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CONTENTS METALS SCIENCE. METALLURGY

FUNCTIONAL MATERIALS

POLYMER COMPOSITE MATERIALS

STRUCTURAL INTEGRITY AND SERVICEABILITY OF MATERIALS

RADIATION MATERIALS SCIENCE

NEWS, EVENTS, MEMORIES

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STRUCTURE AND PROPERTIES OF IRON-NICKEL INVAR SINTERED ALLOYS

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Abstract—The structure and physicomechanical properties of iron-nickel invar alloys obtained by sintering powders are investigated. It is shown that during sintering of iron and nickel powders, an alloy with a face-centered cubic structure is formed, whose lattice parameters correspond to invariant compositions. The resulting invar alloys are characterized by hardness, Young's modulus, and thermal expansion coefficient comparable with the literature data. The Young's modulus is in the range from 83 to 126 GPA, depending on the composition and sintering temperature, the coefficient of thermal expansion in the temperature range from 0 to 150°C is $1.1 \cdot 10^{-6}$°C^{-1}, in the temperature range from 300 to 500°C is $15.8 \cdot 10^{-6}$°C^{-1}. It is shown that a phase transition occurs associated with the loss of magnetic properties at a temperature of 225°C.

Keywords: iron-nickel alloys, invar alloys, sintering, microstructure, Young's modulus, hardness, linear thermal expansion coefficient, phase composition.

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PHASE STRUCTURE AND COMPOSITION OF NICKEL-BASED SUPERALLOY SUBJECT TO SYNTHESIS BY SELECTIVE LASER MELTING PARAMETERS AND HEAT TREATMENT

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Abstract—The structure of ZhS6K-VI alloy samples obtained by selective laser melting in a nitrogen atmosphere was studied at a scanning speed of 600, 1000 and 1200 mm/s, as well as after additional heat treatment. The distribution of alloying elements in the structure of synthesized and heat-treated samples, phase composition, morphology, and phase structure were studied by transmission electron microscopy. The effect of scanning speed on the structure of the synthesized material and distribution of alloying elements within the crystallization cells are shown.

Keywords: selective laser melting (SLM), nickel-based superalloy, γ'-phase, carbides, dendrite axes, cells.

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EFFECT OF PRESHRINKABLE EXPANSION ON DIMENSIONAL ACCURACY OF CASTINGS MADE OF HIGH-STRENGTH CAST IRON

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Abstract—The effect of graphite inclusions on preshrinkable expansion in castings of high-strength cast iron is considered. A simulation model and software are proposed. It has been established that the preshrinkable expansion and as a consequence, the dimensional accuracy of castings of high-strength cast iron with spherical graphite are affected by the number and size of graphite inclusions. It is shown that in the fine-dispersed phase of graphite, the sample expansion is 1.74 times less than in the coarse-grained phase, and the dimensional accuracy of the sample is 2 classes higher.

Keywords: high-strength cast iron, spherical graphite, preshrinkable expansion, dimensional accuracy

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ON CLASSICAL AND MODERN APPROACHES TO THE SECOND LAW OF THERMODYNAMICS AND PHASE EQUILIBRIUM

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Abstract—The paper presents authors' comparison and short analysis of currently accepted and classical approaches to the second law of thermodynamics and phase equilibrium, as well as short comments on the discrepancies. It has been noted that during physicochemical processes, even an ideal mixing (when there is no visible release/absorption of heat) could not go without hidden self-compensating energy processes inside the system. Energy emission happens due to the strengthening of interatomic bonds and its simultaneous absorption due to the increase of the oscillation energy (work done by a system), i.e. of the average heat capacity.

Keywords: thermodynamics, free energy, entropy, mixing entropy, configuration entropy, second law of thermodynamics.

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NANOSTRUCTURED COBALT-BASED ALLOY FOR RESTORATION AND REPAIR OF PRECISION MACHINE PARTS

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Abstract—The data on the development of an alloy of the Co–Cr–Si–B system doped with rare-earth elements such as cerium, lanthanum, and yttrium, are presented. Technologies have been developed for producing powders from this alloy using the disintegrator DEZI-15 and restoring parts and assemblies of precision engineering using the method of supersonic cold gas-dynamic spraying.

Keywords: disintegrator treatment, supersonic cold gas-dynamic spraying, microhardness.

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PRODUCING VOLUME-POROUS COATINGS FOR METAL ELECTRICAL CONDUCTORS

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Abstract—The paper presents results of the development of a technology for producing catalytically active volume-porous coatings for metallic conductors by supersonic cold gas-dynamic and micro-plasma spraying.

Keywords: porous material, supersonic cold gas-dynamic spraying, micro-plasma spraying, catalytic activity, specific surface, open porosity.

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CATALYTICALLY ACTIVE POWDER COMPOSITIONS FOR AIR TOXICS REDUCTION

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Abstract—The results of a study of catalytically active coating of aluminum – aluminum hydroxide system doped with copper oxide, cerium, lanthanum and neodymium oxides, chromium oxide and tungsten oxide are presented. It was established experimentally that the coating has high catalytic activity and high physicomechanical properties. This coating is recommended for systems that reduce the toxicity of exhaust gases of various technological processes, where the gas emitted into the atmosphere contains harmful organic substances and carbon monoxide.

Keywords: catalysis, composite coating, microplasma spraying, metallic carrier.

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DEVELOPMENT OF A SILVER-BASED ALLOY FOR CORROSION-RESISTANT ULTRA-DISPERSED AND NANOSTRUCTURED COATINGS

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Abstract—The paper studies the structure and properties of functional coatings obtained from a silver-based alloy. This corrosion-resistant nanostructured and ultrafine alloy is recommended for power electronics and low-voltage switchgear operating in the temperature range from minus 196 to 250°C.

Keywords: nanostructured and ultrafine alloys, functional coatings, corrosion resistance, cold gas-dynamic spraying.

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OBTAINING METAMATERIALS BASED ON ULTRAFINE CAST GLASS-COATED MICROWIRES

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Abstract—The paper studies the possibility of obtaining metamaterials of ultrafine cast microwires in glass insulation. A method for producing microwires with a diameter of less than 5 microns has been developed. The possibility of manufacturing spirals from microwires by passing a high-density current is shown.

Keywords: metamaterials, cast glass-coated wire, high density current.

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FEATURES OF THE INTERFACIAL ZONE STRUCTURE FORMATION DURING THERMAL DIFFUSION METALLIZATION OF DIAMOND BY TRANSITION METALS

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Abstract—The paper studies morphology, chemical, structural and phase composition of the diamond-metal interphase zone, formed in the process of thermal diffusion metallization of diamond with chromium, titanium, iron, nickel and cobalt powders with the same temperature-time mode that corresponds to the sintering of diamond-containing WC-Co-matrices with copper impregnation. In the process of thermal diffusion metallization of chromium and titanium, a metalized coating is formed on the surface of the diamond, consisting of a mixture of carbides, metals and graphite of variable composition phases. The insignificant content of graphite formations and their intermittent nature of the diamond-metal interfacial zone ensure a strong adhesion of the metalized coating to the diamond through the carbides of the corresponding metals.

When thermal diffusion metallization of diamond with iron occurs at the diamond-metal interfacial zone, the formation of an intermediate layer strongly adhered to the diamond also takes place. The intermediate layer has a complex structural phase composition comprising a mixture of iron phases, a solid solution of carbon in iron and graphite of variable composition. An intermediate layer on the surface of diamond could be formed by solidification of the liquid phase with the eutectic composition resulting from the eutectic melting of the diamond-iron contact pairs. However, this assumption requires additional research to confirm it, and special experiments using highly sensitive research methods.

Under the heating conditions specified in the experiment samples of nickel-diamond and cobalt-diamond cause intense catalytic graphitization of diamond with the formation of numerous traces of erosion on its surface. The observed weak adhesive interaction of these metals with diamond is probably due to the high melting temperatures of the Ni-C and Co-C eutectics, which does not allow the metals to react with diamond under given experimental conditions.

Keywords: diamond, metallization, interphase zone, coating, graphitization, carbides, eutectic melting.

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TRIBOTECHNICAL PROPERTIES OF ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE FILLED WITH SULFUR, DIPHENYLGUANIDINE AND 2-MERCAPTOBENZOTHIAZOLE

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Abstract—The paper studies tribotechnical properties, hardness and density of composites based on ultra-high molecular weight polyethylene (UHMWPE) filled with sulfur, diphenylguanidine (DFG) and 2-mercaptobenzothiazole (MBT) and their mixtures. It has been established that the introduction of selected fillers has practically no effect on hardness and density of the composites, but leads to a significant (by 2–3 times) increase in the wear resistance of materials. Using electron microscopy, it has been established that secondary structures are formed in composites containing MBT that protect the surface layer of the material from wear. Using IR spectroscopy, it was established that tribochemical reactions occur during the wear of composites with the formation of hydroxyl and carbonyl groups. The developed materials UHMWPE / MBT and UHMWPE / FGD / MBT have high wear resistance and can be used as materials for tribological purposes.

Keywords: ultra-high molecular weight polyethylene, polymer composites, fillers, wear resistance, friction coefficient, structure, tribochemical reactions, friction surface.

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PROGRESS, ACHIEVEMENTS AND PROSPECTS IN THE FIELD OF RAW MATERIALS FOR CARBON FIBERS (Review)

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Abstract—The review is devoted to the consideration of the current state of world production of carbon fibers based on various types of raw materials, as well as research in the field of chemistry aimed at expanding the range of solutions in this area. The analysis of data from domestic and foreign scientific, technical and periodical literature and invention patents embraces past 15 years. Special attention is paid to the chemical modification of precursors, which allows expanding the functional properties of the resulting carbon materials.

Keywords: carbon fibers, precursors, production.

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ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE (UHMWPE) AS AN ADVANCED COMPONENT IN POLYMERIC COMPOSITE MATERIALS (Review)

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Abstract—The article presents review of Russian and foreign scientific and technical literature data dedicated to ultra-high molecular weight polyethylene (UHMWPE) as a component in polymer composites. Examples of the practical use of UHMWPE as a reinforcing fibers and polymer matrix are considered. Some physical and mechanical characteristics of the UHMWPE-based products widely used in various

industries are given; the necessity to treat UHMWPE fibers to produce composite materials with a high level of properties is described.

Keywords: ultra-high molecular weight polyethylene, reinforcing filler, polymer matrix, gel spinning, self-reinforced composite materials, plasma treatment.

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RESISTANCE OF HIGH-STRENGTH MEDIUM-ALLOY STEEL TO BRITTLE FRACTURE AND ITS CONNECTION WITH STRUCTURAL STATE PARAMETERS

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Abstract—Tests were carried out on the static crack resistance of sheet metal for experimental melts of high-strength martensitic-bainitic steel. They showed significant differences in the quality of the metal in this characteristic with relatively small differences in the content of alloying elements and production technology. A comparative metallographic analysis of the structural state of the metal, which differs in crack resistance, is performed. Based on the results of this analysis, the main microstructural factors are identified that correlate with the static crack resistance of the investigated material.

Keywords: medium alloy steel, sheet metal, resistance to brittle fracture, structural state parameters.

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ON CORROSION DAMAGE AND ITS CONNECTION WITH NON-METAL INCLUSIONS IN ELEMENTS OF PIPE METAL STRUCTURES OF NPP

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Abstract—The paper reviews damages to metal pipelines in WWER-1000 cooling systems, initiated by nonmetallic inclusions. The nature of damage in steels of different classes is shown. The ways to improve the reliability of metal structures are identified.

Keywords: nonmetallic inclusions, corrosion, heat exchange pipeline, steam generator.

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EVOLUTION OF THE STRUCTURAL PHASE STATE OF E110 FUEL CLADDINGS UNDER HIGH TEMPERATURES AND STRESS

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Abstract—The paper presents results of microstructural studies of E110 alloy specimens in fuel claddings based on sponge and electrolytic zirconium after operation in the fuel elements in VVER-1000. During the creep tests with axial loading no changes were observed in the studied specimens referring the chemical composition, average size and bulk density of the second phases, including radiation-induced ones. It was found that during creep tests, dislocation loops are annealed, i.e. an increase occurs in their average size with a simultaneous decrease in bulk density. It was shown that the specimens of fuel elements claddings from an alloy based on electrolytic zirconium demonstrate greater creep resistance compared with sponge based zirconium specimens, which is apparently linked with a higher density of globular β-Nb precipitates in the irradiated electrolytic zirconium specimenss.

Keywords: VVER-1000, fuel claddings, structural phase state, creep resistance.

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