

Soviet and Japanese Aerospace Literature

Throughout 1991 the *AIAA Journal* will carry selected abstracts on leading research topics from the Soviet aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Composite Materials and Structures from the USSR and Crystal Growth from 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-4373. 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: *Composite Materials and Structures*

A91-33825 Efficient reinforcement of shells for compression (O ratsional'nom armirovanii rabotaushchikh na szhatie obolochek). D. V. BABICH, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Jan.-Feb. 1991, pp. 157-160. 5 Refs.

The effect of the composite structure on the stability of layered and macrohomogeneous (in the thickness direction) shells under axial and radial compression is investigated numerically. Based on the results obtained, a procedure is presented for optimizing the layup angles and reinforcement ratios for maximum stability. Three possible ways of increasing the critical load are examined.

A91-33824 Stability, postbuckling behavior, and optimization of composite shells (Ustoichivost', zakriticheskoe povedenie i optimizatsiya obolochek iz kompozitnykh materialov). N. P. SEMENIUK and N. B. ZHUKOVA, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Jan.-Feb. 1991, pp. 132-137. 12 Refs.

A method is proposed for calculating the stability and initial postbuckling behavior of smooth layered and reinforced composite cylindrical shells. The method is based on equations of the linear theory of Timoshenko shells, with allowance made for transverse shear in the reinforcing ribs and discrete arrangement of the ribs. The principal relations of the theory of initial postbuckling behavior are derived for the shells studied using the principle of possible displacements. It is shown that the application of the method proposed here to structure analysis provides a new estimate of the optimality of structures with initial imperfections.

A91-26450 Dynamics and stability of layered composite structures with interfacial delaminations (K probleme dinamiki i ustoychivosti sloistykh kompozitsionnykh struktur s mezhfaznymi rassloeniyami). B. L. PELEKH and O. S. MACHUGA, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 26, Dec. 1990, pp. 28-32. 11 Refs.

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.

A91-33820 The use of nondestructive methods for estimating the fatigue life and studying crack formation processes in composite materials (Primenenie nerazrushaiushchikh metodov dlia otsenki dolgovechnosti i issledovaniia protsessov treshchinoobrazovaniia v kompozitnykh materialakh). D. P. ALEKSANDROV and V. O. BOR-MOTKIN, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Jan.-Feb. 1991, pp. 93-98. 7 Refs.

A method is proposed for calculating the second- and third-order macroscopic elastic moduli of composites. The method is based on the solution of the problem of binary interactions between inclusions in an effective field, assuming deformation homogeneity within each inclusion. The analysis is based on the assumption of the homogeneity of the second components of deformation fields in the components.

A91-25274 Generalization of the integral Fourier transform in the boundary value problems of composite mechanics (Obobshchenie integral'nogo preobrazovaniia Fur'e v kraevykh zadachakh mekhaniki kompozitov). V. Z. PARTON, B. A. KUDRIAVTSEV, and A. L. KALAMKAROV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 315, No. 1, 1990, pp. 53-56. 14 Refs.

The effective field method is extended to statistically inhomogeneous matrix composites with arbitrary differences between the component moduli. The discussion covers the derivation of general relations, estimation of the interaction of a finite number of inclusions, and estimation of the effective parameters. Several model problems for inclusions and cracks in an inhomogeneous matrix are examined.

A90-41450 The application of probability simulation methods to predict composite structure failures taking into account service damages. A. F. SELIKHOV and A. E. USHAKOV, *Proceedings of the Seventh International Conference on Fracture (ICF7), Advances in fracture research*, Houston, TX, Mar. 20-24, 1989. Vol. 6 (A90-41276 18-39). Oxford, England and Elmsford, NY, Pergamon Press, 1989, pp. 3995-4019. 9 Refs.

The general features of the damage behavior of fiber composites (with particular reference to carbon/epoxy and Kevlar/epoxy composites) are examined in comparison with the damage behavior of metals. It is shown, in particular, that the failure of a damaged composite structure is determined only by the probability of the failure load that increases with time. Based on the characteristics of damage evolution in composites, a probability failure model is formulated which provides a way to predict the residual strength of a composite structure and to establish the inspection schedule. The application of the probability failure model is illustrated by examples.

A91-23816 Microwave heat testing of carbon composite components (SVCh teplovoi kontrol' kachestva izdelii iz ugleplastika). IU. P. PLOKHOV and B. G. TSIKIN, *Defektoskopiia* (ISSN 0130-3082), No. 12, 1990, pp. 66-75. 12 Refs.

The quasi-static growth of an antiplane shear crack in a periodically nonhomogeneous elastic material is considered. An effective velocity dependent energy release rate is found for a semi-infinite crack. Approximate expressions of stress intensity factors for in-plane cracks in periodically nonhomogeneous material are also given.

A91-18864 Residual structural stresses in reinforced shells of revolution (Strukturnye ostatocnyye napriazheniia v armirovannykh obolochkakh vrashcheniia). A. G. KOZIUK and G. I. STAROSTIN, *PMTF—Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki* (ISSN 0044-4626), May-June 1990, pp. 153-159. 9 Refs.

A method is proposed for determining the residual stress-strain state (including structural stresses) of axisymmetric composite shells produced by filament winding and forming techniques. The approach allows for the additional shrinkage and heat-induced deformation as well as for the prestress of the structural elements. Calculations for a pressure-formed glass fiber reinforced shell and a glass tape wound shell are presented as an example.

A91-18819 Statements of the continuous build-up problem for elastic bodies (O postanovkakh zadachi nepreryvnogo narashchivaniia uprugikh tel). I. F. OBRATSOV, V. N. PAIMUSHIN, and I. N. SIDOROV, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 314, No. 4, 1990, pp. 813-816. 5 Refs.

The paper is concerned with the three-dimensional linear elasticity problem for a thin rigidly reinforced periodic layer. Assuming the physical symmetry of the layer relative to the middle surface, a full asymptotic expansion is constructed, and an estimate is made of the proximity of an exact solution and a truncated sum of the asymptotic series. A splitting principle is formulated for the main term of the mean operator. In the case of isotropic reinforcement fibers, explicit formulas are obtained for the effective moduli of the composition layer. The type of the averaged equation is investigated as a function of the reinforcement pattern.

A91-15454 Fracture of a unidirectional ribbon-reinforced composite with an elastoplastic matrix under compression (Razrushenie odnonapravlennoho lentochnogo kompozita s uprugoplasticheskoi matritsei pri szhatii). A. N. GUZ' and DZH. A. MUSAEV, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 26, May 1990, pp. 3-8. 19 Refs.

The stability of unidirectional ribbon-reinforced composites with an elastoplastic matrix is investigated analytically for low filler concentrations using a piecewise homogeneous medium model in the context of a three-dimensional linearized stability theory for deformable bodies at low subcritical deformations. The loss of stability of the structure is used as the fracture criterion. The strength limits of ribbon-reinforced composites are determined under compression along the reinforcement.

A91-15396 Problems in the development of a computer microphotography method for the analysis of articles made of composite materials (Voprosy razrabotki metoda komp'iuternoi mikrografii dlia analiza izdelii iz kompozitnykh materialov). V. I. LELEKOV, V. G. PYKHTIN, and IA. G. SMORODINSKII, *Defektoskopiia* (ISSN 0130-3082), No. 10, 1990, pp. 84-90. 7 Refs.

The development of nondestructive testing equipment using three-dimensional high-resolution computer microphotography is discussed. A mathematical model of the equipment and the requirements that have to be satisfied by its main components are presented. Modular design is suggested for the automated computation units. It is suggested that the complex procedure for calculations can be applied in the solution of a wide variety of scientific tasks.

A91-15393 Automatic ultrasonic inspection of composites using rolling transducers (Avtomaticheskii ul'trazvukovoi kontrol' kompozitov katilashchimisia preobrazovateliami). V. G. IVANOV and L. I. SKOROBOGAT, *Defektoskopiia* (ISSN 0130-3082), No. 5, 1990, pp. 30-37. 9 Refs.

A random scanning procedure using rolling transducers as part of an automatic ultrasonic inspection system is presented. Three-layer composite specimens are tested using a FORTRAN-4-PLUS program and it is concluded that the random scanning produces a three-fold enhancement of the sensitivity of the automatic control; the contrast of the ultrasonic image is improved and the acoustic impedance of the defects differs from the impedance of the material; the defects can be located using digital processing; the saving of machine time is considerable.

A90-50831 Automation of strength analysis and fracture of composite structures (Avtomatizatsiia raschetov na prochnost' i razrushenie konstruktov iz kompozitnykh materialov). R. B. RIKARDS, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Jan.-Feb. 1990, pp. 69-73. 6 Refs.

The general structure of a set of finite-element software for solving problems in the statics, dynamics, and stability of composite structures is examined. As an example, a solution is presented for the problem of the nonstationary deformation of a shallow cylindrical shell of a carbon composite under pulsed loading. The efficiency of the general-purpose software described here is demonstrated.

A90-50838 A study of the characteristics of the integration of disperse polysulfone and reinforcing fibers in composite materials (Issledovanie zakonornostei sovmeshcheniia dispersnogo polisul'fona s armiruiushchimi voloknami pri poluchenii kompozitnykh materialov). L. V. ZABORSKAIA, O. R. IURKEVICH, V. A. DOVGIALO, and E. V. PISANOVA, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), May-June 1990, pp. 403-407. 10 Refs.

The characteristics of a prepreg production process whereby a disperse thermoplastic matrix is combined with a fiber reinforcement are examined with particular reference to polydisperse polysulfone and reinforcements in the form of carbon, glass, and organic fibers and fabrics. The wetting angle of the fibers is determined as a function of the initial size of the polymer matrix particles, and an anomaly in the wetting of a woven reinforcement is identified. It is shown that the interlayer shear strength of the composites depends to a large degree on the initial particle size of the disperse matrix material.

A90-48272 Stability of composite panels under compression and shear (Ustoichivost' kompozitnykh panelei pri szhatii i sdvige). N. S. AZIKOV, V. V. VASIL'EV, and A. D. PATEREKAS, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Mar.-Apr. 1990, pp. 351-353. 5 Refs.

A deformation model for a disperse-filler composite with an elastoplastic matrix and a stiff filler is proposed which is based on the solution of boundary value problems in continuum mechanics for any filler ratios under conditions of nonideal adhesion. The distribution characteristics of the mechanical fields and the effective elastoplastic properties of materials with an ordered structure are investigated. Stress-strain diagrams are presented, with and without the assumption of ideal adhesion.

A90-48268 Some applied problems in the mechanics of dimensionally stable composite structures (Nekotorye prikladnye zadachi mekhaniki razmernostabil'nykh konstruktov iz kompozitov). V. V. VOROBEL and N. I. VOITKOV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Mar.-Apr. 1990, pp. 292-298. 5 Refs.

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.

A90-48266 Experimental study of the strength and stability of carbon composite shells (Eksperimental'noe issledovanie prochnosti i ustoiichivosti obolochek iz ugleplastika). V. T. SHCHERBAKOV and A. G. POPOV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Mar.-Apr. 1990, pp. 256-262. 13 Refs.

Experimental data are presented on the strength and stability of thin walled shells fabricated by the winding of a carbon prepreg tape. The experimental results are compared with calculations, and the extent of the utilization of the strength characteristics of the composite in the plane stress state and the effect of initial stresses on the critical stability stresses are estimated. The dependence of the critical stresses on the R/h parameter and the effect of the fabrication process on the mechanical properties of the shell material are discussed.

A90-46478 Sensitivity analysis in the design of composite structures (Analiz chuvstvitel'nosti pri proektirovanii konstruktov iz kompozitov). V. A. ZARUBIN, *Aviatsionnaia Tekhnika* (ISSN 0579-2975), No. 1, 1990, pp. 3-7. 9 Refs.

A procedure is described for calculating partial derivatives of limit functions (generalized displacements, natural frequencies, and aeroelastic characteristics) for two types of design variables (unidirectional layer thickness and fiber orientation angles in the layers) in the problem of composite structure design using finite element models. Results of a wing structure analysis carried out on a computer-aided design system using a finite element code are reported. The natural vibration modes and divergences are presented.

A90-45115 Composite materials in large-scale optics (Kompozitsionnye materialy v krupnogabaritnoi optike). V. V. APOLLONOV, G. I. BABAIANTS, M. V. GARTMAN, V. M. GOLOMAZOV, IU. D. LOKTIONOV et al., *Pis'ma v Zhurnal Tekhnicheskoi Fiziki* (ISSN 0320-0116), Vol. 16, Jan. 26, 1990, pp. 83-86. 5 Refs.

Recent developments in the use of composite materials for lightweight large scale optics are reviewed. In particular, attention is given to the construction of large-scale optical elements made of composite materials based on the carbon-silicon-silicon carbide composition with an efficient thermal stabilization and good optical characteristics. The advantages of using honeycomb structures are noted in particular.

A90-29012 Divergence of thin-walled composite rods of closed profile in gas flow (Divergentsiia kompozitnykh tonkostennykh sterzhnei zamknutogo profilii v potoke gaza). V. V. KOBELEV and A. D. LARICHEV, *TsAGI, Uchenye Zapiski* (ISSN 0321-3439), Vol. 20, No. 2, 1989, pp. 109-113. 5 Refs.

The divergence of a composite wing of large aspect ratio in gas flow is analyzed using a model of anisotropic thin-walled rods of closed profile. A solution is obtained in closed form which indicates the effect of anisotropy and cross sectional shape on the critical divergence rate. The applicability limits of the model are defined.

A90-45082 Effective Helmholtz operator of matrix composites (Effektivnyi operator Gel'mgol'tsa matrichnykh kompozitov). V. A. BURIACHENKO and V. Z. PARTON, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), May-June 1990, pp. 55-63. 19 Refs.

A general scheme for constructing the effective wave operator is proposed which is based on the effective field concept. The method allows for the multiparticle interaction of inclusions and is capable of providing, in principle, any degree of solution accuracy. Analytical results are obtained using a point approximation of inclusions, assuming homogeneous deformations within the ellipsoidal inclusions.

A90-43016 Fluctuations of stresses in elastic composites (Fluktuatsii napriazhenii v uprugikh kompozitakh). V. Z. PARTON and V. A. BURIACHENKO, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 310, No. 5, 1990, pp. 1075-1078. 10 Refs.

The method of Bobeth and Diener (1986) is extended to obtain accurate estimates of all the tensor components of the second moment of the stress and strain field averaged over the component volume for elastic composites with ellipsoidal inclusions. Attention is given to the general case of the anisotropy of the mechanical properties of the components and their geometrical structure. Under the assumption of uniform random stress field in the vicinity of each ellipsoidal inclusion, a method based on perturbation theory shows that the second moment of the stress fields is constant within the inclusion.

A90-36101 A finite element study of the stress-strain state of composite shells with several holes (Doslidzhennia napruzhenno-deformovanogo stanu kompozitnykh obolonok z kil'koma otvorami metodom skinchennikh elementiv). A. S. BOGATIRCHUK, *Akademiia Nauk Ukrain'skoi RSR, Dopovidy, Seriya A—Fiziko-Matematichni ta Tekhnichni Nauki* (ISSN 0002-3531), March 1990, pp. 41-44. 6 Refs.

A finite element approach to the analysis of the stress-strain state of composite shells weakened by several holes is presented and illustrated by an example. The specific characteristics of the composite material are taken into account by using the two-dimensional theory of Timoshenko shells; the shell material is assumed to be transversally isotropic and linearly elastic. The effect of the distance between the centers of the holes on the stress intensity factors is investigated for spherical and cylindrical shells with two round holes.

A90-29205 Sensitivity analysis in the optimum design of composite shell structures (Analiz chuvstvitel'nosti pri optimal'nom proektirovanii sostavnykh obolocheknykh konstruktii). I. A. G. SAVULA and M. V. SHCHERBATYI, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), Jan.-Feb. 1990, pp. 137-143. 11 Refs.

For shells of complex configurations, expressions are obtained by the method of conjugate variables for determining the sensitivity coefficients of the weight, stiffness, and strength characteristics with respect to the node thickness values. A composite shell optimization algorithm is developed which employs the superelement approach to reduce computational costs during repeat calculations and sensitivity analysis. The efficiency of the approach proposed here is illustrated by an example involving the optimization of a CRT tube.

A90-22382 Effect of radiation on the adhesive strength of composite materials (Vlianie izlucheniia na adgezionnuu prochnost' kompozitsionnykh materialov). P. S. VORONTOV, E. I. GRIGOR'EV, and L. I. TRAKHTENBERG, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 309, No. 6, 1989, pp. 1386-1390. 13 Refs.

Changes in the adhesive strength of composites exposed to high-energy radiation were investigated in relation to the radiation-induced changes in the properties of the adhesive and the substrate. Specimens prepared by polyvinyl alcohol adsorption on Aerosil substrates were tested mechanically following irradiation in vacuum at room temperature at 960 rad/s. The rupture strength of the irradiated specimens, characterizing the absorbed dose dependence of the adhesive interaction, first remained unchanged, then decreased by about 20 percent, and after that remained constant. For the doses investigated, changes in the strength of polyvinyl alcohol were relatively small, becoming noticeable only for doses of about 1000 Mrad. The mechanisms of the radiation-induced changes in the adhesive strength are examined.

A90-15555 Numerical analysis of the impact deformation of plates of layered composites (Chislennyi analiz udarnogo deformirovaniia plastin iz sloistykh kompozitov). A. E. BOGDANOVICH and E. V. IARVE, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Sept.-Oct. 1989, pp. 804-820. 30 Refs.

The existing theoretical approaches to the study of the impact deformation behavior of layered composites are briefly reviewed. The three-dimensional elasticity problem for a rectangular plate loaded by a pressure pulse or a rigid body impact is formulated, and an algorithm is developed for solving this problem using spline approximations of displacements with respect to all the three-dimensional variables. The variational problem of the contact interaction of an elastic layered plate with a rigid impactor is stated, and an algorithm for solving this problem is described. Numerical examples are presented which illustrate stress distribution over the cross section of three-layer and five-layer carbon composite plates with polyurethane core layers loaded by a pressure pulse or by low-velocity impact.

A90-36094 The boundary layer method in the fracture mechanics of periodic composites (Metod pogranichnogo sloia v mekhanike razrusheniia kompozitov periodicheskoi struktury). A. L. KALAMKAROV, B. A. KUDRIAVTSEV, and V. Z. PARTON, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 54, Mar.-Apr. 1990, pp. 322-328. 11 Refs.

Some existing models of composite powder mixtures are briefly examined with particular reference to copper-nitride and copper-graphite mixtures. Experimental data are then presented which cannot be explained in terms of these models, and a new physical model is proposed. The new model accounts for all the experimental data on the stratification of composite powders available to date.

A90-30393 A study of local fields in the vicinity of a macrocrack in a composite with a periodic structure (K issledovaniiu lokal'nykh polei v okrestnosti makrotreshchiny v kompozitsionnom materiale periodicheskoi struktury). V. Z. PARTON, A. L. KALAMKAROV, and V. G. BORISKOVSII, *Fiziko-Khimicheskaiia Mekhanika Materialov* (ISSN 0430-6252), Vol. 26, Jan.-Feb. 1990, pp. 3-9. 10 Refs.

A new numerical-analytical approach is proposed for studying the local structure of the stress-strain state near a macrocrack in a strongly inhomogeneous composite with a periodic structure. The approach is based on the asymptotic averaging of periodic structures with allowance for additional boundary layer solutions that model local effects arising near the crack. The problem of a tearing macrocrack in a two-phase layered composite is analyzed as an example. Local stress field distributions near the crack tip are obtained, and an analysis is made of the dependence of the stress intensity factors on the composite component characteristics.

A90-29051 Composite formation in eutectic nickel alloys with molybdenum carbide (Formirovanie kompozita v evtekticheskikh splavakh nikelia s karbidom molibdena). O. M. BARABASH, R. V. GORSKAIA, T. N. LEGKAIA, and S. P. OSHKADEROV, *Akademiia Nauk SSSR, Izvestiia, Metally* (ISSN 0568-5303), Jan.-Feb. 1990, pp. 82-85. 6 Refs.

The concentration and temperature ranges of the monovariant eutectic transformation liquid phase - gamma + Mo₂C in the ternary system Ni-Mo-C are determined experimentally. The transformation temperature has a maximum at 1623 K for a eutectic containing 20.12 at. pct Mo and 5.1 at. pct Mo. The position of the tie line of the three-phase equilibrium liquid phase - gamma + Mo₂C is determined, and the corresponding polythermal section is plotted. For this polythermal section, the composite growth region is determined where a unidirectional composite structure is formed in nickel alloys with Mo₂C.

A90-27308 Deformation of composite beams under transverse impact (Deformirovanie kompozitnykh balok pri poperechnom udare). S. I. SNISARENKO, *Problemy Prochnosti* (ISSN 0556-171X), Feb. 1990, pp. 114-119. 17 Refs.

The contact force for carbon composite beams loaded in transverse impact is determined experimentally and analytically. The problem is stated and solved using the finite element method and the Timoshenko shear theory. The principal finite element equation is integrated by the Runge-Kutta method. An analysis of the experimental and analytical results indicates that the form, magnitude, and duration of the contact force depend on the elastic and strength characteristics of the contact surface and are largely determined by the natural frequency spectrum. Maximum nonstationary flexural and shear deformations are observed in beams whose first eigenfrequency half-periods are comparable with the impact duration.

A90-23442 Reliability of multilayer three-directionally reinforced plastics in the case of the arbitrary plane stressed state (Nadezhnost' mnogosloynnykh trekhnapravlenno armirovannykh plastikov pri ploskom sluchainom napriazhennom sostoianii). M. R. GURVICH, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Nov.-Dec. 1989, p. 1037-1045. 15 Refs.

An analytical procedure has been developed for the structural prediction of the reliability of three-directionally reinforced composites under conditions of arbitrary combined plane loading. The initial information used in structural prediction includes the composite geometry, number of layers, layer strength distribution, and distribution characteristics of all the plane stressed state components. The effect of the structure and stress data scatter parameters is analyzed. The optimum design problem for multilayer composite structures is stated and implemented in a computer algorithm.

A90-15561 Analysis of the dynamic characteristics of a model of an energy storage system with a composite flywheel. I—Natural frequencies and critical rotation velocities (Analiz dinamicheskikh kharakteristik modeli sistemy nakopleniia energii s makhovikom iz kompozita. I—Sobstvennye chastoty i kriticheskie skorosti vrashcheniia). G. G. PORTNOV, P. A. MOORLAT, and I. N. BARINOV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Sept.-Oct. 1989, pp. 884-895. 10 Refs.

A study is made of the natural frequencies in a kinetic energy storage system consisting of a rigid-rim spoke flywheel and a massive rigid shaft mounted in elastically damped electromagnetic bearings. The natural frequencies and critical rotation velocities are determined as a function of the system parameters. Possibilities for controlling the natural frequencies by varying the stiffness of the spokes are examined.

A90-23444 Optimization of composite shells of revolution with mixed frame and stringer reinforcement (Optimizatsiia obolochek vrashcheniia iz kompozitnykh materialov, podkreplennykh smeshanoi sistemoi nabora). V. T. TOMASHEVSKII, V. N. KALININ, and V. S. IAKOVLEV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Nov.-Dec. 1989, pp. 1054-1059. 6 Refs.

An approach to the optimization of reinforced polymer composite shells of revolution is examined from the standpoint of mathematical programming. In particular, attention is given to cylindrical shells of revolution with regular frame and stringer reinforcement loaded by uniform pressure. The problem is analyzed using a linear geometrical formulation assuming that the shell material is orthotropic, uniform, and linearly elastic.

A90-23441 Modeling of the fracture of composite bodies by the numerical/analytical potential method (Modelirovanie protsessov razrusheniia sostavnykh telchislennno-analiticheskimi metodami). I. U. V. VERIUZHSKI, D. R. GIGINEISHVILI, and A. N. SNITKO, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Nov.-Dec. 1989, pp. 1024-1030. 8 Refs.

By using the numerical/analytical potential method, a procedure has been developed for determining the stress-strain state of composite bodies. The interaction between reinforcement rods and a solution based on epoxy resins is investigated with allowance for friction and slip. Crack formation and stress distributions in element contact zones are simulated on a computer for different classes of reinforcement rods.

A90-23440 Delamination-type fracture of composite structures (Razrushenie konstruktii iz kompozitnykh materialov po tipu rassloeniia). A. N. VORONTSOV, G. KH. MURZAKHANOV, and V. N. SHCHUGOREV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Nov.-Dec. 1989, pp. 1007-1023. 81 Refs.

The available literature on the interface fracture mechanics of composite structures is reviewed in a systematic manner. In particular, attention is given to stability problems for compressed elastic elements of composite materials, including rods, plates, and shells with delamination-type defects. Examples of applications of multiparametric fracture mechanics, combined with damage accumulation theory, to the calculation of the stability and endurance of structures with interlayer defects are presented. Equilibrium dimensions and growth kinetics are determined for ellipsoidal delaminations in a spherical shell under cyclic loading.

A89-54663 A numerical-analytical approach to the study of the deformation of composite shell structures (Chislennno-analiticheskii podkhod k issledovaniiu deformirovaniia obolocheknykh konstruktii iz kompozitov). V. N. BAKULIN and V. O. KALEDIN, *Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela* (ISSN 0572-3299), July-Aug. 1989, pp. 184-188. 6 Refs.

An approach combining the numerical finite element method and the analytical small parameter method is applied to the parametric analysis of the stress-strain state of composite shell structures of anisotropic materials. By using this approach, variable-geometry problems for composite shells are reduced to multiple successive repetitions of a solution to a system of linear algebraic equations with the same coefficient matrix. This approach also allows efficient automation of the parametric analysis of reinforced shell structures.

A89-49175 The use of compensators in tomographic studies of composites (Primenenie kompensatorov pri tomograficheskikh issledovaniakh kompozitov). V. I. BARAKHOV, V. A. CHERNIAEVA, A. P. STEPANOV, and V. S. KISELEV, *Defektoskopiia* (ISSN 0130-3082), No. 6, 1989, pp. 8-12.

The errors typically occurring during the investigation of the internal structure of composites by computerized tomography are briefly examined, and the need for using a compensating layer is demonstrated. Results of tomographic experiments, with calcium chloride solutions used as a compensator are presented, and recommendations are given concerning the selection of solution concentration and compensator layer thickness.

A89-54587 A version of the linear theory of composite shells allowing for transverse shear and reduction (Variant lineinoi teorii kompozitnykh obolochek, uchityvaiushchii deformatsii poperechnogo sdviga i obzhatie). V. K. IVANOV, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), July-Aug. 1989, pp. 682-687. 7 Refs.

A version of the linear theory of composite shells is presented which includes transverse shear, cross-sectional reduction, and nonlinear displacement distribution over the shell thickness. Equilibrium equations in forces and moments are supplemented by equations eliminating the discrepancy between transverse stresses determined by integrating three-dimensional elasticity equations and Hooke law. The accuracy of the solutions depends on the number of the resolved discrepancies.

A89-48912 Trends in the development of nondestructive testing methods for composite materials (Tendentsii razvitiia metodov nerazrushaiushchikh ispytaniia kompozitnykh materialov). I. G. MATIS, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), May-June 1989, pp. 494-502. 19 Refs.

Current developments and trends in the nondestructive testing and quality control of composite materials are reviewed with reference to recent publications in this field and reports presented at international conferences. Particular attention is given to the development of measuring systems using artificial intelligence concepts, systems using new physical phenomena, development of expert systems, and new designs of measuring transducers.

A89-48904 Elasticity and fracture of triorthogonally reinforced media. II—Shear (Uprugost' i razrushenie triortogonal'no armirovannykh sred. II—Sdvig). G. A. VANIN, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), May-June 1989, pp. 431-436. 6 Refs.

The thermoelastic equilibrium of multilayer composite shells of revolution of the cylinder-cone type is analyzed for the case of mechanical loading and convective heat transfer between the shell and the ambient medium. Heat conductivity and thermoelasticity boundary value problems for multilayer composite orthotropic shells are formulated. The elasticity analysis is based on hypotheses allowing for the nonlinear distribution of transverse shear deformations over the thickness of a multilayer stack. The heat conductivity and thermoelasticity boundary value problems are solved numerically using the discrete orthogonalization method.

A89-44691 Radiation-cured polymer composites (Radiatsionno-otverzhdaemye kompozitsionnye polimernye materialy). I. U. P. BOICHENKO, V. T. BLOKHIN, V. N. KESTEL'MAN, and G. E. VISHNEVSKI, *Akademiia Nauk SSSR, Doklady* (ISSN 0002-3264), Vol. 305, No. 6, 1989, pp. 1369-1372. 8 Refs.

A process for the production of glass-reinforced composite laminates is proposed which uses radiation curing of the polymer matrix by a beam of accelerated electrons. Typically, the laminate consists of one or several layers of fiber glass fabric impregnated by a reaction-curable polymer matrix material and sandwiched between two layers of a polymer film or copper foil. The process is described with particular reference to results obtained for a three-component matrix system consisting of dimethylacrylate-(bis-triethylene glykol)phthalate, an epoxy oligomer, and an acrylic monomer (methacrylic acid).

A89-42407 Effective characteristics of governing relations for thermorheologically simple composites (Effektivnye kharakteristiki opredeliaushchikh sootnoshenii termoreologicheskii prostykh kompozitov). V. M. PESTRENIN and I. V. PESTRENINA, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Mar.-Apr. 1989, pp. 214-220. 15 Refs.

Different forms of governing equations for thermorheologically simple composites are presented in which the effective characteristics include relaxation (creep) function tensors, relaxation (creep) nucleus tensors, thermal expansion function vectors, and temperature stress function vectors. For constructing these mathematical entities, an approach is proposed which is based on the nonlinear approximation of the solution in image space using the Laplace transform. An exact solution is obtained for the case of layered materials.

Japanese Aerospace Literature This month: Crystal Growth

A91-21654 Growth and magnetic properties of Ti-Ca-Ba-Cu-O single crystals. KENICHI KAWAGUCHI and MASAO NAKAO, *Journal of Crystal Growth* (ISSN 0022-0248), Vol. 99, No. 1-4, Pt. 2, Jan. 1990, pp. 942-946. 13 Refs.

Single crystals of $Ti_2Ca(n-1)Ba_2Cu(n)O(2n+4)$ where $n = 1, 2, 3$, and 4, were grown by a slow-cooling method. The onset critical temperatures were 70, 104, 122, and 113 K for $Ti_2Ba_2CuO(x)$, $Ti_2CaBa_2Cu_2O(x)$, $Ti_2Ca_2Ba_2Cu_3O(x)$, and $Ti_2Ca_3Ba_2Cu_4O(x)$, respectively. The critical current density J_c of a $Ti_2CaBa_2Cu_2O(x)$ single crystal was strongly reduced with increasing temperature: J_c was 509,000 A/sq cm at 10 K and dropped to 11,000 A/sq cm at 40 K. Large time-logarithmic magnetic relaxation was observed for the same single crystal sample, which suggests a small depinning activation energy of about 0.02.

A91-21628 Direct observation of LPE growth in GaP. Y. INATOMI and K. KURIBAYASHI, *Journal of Crystal Growth* (ISSN 0022-0248), Vol. 99, No. 1-4, Pt. 1, Jan. 1990, pp. 124-127. 8 Refs.

An in situ observation technique using an infrared microscope is developed in order to observe the liquid/solid interface from the bottom side of a substrate during the process of LPE growth of semiconductor crystals. Particular attention is focused on macrosteps, types of ripples appearing on as-grown LPE crystal surfaces which are characterized by a terrace and/or wavelike pattern having no relation to the direction of liquid removal. The technique successfully gives clear images of morphological variations during the LPE GaP crystal growth process. It is pointed out that the appearance of macrosteps, shown in the present observation, will be an aid for the precise discussion of the mechanism of macrostep formation.