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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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LOCAL TEXTURE ANALYSIS OF STRUCTURE NON-UNIFORMITY IN LOW CARBON HIGH-STRENGTH STEEL AFTER DIRECT QUENCHING

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Abstract—The direct quenching of high-strength steels after hot rolling, which enables discard of the reheating operation, is economically efficient but necessitates a careful analysis of corresponding structural features. In particular, this treatment sometimes results in extended domains of coarse bainite decreasing the fracture toughness of steel. To reveal dependence of such effects on ausforming conditions, local textures of the parent γ-phase have been reconstructed from EBSD orientation data with allowance for the inter-phase orientation relationship. According to the obtained results, the unfavorable structural non-uniformity appears in the direct quenching due to excessive work hardening of austenite at the finish rolling stage; however, the structure and properties of steel can be improved by the reheating and subsequent quenching.

Keywords: high strength steel, austenite, texture, orientation relationship, EBSD

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HARDENING MECHANISMS FOR RAILS METAL DURING LONG-TERM OPERATION

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Abstract—A quantitative comparative analysis of the mechanisms of hardening of the surface layers of differentially hardened 100-m rails is carried out. It was based on structure formation, phase composition, defect substructure regularities revealed by the methods of modern physical materials science. The studies were carried out at different depths of up to 10 mm in the rail head along the central axis and along the axis of symmetry of the fillet in the initial state and after various periods of extremely long-term operation (passed tonnage of 691.8 and 1411 mln. tons brutto). The contributions due to the friction of the matrix lattice, interphase boundaries, dislocation substructure, presence of carbide particles, internal stress fields, solid-solution hardening of the pearlite component of the steel structure are estimated.

Keywords: hardening mechanisms, structure, phase composition, rails, long-term operation

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EFFECTS OF STRUCTURAL INHOMOGENEITIES ON THE STEEL BALLS RESISTANCE TO SHOCK LOADS

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Abstract—When conducting impact tests of protective glasses, nonunique cases of destruction of balls made of bearing steel ShKh15 were recorded. The causes of their destruction were determined. The state of the material was studied by fractographic and metallographic analysis, hardness and microhardness measurement. In the structure of the metal of all the balls, no critical defects were found such as flockens, shells and microcracks, but adverse factors were detected in the microstructure of the material, namely, the presence of fine-needle martensite with excessive carbides. It is established that the detected structural factors lead to liability to brittle fracture, an increase in the hardness of the material, a decrease in plasticity. To prevent brittle fracture of the balls and provide a reserve of plasticity of steel ShKh15 at high shock loads assessment calculations of ductility coefficient were made; and it was recommended to limit the maximum hardness of the material critical value HV=5.70 HPa (54 HRC), with the corresponding plasticity coefficient equal to 0.8.

Keywords: balls, impact tests, fracture, crack, microstructure, carbide inhomogeneity, hardness, microhardness, plasticity coefficient

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RESEARCH OF THE PECULIARITIES OF RUTHENIUM DISTRIBUTION IN TITANIUM α-, PSEUDO-α- AND PSEUDO-β-ALLOYS AND ITS EFFECTS ON CORROSION RESISTANCE

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Abstract—The structure of deformed semi-finished products (forgings) from titanium alloys of Ti–Al–Zr + 0.15% Ru, Ti–Al–V– Mo + 0.15% Ru, Ti–Al–V–Cr–Fe–Mo + 0.15% Ru systems has been investigated. The basic mechanical properties, microstructure, results of local elemental and phase analyses obtained by X-ray spectral microanalysis and backscattered electron diffraction, as well as a model of the effect of ruthenium on increasing corrosion resistance of titanium alloys of various classes are presented.

Keywords: heat exchange equipment, titanium alloys, ruthenium distribution, corrosion resistance, mechanical properties

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INCREASING THE SHORT-TERM MECHANICAL PROPERTIES OF NICKEL ALLOYS OF GRADES SLZhS5-VI AND ZhS32-VI DUE TO PROGRAM HARDENING COMBINED WITH THE AGING PROCESS

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Abstract—A method for improving the mechanical properties of nickel monocrystalline alloys of the SLZhS5-VI and ZhS32-VI brands used for gas turbine blades by means of program hardening combined with aging is considered. The mechanical properties of nickel alloys of grades SLZhS5-VI and ZhS32-VI after homogenization, quenching and aging, combined with programmed hardening, have been determined.

Keywords: gas turbine blades, nickel monocrystalline alloys, mechanical properties, programmed hardening, aging

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ON THE THERMOCYCLIC TESTS OF CORSET SHAPE SAMPLES AS A PROMISING METHOD FOR STUDYING THERMAL FATIGUE

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Abstract—The dynamics of deformation and fracture of the corset shape flat samples under cyclic heating was analyzed. These tests allow us to trace metallographic changes in the substructure of the material that is a result of its plastic deformation. The cracks appear in the first test cycles, regardless of the length of their thermal cycle mode. It means that the material is currently in a state favorable for cracking, according to the commonly accepted terminology. The damage accumulation specific for the development of thermal fatigue was completed in the first few cycles, and possibly in the zero half-cycle of tests. Test results could be explained by an excessively large plastic deformation in the cycle and confirmed by the evaluation calculation. We believe that deformation under cyclic heating in the central part of the corset shape samples is of a different mechanism if compared with cylindrical Coffin samples. Deformation occurs as a result of “external force”, which is created by the shoulders of the sample itself. The analysis showed that the range of plastic deformation changes on corset shape samples is more considerable than in the Coffin method, and it is more consistent with what is happening. It seems that thermocyclic tests of corset shape samples are promising for studying the destruction in real products subjected to cyclic heating, so it is necessary to identify dangerous zones and simulate them in corset samples. Published results of thermocyclic tests of the ZhS32 alloy were used to demonstrate the features of fracture development in corset shape samples. For a visual representation of the process in semi-cycle tests, a deformation diagram has been developed, which is useful when planning the thermocyclic tests.

Keywords: thermal fatigue, thermocyclic tests, plastic deformation, thermal fatigue cracks, corset shape samples

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DEVELOPMENT OF COMPOSITE POWDERS AND COATINGS FOR PROTECTION AND RESTORATION OF PRODUCTS UNDER SIGNIFICANT TEMPERATURE EXPOSURE DURING OPERATION

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Abstract—The paper presents results of studies aimed at expanding the range of domestic powder composites for thermal spraying of coatings with great number of performance characteristics used in the power engineering industry. Experimental data on the synthesis of nanostructured powders based on a titanium matrix and reinforced with ceramic nanopowders are presented. Some properties of sprayed coatings are investigated.

Keywords: composite powder, thermal spray, composite coating, protective coating, restorative coating, thermal cycling tests, microhardness, wear resistance, niobium diboride nanopowder, titanium powder.

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TECHNOLOGICAL FEATURES OF OBTAINING PHOSPHOR PIGMENT FOR PAINTS FROM PHOSPHOGYPSUM WASTE

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Abstract—In order to provide the Russian paint and varnish industry with cheap domestic raw materials, research has been carried out to develop a phosphor pigment that meets the following requirements: 1) the production cost per unit of its volume should not exceed the cost of a similar volume of traditional dyes; 2) the pigment should be made exclusively from domestic raw materials. Sulfides were chosen as the most optimal raw materials, because of a fairly simple technology and the possibility of using production waste as a raw material, namely phosphogypsum. The essence and theory of the method for obtaining a phosphor pigment from phosphogypsum, as well as the technological features of its production.

Keywords: phosphor, phosphogypsum, polymer materials, paintwork materials, pigments

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HIGH-TEMPERATURE CARBON PLASTICS BASED ON THERMOREACTIVE POLYIMIDE BINDER

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Abstract—The article presents results of studies of experimental carbon plastics based on thermosetting PMR-polyimide binder. Carbon fiber reinforced plastics (CFRPs) are made from prepregs prepared by

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melt and mortar technologies, so the rheological properties of the polyimide binder were investigated. The heat resistance of carbon plastics was researched and its elastic-strength characteristics were determined at temperatures up to 320°C. The fundamental possibility of manufacturing carbon fiber from prepregs based on polyimide binder, obtained both by melt and mortar technologies, is shown. CFRPs made from two types of prepregs have a high glass transition temperature: 364°C (melt) and 367°C (solution), with this temperature remaining at the 97% level after boiling, and also at approximately the same (86–97%) level of conservation of elastic strength properties at temperature 300°C.

Keywords: polymer matrix composites, high temperature carbon fiber reinforced plastics, carbon fabric, polyimide binder, prepreg, melt technology, mortar technology.

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DETERMINATION OF THE COMPRESSION TEST METHOD FOR HIGH TEMPERATURE-RESISTANT CARBON FIBER REINFORCED PLASTICS

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Abstract—The article presents the results of studies of carbon fiber reinforced plastic VS-51/VTkU-2.200. The influence of the thickness of the specimens and the size of working gage on the compressive strength of carbon fiber reinforced plastic specimens was evaluated; tests were done in accordance with different standards. The results of compression strength tests at high temperature (300–320°C) are given: carbon fiber reinforced plastic VS-51/VTkU-2.200 shows high heat resistance and keeps compressive strength at high temperature tests. Carbon fiber reinforced plastic VS-51/VTkU-2.200 is of increasing interest for application in aircraft structural parts requiring high temperature resistance.

Keywords: polymer composites, high temperature resistant carbon fiber reinforced plastics, test methods, compressive strength

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ON THE DEFINITION OF THE LOCAL BRITTLE FRACTURE CRITERION TO PREDICT THE CRACK RESISTANCE OF HIGH-STRENGTH STEEL

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Abstract—The use of local brittle fracture criteria for predicting the crack resistance of low-alloy steels is a generally accepted approach. The paper analyzes the possibility of its use for experimental melts of high-strength low-alloy steel sheets with yield strength of about 1000 MPa, the structural state of which was previously studied. Cylindrical specimens with an annular notch of three types differing in the stress-strain state in the net cross-section were tested. It is found that the use of the simplest formulation of such a criterion in the form of an energy condition for the propagation of microcracks through structural barriers (large-angle grain boundaries) gives acceptable results for notched specimens made of metal with different grain sizes, and allows linking these results with the crack resistance of the studied materials.

Keywords: high-strength steel, crack resistance, brittle fracture, fracture criterion, microstructure.

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INVESTIGATION OF IRRADIATED METAL OF WWER-TYPE REACTOR INTERNALS AFTER 45 YEARS OF OPERATION.

Part 1. Research program and cutting out of samples from pressure vessel internals

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Abstract—The program is presented for investigations of the metal of the most irradiated elements of the WWER-440 reactor of the Novovoronezh NPP Unit 3 decommissioned after 45 years of operation. The fragments (cylindrical samples) were cut out from various zones of the core baffle and segment of forming ring of core barrel.

Keywords: pressure vessel internal, austenitic steel, fragments cutting, properties after operation

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INVESTIGATION OF IRRADIATED METAL OF WWER-TYPE REACTOR INTERNALS AFTER 45 YEARS OF OPERATION.

Part 2. Calculated and experimental determination of the fast neutron fluence and damage dose

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Abstract—Fast neutron flux, fluence and damage dose have been determined when using experimentally measured specific activity of ^{54}Mn и ^{58}Co isotopes for metal of samples cut out from elements of pressure vessel internals of Novovoronezh NPP Unit No 3 (18Cr-10Ni-Ti steel, analog of AISI 321 steel). The results have been compared with the values calculated by KATRIN-2.5 computer code.

Keywords: PVI, fast neutron fluence, damage dose, specific activity

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INVESTIGATION OF IRRADIATED METAL OF WWER-TYPE REACTOR INTERNALS AFTER 45 YEARS OF OPERATION. Part 3. Microstructure and phase composition

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Abstract—TEM, SEM, and APT techniques have been used to analyze radiation-induced components of metal structure of fragments cut from the pressure vessel internals of Novovoronezh NPP Unit No 3 after 45 years of operation. The fragments differed in the neutron damaging doses (from 14 to 43 dpa) and the irradiation temperature (from 285 to 315°C). The density and dimensions of titanium carbides and carbonitrides, dislocation loops, radiation-induced voids, segregations, and nanoscale precipitates were determined. The contributions of structural components to the radiation hardening of the investigated fragments of 18Cr-10Ni-Ti stainless steel were estimated.

Keywords: internals, neutron irradiation, stainless steel, radiation-induced changes of structure

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STUDY OF CHANGES IN THE PROPERTIES OF TITANIUM ALLOYS SUBJECTED TO NEUTRON IRRADIATION

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Abstract—A change in the natural composition of titanium subjected to neutron irradiation with energies up to 0.1 MeV is shown. The process is accompanied by the formation of hydrogen and radioactive scandium. Gamma rays with energies of 889 and 1120 keV are observed. The effect of changing the natural composition of the titanium alloy and the presence of gamma studies should be taken into account when creating structural products and when creating a neutron shield based on titanium.

Keywords: alloys on the basis of titanium, neutrons, radiation durability, hydrogen absorption

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