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Russian and Japanese Aerospace Literature

Throughout 1993 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 Structural Analysis from Russia and Spacecraft Power Supplies from Japan.

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Russian Aerospace Literature This month: *Structural Analysis*

A92-53888 Theory of dynamic contact problems for elastic bodies of finite dimensions (K teorii dinamicheskikh kontaktnykh zadach dlia uprugikh tel ogranichennykh razmerov). A. V. BELOKON', *Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), No. 2, Mar.–Apr. 1992, pp. 77–84.

Dynamic contact problems are investigated using a method involving special functional spaces. The discrete nature of the spectrum of the dynamic contact problem and the completeness of a system of eigenvalues are demonstrated. Generalized solutions for contact problems are defined with and without allowance for the mass of the punch, allowing the numerical analysis of this class of problems.

A92-53887 Application of the general problem of moments to some optimization problems in elasticity theory (O primenenii obshchei problemy momentov k nekotorym optimizatsionnym zadacham teorii uprugosti). E. I. GRIGOLIUK, V. A. FIL'SHTINSKII, and L. A. FIL'SHTINSKII, *Rossiiskaia Akademiia Nauk, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), No. 2, Mar.–Apr. 1992, pp. 31–37.

Several optimization problems in elasticity theory are formulated which are relevant to geomechanics. Methods are then presented for reducing these problems to general moment problems in continuous-function space. By using polynomial approximations of nonstandard moment functions, the general moment problems are reduced to the classical power-law moment problem. This allows an a priori evaluation of the optimal control structure. Theoretical and computational examples are presented.

A92-51368 Using modified theories to study the vibrations of thin-walled composite cylindrical shells (Primenenie modifitsirovannykh teorii dlia issledovaniia kolebanii tonkostennykh kompozitsionnykh tsilindricheskikh obolochek). MARTIN KUBALA, (Slovak Academy of Sciences, Institute of Materials and Machine Mechanics, Bratislava, Czechoslovakia) *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 28, No. 6, June 1992, pp. 45–51.

First-order modified theories are applied to the vibration analysis of thin- walled layered cylindrical shells in the case where one of the layers is an orthotropic composite material. Equilibrium equations are obtained by using the adjoint transformation of the strain-displacement operator in Hilbert space L2. The variability of the results is found to increase with the material heterogeneity.

A92-18346 Natural vibrations of orthotropic ribbed cylindrical shells (Sobstvennye kolebaniia ortotropnykh rebristykh tsilindricheskikh obolochek). A. E. BOGDANOVICH and V. A. ZARUTSKII, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 27, Oct. 1991, (IAA9205), pp. 83–90.

Equations of motion are presented for multilayer orthotropic ribbed cylindrical shells. Formulas for calculating the natural frequencies are obtained by using the Bubnov-Galerkin method and a single-term approximation of displacement components for a periodic rib net. The formulas are derived with allowance for the discrete arrangement of the ribs. The effect of this factor on the natural frequencies of single-layer orthotropic shells reinforced by only longitudinal or only circumferential ribs is examined with reference to numerical examples.

A92-53864 Parametric oscillations of a deformable spacecraft (O parametricheskikh kolebaniiakh deformiruemogo kosmicheskogo apparata). I. V. SKOROBOGATYKH, *Kosmicheskie Issledovaniia* (ISSN 0023-4206), Vol. 30, No. 2, Mar.– Apr. 1992, pp. 275–278.

A theoretical analysis of the parametric oscillations of a deformable spacecraft is presented. The spacecraft is represented as a dynamically symmetric mechanical system consisting of an elastic part and a rigid part. The elastic part is subjected to a pulsating load.

A92-42651 An effective algorithm for calculating the creep structural elements based on the finite element method (Effektivnyi algoritm rascheta elementov konstruktsii na polzuchest' v ramkakh metoda konechnykh elementov). K. N. RUDAKOV, (Kievskii Politekhnicheskii Institut, Kiev, Ukraine) *Problemy Prochnosti* (ISSN 0556-171X), No. 4, 1992, pp. 8–13.

The method of initial deformations has been modified using a sufficiently general kind of equation for the material state under creep. The algorithm takes into account the temperature effect on the elastic properties of the material accurately and noniteratively based on the finite element calculations of structural elements. The effect of a mean normal strain on the equation of state under creep is also considered.

A92-25283 Determining the dynamic characteristics of vibration-damping coatings by the finite element method (Opredelenie dinamicheskikh kharakteristik vibropogloshchaiushchikh pokrytii metodom konechnykh elementov). R. B. RIKARDS and E. N. BARKANOV, (Rizhskii Tekhnicheskii Universitet, Riga, Latvia) *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Sept.–Oct. 1991, pp. 823–830.

The paper is concerned with the problem of calculating the damping characteristics of coatings under harmonic vibrations at frequencies close to the natural frequencies of the structure. The problem is solved using methods that make it possible to determine the damping characteristics of layered structures for the characteristics of the damping layer. Calculations are carried out by the finite element method in the form of a displacement method. A finite element model of the sandwich type is applied to layered beams with soft layers. Damping is accounted for using a complex theory of internal friction.

A91-25235 A study of the dynamics of annular frame structures on the Progress-40 cargo spacecraft (Doslidzhennia dinamiki kil'tsevikh ramkovikh konstruktsii na vantazhnomu kosmichnomu korabli 'Progres-40'). B. E. PATON, IU. P. SEMENOV, P. M. BILOUSOV, V. D. BLAGOV, and E. IU. BURMENKO et al., *Akademiia Nauk Ukrains'koi RSR, Dopovidi, Seriia A - Fiziko- Matematichni ta Tekhnichni Nauki* (ISSN 0002-3531), Nov. 1990, pp. 35–41.

A method is proposed for solving the problem of the dynamics of the relative motions and free vibrations of annular frame structures of the type 'carrier body-rings'. The results based on the method proposed here are found to be in good agreement with experimental data obtained during the maneuvers of the Progress-40 cargo spacecraft. The results of the study can be useful in the development of methods for the optimal control of the dynamics of large structures.

A92-31988 Relationship between the rotating stall and vibrations of a blade row (Vzaimosviaz' vrashchaiushchegosia sryva i vibratsii lopatochnogo ventsa). N. P. ALESHIN, (Zaporozhskoe Mashinostroitel'noe Konstruktorskoe Biuro Progress, Zaporozhe, Ukraine) *Problemy Prochnosti* (ISSN 0556-171X), No. 1, 1992, pp. 82–87.

Based on an analysis of experimental data obtained for transonic fans and multistage axial-flow compressors, a relationship is established between the rotating stall phenomenon and the associated vibration of blade rows. Expressions describing this relationship are derived. Details of the analytical procedure and graphic representations of the experimental results are presented.

A92-21678 An approach to the analysis of shells of complex shape (Ob odnom podkhode k raschetu obolochek slozhnoi formy). M. N. SERAZUTDINOV and M. F. GARIFULLIN, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 27, Nov. 1991, pp. 48–54.

A method for the analysis of shells of complex shape is proposed whereby all the principal relations are written in Cartesian coordinates and no data on shell curvature are used. Such an approach makes it possible to avoid the need for calculating the second-order derivatives of the radius vector of the shell middle surface. An algorithm for the parameterization of the middle surface is presented. Numerical results illustrating the accuracy of the approach are included.

A92-21634 Models of elastic media with stress relaxation (Modeli uprugikh sred s relaksatsiei napriazhenii). V. G. SUTYRIN, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 55, Nov.– Dec. 1991, pp. 996–1004.

The stress relaxation process is described in relation to changes in the unstressed state tensor of the medium with time. Various possible types of thermodynamically justified relaxation equations are discussed. The asymptotic stability in the sense of Liapunov is considered.

A92-16714 Determination of the dynamic characteristics of a linear elastic system from the characteristics of a system with modified properties (Ob opredelenii dinamicheskikh kharakteristik lineinoi uprugoi sistemy po kharakteristikam sistemy s izmenennymi svoistvami). V. R. AMINOV, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572- 3299), Sept.–Oct. 1991, (IAA9204), pp. 170–176.

The paper is concerned with the problem of determining the dynamic characteristics of an elastic system from the known characteristics of a certain baseline system differing from the system of interest in inertial, stiffness, and dissipative properties. The convergence of the solution proposed in an earlier study (Aminov, 1986) is investigated using the longitudinal and transverse vibrations of a rod with a load at its end as an example. It is shown that the series in the characteristic equations converge at a faster rate when the initial system contains concentrated masses and stiffnesses. Practically important cases of changes in the dynamic properties of the structure that do not affect its natural modes are considered.

A92-14285 Numerical solution of problems in wave dynamics (Russian book) (Chislennoe reshenie zadach volnovoi dinamiki). V. G. CHEBAN, ED. *Kishinev, Izdatel'stvo Shtiintsa* (Matematicheskie Issledovaniia, No. 108), 1989, 144 pp.

The papers presented in this volume are concerned with the use of numerical, analytical, and approximate methods for solving problems in continuum mechanics. The behavior of solutions is investigated with allowance for the effect of various physicomechanical factors. Numerical algorithms are presented for calculating unsteady gas flows and wave fields in structural elements. The results obtained make it possible to investigate the behavior of a solution as a function of external factors.

A92-10854 Numerical study of the nonlinear vibrations of plates and shells under two- frequency excitation (Chislennoe issledovanie nelineinykh kolebanii plastin i obolochek pri dvukhchastotnom vozbuzhdenii). V. A. BAZHENOV, E. S. DEKHTIARIUK, IU. S. PETRINA, and K. O. ENEREMADU, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 27, Aug. 1991, pp. 68–74.

An analysis is made of the steady state nonlinear vibrations of flexible plates and shells under the effect of distributed pressure whose intensity is a two-frequency function of time. The approach used is based of nonlinear finite-dimensional dynamic models constructed by the generalized coordinate method. The numerical analysis combines the continuation in shooting method and the Bubnov-Galerkin method. The efficiency of the approach is significantly increased due to the use of the discrete Fourier transform. The behavior of a cylindrical panel under conditions of one- and two-frequency excitation is investigated as an example.

A91-41208 A study of the vibrations of elastic mechanical systems on the basis of their dynamic compliance (Ob issledovanii kolebanii uprugikh mekhanicheskikh sistem na osnove ikh dinamicheskoi podatlivosti). V. N. VERNIGOR, *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia* (ISSN 0024-0850), Jan. 1991, pp. 70–76.

The paper is concerned with the possibility of using the method of successive approximations for the calculation of the natural frequencies and equivalent masses of an elastic mechanical system. The efficiency of the method is demonstrated for the case of the transverse vibrations of a rod and a rectangular plate. Details of the calculation procedure are included.

A91-50863 Natural vibrations of preloaded anisotropic shells of revolution (Svobodnye kolebaniia predvaritel'no nagruzhennykh anizotropnykh obolochek vrashcheniia). E. I. BESPALOVA, IA. M. GRIGORENKO, A. B. KITAIGORODSKII, and A. I. SHINKAR', *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 27, May 1991, pp. 51–57.

A numerical method for determining the natural frequencies and modes of layered anisotropic shells of revolution under axisymmetric loading are discussed. In accordance with the approach adopted here, the natural vibrations of a shell are treated in the context of the theory of small vibrations as a motion produced by the perturbation of the initial state. The dynamic problem is formulated on the basis of the geometrically nonlinear theory of shells in the quadratic approximation. The lower frequency of an anisotropic elliptical shell of revolution is calculated as an example.

A91-45011 Vibrations of dissipative inhomogeneous viscoelastic shell structures (Kolebaniia dissipativno-neodnorodnykh viazkouprugikh obolochechnykh konstruktsii). E. P. KLIGMAN and V. P. MATVEENKO, *Deformation and fracture of structurally inhomogeneous materials and structures* (A91-45001 19-39). Sverdlovsk, USSR, UrO AN SSSR, 1989, pp. 96–101.

Natural attenuating and steady-state forced vibrations of dissipative inhomogeneous viscoelastic shell structures are examined analytically. The possibility of the substantial reduction of resonance amplitudes and enhancement of the damping properties of layered shells through the introduction of structural elements that change the degree of the dissipative inhomogeneity of the system is demonstrated. Calculations are carried out using the finite element method with allowance for transverse shear in the Timoshenko form. The system energy dissipation under harmonic vibrations is accounted for by using complex dynamic moduli.

A91-39220 Algorithms for calculating the stiffness matrices of an orthotropic annular finite element in curvilinear coordinates (Algoritmy vychisleniia matrits zhestkosti ortotropnogo kol'tsevogo konechnogo elementa v krivolineinoi sisteme koordinat). G. N. OL'SHANSKAIA, *Raschety na Prochnost'* (ISSN 0234-1905), No. 31, 1990, (IAA9116), pp. 71–81.

A method for solving problems in the statics and dynamics of multilayer shells of revolution is presented which is based on a finite element model. The method uses trapezoid annular finite elements whose behavior is described by elasticity relations in curvilinear coordinates. Solutions are obtained without using any assumptions concerning the stress-strain state of the individual layers and provide a way to verify the accuracy of various hypotheses and regions of their applicability.

A91-38572 Stabilizing and destabilizing effects of small damping for structures with finite number of degrees of freedom. N. V. BANICHUK and A. S. BRATUS, *Discretization methods in structural mechanics; Proceedings of the IUTAM/IACM Symposium,* Vienna, Austria, June 5–9, 1989 (A91-38551 15-39). Berlin and New York, Springer-Verlag, 1990, pp. 383–392.

A finite element formulation is used to investigate the dynamic behavior of elastic structures loaded by nonconservative forces. Stability analysis is reduced to a study of the vibration of a nonconservative mechanical system with a finite number of degrees of freedom. Dynamic properties of the system are described by a set of homogeneous ordinary differential equations. The necessary conditions for the perturbations to be ideal and asymptotic formulas for critical values are considered. The structure of the matrices which realize the ideal perturbations is discussed. The formula, evaluating the defect of the damping matrix, is presented for the case of defective perturbations. (Author)

A91-33914 Numerical investigation of bifurcations in stability problems for thin-walled structures (Chislennoe issledovanie bifurkatsii v zadachakh ustoichivosti tonkostennykh konstruktsii). G. V. ISAKHANOV, E. S. DEKHTIARIUK, and A. B. KRITSKII, *Problemy Prochnosti* (ISSN 0556-171X), Feb. 1991, pp. 66–72.

An efficient finite element procedure is proposed for obtaining bifurcating solutions to nonlinear equilibrium equations for thin-walled structures. The initial postcritical behavior of a thin elastic rod is examined as an example using a classical analytical approach and the finite element method. In both cases, the bifurcation solution is obtained by the perturbation method, and the results are compared. The high efficiency and accuracy of the approach proposed here are demonstrated.

A91-26450 Dynamics and stability of layered composite structures with interfacial delaminations (K probleme dinamiki i ustoichivosti sloistykh kompozitsionnykh struktur s mezhfaznymi rassloeniiami). B. L. PELEKH and O. S. MACHUGA, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 26, Dec. 1990, pp. 28–32.

Composite structures with delaminations are treated as piecewise homogeneous bodies with interfacial defects of various kinds. Phase conjugation conditions are formulated for ideal contact regions, and hypotheses are proposed concerning the interaction between delamination surfaces. For layered composite structures, a method for obtaining dynamic equations and equations of neutral equilibrium is proposed. A numerical method based on the Bubnov procedure is proposed for solving problems of the natural vibrations and critical forces of layered composite shells with interfacial delaminations. The natural vibrations and stability of two-layer cylindrical shells with longitudinal and annular delaminations are examined as an example.

A91-32390 Oscillations of the reflector shells of mirror antennas under vibrational excitation (Kolebaniia obolochek reflektorov zerkal'nykh antenn pri vibratsionnom vozbuzhdenii). V. S. GUDRAMOVICH, N. G. BARANOV, N. A. KONOVALOV, and I. M. MAITALA, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 27, Jan. 1991, pp. 64–71.

Experimental data are presented on the three-dimensional oscillations of nearly parabolic reflector shells of large mirror antennas under vibrational excitation. In the experiments, reflector shells were tested in the horizontal and vertical positions using electrodynamic vibration stands. The amplitude-frequency characteristics of the reflectors are determined. The effect of the location and parameters of the shell supports on these characteristics is discussed.

A91-25149 Application of the asymptotic method to the analysis of the finite-amplitude vibrations of shallow shells (Primenenie asimptoticheskogo metoda k issledovaniiu kolebanii pologikh obolochek pri konechnykh amplitudakh). N. I. ZHINZHER and V. E. KHROMATOV, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 26, Nov. 1990, pp. 93–99.

The asymptotic approach proposed by Bolotin (1962, 1979) is used to calculate the nonlinear vibrations of shallow shells and plates. Frequency relations are obtained in finite form for the nonlinear vibrations of shallow shells; the behavior of frequencies is investigated as a function of the vibration amplitude. Asymptotic expressions are obtained for the vibration frequency densities of shells and plates. The limits distributions of the vibration frequencies are determined, and the presence of points where the frequency density is particularly high is demonstrated.

A91-24477 Development of structural strength finite-element analysis techniques. V. D. CHUBAN, *Proceedings of the 17th ICAS Congress,* Vol. 2, Stockholm, Sweden, Sept. 9–14, 1990, (A91-24301 09-01). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, pp. 1747–1754.

The development and application of the finite-element method are reviewed in connection with work done at TsAGI and in the Soviet aircraft industry. Particular emphasis is placed on trends in the development of FEM software and in extension of its field of application. The TsAGI-developed MARS system is described, and examples of its application to the solution of Buran statics/dynamics problems are presented.

A91-13552 Surface instability of two fibers in a matrix (Pripoverkhnostnaia neustoichivost' dvukh volokon v matritse). IU. N. LAPUSTA, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 26, Aug. 1990, pp. 30–36.

The stability of two fibers located in a semiinfinite elastic matrix normal to its free surface is investigated in the case of axial compression using a rigorous approach based on a three-dimensional linearized stability theory and a piecewise homogeneous medium model. A solution method is proposed for compressible isotropic elastic materials under low subcritical deformations. For various flexural stability loss modes, characteristic equations are obtained in the form of infinite determinants. Good convergence of the method is demonstrated over a wide range of stiffness and geometrical parameters.

A91-13551 Dynamics of shell structures under impulsive loading (Review) (Dinamika obolochechnykh konstruktsii pri impul'snykh nagruzkakh /Obzor/). P. Z. LUGOVOI, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 26, Aug. 1990, pp. 3–20.

Research related to the effect of impulsive loading on shell structures is reviewed with reference to work published over the past ten years. Studies concerned with a variety of problems in shell dynamics are classified with allowance for the structural characteristics of the shells. The discussion covers smooth shells, shells with holes, ribbed shells, coupled shells, and shell structures of detonation chambers. (V.L.)

A91-12012 Nonlinear plane elasticity theory and its application to physically and geometrically nonlinear crack mechanics (Nelineinaia ploskaia teoriia uprugosti i ee primenenie k fizicheski i geometricheski nelineinoi mekhanike treshchin). K. F. CHERNYKH, *Uspekhi Mekhaniki - Advances in Mechanics* (ISSN 0137-3722), Vol. 12, No. 4, 1989, (IAA9102), pp. 51–75.

For an elastic potential of a special kind, corresponding to a prestressed material (infinitely linearly elastic), an exact nonlinear elasticity solution is obtained for base boundary value problems, such as a plane with a rectilinear crack and a plane with a linear solid inclusion. The asymptotic behavior of the stresses is determined, as is the configuration of the deformed contour of the crack. The asymptotic form of stresses is also examined for an elastic potential of a more general kind. The exact solutions obtained here are compared with linear elasticity solutions.

A90-48268 Some applied problems in the mechanics of dimensionally stable composite structures (Nekotorye prikladnye zadachi mekhaniki razmernostabil'nykh konstruktsii iz kompozitov). V. V. VOROBEI and N. I. VOITKOV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Mar.–Apr. 1990, pp. 292–298.

The dimensional stability of sandwich-type composite reflectors is examined with reference to the results of experimental and theoretical studies. An alternative transformable reflector structure is proposed which consists of dimensionally stable plates of reinforced composite. The optimum design problem is formulated, with the optimal computational model selected using a finite element code.

A91-12011 Vector Liapunov function method in nonlinear mechanics (Metod vektornykh funktsii Liapunova v nelineinoi mekhanike). M. V. MATROSOV, *Uspekhi Mekhaniki - Advances in Mechanics* (ISSN 0137-3722), Vol. 12, No. 3, 1989, pp. 59–82.

The concept and applications of the vector Liapunov function method are reviewed. In particular, attention is given to differential equations of motion, derivation of theorems on dynamic properties, dynamic property theorems with vector Liapunov functions, and methods for constructing vector Liapunov functions. It is noted that the method of vector Liapunov functions provides a general and efficient way to analyze the stability, algorithmic reliability, dissipativity, and many other dynamic properties of a wide variety of systems in nonlinear mechanics.

A91-12010 Normal vibrations of nonlinear finite-dimensional systems (Normal'nye kolebaniia nelineinykh konechnomernykh sistem). L. I. MANEVICH and IU. V. MIKHLIN, *Uspekhi Mekhaniki - Advances in Mechanics* (ISSN 0137-3722), Vol. 12, No. 3, 1989, pp. 3–38.

The normal vibrations of nonlinear finite-dimensional systems are investigated analytically using small parameter, iteration, and Pade approximation methods. The discussion covers normal vibration paths in configuration space, normal vibrations in conservative systems allowing rectilinear modes, and splicing of local expansions in the problem of the normal vibrations of nonlinear systems. Attention is also given to normal vibrations in near-conservative nonatonomous and self-oscillatory systems and application aspects of the theory of normal vibrations.

A90-50772 A finite element analysis of the natural vibrations of statically stressed turbine blades (Konechnoelementnyi analiz sobstvennykh kolebanii staticheski napriazhennykh lopatok turbomashin). IU. S. VOROB'EV, A. I. SHEPEL', L. G. ROMANENKO, V. N. VODCHENKO, and Z. V. SAPELKINA, *Problemy Prochnosti* (ISSN 0556-171X), July 1990, pp. 88–94.

A finite element procedure for analyzing the natural vibrations of turbine blades is presented which allows for the effect of static loads. The principal stages of the three-dimensional calculation procedure are described, and calculation results are presented for test problems. A study is made of the effect of centrifugal forces and structural characteristics on the vibration characteristics of real blades.

A90-46556 Effect of certain geometrical characteristics of a longitudinal butt joint on stress concentration under uniaxial loading (Vliianie nekotorykh geometricheskikh kharakteristik prodol'nogo styka na kontsentratsiiu napriazhenii pri odnoosnom nagruzhenii). N. A. VIDANOV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 5, 1989, pp. 76–83.

The effect of fastener proximity to the edge of a longitudinal bolted butt joint on stress concentration in the bolt-hole area is investigated by the photoelasticity method using a model of an optically sensitive material. The problem is solved using a plane elastic formulation. Expressions are obtained which describe the characteristics of stress distribution near the filled holes in a stretched specimen when the fasteners are installed using noninterfernce or interference fits.

A90-46481 A finite element analysis of the moderate bending of a thin shell (Konechnoelementnyi analiz srednego izgiba tonkoi obolochki). IU. V. SKVORTSOV and KH. S. KHAZANOV, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 1, 1990, pp. 13–17.

The paper is concerned with a version of the nonlinear theory of moderate bending in the case where the deformations and rotation angle squares remain small for finite deformations. In particular, a finite element model is proposed which is based on an isoparametric formulation following from the Timoshenko kinematic hypothesis. Results of test calculations indicate that the isoparametric approach based on the Timoshenko hypothesis provides a more flexible solution in the supercritical region than the approach based on the Kirchhoff-Love hypothesis.

A90-37830 Vibration equations for a helicopter rotor blade (Uravneniia kolebanii lopasti nesushchego vinta vertoleta). R. A. MIKHEEV and T. D. SMOL'IANINOVA, *Raschety na Prochnost',* No. 29, 1989, pp. 196–201.

The problem of rotor blade vibration is analyzed using a mathematical problem based on differential equations describing blade motions. The differential equations of blade motion are derived using equilibrium equations for a blade element. A linearized system of differential equations of blade motion can be solved using an efficient method based on the Vlasov-Kantorovich approach. The same method can also be used in a more complex (nonlinear) approach.

A90-29001 Approximation of frequency characteristics using identification with a complex mass matrix (Approksimatsiia chastotnykh kharakteristik na osnove identifikatsii s kompleksnoi matritsei mass). M. S. GALKIN and B. V. GRIGOR'EV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 2, 1989, pp. 45–52.

A mathematical model with complex mass and stiffness matrices is proposed. It is shown that the introduction of an additional parameter, the imaginary part of the generalized mass, makes it possible to describe the resonance characteristics near the resonance frequency with a higher accuracy than that obtainable by other known methods. Two methods of frequency characteristic approximation are compared with reference to full-scale test results for aircraft structures.