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## ABSTRACTS OF PUBLISHED ARTICLES

UDC 669.15–194:539.422.22

**Stabilization of 15Cr2MoV steel structure as a factor increasing resistance to brittle fracture.** Olenin M. I., Gorynin V. I., Margolin B. Z., Fedoseev M. L. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 5–12.

The paper studies effects of ferrite ageing temperature and time parameters on resistance to brittle fracture and mechanical properties of 15Cr2MoV steel (15X2HMΦA). Samples cut from the inner surface and central parts of forging of 380 mm thickness. It is shown that ferrite overageing after thermal refining and subsequent coagulation of cementite shifts brittle to ductile transition temperature to negative values, providing greater resistance to brittle fracture.

*Keywords:* 15Cr2MoV reactor steel, ferrite ageing parameters, resistance to brittle fracture, structure stabilization.

UDC 669.15–194:621.039.53

**Development of nuclear engineering products from 09G2S grade A steel. Materials science aspects.** Karzov G. P., Bykovski N. G., Ovanesyan K. K., Olenin M. I., Kalinicheva N. V., Vasilieva N. A. – *Voprosy Materialovedeniya*, 2014, N 4(80), p. 13–25.

The improving of 09G2S grade A steel and its welded joints has been discussed to secure cold resistance of containers for spent nuclear fuel. The paper analyzes manufacturing and welding of oversized forgings for high pressure heaters NPP in the Russian Federation and abroad, as well as its application for casing to the reactor pressure vessel BREST-OD-300 with lead coolant.

*Keywords:* 09G2S grade A steel, containers for spent nuclear fuel, oversized forgings, application prospects.

UDC 621.785.51:536.24.021

**Equivalent modes of materials carburization.** Dushin Yu. A., Oryshchenko A. S., Krasilnikov A. Z., Petrov S. N., Yakovlev S. P. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 26–44.

Carburization is considered as a result of simultaneous diffusion of carbon and its reaction with the most active alloying element. Required parameters are grouped into similarity criteria Bi and Fo and diffusion-kinetic criterion h. Numerical solutions are embodied in similarity maps. Due to the combination of similarity methods and numerical solutions the impact of a carbon-containing medium on the alloy composition can be described. The necessary experimental constant, that is a saturation coefficient  $\beta$ , has been determined for eight deformed and cast materials. Examples have been given for the calculation of long processes and modeling of working conditions in the mode of accelerated tests.

*Keywords:* similarity criteria, carburizing, pyrolysis, modeling, chromium-nickel steels, carbides.

UDC 669.295:621.778

**Influence of mechanical and heat treatment on the structure and mechanical properties of titanium  $\beta$ -alloy TS6 wire.** Shaboldo O. P. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 45–50.

A scheme of thermomechanical treatment of titanium  $\beta$ -alloy TC6 has been studied in a polygonized state after cold drawing, high speed heating and ageing.

*Keywords:* titanium  $\beta$ -alloy, cold drawing, heat treatment, mechanical properties.

UDC 669.295:621.789:621.771.23

**Thermomechanical treatment of titanium  $\beta$ -alloy TC6 cold-rolled sheets.** Shaboldo O. P., Mazurov S. A., Tikhonova A. M., Filippova N. A. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 51–60.

Deformed and vacuum annealed TS6 alloy's kinetic of ageing has been observed. Zones free of  $\alpha$ -phase have been found after ageing of recrystallized TS6 around grain borders. For alloy thermal strengthening is appropriate to apply the ageing in polygonized state.

*Keywords:* titanium  $\beta$ -alloy, kinetics of ageing, cold-rolled sheets, thermomechanical treatment.

UDC 669.715:621.789

**Evolution of structure and mechanical properties of Al–Mg–Si–Cu alloy during low temperature thermomechanical treatment.** Ryabov D. K., Kolobnev N. I., Makhsidov V. V., Uksusnikov A. N. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 61–66.

Al–Mg–Si–Cu alloys demonstrate good corrosion resistance, high mechanical properties and manufacturability that allow using them in automotive and aircraft industries. For the purpose of increasing mechanical characteristics of semi-finished products with high level of corrosion resistance, it is useful to apply thermomechanical treatment consisting of material deformation during artificial ageing.

The paper researches 1370 aluminum alloy. The modes of low-temperature thermomechanical treatment comprising different types of deformation (rolling, stretching) between the stages of artificial ageing have been chosen. Research results of mechanical properties and thin structure of sheets provided by the transmission electron microscope have been cited.

*Keywords:* 1370 alloy, Al–Mg–Si–Cu, low-temperature thermomechanical treatment, transmission electron microscope.

UDC 669.35:621.791.92

**Structural features of bronze cladding composites BrZhNKA18-8-2-1 type.** Potekhin B. A., Khristolubov A. S., Zhiliakov A. Yu. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 67–72.

Morphological features of bronze cladding composites BrZhNKA18-8-2-1 type, the chemical composition of structural components and its change during heat treatment have been studied.

*Keywords:* bronze, steel, dendrite, diffusion, cladding.

UDC 669.35.621.778:539.3

**Damages of the copper wire undergoing large plastic deformations.** Sennikova L. F., Davydenko A. A., Spuskanyuk V. Z., Burkhovetsky V. V., Sliva K. I., Zakoretskaya T. A. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 73–78.

Damages for M0b (99.99%) and FRTP (99.95%) thin copper wires, 0.5 mm diameter, have been studied by scanning electron microscopy. The samples have been damaged under various schemes of severe plastic deformation (SPD). A comparative analysis of copper defects (micropores, microcracks) after monotonic (hydroextrusion + drawing) and non-monotonic (hydroextrusion + angular hydroextrusion + drawing) deformation. It has been shown that angular hydroextrusion scheme reduces the total number of micropores comparing it with monotonic deformation. The paper suggests that larger pores in the sample of FRTP copper, when processed with angular hydroextrusion, may be one of the reasons for the low ductility of the material at the temperatures equal to  $\sim 4.2$  K.

*Keywords:* damage, micropores, thin wire, deformation, angular hydroextrusion, temperature.

UDC 669.35'5:537.811

**Influence of 58Cu–34Zn–3Mn–2Al brass structural components on its electromagnetic properties.** Pugacheva N. B., Zadvorkin S. M., Lebed A. V., Goruleva L. S. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 79–87.

The paper studies the  $\alpha$ -phase leading role in maintaining the integrity of the pressed pipe blanks as it secures its internal stress relaxation. Influence of quantity of 58Cu–34Zn–3Mn–2Al brass structural components on values of hardness, specific electric resistance and magnetic permeability is defined. It is shown that specific electric resistance is sensitive to the contents of  $\alpha$ -phase in the studied alloy, and magnetic permeability is defined by the contents of silicides (Fe, Mn, Ni)<sub>5</sub>Si<sub>3</sub>. These parameters could be preferentially recommended for nondestructive control of quantity of brass blanks phases.

*Keywords:* alloyed brass, microstructure, specific electric resistance, magnetic permeability, hardness, X-ray diffraction analysis.

UDC 666.266.6:539.213.2

**Nonisothermal process of formation of a new phase in model solid solution.** Layman V. I., Walov P. M., Maksimov V. M., Ashkalunin A. L. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 88–95.

The optical spectroscopy was used to study the processes of nucleation in model solid solution of CuCl in glass at positive and negative temperature jumps or at continued cooling. From spectral data the concentration of new phase (CuCl nanocrystals), average radius, particles concentration as well as radius distribution were determined. Two effects were found out: the dissolution of nanoparticles of new phase at positive jumping temperature and the formation of two distributions at negative jumping temperature or slow cooling. The results of the investigations showed the ability to control nucleation in solid solution in order to obtain complex distributions of nanoparticles of new phase.

*Keywords:* nucleation, solid solution, nanocrystals CuCl, optical spectroscopy, nonisothermal processing.

UDC 678.067:544.723.5

**Features of 'strength – waterproof' and kinetics anomalies of mass transition in polar liquids with change their temperature, pressure and pH in structural polyester spheroplasts.** Sedletsky R. V. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 96–114.

Traditional notions on the kinetics of absorption of polar liquids, and strength characteristics of polymeric materials do not give explanations for a whole range of physical and chemical characteristics. The paper offers an explanation based on complex meniscus model 'reversing water mass transition – undulating variation of strength'. It is probable that the high frequency hardening and rapid degradation of strength is associated with the presence of ester groups in the binder composition. It has been established that the appearance of negative area in the kinetic functions is most likely due to high defectiveness of the macromolecular structure of such composites, and the depth and the area of its existence and temporal interval (up to hundreds of hours) depend on the type of the polar liquid (water, methanol, acetone), its temperature, pressure and pH. It is experimentally proved that the "negative area" is not associated with a heterogeneous dissolution on the surface of the composite or with the diffusion "removal" of the polymer substance of its volume.

*Keywords:* spheroplast, liquid meniscus, reversing water mass transition, durability, interface, glass microspheres, hydrostatic pressure, polyesters.

UDC 678.067:544.723.5

**Development of chemisorption protection blocking water absorption of highly structural polymeric materials by methods of kinetic mass spectrometry.** Sedletsky R. V., Pozdniakov A. O. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 115–128.

The paper shows methods of kinetic mass spectrometry: thermodesorption and mechanic desorption used for the first time in the analysis at the molecular level of physical and chemical mechanisms of artificial blocking of water absorption in composite polymers.

The article describes the most important characteristics for anisotropic polymer carbon plastics type FUT and UGET: localization of polar molecules of chemical protective substances (glycine, glutaric and L-glutamic acids) in the volume of composites; optimal modes of protective treatment processes; positive impact of the chemisorption protection on the thermal stability of the composites; increase of tribotechnical resistance to friction wear (1.5–2 times); dependence of the friction wear of the anisotropic composite on the orientation of the reinforcing fibers with respect to the counterface.

*Keywords:* carbon plastics, water mass transition, water absorption, hydrostatic pressure, kinetic mass spectrometry, nanotechnology of chemisorption protection, composite, polymer.

UDC 678.067:620.198

**Influence of perfluoropolyether fluids and packing density epoxy oligomer on the surface properties of antifouling coatings.** Anisimov A. V., Mikhailova M. A., Stepanova I. P., Uvarov E. A. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 129–134.

Three types of film-forming epoxies with different packing densities have been modified by perfluoropolyether fluids for imparting hydrophobic properties to antifouling coating. The tests evaluating the stability of hydrophobic properties have been carried out in the synthetic sea water (3% aqueous solution of NaCl). Results of technological and physical mechanical comparative tests of modified and unmodified epoxy oligomers are presented.

*Keywords:* antifouling, epoxy oligomer, hydrophobic properties, perfluoropolyether fluids.

UDC 621.791.053:669.15–194:621.039.536.2

**Improving of welding consumables and technology for WWER reactor girth welds of 15Kh2MFA-A steel.** Oryshchenko A. S., Karzov G. P., Galiatkin S. N., Mikhaleva E. I., Vorona R. A. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 135–147.

A series of research works has been carried out in order to improve welding consumables and welding process for WWER reactor vessel girth joints of 15Kh2MFA-A (15X2MΦA-A) steel using standard Sv-10KhMFTU (СВ-10ХМФТУ) wire. A set of service characteristics of the weld metal, similar to those of the base metal has been provided, and the standard critical temperature of embrittlement of the weld metal has been significantly reduced.

*Keywords:* WWER nuclear reactors, welding of girth joints, welding materials, welding technology, structure and properties of the weld metal.

UDC 621.791.048:621.039.536.2

**Study of the weld properties for WWER reactor vessels welding by use of highly basic agglomerated fluxes.** Timofeev M. N., Galiatkin S. N., Mikhaleva E. I. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 148–155.

The paper describes results of determination of chemical composition, mechanical properties and microstructure of the metal weld using welding wires of Cr–Mo–V and Cr–Ni–Mo alloying systems in combination with fused and agglomerated welding fluxes. It has been found that the best combination of strength, plastic properties and toughness of the weld metal is provided using Cr–Ni–Mo welding wire and highly basic agglomerated flux.

*Keywords:* WWER nuclear reactors, reactor vessel welding, highly basic agglomerated flux.

UDC 669.295:621.791–112.81:539.4

**Welding and reliability of titanium marine structures.** Leonov V. P., Mikhailov V. I., Sakharov I. Yu. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 156–161.

Marine structures security is vital so it is necessary to make new alloys with higher levels of strength. However, stronger materials are less flexible and more sensitive to the different technological influences. Thus the requirements for ensuring the reliability of the structures in an operational environment are to be improved. The safety is largely dependent on the quality and performance of welded joints. Traditional methods for calculating the strength of the rated voltage do not embrace the additional factors influencing the stress-strain state of welded joints (stress concentrators, welding residual stresses and others). The evaluation of total and local strength of welded joints should be introduced to improve the reliability of welded structures.

*Keywords:* titanium, marine structures, welded structures, strength calculations.

UDC 621.039.53:539.4

**Mechanisms of structural materials destruction and estimate of strength and efficiency of the NPP equipment for various types of reactors.** Karzov G. P., Margolin B. Z. – Voprosy Materialovedeniya, 2014, N 4 (80), p. 162–194.



The paper presents models and procedures developed to determine the main service characteristics of the structural materials for the nuclear reactors elements under prolonged neutron irradiation. The mechanisms and criteria for brittle and ductile fracture and creep rupture under neutron irradiation, as well as methods for predicting macro fracture characteristics by modeling deformation processes, damage accumulation and fracture at different scale levels.

*Keywords:* nuclear power plant equipment, structural materials, prolonged neutron irradiation, creep rupture, process modeling, estimate criteria.

UDC 669.15–194.56:539.431

**Study of austenitic steels durability of different strength levels with low-cycle loading.** Danilov G. I., Ilyin A. V., Kalinin G. Yu., Fedorova T. A. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 195–200.

The paper considers the results of low-cycle tests for high-strength nitrogen-containing austenitic steels with different systems of alloying in order to prevent cyclic softening of the same steels.

*Keywords:* nitrogen-containing austenitic steels, alloying system, cyclic softening.

UDC 669.14.018.298:621.785.52:621.833:539.4

**Character and causes of fractures in casehardened leading and conducted conic gear wheels made from E3310 AISI steel under operation conditions.** Pugacheva N. B., Trushina E. B., Antenorova N. P., Pugacheva E. I. – *Voprosy Materialovedeniya*, 2014, N 4 (80), p. 201–210.

The paper investigates destruction surfaces and microstructure of casehardened leading and conducted conic gear wheels from E3310 AISI steel. It is shown, that higher damage rate of conducted gear in comparison with leader is caused by greater hardness of leader's surface layer. Concepts about character of fatigue fractures are expanded. Local fatigue cracks with the subsequent accelerated tooth destruction forming a slate fracture are possible when there is the least difference between hardness of the strengthened surface layer and the core of a tooth. A great quantity of carbides in casehardened layers accelerates pitting and growth of fatigue cracks.

*Keywords:* gear wheels, steel, case-hardening, hardness, microstructure, pitting, fracture, friction, fatigue.