SCIENTIFIC AND TECHNICAL JOURNAL
"Voprosy Materialovedeniya", 2021, № 3(107)

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UDC 669.15–194.2:621.771.23

STRUCTURE HETEROGENEITY AND MECHANICAL PROPERTIES STUDIED IN THICKNESS UP TO 100 mm OF LOW-ALLOYED SHIPBUILDING STEEL SHEETS WITH A YIELD STRENGTH NOT LESS THAN 420 MPa

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Received June 11, 2021
Revised June 23, 2021
Accepted July 27, 2021

Abstract—This paper presents a study of changes in the structure and properties in thickness of rolled sheets up to 100 mm of low-alloyed shipbuilding steel with a yield point not less than 420 MPa. The fracture surface of samples after impact bending tests at low temperatures was investigated. It was found that the combination of the parameters of lath morphology bainite (fraction, areas average size and length) and the size of structural elements at given tolerance angles of 5 and 15° (indicating the presence or absence of a developed subgrain structure of deformation origin) determine the level of impact work at low temperatures testing.

Keywords: thermomechanical treatment, sheet metal, structure in thickness, structural heterogeneity, lath bainite, quasi-polygonal ferrite, mechanical properties, low temperature of tests.

DOI: 10.22349/1994-6716-2021-107-3-09-27

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UDC 669.14.018.293:539.389:539.421

EFFECT OF NATURAL AND ARTIFICIAL AGEING ON STEEL MECHANICAL PROPERTIES AND FRACTURE TOUGHNESS

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Received June 15, 2021
Revised June 30, 2021
Accepted July 27, 2021

Abstract—The operating conditions of welded structures of shipbuilding steels, including operation at northern latitudes, determine high requirements for their quality. Materials used for such structures should guarantee stable mechanical properties, good processability during hull fabrication and serviceability at subzero temperatures. Strain aging is due to the thermodynamic non-equilibrium of steel structure in its initial state and gradual transition to the equilibrium state provided the diffusion mobility of interstitial atoms is sufficient. In unfavorable conditions, this can lead to the degradation of properties during processing (cold straightening, bending, welding), operation or long-term storage. The paper studies the probability of natural and artificial ageing processes in steels of different chemical compositions due to bulk diffusion and carbon dislocation core diffusion (dislocation pipe diffusion). The effect of strain ageing on mechanical properties and the CTOD parameter value has been examined.

Keywords: low-alloy steel, alloyed steel, thermomechanical controlled processing, quenching, tempering, natural and artificial ageing, ferrite-bainite structure, ferrite-pearlite structure, mechanical properties, fracture toughness

DOI: 10.22349/1994-6716-2021-107-3-28-39

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UDC 669.295:539.2:621.785.3

CHANGES IN THE STRUCTURAL AND TEXTURAL STATE OF TITANIUM ALLOY VT41 AFTER HOT UPSETTING AND ANNEALING

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Received May 26, 2021
Revised July 7, 2021
Accepted July 27, 2021

Abstract—A study of the structure of titanium alloy VT41 (Ti–Al–Si–Zr–Sn– β-stabilizers) was carried out on a sample subjected to hot upsetting in the (α+β)-region – conditions simulating the stamping of a disk of a gas turbine engine (GTE). The features of the formation of the textural state of primary and secondary globular grains, as well as the kinetics of their dissolution with an increase in the annealing temperature, have been determined. As a result of heat treatment at 995°C, the homogeneity of the alloy structure significantly increases comparing to the deformed state, which is associated with the recrystallization of lamellar and small-globular grains and the retention of primary globular grains of the α-phase. The sequence of structural changes has been established during the annealing within the temperature range from 950 to 1040°C.

Keywords: titanium alloys, deformation, recrystallization, metallography, SEM

DOI: 10.22349/1994-6716-2021-107-3-40-50

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UDC 669.295:620.193

SPECIFIC FEATURES OF RUTHENIUM INFLUENCE ON CORROSION CHARACTERISTICS OF DIFFERENT TITANIUM ALLOYS

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Received June 28, 2021
Revised July 21, 2021
Accepted July 27, 2021

Abstract—This article discusses the results of corrosion tests and microstructural studies of forgings from various titanium alloys modified with ruthenium, of systems Ti–Al–Zr + 0.15% Ru, Ti–Al–V–Mo + 0.15% Ru, Ti–Al–V–Cr–Fe–Mo + 0.15% Ru and similar systems of basic compositions. On the basis of the performed complex of studies, the influence of the amount of the β-phase on the local content of ruthenium and, as a consequence, on the effect of cathodic protection in general was analyzed.

Keywords: modified titanium alloys, ruthenium, forgings, corrosion resistance

ACKNOWLEDGEMENTS

Experimental studies were performed on the equipment of the Center for Collective Use "Composition, Structure and Properties of Structural and Functional Materials" of the NRC "Kurchatov Institute" – CRISM "Prometey".

DOI: 10.22349/1994-6716-2021-107-3-51-62

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UDC 669.295:621.791

STRUCTURAL PHASE TRANSFORMATIONS IN WELDING HIGH-ALLOYED TITANIUM ALLOY

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Received July 13, 2021
Revised August 24, 2021
Accepted August 25, 2021

Abstract—This article investigates the change in the phase composition and structural state during the thermal cycle of welding a high-alloyed titanium alloy. It is shown that structural-phase transformations in the welded joint occurring under the influence of the thermal and deformation cycle of welding lead to the formation of metastable phases, and its subsequent decomposition can lead to ductility losses. To bring the metal of the welded joint to an equilibrium state, stabilizing annealing is required.

Keywords: titanium alloys, welded joint, electron microscopic examination, structure, metastable phases, precipitation of secondary phases, microhardness

DOI: 10.22349/1994-6716-2021-107-3-63-81

ACKNOWLEDGEMENTS

Experimental studies were performed on the equipment of the Center for Collective Use "Composition, Structure and Properties of Structural and Functional Materials" of the NRC "Kurchatov Institute" – CRISM "Prometey" with financial support from the Ministry of Science and Higher Education of the RF, Agreement 13.ЦКП.21.0014 (075-11-2021-068), unique identifier RF–2296.61321X0014.

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UDC 621.763:001.891

INNOVATIVE RESEARCH CARRIED OUT AT THE NANOCENTER OF THE NRC "KURCHATOV INSTITUTE" – CRISM "PROMETEY"

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Received June 29, 2021
Revised July 8, 2021
Accepted July 27, 2021

Abstract—This article presents the results of comprehensive innovative research carried out over the past 15 years at the Nanocenter of the NRC "Kurchatov Institute" – CRISM "Prometey" in the following areas: the creation of coatings based on quasicrystals of the Al-Cu-Fe system, laser synthesis technolo-

gies, systems electromagnetic protection of technical equipment and biological objects, structural ceramics and composite materials, technologies for surface modification and magnetron sputtering, obtaining powders by melt spraying, hydrogen and alternative energy.

Keywords: quasicrystals, laser synthesis, electromagnetic shielding, composite materials, surface modification, magnetron sputtering, hydrogen and alternative energy

DOI: 10.22349/1994-6716-2021-107-3-82-108

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UDC 669.017.15:[621.793.7+621.9.048.7]

COATING OF A MULTICOMPONENT SYSTEM Al–Cr–Ni–Co–Fe ON A STEEL SUBSTRATE OBTAINED BY LASER

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Received August 3, 2021
Revised September 3, 2021
Accepted September 8, 2021

Abstract—In recent years, the unique physical and mechanical properties of high-entropy alloys (HEAs) have been the subject of increased attention of researchers. The study of the thermodynamic characteristics of such materials may be of interest for formulating the principles of the formation of structures with the required functional characteristics. Since the processes of structure and phase formation, as well as the diffusion mobility of atoms, the mechanism for the formation of mechanical properties and thermal stability differ significantly from similar processes in traditional alloys, HEAs are singled out into a special group of materials.

The article presents a brief overview of the results of obtaining a high-entropy alloy by the combined method. At the first stage, a precursor layer was deposited by cold gas dynamic spraying (CGDS), and at the second stage, it was subjected to high-energy action using a laser. An alloy of the Al-Cr-Ni-Co-Fe type has been studied. By varying the ratio of the components, it was possible to obtain an almost equimolar composition for this system. A prediction of properties and structure is made based on the phase composition of the system.

Keywords: high-entropy alloy, precursor layer, CGDS, diode laser, precursor layer, equimolar composition, thermodynamic characteristics

ACKNOWLEDGEMENTS

Experimental studies were performed on the equipment of the Center for Collective Use "Composition, Structure and Properties of Structural and Functional Materials" of the NRC "Kurchatov Institute" – CRISM "Prometey".

DOI: 10.22349/1994-6716-2021-107-3-109-117

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UDC 621.793.7:621.762.5:669.017.165

APPLICATION OF COLD GAS DYNAMIC SPRAYING AS AN ADDITIVE TECHNOLOGY FOR PRODUCING MATERIALS BASED ON NICKEL ALUMINIDE AND TITANIUM ALUMINIDE

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Received August 3, 2021
Revised September 6, 2021
Accepted September 8, 2021

Abstract—Metal additive manufacturing is widely studied for its unique advantages over traditional manufacturing processes. It is used to form complex components of Ti, Fe or Ni alloys. However, for non-ferrous alloys – aluminum, magnesium, copper – additive technologies are not used due to rapid melting during laser, electron beam and/or arc treatment. Cold spraying is widely used as an effective technology for applying high quality coatings in the mass production of metal and alloy products and/or metal matrix composite coatings. In addition, cold spraying is a serious and effective tool for the additive manufacturing of metals, and research in this area is currently becoming intense. During heat treatment of materials obtained by cold spraying, new chemical compounds are formed – both intermetallic compounds and hardening ceramic inclusions that increase the microhardness. However, as a result of a change in the structure during chemical transformations, a change in the geometry of the product and the formation of pores can be observed.

Keywords: additive technology, cold gas-dynamic spraying, intermetallic compounds, microhardness, X-ray phase analysis

DOI: 10.22349/1994-6716-2021-107-3-118-127

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UDC 678.074

HYDROGENATED BUTADIENE-NITRILE RUBBER ELASTOMERS: RESEARCH OF FUNCTIONAL PROPERTIES

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Received February 9, 2021
Revised July 16, 2021
Accepted July 27, 2021

Abstract—The subject of the study were rubbers based on partially and fully hydrogenated nitrile-butadiene rubbers (HNBR) Therban AT 5065 VP and Therban AT 5005 VP, taken individually and in the ratios 80:20, 70:30, 60:40, 50:50 accordingly. The purpose of the work was to study the functional properties of rubbers based on HNBR of various degrees of unsaturation using modern methods of analysis. The degree of dispersion of the filler and the thermodynamic compatibility of polymer components in rubbers based on Therban AT 5065 VP and Therban AT 5005 VP mixtures are appreciated. Glass transition and decomposition temperatures, elastic modulus and mechanical loss tangent of HNBR-based and their combined compositions were identified. The microrelief of the surface of rubber samples based on HNBR, taken in different ratios, was investigated.

Keywords: hydrogenated butadiene-nitrile rubbers, polymer mixtures, microscopy, differential scanning calorimetry, dynamic mechanical analysis

DOI: 10.22349/1994-6716-2021-107-3-128-135

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UDC 666.166:621.793

ON THE INFLUENCE OF ION-PLASMA TREATMENT ON THE SURFACE PROPERTIES OF REINFORCING FILLERS

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Received June, 16 2021
Revised June, 28 2021
Accepted July, 28 2021

Abstract—This article presents the results of a study of the hydrophilic properties of VMPS-10 84x4 glass filaments and SYT-49S 12K carbon tows. It has been found that the contact angle of glass and carbon fibers, which decreases after ion-plasma treatment, returns to its original values within 8 days. The capillarity values of both types of fibers increase irreversibly, but for carbon fibers, we observe a more significant change in this parameter. In the course of studying the microstructure of the surface of filler fibers before and after processing, it was found that all samples were uniformly covered with a film of an active lubricant with a microdispersed structure; however, for glass fibers, the size of the sizing particles increased during processing, and for carbon fibers, it decreased. In addition, thermophysical studies of the used reinforcing fillers were carried out, and it was found that during the ion-plasma modification, the erosion of the sizing film occurred.

Keywords: ion-plasma treatment, ion-plasma treatment in vacuum, atmospheric ion-plasma treatment, contact angle, capillarity, surface microstructure

ACKNOWLEDGEMENTS

The authors are grateful to engineer of the 2nd category of laboratory 607 (FSUE VIAM) I.A. Volkov, and the engineer of the 1st category of the laboratory 612 (FSUE VIAM) Kurshev E.V.

DOI: 10.22349/1994-6716-2021-107-3-136-149

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UDC 620.197.5:629.561.5

DEVELOPMENT OF CATHODIC CORROSION PROTECTION SYSTEMS OF NUCLEAR ICE BREAKERS AND ARCTIC OFFSHORE STRUCTURES

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Received June 25, 2021
Revised July 27, 2021
Accepted July 28, 2021

Abstract—This article presents the results of the development and implementation of special ice-resistant anodes on nuclear icebreakers and offshore structures, capable of ensuring long-term effective cathodic corrosion protection systems under shock and abrasive effects of Arctic ice. The results of inspections of the hull and hull elements of the cathodic protection of the nuclear icebreaker “50 Let Pobedy” and the offshore ice-resistant platform “Prirazlomnaya” after their long-term operation are shown. Cathodic protection of the atomic icebreaker “Leader” has been described.

Keywords: nuclear icebreakers, arctic offshore structures, cathodic corrosion protection, ice resistant anodes

DOI: 10.22349/1994-6716-2021-107-3-150-162

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UDC 669.715:620.193.82

RESEARCH OF CORROSION FRACTURE OF D16T AND AMG6 ALUMINUM ALLOYS EXPOSED TO MICROSCOPIC FUNGI

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Received April 13, 2021
Revised June 9, 2021
Accepted July 28, 2021

Abstract—This paper presents an experimental study of biocorrosion of D16T and AMg6 aluminum alloys. The determining role of reactive oxygen species in aluminum biocorrosion by a consortium of molds has been shown. A model is proposed, according to which the initiators of corrosion damage to the metal surface are superoxide anion radical and hydrogen peroxide released during the life of micromycetes. It is assumed that the initiation and development of biocorrosion occurs, among other things, as a result of the process of reductive activation of oxygen and the Fenton decomposition of hydrogen peroxide. A conclusion is made about the mechanism of the occurrence of intergranular and pitting corrosion of aluminum alloys interacting with microscopic fungi.

Keywords: aluminum, D16T, AMg6, biocorrosion, microscopic fungi, reactive oxygen species, superoxide anion radical, hydrogen peroxide, intercrystalline corrosion, pitting corrosion, oxygen reductive activation

DOI: 10.22349/1994-6716-2021-107-3-163-183

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UDC 621.791.019:539.431:669.14.018.295:620.178.3

ON THE FATIGUE STRENGTH CALCULATION OF THE WELDED SHELL STRUCTURES FROM HIGH-STRENGTH STEELS UNDER LOW-CYCLE LOADING.

Part 1: Estimation at the initial stage of fatigue failure

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Received July 6, 2021
Revised July 21, 2021
Accepted July 29, 2021

Abstract—The normative methods for calculating the fatigue strength of welded joints are of limited use for low-cycle loads, as they do not take into account the possible variation in the asymmetry of the operating stress cycle, differences in the expected level of residual stresses, and the possible variety of joint geometry. Estimation procedures have been developed for shell structures made of high-strength steels subjected to external and internal pressure. They were based on experimental data on the resistance to fatigue fracture, physical modeling of individual stages of fatigue damage, and generalization of the results of numerical studies of the FEM of the stress-strain state.

Keywords: high-strength steels, welded shell structures, low-cycle loading, fatigue strength, estimation

DOI: 10.22349/1994-6716-2021-107-3-184-208

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UDC [669.15-194.55+669.15-194.56]:534.222.2:539.375

STUDYING CHANGES OF LIMIT DEFORMATIONS AND MECHANICAL PROPERTIES OF STEELS OF DIFFERENT STRUCTURE UNDER SINGLE AND MULTIPLE EXPLOSIVE LOADING

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Received May 26, 2021
Revised June 11, 2021
Accepted June 15, 2021

Abstract—The ultimate deformation capacity of stainless high-alloyed austenitic nitrogen-containing steel and low-alloyed chromium-nickel-molybdenum steel up to the moment of failure under single and multiple blast loading in the air has been investigated. The paper presents data on the change in the mechanical properties and structure of these steels as a result of explosive loading to the limit and to the specified level of deformation.

Keywords: limit deformation, explosive loading, structure and mechanical properties of low-alloyed and high-alloyed steels

DOI: 10.22349/1994-6716-2021-107-3-209-228

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UDC 669.15'786–194.2:629.561.5

PROMISING USE OF HIGH-STRENGTH NITROGEN STEEL FOR THE ICE BELT OF MARINE MACHINERY OPERATING IN THE EXTREME ARCTIC CONDITIONS

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Received June 4, 2021
Revised July 19, 2021
Accepted July 28, 2021

Abstract—This article shows the possibility of using high-strength nitrogen-containing corrosion-resistant steel grade 04Kh20N6G11M2AFB for the construction of critical elements and units of marine equipment operating at low temperatures, including the Arctic. The advantages of nitrogen-containing steel over clad steel AB2 + 08Kh18N10T always used in shipbuilding and welded steel of F500W category are considered. According to the assessment of testing of homogeneous nitrogen steel sheets, the level of its physical and mechanical properties exceeds the analogous parameters of traditional AB2 + 08Kh18N10T steels in a wide temperature range, up to –90°C.

Keywords: nitrogen-containing steel, corrosion resistance, crack resistance, ice belt
DOI: 10.22349/1994-6716-2021-107-3-229-237

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UDC 669.295:629.58

TITANIUM ALLOYS FOR DEEP MARINE ENGINEERING

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Received June 2, 2021
Revised August 25, 2021
Accepted August 26, 2021

Abstract—The results of the work of the NRC “Kurchatov Institute” – CRISM “Prometey” on the creation of titanium alloys for deep-sea marine equipment, vehicles and submersibles are presented. The paper considers development of titanium alloys with a yield strength of more than 1000 MPa.

Keywords: titanium alloys, deep-sea equipment, heat treatment, welding

DOI: 10.22349/1994-6716-2021-107-3-238-246

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UDC 669.018.44:539.434:621.774.1

ADVANCES IN OPERATING CAPACITY AND LIFE TIME OF CENTRIFUGAL CAST PIPES FOR HIGH-TEMPERATURE PYROLYSIS OF NRC "KURCHATOV INSTITUTE" – CRISM "PROMETEY"

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Received. June 10, 2021
Revised July 19, 2021
Accepted July 29, 2021

Abstract—On the basis of expert examinations of spent pipes metal operated as coil-pipes at pyrolysis furnaces, heat-resistant alloys and technologies for manufacturing standard products from them have been developed. The service characteristics of the developed alloy 45Kh32N43SB and its welded joints at temperatures of 1100 and 1150°C have been investigated. It is shown that the alloy has structural stability and the ability to resist high-temperature creep at operating temperatures up to 1150°C. A method has been developed for assessing the resource of pipe elements, taking into account the peculiarities of its operation, as well as crack-like defects in the pipe material. The reasons for the significant deformation and damage of the crossover piping, leading to the premature failure of the coils, have been found. The most significant operational factor of damage to the heat exchangers at pyrolysis plants has been identified.

Keywords: heat resistant alloy, stress rupture strength, centrifugal cast pipes, weld joints, intermetallic compounds.

DOI: 10.22349/1994-6716-2021-107-3-247-262

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UDC 669.71'721:621.791.14:629.5

CREATION OF LARGE-SCALE THIN-WALLED WELDED PANELS OF HIGH STRENGTH FROM ALUMINUM-MAGNESIUM ALLOYS FOR CONSTRUCTION OF HIGH-SPEED VESSELS OF A NEW TYPE FOR OPERATION IN THE ARCTIC

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Received June 29, 2021
Revised June 30, 2021
Accepted July 29, 2021

Abstract—A new high-strength material has been developed – large-scale thin-walled welded panels made of aluminum-magnesium alloy 1565ch. Its use, combined with modern achievements in the field of strength and aerohydrodynamics, made it possible to create a multifunctional economy skeg-type hovercraft "Haska 10" with unique operational capabilities.

Keywords: aluminum-magnesium alloy, large-scale thin-walled welded panels, high-speed hovercraft

DOI: 10.22349/1994-6716-2021-107-3-263-273

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