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ABSTRACTS OF PUBLISHED ARTICLES

UDC 669.018.29

Prospects for development of structural materials based on refractory metals and compounds. Gorynin I. V., Burkhanov G. S., Farmakovskiy B. V. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 5–15.

The paper identifies a number of approaches to the development of new structural materials for space, aviation and nuclear equipment and tailored coatings based on fundamental physicochemical studies. The proving substantiation of these next-generation materials and technologies is given.

Key words: structural materials, refractory metals and compounds, prospects for application.

UDC 669.15–194.56:621.78.011

Studies of austenite recrystallization in hot rolled steel 09XH2MD by stress relaxation. Zisman A. A., Soshina T. V., Khlusova Ye. I. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 16–24.

The paper shows recrystallization kinetics of austenite with initial midsized grains in low-carbon steel 09HN2MD studied by stress relaxation after deformation by isothermal compression. Incubation periods and termination timing were determined with thermomechanical simulator Gleeble 3800. Given the technological limitations in the “fractional” hot-rolling schemes the main mechanics of the structure formation is static recrystallization of austenite in the intervals between pressings. In case of partial dynamic recrystallization of deformed austenite the nature of stress relaxation during subsequent exposure reveals the characteristics of metadynamical recrystallization.

Key words: low carbon steel, hot rolling, recrystallization kinetics, metadynamical recrystallization.

UDC 669.15–194.56:621.78:621.73

Effect of the final heat treatment on the hot deformed austenitic steel 08X18H10T structure. Dobrynina M. V., Filimonov G. N., Pavlov V. N. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 25–32.

The paper studies the effect of heat treatment conditions on the structure of austenitic steel 08X18H10T after hot deformation by forging and the possibility of poor structure amendment while forging during the stage of heat treatment.

Key words: hot deformed austenitic steel, forging, heat treatment, structure formation.

UDC 669.018.4:620.178:539.4

Research of changes of the structure, phase composition and mechanical properties of the 45X26H33C2E2 alloy at high-temperature stress-rupture test of centrifugal-cast pipe metal. Oryshchenko A. S., Utkin Yu. A., Petrov S. N., Nesterova Ye. V., Mikhailov-Smolnya-kov M. S. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 33–44.

The changes of the structure, phase composition and mechanical properties of the 45H26N33S2B2 alloy at high-temperature stress-rupture test of centrifugal-cast pipe metal in the range of 800–1100°C are studied. The formation of G-phase in $Ni_{16}Si_7Nb_6$ and the temperature interval of its stability were detected. The correlation between the strength properties and the formation of G-phase on intercrystalline boundaries was established.

Key words: 45X26H33C2E2 alloy, centrifugal-cast pipe, structure, phase composition, mechanical properties, intercrystalline boundaries, G-phase.

UDC 669.295:621.78

Thermomechanical hardening of titanium β -alloy TC6. Shaboldo O. P., Vitorskiy Ya. M. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 45–53.

The paper analyzes the efficiency of various thermomechanical processing schemes (cold drawing, high-speed heating and aging) for titanium β -alloy TC6 when used for multipurpose resilient members manufacturing, specifically for helical compression springs and torsion.

Key words: titanium β -alloy, thermomechanical treatment, spring material.

UDC 669.225.5:629

Advanced alloys with face centered cubic lattice for LNG-carriers. Legostaev Yu. L., Osokin Ye. P., Kalinin G. Yu., Teplenicheva A. S. – *Voprosy Materialovedeniya*, 2012, N 2 (70), p. 54–58.

The paper contains physical and mechanical properties of domestic cryogenic alloys and its foreign analogues at a temperature of 20°C and –180/–196°C.

Key words: liquefied natural gas (LNG), impact toughness, cryogenic materials, aluminium-magnesium alloys, invar, austenitic nitrogen steel, LNG-carrier.

UDC 669.131:621.785.6

Research of cast iron structure after liquid state hardening. Gurevich Yu. G., Chudinova Ye. A., Ovsiannikov V. E. – *Voprosy Materialovedeniya*, 2012, N 2 (70), p. 59–63.

The structure of cast iron of various carbon levels is investigated, specifically after liquid state cooling. There were determined conditions under which hypoeutectic, eutectic and hypereutectic pig irons could be produced. They confirmed a linear dependence between relative wear resistance and hardness of cast iron. It is established that layer-depth of white cast iron depends on the heat power and heating temperature. Abrasive wear of white cast iron after liquid state hardening is comparable to the chromium cast iron wear.

Key words: hot metal, eutectic, hardening, wear resistance.

UDC 669.15–194.56:620.186.5

Experimental studies and modeling of static recrystallization kinetics of pipe steel. Vasiliev A. A., Kolbasnikov N. G., Sokolov S. F., Sokolov D. F., Khlusova Ye. I. – *Voprosy Materialovedeniya*, 2012, N 2 (70), p. 64–73.

An experimental study of the austenite static recrystallization was performed for X80, X90 and X100 line-pipe steels, and for AB-1 steel with substantially different chemical composition. All investigations were conducted with the help of the Gleeble 3800 system. Empirical quantitative model of austenite static recrystallization was developed. The model account for the effect of complex alloying by such elements as C; Mn; Si; Ni; Mo; Nb; Ti; and V under the condition that the given elements are in a solid solution. In terms of precision, the developed model exceeds the existing analogues, and could be recommended for analysis of the process kinetics in modern line-pipe steels.

Key words: austenite, static recrystallization, modeling, pipe steels.

UDC 669.15–194:621.039.53:621.785.6

Modeling of the hardening process of large-sized reactor steel billets based on information support adapted to production conditions. Karzov G. P., Teplukhina I. V., Golod V. M., Giulihandanov E. L. – *Voprosy Materialovedeniya*, 2012, N 2 (70), p. 74–89.

Numerical experiments on modeling of hardening of large-sized steel metal forging and their verification are presented. This data have formed a basis for development of an integrated methodology of formation the information support for computer modeling of heat treatment, adapted for industrial conditions of their realization. Formation of information support is based on a combination of thermodynamic modeling of reactor steel grades, the dilatometric investigation of phase transformations and the thermal analysis of heat exchange (in industrial conditions). The definition of temperature-dependent thermophysical characteristics of hardening tanks are carried out by decision of an inverse problem.

Key words: computer modeling, information support, kinetics of phase separation, temperature fields calculation, structure and mechanical properties prognostication, boundary conditions of heat exchange.

UDC 621.763:669.35:539.216.1

Structure and properties of fiber composite Cu–Cu: size effects, temperature and temporal stability. Beloshenko V. A., Spuskanyuk V. Z., Dmitrenko V. Y., Chishko V. V., Sennikova L. F., Nepochatykh Yu. I. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 90–101.

The structure and physical-mechanical properties of Cu–Cu composite, depending on the diameter of the fibers in the range from 17 nm to 550 μm , are studied. The paper describes extremal nature of dependences of physical-mechanical properties of the investigated composites and the critical size of the fibers, when their maximum value is observed. Nanostructured fibrous composites are characterized by high temporal and thermal stability properties.

Key words: batch hydroextrusion, copper, nanostructure, size of the fibers, stability properties.

UDC 621.763:621.891

Characteristics of the contact zone for metallic composites on dry friction at behavior current. Aleutdinova M. I. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 102–108.

Metallographic images of metallic composites surface layers after friction at contact current density more 50 A/cm² without lubricant have been represented. It is shown that electric discharge current is larger than current passing through the real contact spots. It is established that a catastrophic wear stage of metallic model composites is observed at current density more 200 A/cm². Starting of catastrophic wear accompanied by change in character of electric parameter dependence – contact voltage drop, contact zone electrical conduction, current on the real contact spots and ratio of electric discharge current to current at real contact spots. Dry friction at electric current density more than 50 A/cm² leads to surface layer saturation by oxygen and carbon. It is marked that metal components content in surface layer is less than their content in a powder mixture.

Key words: sliding electric contact, sintered composite, current density, microstructure, Auger spectra, voltage-ampere diagram, wear rate, surface layer.

UDC 621.892

Research of load-carrying capacity of lubricating compositions with nanoparticles WS₂ and WSe₂ for rail hubs. Breki A. D., Vasilieva Ye. S., Maximov M. Yu., Chulkin S. G. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 109–113.

The paper studies lubricating compositions based on the И-40А oil with finely dispersed graphite additives, geomodifiers of friction, nanoparticles and tungsten diselenide disulfide at a concentration of particles up to 1 mas. %. The influence of the additives type on the load-carrying capacity of lubricating compositions was evaluated. Tests were conducted on a four-ball machine ЧШМ-3,2. A comparative analysis with previous tribological characteristics of lubricating compositions based on MC-20 oil. The resulting liquid dispersion system based on oils could be used to form self-lubricating surfaces by impregnation of porous materials.

Key words: lubricating compositions, finely dispersed additives, nanoparticles, tribological characteristics.

UDC 621.791.18

Research of the vacuum diffusion welding process for telescopic joints by the example of the electrostatic gyroscope without gimbal mount solid-core rotor. Beliaev S. N. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 114–119.

This article presents the technological aspects of vacuum diffusion welding process projecting for telescopic joints with ability to microplastic deforming process control for welding parts. The design procedures of welding thermomechanical cycle are presented. The principles of control the character and the value of axisymmetric deformations are grounded. The concrete engineering solutions for practical realization of telescopic joints diffusion welding process are suggested. The areas of practical use of the developed manufacturing schemes for making the concrete gyro units (particularly the electrostatic gyroscope without gimbal mount solid-core rotor) are shown.

Key words: vacuum diffusion welding, telescopic joint, solid-core rotor, electrostatic gyroscope without gimbal mount, reinforcing element, microplastic deforming.

UDC 669.15–194.56:539.421

Studies of the rate of crack growth in austenitic steels during long-term static loading under creep conditions. Gulenko A. G., Buchatsky A. A., Margolin B. Z., Kashtanov A. D., Fedorova V. A. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 120–137.

The coefficients in the crack growth equation of the C^* -integral for creep are determined on the basis of a large volume of experimental data on austenitic steels 304 and 316. In order to analyze the applicability of the equation for domestic austenitic steels the studies of crack growth rate have been carried out for base metal, weld joint and zone of steels 10X18H9 and 08X16H11M3 thermoinfluence in the original (austenized) state and after long-term thermal aging. A method of thermal aging rate calculation of crack growth under creep conditions is presented.

Key words: creep, crack growth rate, C^* -integral, base metal, weld, zone of thermoinfluence, thermal aging.

UDC 669.018.4:539.421

Experiment-calculated studies of creep crack kinetics in the arc sample of the alloy 45X26H33C2E2 at 900°C. Popova I. P., Oryshchenko A. S., Margolin B. Z. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 138–149.

The paper describes experimental studies of cracking in the material of reaction tubes of pyrolysis furnaces operating in the temperature range 900–1100°C and made of 45X26H33C2E2 alloy. Evaluation of crack development has been undertaken on the basis of C^* -integral according to ASTM 1457–02. To obtain experimental data special arc samples with the initial incision, allowing to determine the crack growth rate in natural sections of pipe, have been developed. Special curves were made to predict the crack growth rate during long-term static loading and a temperature of 900°C. The results have been compared with predicted dependencies for chromium-nickel austenitic steels.

Key words: reaction tubes, creep crack growth rate, C^* -integral, C_s^* -parameter, reference stress.

UDC 539.421.5:621.643

Development of methods for determining the critical crack-tip-opening-angle (CTOA) as the resistance characteristics of the main ductile fracture of pipe metal. Vinogradov O. P., Gusev M. A., Ilyin A. V. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 150–160.

Currently, much attention is concentrated on the CTOA criterion that characterizes the energy of destruction and main crack propagation velocity under the viscous mechanism. The various testing methods are proposed however there is very limited data for heavy metals, and no information about such tests under lower temperatures. The paper summarizes first results of CTOA definition, specifying the testing standards itself, and posing questions for future theoretical and experimental studies.

Key words: pipe metal, ductile fracture, main crack, critical crack-tip-opening-angle CTOA, testing standards.

UDC 621.791.011:539.4

Assessment of structural and technological stress concentration in welded joints for fatigue strength estimation of hull structures. Ilyin A. V., Sadkin K. E. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 161–176.

On the base of FEM-calculations the disagreement of $S-N$ -curves method and Hot Spot Stress method used in modern standards is shown. The stress analysis for welded joints with two- and three-dimensional geometry has been done and the possibility to determine stress concentration effect as $K_t = K_s \cdot K_w$ is considered being K_s structural concentration factor and K_w technological concentration factor. It is proposed to receive K_w values from the approximate equations found for two-dimensional analyses. For three-dimensional welded joints two cases should be separately considered: the cases of tabulated K_s values and the cases when the FEM-calculation is the only way to find the stress state.

Key words: stress concentration, fatigue strength, welded joints, hull structures.

UDC 621.039.531:539.422.22

Analysis of the neutron flux effects on the irradiation embrittlement of WWER-reactor materials. Margolin B. Z., Yurchenko Ye. V., Morozov A. M., Pirogova N. E. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 177–195.

The paper presents studies of neutron flux effects on the embrittlement of WWER-reactor materials by comparing the test data of samples-witnesses and those irradiated by high neutron flux within the confines of research programs. The analysis of the neutron flux effects for different types of WWER-reactor materials embrittlement has been done.

Key words: radiation embrittlement, WWER-reactor materials, neutron fluence, neutron flux.

UDC 661.665.3:621.762:621.039.562

Helium release from boron carbide powder under control rod shell of the WWER reactor. Svetukhin V. V., Kadochkin A. S., Risovany V. D. – Voprosy Materialovedeniya, 2012, N 2(70), p. 196–202.

The paper offers models describing time and temperature dependence of pressure of helium released from the irradiated boron carbide powder under the control rod shell of the WWER 1000 reactor. The control rod behavior under LOCA condition has been studied. Using the numerical simulation and experimental data they've analyzed the boron carbide powder leakage for safety and control rods, as well as the parameters describing helium desorption from the boron carbide powder at different temperatures. The relation between such critical parameters as temperature and exposition time, which define safe operation conditions of the rods, has been determined.

Key words: boron carbide powder, powder leakage, control and safety rods, Darcy equation, LOCA.

UDC 621.9.014.8:621.961.2

Problems and prospects of scrap metal turnings recycling. Andronov Ye. V., Vinogradov S. E., Oryshchenko A. S., Pimenov A. V., Timofeev V. N. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 203–208.

The analysis of different methods of turnings recycling has been carried out. The main problems of recycling are low density of the final product and contamination by non-metallic inclusions and organic material. Promising research direction for electrode briquettes production consists in scrap metal compaction with simultaneous exposing to pressure and pulses of electric current. Electroslag remelting is used for electrode briquettes castings production providing material with composition very close to original one.

Key words: scrap metal turnings, recycling, compaction, electric current, electrode briquettes.

UDC 539.421:621.961.2

Parameters of directed crack birth for cutting metal. Kornienko V. M. – Voprosy Materialovedeniya, 2012, N 2 (70), p. 209–220.

The paper characterizes the state of affairs in the division (cutting) of metal field using innovation technique based on cutting crack launching along the traced by cumulative anodic metal dissolution incision by liquid nitrogen. Necessary quantity of liquid nitrogen is determined from calculation of its pouring time and numerical value of metal temperature. The principle of birth of crack directed along the incision in the embrittled metal layer has been determined; the means of production equipment to its realization are shown. The development is of great practical importance for production tooling of recycling large metal mass.

Key words: liquid nitrogen, zone of local cooling, impulse load, cumulative anodic dissolution, directed crack, embrittled metal layer, division (cutting) of metal, breaking stress, cracking cross-section.