ABSTRACT AND REFERENCES

MATERIALS SCIENCE

RESEARCH OF FRACTURE OF DOPED TITANIUM ALLOYS UNDER CAVITATION (p. 4–8)

Vladimir Kovalenko, Vladimir Marinin

The paper presents experimental results on the measurement of the fracture value under the influence of cavitation on titanium alloys doped with Al, V, Mo and Ti-Al coatings. The coatings were formed of erosion vacuum-arc discharge plasma at simultaneous operation – Al and Ti cathodes mounted at an angle of 90° with respect to each other. The substrate, on which the coating was deposited, is at an angle of 45° to both cathodes. To create a cavitation zone, in which samples were established, ultrasonic vibration transducer of the exponential profile was used. The vibration frequency of the end surface of the transducer is equal to 20 kHz, amplitude – 30±2 microns. Measurements of the fracture value were carried out by the gravimetric method with an accuracy of ±0.015 mg. The kinetic curves of fracture of the samples were obtained. The dependence of the average failure rate of titanium alloys on the surface vibration amplitude of the transducer, creating a cavitation zone in the form of a ratio $V_{cp}=B\cdot e^{A}$, where B, γ are constants for a given material was established. The dependence of V on the value of microhardness (Hμ) of the alloy is described by analytical relationship $V = aH_{\mu}^{n}$, where a=28.4, n=–2.9, Hμ is measured in GPa. The possibility of increasing the cavitation resistance of alloys more than twofold by drawing the Ti-Al coatings on their surface was shown.

Keywords: titanium alloys, Ti-Al coatings, cavitation, influence, fracture, microhardness, relationship.

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DEVELOPMENT OF THE HIGH-SPEED BORIDING TECHNOLOGY OF ALLOY STEEL (p. 8–15)

Kateryna Kostyk

The aim of the paper is to develop an easy-to-use and energy-efficient boriding nanotechnology of alloy steel parts, which is aimed at reducing the thermochemical treatment duration in obtaining high-quality boride layers, providing the necessary performance characteristics. The method of solving the problem was to find the optimum treatment temperature and time, and the influence of boriding process parameters on the hardened layer depth and hardness was studied for estimating the parameters characteristic of the diffusion layers. The research material was steel 30KhGSA. For paste boriding, the mixture based on nanodispersed boron-containing compounds was used. Heating was performed in a box furnace for 15 up to 120 minutes at temperatures ranging from 800 to 900 °C. It was found that the increase in boriding temperature and time leads to the growth of borated layers and the transition zone. Paste boriding provides a surface hardness within 22–20 GPa with the decrease to 18–16 GPa along the layer to the transition zone. The obtained mathematical model and nomogram allow to determine the specific conditions of boriding (temperature and duration) based on a given layer depth of borides, which is of great practical importance. The resulting dependence of the experimental effective diffusion coefficient of boron for alloy steel confirmed the threefold acceleration of the boriding process. The practical significance of the work lies in the fact that the developed technology can be used on plants without having to install additional and update existing equipment. Thus, a new high-speed boriding method, allowing to carry out processing to produce high-quality diffusion layers was proposed.

Keywords: boriding, steel, diffusion layers, microhardness, layer depth, mathematical model, nomogram.

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STUDY OF THE DYNAMICS OF CHANGES IN THE STRUCTURE OF PLAIN WEAVE FABRICS IN THE FORMATION PROCESS (p. 15–20)

Olena Fedorchenko, Oksana Zakora, Olena Riazanova

Experimental studies of the structure of plain weave fabrics to predict the real structure and properties were carried out in the paper. To this end, dynamic processes of changes in the structure of fabrics at the stages of manufacturing: in the design, in threading on the loom and after removal from the loom at steady state were analyzed. The order of the phase structure, as a characteristic of mutual spatial orientation of the systems of warp and weft threads in the fabric, was selected as a criterion. To determine the structure phase of fabrics, the method of micro-sections, whose images were processed using a special computer program was applied. Analysis of the data showed that the order of the phase structure of the fabric increases during the transition from one fabric formation stage to another, but the nature of these changes is ambiguous and depends on the ratio of diameters and bending waves of threads taking into account their mutual position. Defining the patterns of these changes for plain weave fabrics will allow to improve the design methods of fabrics of other weaves.

Keywords: plain weave, order of structure phase, stages of manufacturing, design, fabric structure stabilization, method of micro-sections.

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SIMULATION OF THERMAL CONDUCTIVUTY OF POLYMER COMPOSITES BASED ON POLY(METHYL METHACRYLATE) WITH DIFFERENT TYPES OF FILLERS (p. 21–24)

Roman Dinzhos, Eduard Lysenkov, Nataliia Fialko

The results of investigating the influence of fillers of different nature on the thermal conductivity of polymer composites are widely presented in modern scientific works of many authors. However, there has been little analysis of the obtained data within existing percolation models of thermal conductivity. Using mathematical simulation allows to improve the methods of manufacturing composites and manage the properties in a wide range.

The paper presents the results of experimental and numerical studies of thermal conductivity of poly(methyl methacrylate) and composites containing aerosil, carbon nanotubes, iron oxide and dispersed aluminum particles. The influence of the type and size of fillers on the features of thermal conductivity of the studied polymer composites was investigated. It was found that in the studied systems, there is a typical percolation transition, which is associated with the formation of the filler particles of "continuous" cluster. It was revealed that the lowest percolation threshold is observed for aerosil-filled composites. After reaching the percolation threshold, thermal conductivity for a system based on poly(methyl methacrylate) and carbon nanotubes increases threefold. Mathematical simulation of the percolation behavior of thermal conductivity of polymer composites within the basic theoretical models was carried out. It was shown that using the McLachlan's allows to accurately predict the value of the thermal conductivity coefficient for polymer composites.

The investigated polymer composites based on poly(methyl methacrylate) can be used as materials for creating products of the thermal power complex.

Keywords: thermal conductivity coefficient, percolation behavior, polymer composites, inorganic fillers, theoretical models.

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COMPARATIVE STUDIES OF RADIATION-PROTECTION FILLERS FOR COMPOSITE MATERIALS BASED ON FOSFOGIPSUM BINDER (p. 25–29)

Anatoliy Bulat, Valery Ivanov, Ephim Zvyagilskiy, Konstantin Golov, Volodymyr Bolshakov

The results of comparative experimental studies of the effect of various radiation-protection (RP) fillers for composite materials based on phosphogypsum binder on their RP properties were considered.

The regularities of the influence of the parameters of X-ray protection structures, such as thickness, RP filler concentration, composite material density and matrix, etc. on the level of radiation protection of personnel taking into account the properties of phosphogypsum-based composite materials were established and, thus, creation technology parameters and efficiency of such structures were substantiated.

The high efficiency of the rare earth elements (REE) as RP fillers for the phosphogypsum binder at a concentration of 30 % by weight is associated with high RP properties at significantly lower cost compared to other investigated RP fillers.

Comparative experimental studies have convincingly shown that REE are technologically advanced and the most efficient RP filler for gypsum binder, which offers the prospect of creating X-ray protection means (including collective) of a new technological level.

Keywords: phosphogypsum, concentration, radiation protection, filler, rare earth elements, barium sulfate, tungsten.

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SYNTHESIS AND PROPERTIES OF SPINEL PHASE $ND_xMG_{1-x}Al_2O_4$ (p. 30–34)

Teymur Ilyasly, Zakir Ismailov, Humane Huseynova, Rena Abbasova, Lala Mamedova, Sitara Veysova

Crystallization of the amorphous mass and formation of the spinel structure begins at 800 °C. At that, the dimensions of the newly formed crystals are less than 6 nm. Introduction of neodymium has virtually no effect on the crystallographic parameters of pure spinel. Heat-treated samples at 800 °C and higher temperatures have mainly a spinel structure. However, in the samples, sintered to 1000 °C, with the composition $Nd_{0.05}Mg_{0.95}Al_2O_4$ and $Nd_{0.1}Mg_{0.9}Al_2O_4$, weak unidentified reflexes are revealed. In the heat-treated at 1200 °C neodymium-doped samples, reflexes only of the spinel structure are observed.

The chemical and phase composition of the obtained pigment was examined using various methods, such as thermal analysis (TGA and DTA), X-ray diffraction (XRD) and transmission electron microscopy (TEM). The spectral characteristic of inorganic pigments was studied by infrared spectroscopy (IR), and UV-Vis spectroscopy (200–800 nm).

Keywords: nanoparticles, inorganic pigments, spectroscopy, spinels, amorphous mass, reflexes, crystals, crystallization, heat treatment.

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THE EFFECT OF HEAT TREATMENT ON THE PROPERTIES OF THE NEW IRON-BASE ALLOY (p. 35–40)

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The aim of the research was to develop a new austenitic dispersion-hardened corrosion-proof and scaling-resistant iron-base alloy. We have selected and analyzed in detail the chemical composition of the desired alloy, made calculation of the charge and held melting in an induction furnace. We have devised a technology of thermal treatment of the resulting alloy and proved that the best mode is hardening at a temperature of 1180 °C and aging at a temperature of 1000 °C that lasts for 1 hour and is followed by cooling in the air. The more intense dispersion hardening of the alloy results in higher values of its strength and ductility. The study of the scaling resistance shows that it is appropriate to use the alloy at temperatures raised up to 750 °C. The experimental study of corrosion resistance of the alloy shows that the alloy is corrosion-proof and not subject to changes in mass when exposed to a 10 % sulfuric acid solution.

Keywords: austenitic steel, alloy with a shape memory effect, strength, ductility, resistance to scaling, corrosion resistance.

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DEVELOPMENT OF PROTECTIVE MATERIALS BASED ON GLASS- AND SLAG-CONTAINING PORTLAND CEMENT STRUCTURES (p. 41–47)

Olga Bondarenko, Sergii Guzii, Kate Zaharchenko, Elizabeth Novoselenko

The effect of the glass powder of the broken container glass on the strength and corrosion resistance of protective materials based on the slag-containing Portland cement is investigated.

Using the three-factor simplex-centroid experimental design, the optimization of structures of protective materials, bounded on the axis X_1 by the content of granulated blast-furnace slag (GBFS) of 25–50 %, on the axis X_2 – the amount of glass powder (GP) of 5–10 %, on the axis X_3 – the changes in W/C of 0.24–0.3 is carried out.

As a result, the optimum structure of the protective material comprising 40 % of GBFS (X_1 factor), 10 % of GP (X_2 factor) at W/C=0.3 (X_3 factor) is obtained. The material is characterized by a flexural strength of 6.5–8.1 MPa in the range of 2–28 days and the resistance coefficient of 1.38–2.1 after curing samples in corrosive environments for 60 days.

A slight loosening of the surface layer of the protective material of the optimum structure in the environment of 5 % sodium sulfate solution due to the formation of the corrosion product – calcium sulfate is observed. The macrostructure of the stone chip of the investigated structure aged for 60 days in solutions of 5 % sodium chloride and sulfate was not affected.

The approbation of the protective material of the optimum structure to determine its resistance to aggressive influences of an urban environment when restoring the damaged section of the reinforced concrete slab on the "Kyivska Rusanivka" railway halt is performed. It is shown that after 7 days of hardening in difficult weather conditions, no changes on the surface of the developed protective material, as well as gaps between the material and the concrete base were observed.

The data obtained allow to recommend the developed material for restoring and protecting concrete and reinforced concrete structures of transport facilities in an aggressive urban environment, and also for improving the ecology of the region by recycling of broken container glass.

Keywords: aggressive urban environment, granulated blast-furnace slag, protective material, corrosion resistance coefficient, flexural strength, Portland cement, glass powder.

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EFFECT OF LATTICE EXPANSION DEGREE ON PROPERTIES AND ELECTROMAGNETIC FIELD RESPONSE OF InSe, GaSe AND CLATHRATES ON THEIR BASIS (p. 48–56)

Fedir Ivashchyshyn, Ivan Grygorchak, Tetiana Gordiyuk, Roman Shvets, Yuriy Kulyk

The effect of the expansion degree of the crystal lattice of layered semiconductors GaSe and InSe on their properties and behavior in a constant magnetic field and under light is investigated. It is revealed that changes in the crystallographic parameters, as well as in the parameters of the energy spectrum of the defects that determine their kinetic and polarization properties at room temperature are not monotonic functions of the expansion degree. It is found that changs es in response to the magnetic field and the light wave field have the same nature. As an example, the changes in the structure and physical properties of InSe<$CS(NH_2)_2$> clathrates for the 2- and 4-fold expansion, synthesized under different conditions are examined. Thus, the synthesis of these clathrates in a magnetic field leads to the appearance of positive and negative magnetoresistance for the 2- and 4-fold lattice expansion respectively. Opposite effects may be caused by asymmetry inversion of the density of states above and below the Fermi level depending on the expansion degree of the single crystal lattice.

Keywords: intercalation, GaSe, InSe, impedance spectroscopy, magnetocapacitance effect, clathrates.

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