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INFLUENCE OF PRODUCTION TECHNOLOGY OF THICK PLATE ROLLED FROM SHIPBUILDING STEEL OF STRENGTH LEVEL 500 ON STRUCTURE PARAMETERS AND WORKABILITY CHARACTERISTICS AT LOW TEMPERATURES

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Abstract—The influence of manufacturing technology of low-alloy steel with yield strength not less than 500 MPa on structure parameters has been studied. Under industrial conditions, two 50 mm thick sheets were produced by different technologies: 1) hot rolling followed by furnace quenching and high-temperature tempering; 2) quenching from rolling heating followed by high-temperature tempering. By means of optical, scanning and transmission electron microscopy the structural features of steel were revealed. Standard mechanical properties and low-temperature serviceability characteristics were determined.

Keywords: high-strength steel, furnace quenching, quenching from rolling heating, rolled products, structure, lath martensite, granular bainite, lath bainite, properties

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EFFECT OF HOT ROLLING MODE ON CRYSTALLOGRAPHIC TEXTURE AND MECHANICAL PROPERTIES OF DIRECTLY QUENCHED BAINITIC STEEL

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Abstract—The paper considers the effect of hot rolling mode on the structure, mechanical properties and crystallographic texture, as determined by EBSD, for a directly quenched thick plate of high strength bainitic steel. According to the obtained results, stronger strain hardening of austenite before the phase transformation leads to appearance of granular bainite and hence diminishes the final steel strength.

Keywords: high strength bainitic steel, deformation mode of hot rolling, direct quenching, crystallographic texture, deformed austenite, lath bainite, granular bainite

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HARDENING AND IMPROVING THE CORROSION RESISTANCE OF CARBON STEEL 45 WITH THERMAL CHEMICAL TREATMENT

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Abstract—The issues of creating a hardening coating by plasma spraying of Ti powder on steel grade 45 with subsequent cementation in pastes are considered. The properties of the resulting coating are studied by measuring the Vickers microhardness.

Keywords: plasma spraying, carburizing, steel 45, induction heating

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INFLUENCE OF LITHIUM ON THE TEMPERATURE DEPENDENCE OF HEAT CAPACITY AND THERMODYNAMIC FUNCTIONS CHANGES IN AK1 ALLOY BASED ON HIGH-PURITY ALUMINUM

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Abstract—The heat capacity of the AK1 alloy based on high-purity aluminum with lithium was determined in the cooling mode using the known heat capacity of the reference aluminum sample. By means of mathematical processing of cooling rate curves of samples from AK1 alloy with lithium and the reference sample, polynomials describing their cooling rates were obtained. Further, the polynomials of the temperature dependence of the heat capacity of alloys, described by a four-member equation, were established using the experimentally found values of the cooling rates of samples from alloys and the standard, taking into account their mass. Using integrals from specific heat capacity, models of temperature dependence of enthalpy, entropy and Gibbs energy changes were established. It was found that the heat capacity of the alloys increases with rising temperature. The addition of lithium when the temperature is up to 600 K significantly increases the heat capacity, and at temperatures above 600 K lithium in amounts of 0.5 wt. %

reduces the heat capacity of the initial alloy AK1. It is shown that lithium addition increases the enthalpy and entropy of the initial AK1 alloy and decreases the Gibbs energy value.

Keywords: aluminum alloy AK1, lithium, heat capacity, cooling mode, enthalpy, entropy, Gibbs energy

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REGULARITIES OF FORMATION OF MICROSTRUCTURE AND MECHANICAL PROPERTIES OF COPPER M1 UNDER COMBINED PLASTIC DEFORMATION

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Abstract—The influence of combined plastic deformation, including methods of intense plastic deformation and traditional metal forming, on the structure and mechanical properties of M1 copper was studied. It has been shown that combined processing helps to increase the dimensional uniformity of hardness across the cross-section of the workpiece and contributes to the refinement of microstructure elements. Thus, with an increase in the equivalent degree of deformation, the level of mechanical properties of M1 copper increases accordingly.

Keywords: combined plastic deformation, helical extrusion, hardness, structure, grain size, copper, equal channel angular pressing, hydroextrusion

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STUDY OF STRUCTURE AND PROPERTIES OF A NEW POROUS COMPOSITE MATERIAL OBTAINED BY DIRECT LASER DEPOSITION

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Abstract—The possibility of formation of porous materials for biomedical applications from VT6/Ta/Zr alloy by direct laser deposition has been shown. Varying the laser power allowed to obtain alloys with variable porosity. The modes providing formation of porous material with normal elasticity modulus corresponding to human bone were selected. It was found that the porosity value of 32% is achieved at the laser power of 50 W, which meets the requirements, for example, for dental prosthetics. In the process of direct laser deposition of materials in VT6/Ta/Zr alloys with variable porosity tantalum particles do not melt and act as crystallization centers. Such conditions ensure the formation of a highly dispersed metal structure consisting mainly of VT6 powders with evenly distributed Ta and Zr particles.

Keywords: direct laser deposition, microstructure, variable porosity, titanium alloy, tantalum, zirconium

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FORMATION OF FUNCTIONAL NIOBIUM BINARY FINE STRUCTURES

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Abstract—Technological schemes of niobium carbide and nitride formation obtained by thermal and laser treatment are developed. The results of X-ray powder diffraction (XRD) analysis are in agreement with theoretical evaluations based on thermodynamic calculations proving the effectiveness of suggested approach. The perspectives of a practical application of the proposed technological solutions for the cryogenic gyroscope manufacturing technology are presented.

Keywords: rotor, cryogenic gyroscope, superconductivity, niobium carbides and nitrides, carbon nanocomposite, laser marking, thermodynamic analysis, raster image, XRD analysis

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DEVELOPMENT OF TECHNOLOGY FOR OBTAINING NANOSTRUCTURED COMPOSITE COATING OF Kh20N80–Cr–TiC

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Abstract—The paper presents results of a comprehensive study on the development of technology for the production of composite nanostructured functional coatings based on the Kh20N80 – chromium – TiC system using the supersonic cold gas dynamic spraying method. Composite coating powders are obtained by chromium plating of a matrix powder made of alloy Kh20N80 followed by the application of a reinforcing coating of TiC nanoparticles. The resulting coating has a high level of microhardness, modulus of elasticity and resistance to wear. A distinctive feature of the resulting coating is its reliable operation without destruction for a long time (more than 4800 hours).

Keywords: nanocomposite, matrix powder, reinforcing powder, cold gas dynamic spraying, functional coating

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STUDY OF THE INFLUENCE OF THE RATIO OF BUTADIENE AND NITRILE-BUTADIENE RUBBERS ON THE PROPERTIES OF THEIR BLENDS

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Abstract—In this study the influence of the content of SKD-B butadiene rubber and BNKS-18 AMN nitrile rubber in the blend on the properties of the resulting elastomers is investigated. The combination of frost-resistant and aggressive media resistant rubbers in the blend allows to adapt the properties of vulcanizates to the required operating conditions. The research revealed that the level of physical and mechanical properties, aggressive media resistance and frost resistance depend on the ratio of rubbers. The study of properties of elastomers revealed two glass transition temperatures and two thermal transitions at negative temperatures corresponding to nitrile-butadiene and butadiene rubbers. The phase morphology of elastomers, characteristic for butadiene nitrile or butadiene rubbers in dependence on their ratio in the blend, was investigated by electron microscopy. Based on the developed elastomer, dust covers for CV-joints were produced. They were tested in real operating conditions in the temperature range from –52 to 33°C.

Keywords: elastomeric materials, butadiene rubber, nitrile butadiene rubber, frost resistance, aggressive media resistance, wear resistance, physical and mechanical properties

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STUDY OF THE POSSIBILITY OF APPLICATION OF OPTICALLY TRANSPARENT EPOXY RESINS FOR RESTORATION OF VITRIC ENAMELS

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Abstract—Objects of decorative and applied arts of historical value, over time, undergo physical and mechanical changes caused by the influence of external factors. For example, vitreous enamels can lose their luster, crack, and archaeological objects can also suffer due to the corrosion processes of glass and metal base. Therefore, it seems an important task to develop approaches to the restoration of products with vitreous enamels. In the work on the results of the use of studies of optically transparent epoxy resins as a restoration material when working with objects of cultural investigation, which consists in the restoration of vitreous enamels. To assess the admissibility of using the material as a restorative, an accelerated test method was also developed and tested.

Keywords: vitreous enamels, restoration, optically transparent resins, cultural heritage.

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EFFECTS OF EXTERNAL INFLUENCING FACTORS ON THE MICROSTRUCTURE AND PHYSICO-MECHANICAL CHARACTERISTICS OF GLASS-REINFORCED POLYMER COMPOSITE MATERIAL BASED ON POLYIMIDE BINDER

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Abstract—The article presents the results of experimental studies of the effects of external influencing factors (natural exposure in climatic zones, such as a temperate climate and a climate with an industrial atmosphere, during accelerated climatic tests in a thermal humidity chamber, during thermal aging, exposure in technical environments) on the microstructure and physical and mechanical characteristics of a glass-reinforced polymer composite material grade VPS-72 based on polyimide binder grade VS-51. The state of the surface of fiberglass samples after exposure was studied for 1 year.

Keywords: PCM, polymeric polyimide binders, fiberglass, microstructure, external influencing factors

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POLYMER COMPOSITE MATERIALS AND TECHNOLOGIES USED IN SPORTS INDUSTRY: A REVIEW

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Abstract—The article provides a review of scientific and technical literature, including Russian and foreign periodicals, patents for inventions in the field of creating products for the sports industry from polymer composite materials. The technologies and technical solutions used to achieve the assigned tasks, the advantages and disadvantages of using the methods are considered. It is shown that the use of modern achievements in materials science, a new generation of materials and advanced technologies can contribute to the achievement of high sports results.

Keywords: polymer composite materials, PCM, reinforcing fillers, sports industry, technologies, technical solutions

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INFLUENCE OF DIFFERENT TYPES OF COUNTERBODIES ON TRIBOTECHNICAL PROPERTIES OF POLYTETRAFLUOROETHYLENE

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Abstract—This paper presents the results of a study of different types of counterbodies on the tribological properties of polytetrafluoroethylene (PTFE). The characteristics of the polymer, the roughness and hardness of counterbodies made of the following materials are given: copper, aluminum, brass and steel grade 45. It is shown that the best wear resistance is obtained for a friction pair – polytetrafluoroethylene with steel grade 45 and brass. The friction surfaces of the counterbodies and the polymer were studied by optical, electron microscopy, and IR spectroscopy.

Keywords: polytetrafluoroethylene, wear resistance, coefficient of friction, counterbody, friction surface

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INFLUENCE OF UNFAVORABLE CLIMATIC FACTORS CHARACTERISTIC OF THE ARCTIC ZONE ON THE PROPERTIES OF POLYMERIC MATERIALS AND COMPOSITES: A REVIEW

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Abstract—The paper reviews studies of the influence of external influencing factors characteristic of the Arctic zone on the properties of polymer materials and polymer composites. In the cited works, the influence of factors such as low temperatures, thermal cycling, high humidity, and other aggressive environmental conditions on the strength properties of a number of thermosetting and thermoplastic matrices, as well as composites based on them, has been studied. A comparative analysis of resistance of various materials to unfavorable climatic factors typical for the Arctic climate has been carried out. This review can be used when choosing materials for work in the Arctic and subarctic zones, as well as in other regions where the described factors may affect the operation of products, machines and structures.

Keywords: structural materials, arctic conditions, reduced temperatures, physical and mechanical properties

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INFLUENCE OF PHYSICAL PROPERTIES OF WELD METAL ON HYDROGEN DIFFUSION INTO THE HEAT AFFECTED ZONE OF HETEROGENEOUS WELDED JOINTS

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Abstract—The paper presents the analytical solution of one-dimensional problem on hydrogen diffusion in butt heterogeneous welded joints. Such parameters as welded joint thickness, weld thickness, diffusion coefficients, solubilities and initial concentrations of hydrogen in the weld metal and base metal have been taken into account. The effects of microstructure on hydrogen kinetics in homogeneous and heterogeneous welded joints are considered. It is shown that hydrogen concentration in the heat affected zone (HAZ) to a great extent depends on the ratios of the initial concentrations, hydrogen diffusion coefficients and solubilities in the weld metal to those in the base metal. The concentration of hydrogen in the HAZ decreases by three orders of magnitude when welding martensitic steel with austenitic electrodes as compared to homogeneous joints.

Keywords: welding, steel, hydrogen, diffusion, welded joint, heat affected zone

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ALLOYING SYSTEMS FOR MODERN FLUX-CORED WIRES FOR MECHANIZED WELDING IN SHIELDING GASES OF HIGH-STRENGTH SHIPBUILDING STEELS

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Abstract— An analysis of the domestic market for flux-cored wire used for welding low-alloy high-strength shipbuilding steels has been carried out. It has been established that to ensure a guaranteed value of the yield strength of the weld metal from 420 to 620 MPa, alloying systems such as Mn–Si, Mn–Si–Ni and Mn–Si–Ni–Mo are taken as a basis. The influence of alloying elements used in these systems on the formation of the microstructure and properties of welds was experimentally established.

Keywords: flux-cored welding wires, mechanized welding in shielding gases, cold resistance, high-strength steels, alloying of welds.

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MATHEMATICAL MODELING AND PREDICTION OF VALUES OF PARTIAL INDICATORS OF HEAT-EXCHANGE PROCESSES AT UNDERWATER WET WELDING

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Abstract—At computer modeling of heat-exchange processes there arises a necessity of parametric forecasting of values of partial indicators of multifactor systems of underwater wet welding. Ensuring the reliability of such a prediction makes it possible to use the obtained models for engineering calculations in the design of technological welding processes. On the example of experimental data on the estimation of gas formation in the process of arc combustion the methodology – approved in shipbuilding production – is proposed. Mathematical dependences providing the minimum error of estimation at changing the values of influencing parameters, are obtained. The formation of gas bubbles significantly affects the heat-exchange processes in underwater welding, which determines the cooling rate of the welded joint and affects the formation of hardening structures.

Keywords: wet underwater welding, parametric dependences, setting error, prediction of parameters

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FINAL ASSESSMENT OF MULTIFACTOR EXPERIMENTS OF HEAT TRANSFER IN THE UNDERWATER WET WELDING

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Abstract—The multifactorial nature and interconnection of phenomena occurring during welding, especially under water, are important for deepening knowledge in this area. An analysis of the research carried out and the solutions obtained in the field of underwater wet welding of low-carbon steels shows that in this area, adequate assessments of the effectiveness of various types of welding with comprehensive consideration of the interaction of various physical phenomena, significantly different in nature from each other, have not been obtained. Integrated approaches to the assessment and analysis of heat transfer coefficients from the side of the arc combustion surface and from the opposite side are proposed. For the first time, the potential values were calculated as a change in the values of heat transfer indicators for various welding conditions based on verified experimental data. The ultimate goal of the work is to calculate the cooling rates of the metal of the welded joint, which will subsequently make it possible to predict the mechanical properties of the weld metal and the likelihood of the formation of hardening structures.

Keywords: underwater wet welding, air welding, weld position, heat transfer coefficient, heat transfer potentials

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INFLUENCE OF ALKALINE EARTH METALS ON THE CORROSION-ELECTROCHEMICAL BEHAVIOR OF LEAD BABBIT BKa, BSt, BBa (PbSb15Sn10) IN NaCl ELECTROLYTE MEDIUM

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Abstract—The article presents the results of study of the effect of additions of calcium, strontium and barium (0.01–1.0 wt %) as a structure modifier on the anodic behavior of lead babbits BKa, BSt, BBa (PbSb15Sn10) in NaCl electrolyte medium. The studies were carried out by the potentiostatic method in a potentiodynamic mode with a potential sweep rate of 2 mV/s.

Studies show that with time the free corrosion potential of alloys shifts to the positive side, and with an increase in the concentration of the modifier (calcium, strontium and barium) in lead babbits, acquires a positive value. The addition of calcium to lead babbit BKa (PbSb15Sn10Ca) increases its corrosion resistance by 10–15%, strontium BST (PbSb15Sn10Sr) by 15–20%, and barium BBa (PbSb15Sn10Ba) by 20–25%. An increase in the corrosion rate of alloys was noted, regardless of their composition from the NaCl concentration in the solution. It has been shown that an increase in the chloride ion concentration in the NaCl electrolyte leads to a decrease in the potentials of free corrosion, repassivation, and pitting formation of alloys.

Keywords: lead babbits BKa, Bst, BBa (PbSb15Sn10), calcium, strontium, barium, potentiostatic method, electrochemical behavior, NaCl electrolyte, free corrosion potential, corrosion rate

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ON BRITTLE FRACTURE RESISTANCE DETERMINATION OF CHROMIUM STAINLESS STEEL IRRADIATED IN ION ACCELERATOR

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Abstract—The possibility of brittle fracture resistance (BFR) determination is investigated with mechanical testing for ion-irradiated chromium stainless steel. To consider the ion irradiation effect on material properties disc specimens in initial and irradiated states were tested by mechanical loading until brittle fracture. The microhardness of specimens before and after ion irradiation was also determined. It was found that the microhardness of ion-irradiated steel is higher than the microhardness of steel in initial state. However, critical loads for brittle fracture of disc specimens are practically equal for initial and ion-irradiated states. The performed calculations, SEM investigations and also analysis of mechanisms of cleavage microcrack nucleation in disc specimen surfaces allowed us to explain the brittle fracture test results. As fracture tests do not allow us to estimate BFR, it is proposed to estimate BFR by microhardness measurement results.

Keywords: ferritic-martensitic steel, ion irradiation, ion accelerator, brittle fracture resistance, mechanical testing, microhardness

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PREDICTION OF RADIATION EMBRITTLEMENT OF VVER-1000 RPV WELDED SEAM MATERIAL AT LIFETIME EXTENSION UP TO 60 YEARS AND MORE

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Abstract—The correctness of the model assumption about additivity of the contributions of hardening (formation of dislocation loops and radiation-induced precipitates) and non-hardening (formation and accumulation of grain boundary segregations) mechanisms to the final radiation embrittlement of VVER-1000 RPV weld materials has been verified. The paper presents the results of the experiment to obtain predicted values of the critical embrittlement temperature of weld metal with nickel content of 1.59–1.88% using accelerated irradiation in the IR-8 research reactor from states characterized by different starting level of grain boundary segregation. The procedure of accounting for the flux effect for the values of critical embrittlement temperature obtained using accelerated irradiation has been proposed. The conservativity of the weld metal radiation embrittlement dependence has been verified based on the modal assumption of additivity of the contributions of the strengthening and non-strengthening mechanisms up to the values of fast neutron fluence ~75–1022 neutrons/m^2.

Keywords: weld, critical embrittlement temperature, VVER-1000 reactor vessel, fast neutron fluence, radiation embrittlement, flux effect, service life extension

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STUDY OF STRESS CORROSION CRACKING SUSCEPTIBILITY OF IRRADIATED FERRITE-MARTENSITIC STAINLESS STEEL 07Kh12NMFB IN SUPERCRITICAL WATER. Part 2. Development of corrosion crack identification technique and analysis of autoclave test results

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Abstract—The studies of stress corrosion cracking have been carried out for the stainless ferritic-martensitic steel with chromium content of 12% irradiated to a damage neutron dose of ~12 dpa. This steel was chosen as a candidate material for the internals of supercritical water-cooled reactors (SWCR).

The first part of the paper was devoted to autoclave testing of specially designed disk specimens under constant load in a supercritical water environment (at 450°C and 250 atm pressure). In this part of the article the developed technique for corrosion cracks identification is presented and analysis of autoclave tests results is performed.

As a result of the experiments performed, the threshold stress values below which stress corrosion cracking initiation doesn't occur. The values of threshold stresses are determined for the studied steel irradiated at temperatures of 390 and 550°C. Possible mechanisms of stress corrosion cracking of the studied steel are analyzed and directions for further research are proposed.

Keywords: ferritic-martensitic stainless steel, SWCR, WWER-SKD reactor, neutron irradiation, stress corrosion cracking, corrosion cracking identification, autoclave tests

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