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ABSTRACTS OF PUBLISHED ARTICLES

UDC 669.15–194.56:621.771.016.2:620.186.5

Effect of thermal deformation treatment on the recrystallization during 45G17YU3 steel rolling. Golub Yu. V., Pankova E. A. – *Voprosy Materialovedeniya*, 2015, N 4(84), p. 7–16.

The features of dynamic, static and metadynamic recrystallization at various modes of 45G17YU3 steel rolling, including interdeformation pauses, have been observed. Recommendations on modes of temperature and deformation processing of steel for a given level of properties are given.

Keywords: steel, thermal deformation treatment, rolling, recrystallization, structure and properties.

UDC 669.018.44:539.374

Analysis of the cracking causes during hot plastic deformation of the KhN55MVTs-ID alloy. Kashtanov A. D., Petrov S. N., Kudriavtsev A. S., Okhapkin K. A., Gruzdev D. A. – *Voprosy Materialovedeniya*, 2015, N 4(84), p. 17–22.

Nature and causes of defects in the KhN55MVTs-ID alloy in the hot plastic deformation have been investigated. Stage of metallurgical transformation in which their formation occurs is identified.

Keywords: heat resistant alloy, high temperature equipment of nuclear plants, hot plastic deformation, defect formation.

UDC 669.018.44:621.73

Effect of chemical heterogeneity on the hot mechanical properties of the KhN55MVTs-ID alloy and increase of technological processibility under thermal deformation. Karzov G. P., Kashtanov A. D., Kudriavtsev A. S., Okhapkin K. A., Gruzdev D. A. – *Voprosy Materialovedeniya*, 2015, N 4(84), p. 23–28.

The influence of the chemical heterogeneity on the mechanical properties of the alloy brand KhN55MVTs-ID while forging and evaluation of the quality raising possibility of technological blanks by heat treatment of ingots and optimization of deformation technology.

Keywords: heat resistant alloy, high temperature equipment of nuclear plants, chemical heterogeneity, heat treatment, mechanical properties.

UDC 669.721:620.18.194:539.4

Research of structure and mechanical properties of the alloy VMD10 after operation. Pugacheva N. B., Vichuzhanin D. I., Smirnov S. V., Kalashnikov S. T., Chekushkin V. S., Lazunina V. A., Antenorova N. P., Pankratov A. A. – *Voprosy Materialovedeniya*, 2015, N 4(84), p. 29–37.

The microstructure and mechanical properties of deformable high-strength magnesium alloy VMD10 in capsule design after 20 years operation in different climatic conditions have been investigated. The assessment of corrosion damages of the alloy after design operation and the subsequent tests in the climatic camera has been carried out. It has been shown that the alloy VMD10 consists of 6 phases: α -solid solution of the alloying elements in magnesium, β -solid solution of magnesium and zirconium in yttrium, the H-phase Mg–Y–Zn and intermetallides $Mg_{24}Y_5$, ZrFe, CdZn. Alloy strength indicators after capsule design operation during 20 years correspond to minimum admissible values, and plasticity decreased a little due to formation of internal microcavities and micropeelings. Corrosion damages of the alloy are insignificant.

Keywords: magnesium alloy, microstructure, intermetallide, hardness, strength, plasticity, corrosion, oxides.

UDC 669.35:621.74.043

The structure and properties of composite bronze BrZhNA-12-7-1 obtained by casting, welding and vacuum suction. Potekhin B. A., Khristoliubov A. S., Zhiliakov A. Yu., Ilyushin V. V., Djemilev N. K. – Voprosy Materialovedeniya, 2015, N 4(84), p. 38–44.

The features of the structure, mechanical and tribological properties of the composite bronze BrZhNA12-7-1, reinforced by steel dendrites, in castings produced by vacuum suction and argon arc welding (remelting), have been researched.

Keywords: bronze, dendrite, vacuum casting, welding, mechanical and tribological properties.

UDC 621.763:669.24'71

Synthesis of composites based on nickel aluminide and molybdenum borides. Gostishchev V. V., Astapov I. A., Medneva A. V. – Voprosy Materialovedeniya, 2015, N 4(84), p. 45–50.

The paper shows that cast nickel aluminides and their alloys with molybdenum borides could be solved by means of metallothermic reduction of metal oxides. The results of elemental analysis and XRD showed that the composition of the intermetallic NiAl is characterized by varying content of molybdenum borides MoB or Mo₂B₅. Volume fraction of the borides phase equals to 23 and 36%. The microhardness of MoB and Mo₂B₅ alloys is considerably higher than that of nickel aluminides (24–26 GPa).

Keywords: nickel aluminide, molybdenum boride, SHS, microhardness, microstructure.

UDC 669.018.44:621.793.16

Catalytically active layers on the FeCrAl surface. Naguryanskaya Yu. N, Vlasov E. A. – Voprosy Materialovedeniya, 2015, N 4(84), p. 51–57.

The work presents results of FeCrAl oxidation in the range of temperatures of 600–1000°C during 5–15 h at air consumption of 40 h⁻¹. Optimum conditions for obtaining the solid oxide layer are studied. The surface texture of the initial and oxidized alloys, thickness and layers chemical composition is investigated. Catalytic activity of samples under oxidation of carbon monoxide, methane and hydrogen on flowing installations in the temperature range 250–550°C is defined.

Keywords: FeCrAl, oxide layers, oxidation, research methods.

UDC 669.017.165:621.315.3

Long-measuring cast microwire in glass insulation with a sinew from intermetallic compounds. Gorynin I. V., Farmakovskiy B. V. – Voprosy Materialovedeniya, 2015, N 4(84), p. 58–61.

The technology of long-measuring high-strength microwire casting in glass insulation of the intermetallic composition Bi₂Te₃–Sb₂Te₃ for thermoelectric devices has been developed. Due to physical and mechanical properties of microwires there are good prospects of high-strength thermocouples and thermoelectric modules manufacturing.

Keywords: intermetallic compounds, microwire in glass insulation, molding, physical and mechanical properties.

UDC 678.067:544.723.5

Molecular chemisorption protection against water absorption and strength for degradation of structural polymer composites. Depth protection, life time, stoichiometry and macromolecular defects influence, efficiency and mechanical strength. Sedletsky R. V. – Voprosy Materialovedeniya, 2015, N 4(84), p. 62–79.

The paper shows problems associated with the volume and nature of the temporary resource of chemisorption protection against water absorption, polymer matrix stoichiometry impact and its macromolecular defects for spheroplastic. Also the effectiveness of such protection and stabilization strength has been examined during hydraulic tests at a pressure of 0.1 and 60 MPa.

Keywords: spheroplastic, chemisorption protection against water absorption, polymer matrix stoichiometry, macromolecular defects.

UDC 678.067:544.723.5:620.17

Analysis and experimental study of the synchronous wave-like nature of the change of mechanical strength and dielectric losses in the water absorption in structural polymer composites (sferoplasts, fiberglass, CFRP). Perren A. A., Sedletsky R. V. – Voprosy Materialovedeniya, 2015, N 4(84), p. 80–90.

Within parallel experiments using mechanical testing and electrical capacitive and dielectric method the ideas on synchronous waves of mechanical strength and dielectric losses associated with water mass transition in quasi-isotropic and anisotropic structural polymer composites have been tested. Based on the concept of meniscus reversing water mass transition in such materials physical and chemical bases and sources of such synchronization have been discussed. It has been found that after chemisorption protection composites from water absorption level of fluctuations in the dielectric loss is dramatically reduced, which is a significant factor in their operation as a part of constructions. It is shown that the combination of dielectric method and the traditional mechanical testing can be very cost-effective and efficient in research, development and creation of new composites with the optimum range of physical, mechanical and dielectric properties.

Keywords: quasi-isotropic polymer composite materials, mechanical tests, electrical capacitive and dielectric method, reversing water mass transition, chemisorption protection.

UDC 678.067:621.785.78

Thermal aging of heat-resistant carbon fiberreinforced plastics. Valevin E. O., Zelenin I. V., Shvedkova A. K., Gulyaev I. N. – Voprosy Materialovedeniya, 2015, N 4(84), p. 91–99.

The interrelation of mass loss in the heat-resistant carbon fiber during its strength changes in the heat aging process at different temperatures has been considered. Correlation between weight changes of samples and change of mechanical characteristics has been defined. With the help of the apparent activation energy, evaluation of mass loss of thermotolerant CFRP at a given operating temperature has been conducted. The calculated values of the mass loss and the corresponding changes in the strength are confirmed experimentally. Thus, the offered method of forecasting of mechanical properties changes carbon fiber composites through seeming activation energy of process of loss of weight at heat aging can be used for assessment of behavior of the materials working in the broad temperature range from minus, and in those cases where the material operating mode in product is complex combination of different temperature and mechanical influences.

Keywords: thermal aging, carbon fiber, weight changes, activation energy, flexural strength, shear strength.

UDC 678.067:620.178.7

Investigation of impact effects on spectral characteristics of fiber optic Bragg grating sensors embedded into polymer composite material. Fedotov M. Yu., Shienok A. M., Gulyaev I. N., Vasil'ev S. A., Medvedkov O. I. – Voprosy Materialovedeniya, 2015, N 4(84), p. 100–108.

The article describes results of studies of impact effects on spectral characteristics of fiber optic sensors based on fiber Bragg gratings embedded into the carbon fiber reinforced plastic are presented. The main properties of fiber Bragg grating before and after embedding into the carbon fiber reinforced plastic. The influence of impact testing of carbon fiber reinforced plastic on properties of fiber Bragg grating was analyzed.

Keywords: polymer composite material, fiber optic sensor, fiber Bragg grating, optical fiber, carbon fiber reinforced plastic, spectral characteristics, impact.

UDC 678.067.2:661.666

Theoretical and experimental studies of composite materials reinforced by carbon fabrics. Part 1. Research of carbon threads contact area in the woven structure. Primachenko B. M., Strokin K. O. – Voprosy Materialovedeniya, 2015, N 4(84), p. 109–116.

The paper presents theoretical and experimental research of the contact area of the carbon threads in the woven structure to build its mechanical-analytical model. This model can predict the

properties of woven reinforcement composite components. Based on the condition that a reinforcing component assumes the main stresses in the material, this model can be the basis for another model of structure deformation and prediction of the overall composite properties. The work results include analytical dependencies between the radius of the contact area, compression threads, maximum pressure and the force of mutual pressure. The experimental results are used to determine the elastic modulus and Poisson's ratio of carbon filaments in the woven structure in compression.

Keywords: carbon fiber, woven structure, contact area, reinforcing component, composite, mechanics analytical model.

UDC 678.678:539.214

Oligo oxy propylene glycol as effective plasticizer for epoxy polymers. Mostovoy A. S. – Voprosy Materialovedeniya, 2015, N 4(84), p. 117–122.

The compositions based on bisphenol epoxy resin brand ED-20 have been developed. Polyethylene polyamine has been used as the hardener for epoxy oligomer. This amine type hardener is capable of forming a three-dimensional network structure in the absence of heating. Oligo oxy propylene glycol has been used as plasticizing agent for epoxy composites. Rational percentage of oligo oxy propylene glycol has been determined: 15 parts by weight provides stable a 4-time increase of epoxy composite to bending stress and more than 3-time impact resistance. The presence of the chemical interaction between functional groups of oligo oxy propylene glycol and epoxy oligomer has been proven by IR spectroscopy. Introduction of oligo oxy propylene in epoxy composites provides 2-times increasing of heat endurance by Vicat. Data of thermogravimetric analysis shows high thermal stability of the epoxy composite with oligo oxy propylene glycol manifesting itself in the temperature shift of composition destruction to higher temperatures.

Keywords: epoxy resin, modification, plasticizer, elastic properties, oligo oxy propylene glycol.

UDC 621.791.725:669.14.018.41

Laser welding of cold-resistant steels for ship structures used in the Arctic. Baranov A. V., Gezha V. V., Pronin M. M., Startsev V. N. – Voprosy Materialovedeniya, 2015, N 4(84), p. 123–129.

The results of research and testing of welded joints obtained during the experimental work to establish and improve the technology of laser welding cold-resistant steel used in the construction of ship structures for the Arctic. The paper evaluates prospects of extending the scope of laser welding, taking into account the appearance of a new generation of highly efficient flexible light guides.

Keywords: laser welding, cold-resistant steels, fiber lasers, emission by light guide.

UDC 669.15–194.56:621.791.052:621.78–978

Experimental of the high-temperature heat treatment of welded joints made of corrosion-resistant austenitic steel for pipelines of Leningradskaya NPP. Vasilyev N. V., Karzov G. P., Bliumin A. A., Shalygin A. S., Borkin P. I. – Voprosy Materialovedeniya, 2015, N 4(84), p. 130–137.

Experimental of the high-temperature heat treatment of welded joints made of corrosion-resistant austenitic steel for pipelines of Leningradskaya NPP have been considered. Development and production of equipment for the high-temperature inductive heat treatment of austenitic welded joints, quality control in the performance of austenification of welded joints have been analyzed.

Keywords: welded joints, high-temperature heat treatment, austenization, sensitization degree, heat-affected zone of the welded joint, intergranular stress corrosion cracking, potentiodynamic reactivation, diagnostic complex "SAKhS-1".

UDC 621.039.534.25:621.791.019

Operating experience of weld metal in the steam generator equipment RU BN-600. Ananieva M. A., Zelenin Yu. V., Galiatkin S. N., Ermakov F. S., Nosov Yu. V., Potapov O. A. – Voprosy Materialovedeniya, 2015, N 4(84), p. 138–151.

The causes of depressurization of the primary circuit modules and reheat steam generating equipment RU BN-600. Local fractures in the weld zone of welded joints occur at an elevated level of

stress along the length of the pipes, under the joint deformation of the tubes with the tube sheet because of additional unrecorded voltages during start-up and operation, as well as of the workmanship and corrosion damage.

Keywords: steam-generating equipment BN-600, causes of circuits decompression, local destruction in the welded zone.

UDC 621.791.725:669.14.018.41

Study of the technological factors of cored wire production on the hydrogen content in the weld metal. Melnikov P. V., Mogilnikov V. A., Startsev V. N. – Voprosy Materialovedeniya, 2015, N 4(84), p. 152–158.

The influence of various factors of manufacturing techniques of low-alloyed welding flux-cored wires on the amount of hydrogen in the weld metal has been analyzed. The paper states that it is necessary to take into account the hydrogenation when choosing lubricant and additional measures at the stage of drawing.

Keywords: hydrogen, welding, flux-cored wire, thermodynamic model.

UDC 621.791.04:66.065.5

Phenomenological models of nucleation in the melt during welding under the influence of ultrafine refractory components. Sokolov G. N., Lysak V. I., Zorin I. V., Artemyev A. A., Dubtsov Yu. N., Kharlamov V. O., Antonov A. A. – Voprosy Materialovedeniya, 2015, N 4(84), p. 159–168.

Metallographical methods revealed the relationship between the number, size and morphology of ultrafine particles in welding materials (powder and composite wire coated electrodes, agglomerated flux) and the process of formation in the weld pool of exogenous nucleation promoting the modification of the structure improving the technological and operational properties of welded metal. The phenomenological model of nucleation on clusters of nanoparticles of refractory chemical compounds of exogenous origin is developed. The model is based on the experimental data, as well as on existing ideas about the kinetics of physical and chemical processes, rapidly occurring in the reaction zone of welding.

Keywords: heat-resistant and wear-resistant alloys, refractory chemical compounds exogenous modifier, crystallization centers, model.

UDC 669.14.018.8:620.194.2

Features of corrosion cracking of flat samples of small thickness with sharp notch made of Kh18N10T steel at room temperature in 1N solution of HCl. Malyshev V. N., Barakhtin B. K. – Voprosy Materialovedeniya, 2015, N 4(84), p. 169–174.

The paper gives data on the static corrosion resistance against cracks formation at room temperature in flat samples in 1N HCl solution. Specimens with sharp notch had intensity factor $K_c = 120\text{--}500 \text{ N/mm}^{3/2}$, and net stress $\sigma_n < 0,4\sigma_{0.2}$. It has been shown that in the flat dense state of loaded sample slow growth of the through cracks occurs discretely by merging of the front and surface non-through corrosion cracks formed in the plastic zone at the top of the notch (crack).

Keywords: corrosion-resistant steel, samples of small thickness with sharp notch, static crack resistance, stress corrosion cracking.

UDC 669.15–194.56:621.039.53:539.376

Crack growth rate estimates in the pressure vessel internals of WWER-1000 under irradiation creep. Margolin B. Z., Sorokin A. A., Buchatsky A. A. – Voprosy Materialovedeniya, 2015, N 4(84), p. 175–186.

A method that allows predicting the crack growth rate in austenitic steels under conditions of neutron irradiation has been developed. Estimates of the crack growth rate under irradiation creep in the pressure vessel internals of WWER-1000 have been formulated and its maximum value assessment has been suggested.

Keywords: pressure vessel internals of WWER-1000, austenitic steel, irradiation creep, crack growth rate.

UDC 621.039.536.2:539.422.23

Development of methodology of ST-specimens reconstruction from surveillance specimens (SS) taken from reactor pressure vessels of WWER. Part 1. Estimated study. Margolin B. Z., Kostylev V. I., Fomenko V. N., Zhurko D. A., Bubiakin S. A., Bandura A. P. – *Voprosy Materialovedeniya*, 2015, N 4(84), p. 187–205.

The technique of reconstruction of ST-specimens from metal fragments of irradiated Charpy SS (V-notch or cracked) has been developed. The optimum variants of welded ST-specimens in terms of minimization of residual welding stresses have been defined. The paper shows the range of acceptable values of yield strength when stress-strain state at the crack tip is identical in reconstructed and standard specimens. The three-dimensional analysis by finite element method and experiments have been made to confirm the optimal choice of the reconstruction of the ST-type specimens. It is shown by the example of the weld metal WWER-1000, that the fracture toughness values defined in the reconstructed and standard homogeneous specimens such as ST are close enough.

Keywords: reactor vessel, reconstructed specimen of the ST-type, surveillance specimens of the Charpy type with V-notch or cracked, welding residual stress, fracture toughness.

UDC 621.039.536.2:539.422.23

Development of methodology of ST-specimens reconstruction from surveillance specimens (SS) taken from reactor pressure vessels of WWER-1000. Part 2. Experimental study. Zhurko D. A., Bubiakin S. A., Bandura A. P., Margolin B. Z., Kostylev V. I., Fomenko V. N. – *Voprosy Materialovedeniya*, 2015, N 4(84), p. 206–210.

Reconstructed ST-specimens have been produced on the basis of calculating the best options for preparation of ST-specimens with minimal residual welding stresses. Complex experiments on optimization of the parameters of the reconstruction have been conducted. Original data on the fracture toughness of standard samples and reconstructed ST type of materials for WWER-1000 reactors vessels is presented along with a comparison of fracture toughness obtained on standard and reconstructed ST-specimens. Proposed methods proved to be applicable for obtaining adequate data on the fracture toughness of reactor vessel materials.

Keywords: reactor vessel, surveillance specimens, fracture toughness, reconstructed specimens.