turbulent transition; IUTAM Symposium*, Sendai, Japan, 1994, Proceedings (A96-19558 04-34), Berlin, Germany, Springer–Verlag, 1995, pp. 289–295. 8 Refs. Documents available from Aeroplus Dispatch.

Results of an experimental simulation of the laminar-turbulent transition in a single stationary vortex artificially generated in a swept wing boundary layer are presented. It was observed that two wave packets are formed on the vortex, which leads to downstream transition. The influence of the riblet on the transition was investigated. It was found that placing the riblets along the vortex results in a significant prolongation of the laminar regime. (Author)

A96-19579 High-speed boundary-layer stability and transition. V. I. LYSENKO (Russian Academy of Sciences, Inst. of Theoretical and Applied Mechanics, Novosibirsk, Russia), *Laminar-turbulent transition; IUTAM Symposium*, Sendai, Japan, 1994, Proceedings (A96-19558 04-34), Berlin, Germany, Springer–Verlag, 1995, pp. 213–220. Documents available from Aeroplus Dispatch.

Experimental and numerical investigations of high-speed boundary-layer stability and transition were carried out. The hotshot, nitrogen, wind tunnels and shock tube were used. The influence of Mach number, temperature factor, ratio of specific heats, entropy layer, dissociation, ionization, and magnetic field were studied. The problem of turbulization of a stable hypersonic boundary layer by means of an obstacle was considered as well. In addition, the stability and laminar/turbulent transition in high-speed wakes behind a flat plate were studied experimentally. (Author)

A96-19576 Analysis of the formation of a turbulent spot in a laminar boundary layer. V. A. KAZAKOV (TsAGI, Zhukovsky, Russia), *Laminar-turbulent transition; IUTAM Symposium*, Sendai, Japan, 1994, Proceedings (A96-19558 04-34), Berlin, Germany, Springer–Verlag, 1995, pp. 189–196. 13 Refs. Documents available from Aeroplus Dispatch.

The process of the formation of a turbulent spot in a laminar boundary layer on a flat plate in an incompressible fluid has been analyzed numerically. The initial disturbance is introduced by a local distortion of the plate. The analysis has been made for large Reynolds numbers within the framework of triple-deck theory. All stages of the flow evolution have been traced through the formation of a linear wave packet from the unstable Tollmien–Schlichting waves, and then its nonlinear deformation and disintegration. This process results in localized ejections of the near-wall fluid (bursts) and leads to the formation of a characteristic arrow shape of a turbulent spot observed in experiments. (Author)

A96-18390 Relaxation effects simulation in a turbulent boundary layer with nonzero free stream turbulence. E. DYBAN (Ukraine Academy of Science, Inst. of Thermophysics, Kiev, Ukraine) and E. FRIDMAN (Toledo, Univ., OH), *AIAA 34th Aerospace Sciences Meeting and Exhibit*, Reno, NV, 1996, p. 7. 8 Refs. Documents available from Aeroplus Dispatch.

To study the relaxation effects in a turbulent boundary layer with zero and nonzero free stream turbulence the Reynolds-averaged equations of motion and energy are solved. As the closure of the Reynolds-averaged equations the transport equation for turbulent shear stresses is used. The proposed approach allows the calculation of the relaxation scales in the turbulent boundary layer with zero and nonzero free stream turbulence. The calculation results for friction coefficients, velocity profiles, shear stresses, and thicknesses of the boundary layer and the so-called sublayer in a flat-plate turbulent boundary layer are presented. These results, which account for the relaxation effects in a turbulent boundary layer, are in agreement with the available experimental data. (Author)

A96-17270 Optimizing the delay of the laminar-turbulent transition by local surface heating (Optimizatsiya zatyagivaniya laminarno-turbulentnogo perekhoda s pomoshch'yu lokal'nogo nagreva poverkhnosti).

A. V. KAZAKOV, M. N. KOGAN, and V. A. KUPAREV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 4, 1995, pp. 90–99. In Russian. 16 Refs. Documents available from Aeroplus Dispatch.

A study is made of the stability and location of the laminar-turbulent transition in a boundary layer with surface heating near the leading edge of the body. It is shown that the heating of a small surface area near the leading edge to temperatures 2–4 times that of the incoming flow delays the transition even on the thermally insulated surface. On a high-emissivity surface, the energy saving due to a reduction in friction may exceed the energy of surface heating by a factor of 3. The possibility of increasing the lift of an airfoil by varying the surface heating and pressure distribution is demonstrated.

A96-17267 Effect of steady state periodic velocity nonuniformity on the boundary layer stability (Vliyanie statsionarnoj periodicheskoj neodnorodnosti skorosti na ustojchivost' pogranichnogo sloya). M. V. USTINOV, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 4, 1995, pp. 45–52. In Russian. 5 Refs. Documents available from Aeroplus Dispatch.

The laminar-turbulent transition in a boundary layer with an artificially generated velocity profile nonuniformity with a periodic amplitude is investigated using a direct numerical simulation. It is shown that the presence of velocity nonuniformity decreases the growth rate of unsteady perturbations and slows down the laminar-turbulent transition.

A96-16421 Friction and heat transfer calculations for hypersonic flow in the approximation of a turbulent boundary layer (Raschet treniya i teploobmena pri giperzvukovom techenii v priblizhenii turbulentnogo pogranichnogo sloya). V. M. EPIFANOV and V. P. YUGOV (Moskovskij Gosudarstvennyj Tekhnicheskij Univ., Moscow, Russia), *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 33, No. 1, 1995, pp. 61–65. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

A method for calculating the hypersonic boundary layer is proposed which employs a k-epsilon turbulence model. The turbulence model and the numerical calculation method proposed here make it possible to determine the friction coefficient and the Stanton number with relative errors not exceeding 2.5 and 3.5%, respectively. Details of the calculation procedure are presented.

A96-16420 Using dynamic velocity as a characteristic scale of turbulent viscosity in the outer region of the boundary layer (Ispol'zovanie dinamicheskoj skorosti v kachestve kharakternogo masshtaba dlya turbulentnoj vyazkosti vo vneshnej oblasti pogranichnogo sloya). E. A. RUDINSKIJ (Sankt-Peterburgskij Gosudarstvennyj Tekhnologicheskij Univ., St. Petersburg, Russia), *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 33, No. 1, 1995, pp. 54–60. In Russian. 24 Refs. Documents available from Aeroplus Dispatch.

The possibility of using the dynamic velocity as the characteristic scale of turbulent viscosity in outer region of the boundary layer is demonstrated analytically. By using several examples, it is shown that the use of the dynamic velocity as the characteristic scale of turbulent viscosity in the outer region of the boundary layer makes it posible to substantially expand the class of flows that can be calculated on the basis of the Cebeci-Smith algebraic model without using any special corrections.

A96-11494 A study of a three-dimensional turbulent boundary layer on bodies of complex shapes in flow at large angles of attack (Issledovanie prostranstvennogo turbulentnogo pogranichnogo sloya na telakh slozhnoj formy pri obtekanii pod bol'shimi uglami ataki). V. A. ALEKSIN, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 3, 1995, pp. 55–66. In Russian. 19 Refs. Documents available from Aeroplus Dispatch.

Flow and heat transfer characteristics in the case of three-dimensional flow of a compressible gas past models of complex shapes at large angles of attack are investigated in the context of the boundary layer theory. Results of numerical calculations of equations of a three-dimensional turbulent boundary layer, external nonviscous flow, and body geometry are presented. Results of the numerical analysis of flow and heat transfer characteristics demonstrate the three-dimensional nature of flow patterns in the boundary layer.

A96-11446 Three-dimensional boundary layers on bodies of complex shape in flow at angle of attack (Prostranstvennye pogranichnye sloi na telakh slozhnoj formy pri obtekanii pod uglami ataki). V. A. ALEKSIN and S. N. KAZEJKIN, *Prikladnaya Matematika i Mekhanika* (ISSN 0032-8235), Vol. 59, No. 1, 1995, pp. 109–120. In Russian. 16 Refs. Documents available from Aeroplus Dispatch.

The paper is concerned with flow and heat transfer in a three-dimensional boundary layer in the case of flow of a compressible gas past a model body of complex shape at angles of attack up to 30 deg and past a spherically blunted body at angles of attack up to 10 deg. Full and simplified formulations, with the corresponding systems of equations, are presented. Analytical and numerical methods for solving equations of a laminar and a turbulent boundary layer are presented. Particular attention is given to the analysis of systems of equations in cases where simplification is possible; closure of averaged equations of the boundary layer in the turbulent regime; selection of curvilinear coordinates; and analysis of the effect of the governing parameters on the formation of flow separation and characteristic flow regions.

A95-39988 A numerical study of supersonic turbulent separated flows in the vicinity of oblique steps (Chislennoe issledovanie sverkhzvukovykh turbulentnykh otryvnykh techenij v okrestnosti naklonnykh stupenek). A. V. BORISOV, A. A. ZHELTOVODOV (RAN, Inst. Teoreticheskoj i Prikladnoj Mekhaniki, Novosibirsk, Russia), D. BADEKAS, and N. NARAYANSWAMI (Rutgers Univ., New Brunswick, NJ), *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 36, No. 2, 1995, pp. 68–80. In Russian. 39 Refs. Documents available from Aeroplus Dispatch.

Results of a numerical study of the interaction of a turbulent boundary layer with compression shocks and rarefaction waves in flows past oblique steps, a joint research project of the Russian Academy of Sciences, Siberian Branch, and Rutgers University, New Jersey, are reported. The results demonstrate the possibility of solving this problem by using averaged Navier–Stokes equations and one of the well-known turbulence models. The predictions of the principal gasdynamic flow characteristics and pressure distributions in the vicinity of oblique steps in supersonic flow are found to be in satisfactory agreement with experimental data.

A95-39034 Effect of free-stream turbulence on the surface friction in a turbulent boundary layer (Vliyanie turbulentnosti nabegayushchego potoka na poverkhnostnoe trenie v turbulentnom pogranichnom sloe). V. K. KUZENKOV, V. N. LEVITSKIJ, E. U. REPIK, and Y. P. SOSEDKO, *Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza* (ISSN 0568-5281), No. 2, 1995, pp. 65–75. In Russian. 22 Refs. Documents available from Aeroplus Dispatch.

The influence of turbulence intensity, turbulence scale, and Reynolds number on the surface friction coefficient in a turbulent boundary layer is investigated. The dependence of the relative friction increment on the equivalent degree of turbulence is determined, taking into account the simultaneous variation of the aforementioned parameters.

N95-24472 JPRS report: Science and technology. Central Eurasia. Joint Publications Research Service, Washington, DC. Documents available from Aeroplus Dispatch.

Translated articles cover the following topics: estimating life of structural ceramic on basis of dynamic fatigue test results; numerical solution of three-dimensional problems of non-axisymmetrical deformation of laminated anisotropic rotation shells; edge effects in laminated plates; miniature high-temperature superconducting microwave antenna; device for diagnostic sounding of ionospheric plasma with neutralized effect of charge-carrying spacecraft; new types of diagnosis of ionospheric parameters by surface and remote radio sounding; development and use of new weldable structural alloys in the aircraft industry; aerodynamic characteristics of delta wing in hypersonic flow; interrelationship between acoustic properties of nozzle head and combustion chamber with exciting transverse gas oscillations; study of effect of refraction parallax on accuracy of measurements of angular coordinates of artificial Earth satellite; assessment of possibility of observation of artificial Earth satellite by passive optical means in a twilight and daylight conditions; experimental study of friction against fluid at high speeds; construction of airfoil profiles streamlined with separation of turbulent boundary layer; dependence of aerodynamic characteristics of circular cylinder in supersonic stream of ideal gas on temperature factor; optimum conditions for control of turbulence intensity in stream by means of honeycombs; ionospheric effects of spacecraft launches; and consequences of greenhouse effect: predictions and reality. (Author)

A95-28674 Analysis of changes in the boundary layer in diffuser flow from the standpoint of the maximum stability of mean turbulent flows (Analiz izmenenij v pogranichnom sloe pri diffuzornom techenii s tochki zreniya maksimal'noj ustojchivosti osrednennykh turbulentnykh techenij). S. S. DMITRIEV, *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 36, No. 1, 1995, pp. 52–64. In Russian. 30 Refs. Documents available from Aeroplus Dispatch.

The transformation of velocity profiles in a turbulent boundary layer on a deflecting wall in a plane nonsymmetric diffuser channel is investigated experimentally. It is shown that, in nonseparated flow, velocity distribution in the internal turbulence region of the boundary layer is determined by a universal logarithmic dependence, with the constant in this dependence decreasing downstream as the channel taper angle increases. It is further shown that flow separation corresponds to a transition to a new stable state where the classic wall flow in the boundary layer cannot provide for an adequate response of the flow to a positive pressure gradient, which is determined by the channel geometry.

A95-28414 Three-dimensional turbulent flows in the regions of aerodynamic surfaces junctions. V. I. KORNILOV (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. 3 (A95-28244 07-99), Tainan, Taiwan, National Cheng Kung University, 1993, pp. 1184–1190. 12 Refs. Documents available from Aeroplus Dispatch.

Results of experimental investigations on the best known types of three-dimensional turbulent near-wall flow realized along various streamwise corner configurations are presented. The studies are carried out in a wide range of variation of geometric as well as operating parameters including the cases of both incompressible and compressible flows. The most attention was paid to the analysis of both symmetric and asymmetric types of the flow as well as the conditions of three-dimensional corner turbulent boundary layer/impinging from outside the shock wave interaction. The flow peculiarities along a wing/body junction are also considered. (Author)