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CONTENTS

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INFLUENCE OF VANADIUM, NIOBIUM AND BORON ON KINETICS OF AUSTENITE RECRYSTALLIZATION OF STEELS WITH DIFFERENT STRENGTH LEVELS UNDER HOT DEFORMATION CONDITIONS

T.V. KNYAZYUK, Cand. Sc. (Eng), N.S. NOVOSKOLTSEV, E.I. KHLUSOVA, Dr. Sc. (Eng), A.A. ZISMAN, Dr. Sc. (Phys-Math)

NRC "Kurchatov Institute" – CRISM "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru

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Abstract—Summarized results of research of the dynamic and static austenite recrystallization kinetics of low-carbon low-alloy and alloyed steels of strength classes 420, 620, 690, 750 and 890 and medium-carbon steels of strength class 1700 containing different amounts of vanadium, niobium and boron are presented. Studies were carried out by the plasmetric method under deformation conditions close to hot rolling. It was found that vanadium has a weak effect on recrystallization, and niobium in all the studied steels significantly slows it down in the hot rolling temperature range, regardless of the total doping level; microalloying of steels with boron leads to acceleration of austenite recrystallization.

Keywords: high-tensile steels, microalloying, recrystallization, hot rolling

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STRUCTURE FORMING PROCESSES IN ECONOMICALLY ALLOYED SHIPBUILDING STEEL OF 890 MPa YIELD STRENGTH LEVEL WITH A BAINITE-MARTENSITE STRUCTURE WHEN MICROALLOYED WITH VANADIUM

O.V. SYCH, Cand Sc. (Eng), S.V. KOROTOVSKAYA, Cand Sc. (Eng),
N.S. NOVOSKOLTSEV, E.I. KHLUSOVA, Dr Sc. (Eng)

NRC "Kurchatov Institute" – CRISM "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru

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Abstract—The kinetics of growth of austenite grains during heating, the features of the processes of dynamic and static recrystallization occurring under various temperature-deformation regimes of hot plastic deformation have been studied. Phase transformations have been studied during continuous cooling of hot-worked austenite in a low-carbon low-alloy steel with a guaranteed yield strength of 890 MPa. As a result, the boundary temperature-deformation conditions for the formation of a finely dispersed bainite-martensite structure were established, on the basis of which technological modes for the production of thick-plate rolled products in industrial conditions were developed. The structure and properties of rolled sheets 35 mm thick from shipbuilding sparingly alloyed steel of strength level 890 are presented.

Keywords: economically alloyed high-strength steel, rolling-heat hardening, vacuum etching, austenite grain size, GLEEBLE 3800, dynamic recrystallization, static recrystallization, phase transformations, rolled sheets, structure, properties

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STUDY OF STRUCTURAL ARCTIC STEEL IN A FRICTION PAIR WITH ICE

R.Yu. BYSTROV, D.A. GERASHCHENKOV, Cand Sc. (Eng), E.Yu. GERASHCHENKOVA, P.A. KUZNETSOV, Dr Sc (Eng)

NRC “Kurchatov Institute” – CRISM “Prometey”, 49 Shpalernaya St, 191015, St Petersburg, Russian Federation. E-mail: mail@crism.ru

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Abstract—Tests of friction pairs steel–ice for two grades of structural steel with a yield strength of 540 and 760 MPa were carried out. The dependences of the friction coefficients on the applied load and changes in the ambient temperature are studied. It is shown that the coefficient of static friction of the samples is noticeably higher than the kinetic one, which indicates the adhesion of ice to steel.

Keywords: friction coefficient, structural steels, arctic steels, wear

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ON THE MECHANISM OF CHROMIUM-NICKEL TWO-PHASE ALLOY STRENGTHENING AND FRACTURE

A. M. ADASKIN[1], Cand Sc. (Eng), V. N. BUTRIM[2], Dr Sc. (Eng), V. S. KUBATKIN[1]

[1] *Moscow State Technological University "STANKIN", 3A/bld. 1 Vadkovsky lane, 127055 Moscow, Russian Federation*

[2] *JSC "Kompozit", 4 Pionerskaya St, 141070 Moscow Region, Korolev, Russian Federation*

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Abstract—The mechanism of strengthening of a two-phase chromium-nickel alloy 65Cr-(31-35)Ni–Ti–V–W depends on the heat treatment mode: the lattice periods of the α-phase (alloy matrix is a solid solution of Ni in Cr) in the hardened and equilibrium conditions are almost the same; level of strength and ductility properties of alloy determines dispersion and amount of γ-soft nuclei released during heat treatment (solid solution of Cr in Ni), its hardness is less than that of α-phase. Quenching from single-phase area from 1250°C and tempering at 800−900°C provides a higher strength than annealed alloy and increases the start temperature of high temperature failure. The nature of the destruction depends on the temperature. The influence of γ-phase is manifested more significantly at temperatures below equicohesive.

Keywords: chromium-based alloy, hardening, equicohesive temperature, solid solutions of Ni substitution in Cr and Cr in Ni, fracture mechanism

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STUDY OF HIGH TEMPERATURE AGING OF CAST NICKEL ALLOY STRUCTURE AND PROPERTIES

O.B. BERDNIK, Cand Sc. (Eng), I.N. TSAREVA Cand Sc. (Phys-Math)

Institute for Problems in Mechanical Engineering RAS (IPMash RAS), branch of the Federal Research Center "Institute of Applied Physics" of the Russian Academy of Sciences (FRC IAP RAS), 85 Belinsky St, 603024 Nizhny Novgorod, Russian Federation. E-mail: berdnik80@mail.ru

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Abstract—The paper presents the results of a study of changes in the structure and strength properties of a heat-resistant nickel alloy after various periods of operation in a gas turbine engine. It is shown that after 25,000 hours of operation, irreversible changes occur in the microstructure of the alloy, which adversely affect the performance of the parts. Ensuring the stability of the structural state and mechanical properties are very important in assessing the reliability and extending the service life. The results of a study of the effect of heat treatment parameters on the structural characteristics of the CrNi65CoMoWAlTi alloy are presented, and an assessment is made of the effect of structural parameters on mechanical properties. Timely application of recovery technologies can extend the service life of products.

Keywords: nickel alloy, microstructure, carbide phase, intermetallic phase, heat treatment, mechanical characteristics

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CALCULATION AND INVESTIGATION OF THE PHASE COMPOSITION OF A COMPOSITE INTERMETALLIC LAYER SYNTHESIZED ON THE SURFACE OF VT6 TITANIUM ALLOY FROM Cu–SiC AND Al–SiC POWDERS

D.A. GERASHCHENKOV, Cand Sc. (Eng), Yu.P. UDALOV, Dr Sc. (Chem)

[1] *NRC "Kurchatov Institute" – CRISM "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

[2] *SPbGTI (TU), 26 Ave Moskovsky, 190013 St Petersburg, Russian Federation. E-mail: udalov@lti-gti.ru*

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Abstract—The physical and chemical foundations of the technology of cold gas-dynamic spraying of coatings on titanium for two types of charge are considered, in one of which chemically inactive copper is used as a ductile metal in combination with abrasive silicon carbide powder, in the other – chemically active aluminum in combined with silicon carbide. A thermodynamic modeling technique has been developed to select the composition of the coating charge and predict the change in its phase composition at high temperature.

Keywords: titanium alloy, composite intermetallic coating, cold gas-dynamic spraying, copper-silicon carbide, aluminum-silicon carbide, laser processing

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STUDY OF THE RESISTANCE OF NITRILE BUTADIENE RUBBER TO THERMAL CYCLING IN A HYDROCARBON MEDIUM

N.V. SHADRINOV, Cand Sc. (Eng), A.F. FEDOROVA, Cand Sc. (Eng),
M.L. DAVYDOVA, Cand Sc. (Eng), A.L. FEDOROV, Cand Sc. (Eng)

*Yakut Research Centre of the Siberian Branch of Russian Academy of Sciences,
Institute of Oil and Gas Problems RAS, 20 Avtodorozhnaya St, 677007 Yakutsk, Russian Federation.
E-mail: davmlar@mail.ru*

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Abstract—The change in the properties of rubbers 98-1 and RP-10 based on nitrile butadiene rubbers with 17–20% of acrylonitrile content under thermal cycling conditions in the range from –50 to +80°C is evaluated. The samples are exposed in the air and working hydrocarbon medium of hydraulic oil I-20A in stress-free and deformed states. It has been established that 98-1 rubber is more resistant in air and RP-10 rubber containing a sulfur-peroxide vulcanizing system and UHMWPE demonstrates high durability in a hydrocarbon medium in comparison with first one. The paper shows insignificant deformation on the rubbers properties and deterioration of the frost resistance of rubbers up to its complete loss during thermal cycling in the medium of I-20A hydraulic oil.

Keywords: thermal cycling, rubber aging, physical and mechanical properties, frost resistance, nitrile butadiene rubber, ultra-high molecular weight polyethylene

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STUDY OF THE ATTENUATION OF ULTRASONIC OSCILLIATIONS IN 3D-ORTHOGONAL WOVEN COMPOSITE

S.I. YAKOVLEVA[1], M.A. DALIN[1], O.A. KRUPNINA[1], V.A. KRUPENNIKOV[2]

[1]National Research Center "Kurchatov Institute" – VIAM, 17 Radio St, 105005 Moscow, Russian Federation. E-mail: viam-dma@mail.ru

[2]PAO "ODK Saturn", 163 Lenin Ave, 152903 Rybinsk, Yaroslavl region, Russian Federation

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Abstract—The particularities of 3D-woven composite's defects are observed. Automated ultrasonic immersion through-transmission technique for their non-destructive testing is offered. X-ray computed tomography (X-ray CT) application for the definition of the reasons of ultrasonic waves high attenuation in 3D-orthogonal woven composite sample is described. The analysis of defects detected with X-ray CT is shown. The suggestion about connection between quantity of projection of defects total area at the plane which is perpendicular to ultrasonic wave propagation and ultrasonic wave attenuation has been made.

Keywords: automated ultrasonic through-transmission technique, 3D-woven composite, defect, porosity, crack, X-ray computed tomography

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ON THE ABILITY OF POLYMERS TO SELF-LUBRICATION IN METAL – POLYMER FRICTION PAIRS

E.B. SEDAKOVA[1,2], Dr Sc. (Eng), LI SYANSHUN[2], V.E. ZHAROV[2], A.D. BREKI[2], Dr Sc. (Phys-Math), A.O. POZDNYAKOV[1,3], Cand Sc. (Eng), A.A. SMIRNOV[2]

[1] *Institute for Problems in Mechanical Engineering of the Russian Academy of Sciences, St Petersburg, Russian Federation. E-mail: elenasedakova2006@yandex.ru*

[2] *Peter the Great St Petersburg University, 29 Polytekhnicheskaya St, 195251 St Petersburg, Russian Federation*

[3] *Ioffe Institute of the Russian Academy of Sciences, 26, Polytechnicheskaya St, 194021 St Petersburg, Russian Federation*

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Abstract—Results of comparative research of wear resistance of polytetrafluoroethylene (PTFE), polyetheretherketone (PEEK), ultrahigh molecular weight polyethylene (UHMWPE) and polyamide 6 (PA6) in friction pairs with 18Kh2N4MA, 08Kh18N10T and 40Kh13 are presented. Self-lubricating ability of polymers was determined by the contact pressure value corresponding to the upper border of the diapason, in which the effect of stabilization of linear wear intensity values and by the length of this diapason along the axis of loads is shown. Carbon steel 45 was used as a base steel in the comparison. PEEK, UHMWPE and PA6 friction pairs show higher values of intensity of linear wear but decrease in ability to self-lubrication. However in friction pair PTFE – steel 18Kh2N4MA with the prevailing content of nickel (about 4%), expansion of a range of stabilization of linear wear intensity is observed. In friction pairs PTFE with steel 40Kh13, containing a considerable percentage of chrome (13%), in absence of nickel, and with steel 18Kh2N4MA containing a complex of nickel and chrome (10% and 18%, respectively), the least wear resistance and ability to self-lubrication of polymer are marked. Temperatures on polymer tribocontact corresponding to ranges of wear stabilization loadings in researched friction pairs are determined.

Keywords: friction, wear, polytetrafluoroethylene, polyetheretherketone, ultra-high molecular weight polyethylene, and polyamide 6, linear wear intensity, alloyed steels, adhesion mechanism of wear, frictional heating

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CORRELATION OF FRACTURE TOUGHNESS WITH MICROSTRUCTURAL PARAMETERS AND STANDARD MECHANICAL PROPERTIES OF HIGH-STRENGTH MEDIUM-ALLOY STEEL

A.V. ILYIN, Dr Sc (Eng), A.A. LAVRENTIEV, G.D. MOTOVILINA, Cand Sc. (Eng), E.V. ZABAVICHEVA, S.N. PETROV, Dr Sc (Eng)

NRC "Kurchatov Institute" – CRISM "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. *E-mail: mail@crism.ru*

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Abstract—Fracture toughness of rolled plates of high-strength medium-alloy steel with a martensitic or martensitic-bainite microstructure can vary widely depending on the parameters of their microstructure, which depends on the specific chemical composition, rolling parameters, quenching and tempering. In previous works, the authors studied the metal of various experimental smelts. The studied materials were significantly different in the size of structural components separated by large-angle boundaries (hereditary austenitic grain, martensite packages, and bainite crystallites). The continuation of these studies is the analysis of the relationship between the fracture toughness of a metal of one smelt and the general quenching parameters and, as a consequence, with the same parameters of the microstructure formed during quenching, but with different tempering parameters. A general structural state parameter based on the obtained data, and correlated with fracture toughness is proposed.

Keywords: high-strength steel, fracture toughness brittle fracture, fracture criterion, microstructure

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COMPARATIVE ANALYSIS OF COMPRESSED HYDROGEN LOSSES DURING ITS TRANSPORTATION THROUGH PIPELINES FROM DIFFERENT MATERIALS

V.I. BOLOBOV, Dr Sc (Eng), I.U. LATIPOV, Dr Sc (Eng), A.O. SHERSTNEVA, Cand Sc. (Eng), V.A. ZLOTIN, I.V. ZHUIKOV, G.G. POPOV, A.P. PETKOVA

St Petersburg Mining University, 2, 21st Line V.O., 199106, St Petersburg, Russian Federation. E-mail: zlotinvladimir@mail.ru

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Abstract––The authors estimate possible losses of transported compressed hydrogen (*P* = 10 MPa) due to diffusion through the pipe wall applying Sieverts law and Arrhenius equation and using tabular data on the coefficients of permeability and solubility. The calculation was carried out for pipelines made of various metallic and non-metallic materials at room and elevated temperatures. It is shown that the volume of the diffused gas at *T* = 298 K (25°C) is only fractions of a percent of the pumped hydrogen volume. At the same time, the biggest loss occurs in a pipeline made of polyethylene (~0.03%), and the most insignificant one in austenitic steels (~10^{-6}%). For carbon and low-alloy steels, the main materials of gas pipelines, these losses are at the level of 10^{-4}–10^{-5} %. When the temperature rises to 683°K (410°C), the losses in steel pipelines increase to 0.25%, in polymer pipelines to 20%.

Keywords: compressed hydrogen, pipeline, diffusion, permeability, loss

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LONG-TERM HIGH-TEMPERATURE EXPOSURE EFFECTS ON MECHANICAL PROPERTIES AND STRUCTURE OF THE 42XNM ALLOY AFTER NEUTRON IRRADIATION IN THE VVER-1000. Part 1: MECHANICAL TESTS

B. A. GUROVICH[1], Dr Sc (Eng), A.S. FROLOV[1], Cand Sc (Eng), E. A. KULESHOVA[1,2], Dr Sc (Eng), I.V. FEDOTOV[1]

[1]*National Research Center “Kurchatov Institute”, 1 Akademika Kurchatova Square, 123182 Moscow, Russian Federation. E-mail: Frolov_AS@nrcki.ru*

[2]*National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe shosse, 115409 Moscow, Russian Federation*

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Abstract—The paper presents the results of mechanical tests of ring specimens made of the 42XNM alloy after irradiation as part of the control and protection system of the VVER-1000 reactor to a damaging dose of ~12 dpa at a temperature of ~350°C and subsequent isothermal annealings in the temperature range of 400–1150°C (heating and holding for ~2 h). A model was constructed and validated by the finite element method, it describes the mechanical characteristics of irradiated and non-irradiated samples from the 42XNM alloy during tests in the temperature range from 500 to 1000°C. The model was used to plot the temperature dependences of the maximum local plastic deformation and the yield strength of the material under study.

Keywords: VVER-100 reactor, ring specimens, irradiation, mechanical testing, finite element method, plastic deformation, yield stress.

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LONG-TERM HIGH-TEMPERATURE EXPOSURE EFFECTS ON MECHANICAL PROPERTIES AND STRUCTURE OF THE 42HNM ALLOY AFTER NEUTRON IRRADIATION IN THE VVER-1000. Part 2: STRUCTURAL STUDIES

B.A. GUROVICH[1], Dr Sc. (Eng), A.S. FROLOV[1], Cand Sc. (Eng), E.A. KULESHOVA[1,2], Dr Sc. (Eng), D.A. MALTSEV[1], Cand Sc. (Eng), I.V. FEDOTOV[1], D.V. SAFONOV[1], Cand Sc. (Eng)

[1]National Research Center "Kurchatov Institute", 1 Akademika Kurchatova Square, 123182 Moscow, Russian Federation. E-mail: Frolov_AS@nrcki.ru

[2]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe shosse, 115409 Moscow, Russian Federation

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Abstract—The paper presents the results of structural studies of ring specimens made of the 42XNM alloy after irradiation as part of the control and protection system of the VVER-1000 reactor to a damaging dose of ~12 dpa at a temperature of ~350°C and subsequent isothermal annealings in the temperature range of 400–1150°C (heating and holding for ~2 h). It is shown that during long-term isothermal annealing, a change in the phase composition of the alloy is observed, dislocation structures and grain-boundary segregations are annealed, and porosity evolves. It has been confirmed that decrease in the plastic properties of the 42XNM alloy after irradiation and subsequent isothermal annealing in the temperature range of 400–1000°C could be explained by the formation of precipitates of the second phases (zones of discontinuous decomposition of the solid solution with the release of α-Cr particles along the grain boundaries) and pores at the grain boundaries.

Keywords: VVER-100 reactor, ring specimens, irradiation, mechanical testing, finite element method, plastic deformation, yield stress.

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STUDY OF MECHANICAL PROPERTIES AND BRITTLE FRACTURE RESISTANCE FOR WELD METAL OF WWER RPV

E.V. YURCHENKO, Cand Sc. (Eng), M.N. TIMOFEEV, Cand Sc. (Eng), B.Z. MARGOLIN, Dr Sc (Eng), S.N. GALYATKIN, Cand Sc. (Eng)

NRC “Kurchatov Institute” – CRISM “Prometey”, 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru

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Abstract—The results of the study of mechanical properties and brittle fracture resistance (BFR) are presented for weld metal of WWER RPV performed by automatic arc welding with use welding wire Sv-15CrNiMoTiA and ceramic flux 48AF-71. Mechanical properties are determined on the basis of test results of tensile smooth round bar. BFR are determined from impact strength tests and fracture toughness tests. The anisotropy of mechanical properties and BFR is investigated by testing the specimens with different orientations. Tests are conducted for specimens of two orientations: first orientation corresponds to the position of the specimen, in which the fracture surface is perpendicular to the axis of the weld; second orientation corresponds fracture surface parallel to the axis of the weld. It is shown that the weld metal performed according to above mentioned technology has no anisotropy both in mechanical properties and in BFR. An explanation of the significant scatter of BFR on the basis of the results of metallographic studies is proposed. The obtained experimental results on mechanical properties for investigated weld metal allow to use tensile smooth round bar with 3 mm diameter with transverse orientation instead of specimens with 6 mm diameter with longitudinal orientation as the scale factor and anisotropy are negligible. The correlation dependence between the values of reference temperature T_0 determined by the Master Curve method and reference temperature T_{100} determined by the Advanced Unified Curve method and the value of critical brittleness temperature T_{K0} for the studied weld metal in the initial state is established.

Keyworlds: weld metal, automatic arc welding, brittle fracture resistance, mechanical properties, anisotropy of properties, scale factor, correlation dependence.

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