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INFLUENCE OF HOT PLASTIC DEFORMATION MODES ON THE STRUCTURE AND PROPERTIES OF QUENCHED HOT ROLLED ECONOMICALLY ALLOYED HIGH-STRENGTH STEEL

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Abstract—The peculiarities of the structure formation of the low-carbon high-strength economically alloyed steel with guaranteed yield strength of 750 MPa were studied using the EBSD analysis, depending on the temperature modes of hot plastic deformation that were imitated on the plastometer GLEEBLE 3800. A comprehensive approach includes estimation of austenite grains size, their heterogeneity, and hardness, construction of histograms according the distribution of structural elements' size and angles of misorientations between them, and an analysis of the relative extent of the small-angle boundaries. The results are confirmed by manufacturing of sheet metal with a thickness of up to 40 mm under experimental industrial conditions.

Key words: high-strength economically alloyed steel, guaranteed yield strength of 750 MPa, plastometer GLEEBLE 3800, static austenite recrystallization, grain size, bainitic martensitic structure, size of structural elements, misorientations, EBSD analysis.

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THERMOCYCLING REGIMES INFLUENCE ON PROPERTIES OF BORON-TREATED STAMPING STEEL SURFACE LAYERS

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Abstract—The paper investigates the effectiveness of thermocyclic boriding for hardening of steels intended for the manufacture of stamping tools. A significant increase of microhardness and wear resistance has been established. The depth of the boride layer and its structure were determined by metallographic methods.

Keywords: stamping steel, boriding, temperature, layer, microhardness, wear resistance, diffusion, thermocycling.

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PATTERNS OF STRUCTURE FORMATION OF Ti–6Al–4V FABRICATED BY SELECTIVE ELECTRON BEAM MELTING AND HOT ISOSTATIC PRESSING

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Abstract—The paper investigates the microstructure of the alloy Ti–6Al–4V basing on methods of optical and scanning electron microscopy. The alloy was obtained by the selective electron beam melting (EBM). The results of microscopy study revealed hardened state with non-equilibrium α'+β structure of synthesized alloy. During age hardening, the disintegration of martensite occurs according to the scheme α'→α+β. Thus, the microhardness is reduced to ~130 MPa. Full recrystallization occurs after hot isostatic pressing of the alloy. The size of α- and β-phases plates increases about 1.5 times. Hot isostatic pressing does not increase the density of the alloy, the microhardness increases by ~100 MPa. EBM technology forms Ti–6Al–4V structure of high density and dispersion.

Keywords: additive technology, selective electron beam melting, hot isostatic pressing, titanium alloy.

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MAGNETOHYDRODYNAMIC TREATMENT OF ALUMINUM ALLOY 1417M FOR REDUCING THE CONTENT OF HYDROGEN

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Abstract—The paper describes magnetohydrodynamic treatment (MHDT) of aluminum melts. The studies have shown that electric field induced in the molten aluminum alloy 1417M changes the concentration of alloying elements and hydrogen in the direction of the electric field. Analysis of the results proves that the content of alloying elements and hydrogen changes in the electric field under MHDT. The presence of a concentration gradient of alloying elements and hydrogen according to the height of the ingot (parallel to the vector of the induced electric field) shows the prospects of selected research areas and the possibility of improving the corrosion resistance of the surface layer due to the decrease in content of heterogeneous phase and hydrogen while maintaining the strength characteristics of the base metal of the product.

Keywords: aluminum alloys, MHD treatment, concentration of hydrogen, REM

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ANTIFRICTION COVERINGS ON ELEMENTS AND NODES MADE OF TITANIUM ALLOYS FOR SHIPBUILDING

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Abstract—This article presents the results of work on the choice of coating materials deposited on the surface of the friction structures of titanium alloys in relation to the products of marine equipment. For titanium alloys due to the low anti-friction properties and high coefficient of friction the risk of occurrence of burrs and occurrence of cold welding in friction pairs at high unit pressures.

Offer a solution to this problem of the use of titanium in the joints moving through the development of different methods of coating on the surface of Titan and selection of antifriction materials for friction pairs

Keywords: titanium alloys, antifriction coverings, powder materials, ligament, detonation deposition, plasma deposition.

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EFFECT OF ADDITIVES ON THE STRUCTURE AND STRENGTH OF SINTERED COMPOSITES BASED ON VANADIUM-CONTAINING IRON POWDER

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Abstract—The paper investigates influence of additives of zinc, copper, phosphorus and graphite powders on structural state, phase and chemical composition, hardness and compression strength of the sintering composites based on vanadium-bearing iron powder. It is shown that the change of Brinell hardness after sintering of the studied compositions is explained by particularities of microstructure. Billets with graphite are characterized by the highest values of hardness that is bound to a carbonizing of an iron matrix and formation of perlitic structure during a sintering process. In samples with phosphorus on borders of matrix grains the phosphide eutectic is formed that in some cases leads to their brittle failure at an axial compression.

Keywords: iron powder, compression testing, microstructure, oxides, eutectic, hardness, strength.

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ELECTROCHEMICAL FRETTING CORROSION OF NICKEL-PHOSPHORUS COATINGS

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Abstract—Fretting corrosion of electrolytic NiP coatings with reinforcing submicron SiC particles in NaCl solution has been investigated. Potentsiostatic research of fretting corrosion has confirmed chemical components of wear due to removal of surface passive film and anode dissolution with pitting formation. It is shown that in the area of active dissolution corrosion resistance of friction surface of NiP and NiP-SiC coatings is defined by the level of residual stresses and surface uniformity. Introduction of silicon carbides in NiP coatings leads to increase the number of pittings at fretting corrosion, but pittings are located evenly on friction surface and do not have a multiple nature.

Keywords: coatings, friction, wear, fretting corrosion, oxides.

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PRODUCTION OF HIGH-NITROGEN STEEL SPHERICAL POWDER BY MECHANICAL ALLOYING AND PLASMA SPHEROIDIZATION

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Abstract—The paper studies the treatment in the thermal plasma flow of high-nitrogen steel powders Fe–23Cr–11Mn–1N obtained by mechanical alloying (MA). The performed works show that there is a possibility to use spherical powders in additive manufacturing technologies. It is shown that the surface of the particles after the spheroidization is uneven, and displays a cast structure of the material. It has been found that after plasma spheroidization a practically uniform distribution of the elements is preserved in the particle. It is established that during the plasma spheroidization some of the nitrogen leaves the alloy. The rate of nitrogen loss depends on the size of the original particles.

Keywords: high-nitrogen steel, mechanical alloying, plasma spheroidization, spherical powder.

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ANTIFRICTION POLYMERIC COMPOSITES FOR FRICTION UNITS OPERATING IN CONDITIONS OF THE FAR NORTH

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Abstract—The further development of Russian Arctic demands modern technics, machines and mechanisms able to work in conditions of Arctic and Far North. The reliability of such equipment depends to great extent on working ability of friction units in extreme climate conditions. The most promising are fluorine plastics and carbon plastics modified by fluorine plastics at various levels of modification.

Keywords: Arctic and Far North conditions, Arctic version of equipment, friction unit, fluorine plastics, antifriction carbon plastics, modification by fluorine plastics.

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STRUCTURAL FEATURES OF FRICTION SURFACE OF PTFE BASED COMPOSITES CONTAINING TITANIUM DIOXIDE PARTICLES

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Abstract—The paper shows results of tribotechnical tests and structural investigations of friction surface of PTFE based composites containing TiO_2. It was established that formation of filler particles layer on friction surface occurs. Filler particles hold on the surface owing to chemical bonding with perfluorinated carboxylic acids as the result of the interaction between acids and filler. The concentration of perfluorinated carboxylic acids salts on friction surface is related with composite wear resistance.

Keywords: polytetrafluoroethylene, titanium dioxide, perfluorinated carboxylic acids salts, IR-spectroscopy, scanning electron microscopy, friction surface.

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SMART POLYMER MATERIALS AND THEIR APPLICATION IN AEROSPACE

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Abstract—Recently, variety of carbon fiber reinforced plastic (CFRP) applications in aerospace has been increased due to their low density and high strength. Tendencies to minimization of structure weight and creation of reliable construction push material scientists to embody necessary functions in the materials. In the last few decades in material science appeared the concept of "smart" material that predetermined evolution in material science. Firstly, there were created materials based on metal alloy with a shape memory effect. However, such smart materials are too heavy for aerospace application. Some years later appear different polymers, which have shape memory effect. Comparing with shape memory metals, the polymer products are significantly lighter, and can be produced by different methods and have more functions as refers to shape memory. The paper presents Japan, USA and Russian concepts of smart materials and shows their application in aerospace.

Keywords: shape memory polymers, smart material, carbon fiber reinforced plastic.

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RESEARCH OF INFLUENCE OF DIFFERENT TECHNOLOGIES OF OBTAINING ON THE PROPERTIES OF COMPOSITES BASED ON UHMWPE

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Abstract—In this paper, the results of studies on the development of promising polymeric composite materials based on ultrahigh-molecular polyethylene containing a layered filler are presented. It is shown that physical methods of action, provide for the activation of materials and allow to achieve a significant increase in mechanical and tribological properties of polymeric composite materials based on UHMWPE.

Keywords: ultrahigh-molecular weight polyethylene, vermiculite, structure formation, mechanical activation, joint activation, ultrasonic effect.

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POLYMER/POLYMER BLENDS BASED ON NITRILE-BUTADIENE RUBBER AND NOVOLAC RESIN

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Abstract—The paper describes nitrile-butadiene rubber interaction with novolac dinitrile cured resin. A method for producing composites with solid lubricating materials is proposed. Physical, mechanical, tribotechnical laboratory data and production tests of the developed composites are shown. The operating life of friction units of submersible pumps is increased by 2.5–3.0 times.

Keywords: polymer/polymer mixtures, nitrile-butadiene rubber, novolac resin, coke-graphite mixture, tribotechnical properties.

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TEMPERATURE-FREQUENCY DEPENDENCE OF DISSIPATIVE PROPERTIES OF HARD VIBRATION DAMPING COATINGS

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Abstract—Investigation of the temperature-frequency mechanical loss factors and elastic moduli of polymeric materials allows calculating efficiency of damping coatings on substrates of metals and rigid composites in specified ranges of operation. The calculated and experimental data for different compositions of damping materials are compared. The investigations were carried out using polymer compositions based on modified epoxy resins and reinforcing fillers.

Key words: mechanical loss factor, elastic modulus, damping coatings.

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POLYETHYLENE COMPOSITES WITH SURFACE-MODIFIED BASALT AND CARBON FIBERS

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Abstract—The paper presents results of an investigation of polyethylene composite materials reinforced by disperse carbon and basalt fibers. The structural features of the fiber surface before and after the surface modification are studied. It is shown that treatment of basalt fibers by growing carbon nanofibers on their surface does not affect the characteristics of interfacial interaction in the system of polyethylene/fiber and the physical and mechanical properties of composites. It is established that the modifying layer on the surface of carbon fibers provides an increase in tensile strength of composite due to wetting of the fibers by the polymer melt caused by the reduced surface energy of organic fluorine layer.

Keywords: polyethylene, carbon fiber, basalt fiber, surface modification, composite, structure, physical and mechanical characteristics, interfacial interaction.

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THEORETICAL AND EXPERIMENTAL STUDIES OF COMPOSITE MATERIALS REINFORCED BY CARBON FABRICS. PART 2: MECHANIC-ANALYTICAL MODEL OF THE CARBON FABRIC STRUCTURE

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Abstract—The paper presents mechanic-analytical model of the carbon fabric structure. Based on theoretical research of interaction between warp and weft threads of the fabric repeat the model permits to determine following parameters of the fabric structure: forces of threads tension inside the structure, mutual pressure force between warp and weft threads in contact areas, lengths, deflections, structure angles and compression of threads, phase of fabric construction, thickness of structure, linier, surface and volume threads filling, surface and volume porosity, surface and volume density.

Keywords: carbon thread, fabric, structure, mechanic-analytical model, parameters of structure.

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CONSTRUCTION OF CALCULATED CURVES OF THE LONG-TERM STRENGTH FOR NEUTRON-IRRADIATED AUSTENITIC STEELS Kh18N9 AND 08Kh16N11M3

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Abstract—Having analyzed experimental data on the long-term strength of unirradiated austenitic materials and dependencies prediction obtained by intergranular fracture model, the authors determined an assurance factor for constructing curves for the long-term strength of unirradiated and irradiated materials. On the basis of physical mechanical model and experiments, the normative curves for the initial and irradiated states of Kh18N9 and 08Kh16N11M3 steels were calculated and verified on the premise of external and intrareactor tests.

Keywords: creep, long-term strength and plasticity, calculated curves, intrareactor tests.

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SYNERGETIC MECHANISM OF RADIATION EMBRITTLEMENT OF AUSTENITIC STAINLESS STEELS UNDER HIGH-TEMPERATURE LONG-TERM IRRADIATION

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Abstract—The study results of fracture and embrittlement mechanisms are represented for austenitic steels of 18Cr–9Ni and 18Cr–10Ni–Ti grades after long term neutron irradiation at high temperatures. The effect of irradiation temperature and time as well as neutron dose on the fracture strain and fracture mechanisms has been considered. On the basis of the obtained results and special tests a new mechanism of high temperature radiation embrittlement is proposed and justified as caused by the synergetic action of helium and thermal aging. Thermal aging leads to the formation of various phases on grain boundaries and, hence, to decrease of grain boundary strength. Helium diffusion at high test temperatures stimulates accumulation and growth of helium bubbles on weakened grain boundaries.

Ключевые слова: austenitic steels, neutron irradiation at high temperatures, fracture and embrittlement mechanisms, synergetic action of helium and thermal aging, radiation embrittlement.

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IMPROVEMENT OF THE APPROACH TO PREDICT THE FRACTURE TOUGHNESS OF IRRADIATED ANTICORROSIVE CLADDING FOR WWER-TYPE REACTORS

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The paper presents results of experimental investigations on the fracture toughness of anticorrosive cladding for RPV of WWER-type reactors after irradiation in the range from 0 to $1.8 \cdot 10^{20}$ neutron/cm^2. On the basis of these data and data obtained earlier the dependence of the fracture toughness on neutron fluence and temperature was derived by statistical analysis methods.

Keywords: anticorrosive cladding, irradiation, fracture toughness, prediction.

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INFLUENCE OF NEUTRON IRRADIATION AND POST-RADITION ANNEALING ON MECHANICAL PROPERTIES AND FRACTURE TOUGHNESS OF ANTICORROSIVE CLADDING FOR WWER-TYPE REACTORS.

Part 1. Mechanisms of embrittlement and restoring of cladding properties

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Abstract—The influence of neutron irradiation and post-radiation annealing on the fracture toughness of anticorrosive cladding material for reactor pressure vessel with different content of phosphorus and δ-ferrite has been investigated. The effect of the annealing temperature on the degree of degradation and restoration of the weld metal has been considered. The mechanisms that occur during annealing have both positive and negative effect on the restoration of weld metal properties. The results of the research can be used for justification of the resistance to brittle fracture of reactor pressure vessels after annealing.

Keywords: reactor vessel, anticorrosive cladding, post-radiation annealing, resistance against irradiation embrittlement.

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INFLUENCE OF NEUTRON IRRADIATION AND POSTRADITION ANNEALING ON MECHANICAL PROPERTIES AND FRACTURE TOUGHNESS OF ANTICORROSIVE CLADDING FOR WWER-TYPE REACTORS

Part 2. Prediction of mechanical properties embrittlement and restoring of cladding

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Abstract—The influence of neutron irradiation, post-radiation annealing and repeated irradiation on the fracture toughness and mechanical properties of anticorrosive cladding material for reactor pressure vessel has been investigated. The authors propose dependencies for predicting the deformation diagram and the cracking resistance of the weld metal taking into account the effect of annealing and repeated neutron irradiation. The obtained curves can be used to calculate the stress-strain state of reactor pressure vessels, as well as to assess the brittle fracture of the material during reactor vessel's operation after annealing.

Keywords: reactor vessel, anticorrosive cladding, post-radiation annealing, resistance against irradiation embrittlement.

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