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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 Mechanical Properties from Russia and Fracture Mechanics from Japan.

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Russian Aerospace Literature
This month: *Mechanical Properties*

A95-44612 Influence of fine grained structure and superplastic deformation on the strength of aluminium alloys. I—The phenomenology of the influence of fine grained structure and superplastic deformation on t. M. K. RABINOVICH (Ufa State Aviation Technical Univ., Russia) and M. V. MARKUSHEV (Russian Academy of Sciences, Inst. for Metals Superplasticity Problems, Ufa, Russia), *Journal of Materials Science* (ISSN 0022-2461), Vol. 30, No. 18, 1995, pp. 4692–4702. 29 Refs. Documents available from Aeroplus Dispatch.

The influences of fine grained (FG) structure and superplastic deformation on the mechanical properties under quasistatic impact and cyclic loading conditions were established for the aluminum alloys 1560 (Al-Mg-Mn), 1141 (Al-Cu-Mg-Ni-Fe), and 1960 (Al-Zn-Mg-Cu-Zr). FG materials, compared with recrystallized coarse-grained (CG) ones, have improved tensile strength and ductility and high-cycle fatigue endurance, but have less static and impact toughnesses. The effect of grain refinement on crack resistance is directly manifested in the difficulty of crack initiation and in facilitating its growth. Blanks with FG structure, after superplastic processing, are recommended instead of the CG recrystallized ones for the production of principal parts whose service life is limited by first crack appearance. In the presence of cracks, higher strength can be obtained by the use of blanks made of CG commercial semifinished products and those manufactured by the traditional methods of hot die forging. (Author)

A95-39995 Selecting a phase diagram approximation and a martensite crystal disintegration model for shape memory alloys (Vybor approksimatsii diagrammy perekhoda i modeli ischeznoveniya kristallov martensita dlya splavov s pamyat'yu formy). A. A. MOVCHAN (Moskovskij Aviatsionnyj Inst., Moscow, Russia), *PMTF—Prikladnaya Mekhanika i Tekhnicheskaya Fizika* (ISSN 0869-5032), Vol. 36, No. 2, 1995, pp. 173–181. In Russian. 22 Refs. Documents available from Aeroplus Dispatch.

Governing equations describing phase deformations in shape memory alloys are obtained using a micromechanical scheme. A phase diagram approximation is proposed which provides the best description of the effects of direct and oriented transformations. A martensite crystal disintegration model is also developed for describing the conventional and reverse shape memory effects. The approach used here may be extended to allow for several structural levels of the deformation process.

A95-39983 Equipment and method for the strength testing of composite materials at temperatures up to 3300 K (Ustanovka i metodika dlya prochnostnykh ispytanij kompozitsionnykh materialov pri temperaturakh do 3300 K). V. S. DZYUBA, A. V. VYSOTSKIJ, and S. V. ZUBIK (NANU, Inst. Problem Prochnosti, Kiev, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 9, 1994, pp. 86–90. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

A machine for testing carbon/carbon composites in tension, compression, and bending at temperatures up to 3300 K in vacuum, air, and inert medium is described. Design features of the test machine which provide for a uniform temperature field distribution throughout the specimen volume are described, as are methods of measuring deformation and temperature with high accuracy. The test procedure and the computer-based test control system are briefly discussed.

A95-39976 Dynamic mechanical properties of composites based on polyethylene and thermally expanded graphite (Dinamicheskie mekhanicheskie svojstva kompozitsionnykh materialov na osnove poliehtilena i termorasshirennogo grafita). L. S. SEMKO, I. G. CHERNYSH, and N. I. SVINTSITSKIJ (NANU, Inst. Khimii Poverkhnosti, Kiev, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 7, 1994, pp. 84–91. In Russian. 19 Refs. Documents available from Aeroplus Dispatch.

The dynamic mechanical and relaxation properties of polyethylene-matrix composites reinforced by thermally expanded graphite particles were investigated in the temperature range 180–80 C for particle volume fractions of 0–1. It is found that thermally expanded graphite is an effective filler for improving the elastic properties of composites. The three-dimensional structures formed by graphite particles are shown to have a significant effect on mechanical relaxation processes occurring in polyethylene and composite materials. The results obtained are examined in terms of the percolation theory. The relations of this theory are used in a mathematical description of changes in the dynamic shear modulus as a function of graphite content over a range of component concentrations and temperatures.

A95-37967 Residual stresses influence on the dimensional accuracy of carbon-epoxy plastic reflectors. S. CHERNOPAZOV, Y. NYASHIN, V. BARANOV, and V. PECHENOV (Perm Polytechnic Inst., Russia), *ICRS-4—Proceedings of the 4th International Conference on Residual Stresses*, Baltimore, MD, 1994 (A95-37926 10-39), Bethel, CT, Society for Experimental Mechanics, Inc., 1994, pp. 724–731. 3 Refs. Documents available from Aeroplus Dispatch.

The problem of the residual stresses and satellite aerial reflector manufacturing precision is considered. The analysis of the residual stress forming is given and on its basis a model of reflector manufacturing precision prediction is suggested. The influence of thermocycling on the mechanical properties, residual stresses in the carbon plastic, manufacturing precision, and dimensional stability of the reflectors is investigated. (Author)

A95-35700 Effect of zirconia powder prehistory on strength of zirconia-toughened nickel aluminide. S. M. BARINOV and V. Y. EVDOKIMOV (Russian Academy of Sciences, High Tech Ceramics Research Center, Moscow, Russia), *Journal of Materials Science Letters* (ISSN 0261-8028), Vol. 14, No. 11, 1995, pp. 820–822. 9 Refs. Documents available from Aeroplus Dispatch.

A comparison is conducted between the strength behavior of NiAl/ZrO_2 composites that have been toughened by various zirconia dispersoids. It is established that substantial improvements in composite mechanical properties are achievable through the use of both partially stabilized and nonstabilized zirconia dispersoids, but that this effect is strongly dependent on the precompositing processing history of the zirconia powder.

A95-35411 The peculiarities of structure and properties formation of diamond-containing functional gradient materials in the SHS-regime. E. LEVASHOV (Moscow Steel and Alloys Inst., Russia), *FGM 94; Proceedings of the 3rd International Symposium on Structural and Functional Gradient Materials*, Swiss Federal Inst. of Technology, Lausanne, Switzerland, 1994 (A95-35401 09-23), Lausanne, Switzerland, Presses Polytechniques et Universitaires Romandes, 1995, pp. 95–100. 5 Refs. Documents available from Aeroplus Dispatch.

Some peculiarities of diamond-containing FGM manufacturing in the self-propagating high-temperature synthesis (SHS) regime were studied.

Because of the short characteristic periods that a diamond stays in the high-temperature zone of the combustion wave, it appears possible to produce new materials impregnated with diamond grains by the SHS method without application of high pressure. Conditions were found in which a diamond preserves its strength properties in the combustion wave, and a new approach to the FGM synthesis allows one to significantly raise the limit of exothermic mixture dilution by diamond and to produce a material with a diamond concentration in the layer of up to 50 vol%. The influence of the mass and composition of the diamond-free exothermic mixture layer on the method of structure formation of various SHS FGMs containing diamond was studied. FGM of the systems NiAl/(NiAl + diamond), TiB/(TiB + diamond) were produced. (Author)

A95-35307 Natural aging of aluminum-magnesium alloys—Ways of stabilizing properties (Estestvennoe starenie splavov alyuminij-magnij—Puti stabilizatsii svojstv). L. I. KAJGORODOVA (RAN, Inst. Fiziki Metallov, Yekaterinburg, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 78, No. 5, 1994, pp. 29–39. In Russian. 22 Refs. Documents available from Aeroplus Dispatch.

Data in the literature related to the natural aging of aluminum-magnesium alloys are reviewed. It is shown that the observed reduction in ductility and corrosion resistance during aging is caused by grain-boundary precipitates. The possibility of obtaining a grain-boundary structure with specified parameters by using thermomechanical and thermal cycling treatments is examined. Data on the alloying of the Al-Mg system by small additions are analyzed. The effect of alloying elements on phase transformations during aging is discussed.

A95-35305 Structure and mechanical properties of alloys following stepped aging (Struktura i mekhanicheskie svojstva splavov, podvergnutykh stupenchatomu stareniyu). R. R. ROMANOVA, A. N. UKSUSNIKOV, and Y. M. USTYUGOV (RAN, Inst. Fiziki Metallov, Yekaterinburg, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 78, No. 5, 1994, pp. 5–18. In Russian. 46 Refs. Documents available from Aeroplus Dispatch.

Results of an experimental study and data in the literature are generalized with a view to determining the mechanism of the stepped aging of metal alloys. The existing concepts of the recovery are reexamined, and the recovery process in alloys is explained from a unified standpoint. It is shown that elastic stresses due to the mismatch between the matrix and precipitate lattices, along with such factors as the temperature and time of low-temperature aging and temperature of high-temperature aging determine the thermal stability of precipitates at the high-temperature stage. In particular, the possibility of recovery during the heating of an aged alloy to a temperature below the coherent solubility curve is demonstrated.

A95-35300 The relationship between the structural characteristics of AL9 alloy and its properties (Svyaz' strukturnykh kharakteristik splava AL9 s ego svojstvami). I. G. BRODOVA, D. V. BASHLYKOV, and I. V. POLENTS (RAN, Inst. Fiziki Metallov, Yekaterinburg, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 78, No. 3, 1994, pp. 123–129. In Russian. 4 Refs. Documents available from Aeroplus Dispatch.

The objective of the study was to investigate the possibility of improving the structure and mechanial propertries of AL9 silumins by using a special casting process involving superheating of the molten metal. It is found that there exists a critical temperature of melt heating which leads to changes in the morphology and structural components of the alloy. Holding the liquid metal at a specified temperature prior to casting makes it possible to improve the ductile properties of the alloy.

A95-33484 Effect of the rolling direction on the strength and ductile characteristics of wide sheets of PT-3Vkt alloy (Vliyanie napravleniya prokatki na kharakteristiki prochnosti i plastichnosti 'shirokikh' listov splava PT-3Vkt). A. A. BRYUKHANOV, A. R. GOKHMAN, and Y. G. MIKHAJLIVSKIJ (Odesskij Pedagogicheskij Inst., Odessa, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 6, 1994, pp. 72–77. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

A study is made of the orientation dependence of the mechanical properties of a Ti-Al-V alloy, PT-3Vkt, after warm transverse rolling followed by cold rolling. Fourier series are obtained for describing the anisotropy of each property based on the experimental data and a strength criterion which allows for the effect of hydrostatic pressure on the material strength. Correlations are established between the physical and mechanical properties of the material.

A95-33477 Controlling the dimensions of quasi-single crystals of an aluminum alloy during their fabrication (Upravlenie razmerami kvazimonokristallov alyuminievogo splava pri ikh izgotovlenii). A. I. RADCHENKO, M. V. KARUSKEVICH, and V. R. NAIM (Kievskij Inst. Inzhenerov Grazhdanskoj Aviatsii, Kiev, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 5, 1994, pp. 41–44. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

A method is presented for controlling the dimensions of quasi-single crystals of D16 aluminum alloy, commonly used in aircraft engineering. The quasi-single crystals are used instead of single crystals in static fatigue tests with a view to validating a discrete-probability fatigue model for metals and alloys. A mathematical model is developed for the dimensional control of aluminum alloy quasi-single crystals.

A95-33473 Fractionation of compact elements under thin plate impact (Droblenie kompaktnykh ehlementov pri udarnom vzaimodejstvii s tonkoj plastinoj). G. V. STEPANOV, V. I. ZUBOV, A. P. LYAPUNOV, and V. A. MARTYNOV (ANU, Inst. Problem Prochnosti, Kiev, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 4, 1994, pp. 51–57. In Russian. 2 Refs. Documents available from Aeroplus Dispatch.

Results of an experimental study of the fracture and fractionation of solid bodies in the form of a short cylinder resulting from the impact of a thin metal plate are presented. It is shown, in particular, that the limiting fractionation velocities are largely determined by the scale factor, plasticity, and other physicomechanical properties of the material. Fractionation is caused by one or several related phenomena, such as intense plastic deformation, wave processes, and residual stress fields.

A95-33097 Fracture toughness of modern high-temperature nickel alloys under prolonged static loading at elevated temperatures (Treshchinostojkost' sovremennykh zharoprochnykh nikelevykh splavov v usloviyakh dlitel'nogo staticheskogo nagruzheniya pri povyshennykh temperaturakh). N. A. VOROB'EV, *Metally* (ISSN 0869-5733), No. 2, 1995, pp. 131–138. In Russian. 7 Refs. Documents available from Aeroplus Dispatch.

The fracture toughness of high-temperature nickel alloys during prolonged static loading at elevated temperatures was investigated in relation to the structure and mechanical properties of the alloys. It is found that the fracture toughness of the alloys is dependent on the size of the gamma prime phase particles and the structure type. The acceptable defect size is shown to decrease as the creep limit increases. The acceptable defect size can be used for optimizing the process to achieve maximum fracture toughness and creep strength.

A95-33095 Structure and properties of rapidly solidified nickel aluminide foil (Struktura i svojstva fol'gi iz alyuminida nikelya, poluchennoj bystroj kristallizatsiej). A. F. EDNERAL, O. A. SKACHKOV, K. B. POVAROVA, E. I. MALIENKO, V. D. PLAKHTIJ, Z. I. DZNELADZE, and V. V. LARIN, *Metally* (ISSN 0869-5733), No. 2, 1995, pp. 101–107. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

A study is made of the structure and properties of 120–200-μ foil of a rapidly solidified Ni_3Al-based alloy containing (at. pct) 6.68 Cr, 0.86 Mo, 1.14 Zr, and 0.98 B. The foil has an inhomogeneous structure: the surface layer consists of equiaxed dendritic cells up to 1μ in size; the central area has a fine-grained structure consisting of equiaxed grains (cells) with a cross section of 1–2μ. The mechanical properties of the as-cast foil vary over a wide range in different areas under tensile loading. The maximum tensile strength is 1832 N/sq mm; the 0.2 yield stength is 1105 N/sq mm; the elongation is 2.27%.

N95-16397 US-Russian workshop on computer synthesis of structure and properties of advanced composites final report. Y. G. YANOVSKY, *Academy of Sciences* (USSR), Moscow (USSR). Inst. of Applied Mechanics. Documents available from Aeroplus Dispatch.

The objective of this workshop is to discuss the results of recent studies and experience accumulated by Russian and American scientists in the development of fundamental theoretical concepts, computer programs, methodology, and techniques for numerical and experimental modeling of structure and mechanical properties of advanced composite materials, in particular with polymer matrices.

A95-26015 Metallurgical and technological aspects of titanium alloys application for helicopter industry. M. G. VEITSMAN (Mil Moscow Helicopter Plant, Russia), *20th European Rotorcraft Forum*, Amsterdam, Netherlands, 1994, Proceedings. Vol. 4 (A95-25916 06-01), Amsterdam, Netherlands, National Aerospace Laboratory, 1994, pp. 110-2–110-11. Documents available from Aeroplus Dispatch.

The paper gives information on titanium alloys used in helicopters developed by the Mil Moscow Helicopter Plant, shows different principles of technology used for manufacturing of forgings on metallurgical and of parts on machine-building plants, and presents data indicating their quality level. Special attention is given to the development of specific quality control methods for components and half-finished products which assure their high quality and long service life. (Author)

A95-26006 Application of high-strength polymer composites in Mil helicopter designs. E. L. APARTSEVA (Mil Moscow Helicopter Plant, Russia), *20th European Rotorcraft Forum*, Amsterdam, Netherlands, 1994, Proceedings. Vol. 4 (A95-25916 06-01), Amsterdam, Netherlands, National Aerospace Laboratory, 1994, pp. 101-2–101-8. 3 Refs. Documents available from Aeroplus Dispatch.

The characteristics of high-strength polymer composites and their advantages of their use in the design of Mil helicopters are briefly reviewed. As a result of this use, the utilization factor of materials in Mil helicopters has increased by 0.8–0.9%, man-hour and power requirements have been reduced by 1.5–3.0 times in manufacture of sophisticated components, the weight of airframe components has been reduced by 14%, and the service lives of these components have increased by factor of 3–4, while calender lives have increased by up to 10 years.