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EFFECTS OF STRAIN AGING ON FRACTURE OF LOW-ALLOY STEELS WITH DIFFERENT STRUCTURE

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Abstract—Low-alloy shipbuilding and pipeline steels are commonly subjected to thermomechanical treatment in order to form a ferrite-pearlite or ferrite-bainite structure. At the same time, a high density of lattice defect appearing in this treatment results in some structural instability fraught with the following aging in the production cycle or during the storage and exploitation. The present paper considers effects of the strain aging on steel fracture mechanism as well as efficient ways to reduce such effects.

Key words: low alloy steel, thermomechanical treatment, natural aging, artificial aging, tempering, ferrite-bainite structure, ferrite-pearlite structure.

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RESEARCH OF QUALITY OF HIGH-STRENGTH SHIPBUILDING STEEL WITH HIGH CONCENTRATION OF CALCIUM

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Abstract—The paper studies the microstructure, presence and qualitative composition of nonmetallic inclusions, mechanical tests of industrial smelting of high-strength shipbuilding steel with calcium concentration in the bucket sample of 0.009% have been performed. Steel with a high concentration of calcium is contaminated with a variety of stitch oxide inclusions, and therefore the mechanical properties of the rolled product are sharply reduced (impact strength, ductility in the Z-direction, fracture quality of technological samples). It is shown that the upper permissible limit of calcium content in steel is within the range 0.004–0.009%, but it is necessary to clarify it performing additional research. To ensure high purity of high-strength shipbuilding steel for non-metallic inclusions, it is vital to observe a strictly regulated technology of aluminum deoxidation and modification by ferrocalcium with obtaining the content of these elements in the metal in the previously recommended limits 0.01–0.02 and 0.002–0.004% respectively.

Keywords: high-strength shipbuilding steel, calcium content, non-metallic inclusions, mechanical properties.

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CARBON ADDITIVES INFLUENCE ON MECHANICAL PROPERTIES OF TITANIUM NEAR-ALPHA ALLOY

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Abstract—The article considers the influence of carbon in the range from 0.008 to 0.18 mass. % at the temperature of complete polymorphic transformation, microstructure and mechanical properties of near-alpha-titanium alloy systems Ti–6.2Al–Sn–Zr–(2.19–3.53) Mo^{eq}–(0.18–0.28)Si–(0.008–0.18)C. Alloying with carbon is possible due to special titanium sponge or industrial ligatures. Six experimental forgings performed on bimodal microstructured ingots allowed to establish a rational level of carbon. It is shown that carbon alloying at solubility limit (up to 0.08% by weight) increases the heat resistance of the material, while a similar alloying with silicon gives a greater effect. The carbon effect on the strength at room temperature is negligible. Negative effect of carbon on the impact toughness of the alloys is marked. For the selected carbon alloying level at strength of 1165–1180 MPa, the impact viscosity remains at an acceptable level of *KC*U = 330–381 kJ/m^2. The alloys of the investigated system allow hot deformation in heavy conditions under hammer forging at relatively low temperatures of the two-phase region.

Keywords: heat-resistant titanium alloys, polymorphic transformation temperature, microstructure, short-term strength, creep, durability.

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APPLICATION OF COBALT-BASED ALLOYS OF Co–Cr–Si–B SYSTEM FOR PROTECTIVE COATINGS

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Abstract—The paper studies an alloy of Co–Cr–Si–B system for obtaining powder materials and functional coatings based on it. It is shown that nanocrystalline precipitates are formed and increase substantially the microhardness of the coating when rare-earth elements, namely yttrium, lanthanum, and cerium, are introduced into the alloy.

Keywords: rare earth elements, microhardness, functional coatings, nanostructured precipitates.

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OBTAINING SOFT MAGNETIC POWDER COMPOSITES OF THE SYSTEM FERROMAGNETIC – DIAMAGNETIC

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Abstract—A method has been developed for producing a powder material of the ferromagnetic – diamagnetic system, intended for the manufacture of composite radar absorbing materials and coatings in the ultra-high frequency range. Composite powder material with a polymer diamagnetic matrix reinforced with a ferromagnetic nanocrystalline hardener is obtained by the method of ultrafast mechanosynthesis. The proposed technology of superfast mechanosynthesis allows to obtain a powder composition where each particle is a single mechanically connected system, while reducing the degree of amorphousness (no more than 80%) by maintaining the proportion of nanocrystalline precipitates in the amorphous matrix and, accordingly, increasing the magnetic permeability (up to 90 or more). The composite powder of the ferromagnetic – diamagnetic system thus obtained can be used to obtain radar absorbing materials with high shielding efficiency and a large absorption coefficient (at least 25 dB) in the frequency range from 1 MHz to 40 GHz.

Keywords: high-speed mechanosynthesis, disintegrator, magneto-powder, composite powder, radar absorbing composites, amorphousness, reinforcement.

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COMPOSITE ALLOY BASED ON Co–Cr–Si–Zr–TiB_2–BN SYSTEM FOR NANOSTRUCTURED POWDERS AND FUNCTIONAL COATINGS

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Abstract—The paper studies the preparation of a composite nanostructured powder manufactured from an alloy of Co–Cr–Si–Zr–TiB_2–BN system and describes functional coatings with high microhardness and corrosion resistance based on that powder.

Keywords: composite powder, adhesion, microhardness, microplasma spraying, supersonic cold gas-dynamic spraying, mechanosynthesis.

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COMPOSITE COBALT-BASED ALLOY FOR FUNCTIONAL COATINGS DEPOSITION USING HETEROPHASE TRANSFER

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Abstract—The paper describes an alloy with a content of 20–26% Co, 17.4–21.1% Cr, 2.6–4.9% Si, 3–5% Re, 4–6% Zr, 0.2–0,6% Ce, 0.1–0.5% La, 0.3–0.7%Y, 2–4% Al. The cobalt-based alloy is applied as protective coating on components of precision engineering with adhesion 42–45 MPa, microhardness 3.6 GPa, corrosion resistance class 1, within the range of operating temperatures from –60 to 550°C.

Keywords: cobalt-based composite alloy, functional coatings, heterophase transfer, precision engineering.

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RESTORATION AND REPAIR OF EQUIPMENT BY SUPERSONIC COLD GAS-DYNAMIC AND MICRO-PLASMA SPRAYING

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Abstract—The technological process of restoring and repairing of equipment and its components by supersonic cold gas-dynamic and micro-plasma spraying has been developed. For steel products Fe–Cr–Al-based composite powder has been used being surface reinforced with tungsten carbide particles. For nickel and titanium- products composite powder from an alloy of the Ni–Cr–Mn–Sn–Si–W–Re system (Ce, La, Y) has been applied being superficially reinforced by corundum nanopowder. During the work, a high hardness of the applied coating, corrosion resistance and wear resistance were achieved. Real examples of the successful restoration and repair by powder materials are given, and spraying technologies are proposed.

Keywords: supersonic cold gas-dynamic spraying, micro-plasma spraying, mechanosynthesis, adhesion, hardness, corrosion resistance, wear.

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RESEARCHING INTERNAL FRICTION MODULE OF POLYURETHANE ELASTOMERS UNDER ALTERNATING BENDING WITH ROTATION

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Abstract—Today there is a large number of vibration-proof materials for the manufacture of shock absorbers in the market of structural materials. For a reasonable choice, it is necessary to perform comparative tests of different elastomers according to several criteria. The paper presents the results of two-parameters comparative tests of three brands of polyurethane elastomers. As the evaluation criteria, the internal friction module and the loss tangent of elastomeric materials under alternating bending with rotation are chosen. High stability of physicomechanical properties of polyurethane elastomers is studied in the entire frequency range of mechanical vibrations.

Keywords: polyurethane elastomer, shock absorbers, vibration damping, internal friction module, loss tangent.

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PROMISING HYBRID FABRICS BASED ON CARBON AND ARAMID FIBERS AS A REINFORCING FILLER FOR POLYMER COMPOSITES

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Abstract—The paper considers possibilities of using a hybrid fabric made of high-modulus carbon yarn brand ZhGV and high-strength aramid yarns brand Rusar-NT for polymer composites reinforcement. The results of studies of the physical and mechanical characteristics of hybrid composite material and values of the implementation of the strength and elasticity carbon fibers and aramid module for composite material are presented.

Keywords: aramid fibers, carbon fibers, organoplastic, carbon fiber, hybrid polymer composites

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EFFECT OF OXIDIZED TECHNICAL CARBON ON SURFACE ENERGY OF RUBBER

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Abstract—The influence of carbon black N121 and N326, oxidized by active oxygen forms, in comparison with the influence of channel carbon black K 354 on the properties of rubbers based on butyl rubber was investigated. It was revealed that the introduction of oxidized carbon black samples into the composition of rubber compounds allows increasing the start time of rubber mixture scorching from 8.82 to 11.17 minutes, increasing the level of conventional tensile strength from 15, 52 to 16.68 MPa. It has been established that using rubber based on butyl rubber as a filler for carbon black N121 or N326, oxidized with 30% hydrogen peroxide, makes it possible to obtain rubber with a surface energy similar to rubber K 354.

Keywords: rubber, carbon black, oxidative modification, surface energy.

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AQUEOUS ACID-AIDED CORROSION PRODUCTS REMOVAL FROM THE SURFACE OF THE BRASS ELEMENTS OF HEAT EXCHANGERS

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Abstract—The paper studies complex effect of various factors on the process of cleaning brass brand L-68, used for the manufacture of heat exchange equipment. It has been established that acids of various

strengths can be used as working solutions. The speed of the cleaning process depends on the nature of the acid and its initial concentration. For strong acids, a working solution with low concentration is recommended, followed by an increase in their concentration during the cleaning process. Additional input of oxygen into the system and an increase of the working solution temperature increase the cleaning rate of brass. The cleaning process proceeds without significant changes in the surface configuration, and, consequently, the expenditure of metal.

Keywords: brass, heat exchange equipment, removing corrosion products, acid, kinetics research

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ON CORROSION PROPERTIES OF CERAMIC MATERIALS FOR PUMP FRICTION PAIRS IN LEAD – BISMUTH ENVIRONMENT

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Abstract—We consider the results of studies on the choice of material of the lower radial bearing of the pump, designed to circulate the coolant lead – bismuth. The circulation of the liquid coolant is provided by a vertical axial pump having a "long" shaft. In this design it is necessary to provide for the lower bearing the lubrication carried out with lead – bismuth coolant. Having analyzed the operating conditions of the axial pump, we decided to carry out the lower bearing in accordance with the scheme of a hydrodynamic sliding bearing. The materials of friction pairs in such a bearing must withstand the stresses arising from the operation of the pump, as well as the aggressive conditions of the coolant. Non-metallic materials – ceramics and carbon-based composite materials – were selected basing on the study of literature data for experimental research on the corrosion and heat resistance in the lead-bismuth environment.

Keywords: ceramics, lead – bismuth, coolant, pump, coatings, metallography

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EVALUATION OF CRACK RESISTANCE OF 38KhN3MFA-Sh STRUCTURAL STEEL BY FRACTURE PROPERTIES AND ELASTIC WAVE VELOCITIES

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Abstract—The results of the study on the effects of tempering temperature on 38KhN3MFA-Sh steel static strength and crack resistance are given. The fractured surface texture has been studied after various heat treatment modes using electron-fractography analysis. Relationships between the fracture properties and the critical stress intensity factor have been established.

The effect of tempering temperature on the velocities of ultrasonic bulk waves has been investigated. A linear relationship has been found between the velocity of elastic waves and the critical stress intensity factor of 38KhN3MFA-Sh steel. The dependence discovered allows us to estimate the changes in crack resistance of steel using a non-destructive test method with variations in tempering temperature.

The method of electron fractography has been used to analyze specimen fractures having a crack in structural high-quality 38KhN3MFA-Sh steel. Investigations of the fractured surface texture subjected to various heat treatment modes have shown that the microrelief is represented by flattened cone-shape pits. An increase in tempering temperature is accompanied by an increase in the diameter of flattened cone pits on the fractured surface. A quadratic dependence has been established between the crack resistance parameter and the diameter of the pits. It is shown that the contribution of ferrite matrix structural condition to crack resistance value is much more significant than the contribution of isolated carbides.

The velocities of elastic waves in steel have been measured; their values increase with the growth of tempering temperature. The characteristics of strength and crack resistance of structural steel exposed to high-temperature tempering have been predicted based on the values of transverse wave velocities. Deviation of the predicted values of crack resistance K_{1C} and ultimate strength σ_b from the experimental values does not exceed 5.4% and 12.6%, respectively.

Keywords: crack resistance, elastic wave velocity, heat treatment, electron fractography.

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QUALITY CONTROL OF STEEL FOR LARGE-SIZED WELDED STRUCTURES OF ARCTIC SHELF. APPLICATION OF RUSSIAN AND FOREIGN REQUIREMENTS

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Abstract—Future large-scale development of Arctic inevitably requires marine structures both of Russian and foreign manufacturers and, correspondingly, applying of domestic and foreign steels. So, it is expedient to compare Russian and foreign systems of standard requirements for steel products and welded joints' metal applied at low temperatures. The paper analyzes their theoretical and experimental grounding as it is extremely important because the difference in requirements serves an instrument to drive out Russian steel manufacturers from international projects.

Keywords: Arctic structures, materials requirements, fracture toughness, brittle crack arrest

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MODEL OF CORROSION CRACKING OF IRRADIATED AUSTENITIC STEELS. Part 1. Analysis of damage mechanisms and formulation of the defining equations

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Abstract—Mechanisms having a potential effect on irradiation assisted stress corrosion cracking (IASCC) of austenitic steels in the LWR environment have been analyzed. Based on the analysis and generalization of reference and original data on IASCC, an IASCC initiation criterion has been formulated. Conditions for

grain-boundary microcrack propagation by IASCC mechanism have been formulated. The nature of low-temperature creep of irradiated austenitic steels has been considered, constitutive equations have been derived. Relying on the formulated criterion of grain-boundary microcrack nucleation and the derived creep equations, an IASCC initiation model has been developed. The model allows one to predict the dependence of the threshold stress σ_{th}^{IASCC} on neutron dose and also to calculate the IASCC initiation time with stresses exceeding σ_{th}^{IASCC}.

Keywords: RPV internals, austenitic steels, irradiation assisted stress corrosion cracking, neutron irradiation, damage dose, localized deformation, grain boundary sliding, passive film, constant load tests, slow strain rate tests, intergranular fracture, creep, microcrack, constitutive equations

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MODEL OF CORROSION CRACKING OF IRRADIATED AUSTENITIC STEELS. Part 2. Determination of model parameters and its verification

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Abstract—Based on the analysis and generalization of reference and original experimental data unknown coefficients, parameters and functions in constitutive equations of the model developed in the first

part of article have been defined. The model has been verified. The model allows one to predict the dependence σ_{th}^{IASCC} (below which SCC does not occur at any time of tests) on neutron dose and to calculate the time of SCC initiation at stresses higher than σ_{th}^{IASCC}.

Keywords: RPV internals, austenitic steels, irradiation assisted stress corrosion cracking, neutron irradiation, damage dose, localized deformation, grain boundary sliding, passive film, constant load tests, slow strain rate tests, intergranular fracture, creep, microcrack, constitutive equations

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METHODICAL APPROACH FOR STUDYING KINETICS OF SHORT AND LONG FATIGUE CRACKS GROWTH FOR IRRADIATED REACTOR MATERIALS. Part 1. Statement of problem. The effect of the initial notch acuity on the fatigue crack rate on small-sized specimens

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Abstract—The paper considers methodical issues in the experimental research of fatigue crack growth kinetics when testing irradiated small-sized specimens. The effect of the initial notch acuity is studied on the long crack growth rate. The stress concentration zone sizes are estimated for notches of various types. A brif literature review of the main problems in the study of the growth kinetics of short fatigue cracks has been performed. The tasks of further research are formulated.

Keyword: austenitic steel, neutron irradiation, cyclic crack resistance, fatigue crack growth, short and long fatigue crack.

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