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## ABSTRACTS OF PUBLISHED ARTICLES

UDC 669.14.018.295:539.422.22:621.774–418.1

**Mechanical and cold resisting properties to brittle failure destruction of strip metal and tube from steel of strength class K60 changing at various fabrication stages.** Vladimirov N. F., Ilyin A. V., Larionov A. V., Leonov V. P., Miroshnikov B. L. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 5–16.

The paper studies the heterogeneity of mechanical properties upon thickness of strip and tube of large diameter and change of resistance properties and cold resistance of steel during manufacturing of tubes from strip. During testing of strip and tubes from steel of strength class K60 of 24, 31 and 40 mm thickness it was determined that yield strength and ultimate strength of metal of an external surface have been increased a little, and internal surface – decreased. Decrease in level of properties is connected with hardening of these layers at formation. The estimation of cold resistance upon impact strength (KCV, KCT) and upon critical temperatures  $T_{DWT}$  and  $T_{KB}$  has shown that plastic deformation at formation and expanding of the tube leads to decrease in cold resistance of metal, and that metal with ferrite-perlite structure by criterion of impact strength is more inclined to brittleness than metal with ferrite-bainite structure whereas upon  $T_{KB}$  it had increased cold resistance.

Keywords: steel of strength class K60, strip, tube of large diameter, strength properties, cold resistance.

UDC 669.15–194.2:669.017.3

**Inheritance of off-orientations and formation model of bainite structure in low carbon steels at influence of deformation of austenite.** [Nesterova Ye. V.], Zolotarevsky N. Yu., Titovets Yu. F., Khlusova Ye. I. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 17–26.

The paper studies structure and spectrums of off-orientations in carbideless bainite of low carbon low-alloyed tube steel. It is shown that increase of fraction of low-angle off-orientations in deformed steel is caused by inheritance bainite of deformation structure of austenite. The authors offer the calculation model for kinetic bainite transformation of deformed austenite which allows to predict the average size of structural element with prescribed off-orientation depending on regime of thermomechanical processing.

Keywords: low carbon low-alloyed tube steel, deformation of austenite, structure, spectrums of off-orientations, model of structure formation.

UDC 669.14.018.295: 621.789

**Influence of austenite grains size and deformation grade upon structure formation of steel of strength class K60.** Schastlivtsev V. M., Tabatchikova T. I., Yakovleva I. L., Egorova L. Yu., Kruglova A. A., Khlusova Ye. I., Orlov V. V. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 27–35.

The paper studies influence of hot deformation and size of austenite grain effect upon structure formation of steel of strength class K60 after heat and thermomechanical treatments in laboratory conditions. The structure is researched by metallographic methods and transmission electron microscope. The quantitative analysis of structural components is effectuated; the morphology of bainite is diagnosed. It is established that amount of bainite in steel structure after thermomechanical treatment increases with increasing of austenite grain size. Stimulating influence of austenite deformation upon development of austenite-ferrite transformations is confirmed. It is shown that bainite of nonlath subgrain structure it is formed mainly from coarse-grained deformed austenite as result of  $\gamma \rightarrow \alpha$ -transformation proceeding at cooling.

Keywords: austenite steel of strength class K60, hot deformation, size of grain, structure formation, bainite,  $\gamma \rightarrow \alpha$ -transformation.

UDC 669.14.018.295: 621.771:621.785.6

**Structure and properties of steel strength class K70 hardened with rolling heating.** Golosienko V. A., [Nesterova Ye. V.], Khlusova E. I., Motovilina G. D., Yashina Ye. A. – Voprosy Materialovedeniya. 2011, N 4 (68), p. 36–44.

The paper studies the structure of flat steel for pipes of main pipelines, strength class K70, hardened by rolling heating and then leaving by methods of optical metallography, translucent and radiation electronic microscopy using the analysis of diffraction patterns inverse scattering of electrons (EBSD).

The level of the steel strength attained by the technology in question is provided by formation of granular and lath bainite while tempering with rolling heating. The limit of fluidity increases with increase of the share of lath bainite resulting in strengthening of large angle borders section, the increase of the share of small angle boundaries and increasing of the density of uniformly distributed dislocations.

Keywords: steel of strength class K70, steel products, structure, properties.

UDC 669.71:537.315

**The evolution of dislocation aluminium substructure at stress relaxation in conditions of weak electrical actions.** Nevsky S. A., Ivanov Yu. F., Konovalov S. V., Gromov V. E. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 45–51.

Influence of weak electrical potential on evolution of a dislocation aluminium substructure is explored at a stress relaxation. It is established that at magnification of electrical potential volume fractions of a chaotic and band-pass substructure are incremented, but the line density flexural extinction contours decreases. This last fact testifies that electrical potential promotes boost of a stress relaxation process.

Keywords: aluminium, stress relaxation, electrical potential, dislocation substructure.

UDC 669.71:621.745.5

**Influence of outward treatment of AL9 melt on its structure and properties under crystallization.** Hosen, Ri E. H., Khimukhin S. N., Teslina M. A., Astapov I. A., Gostishchev V. V. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 52–56.

They investigated vibromechanical treatment of AL9 melt at various temperatures influencing on its grain size, axis length of the first order of dendrites and hardness distribution along the casting cross-section. The greatest grains and dendrites refinement is attained at 660°C. Vibromechanical treatment leads to a more uniform distribution of metal structural components and hardness along the casting cross-section. They studied influence of temperature of the metal melt under vibromechanical treatment on dominant formation of the defects of a certain type on the surface of a casting.

Keywords: vibromechanical treatment of melt, grain size, axis length of dendrites, hardness distribution.

UDC 669.296: 620.193.2

**Modelling of criterial conditions of crisis in kinetic oxidation of zirconium alloys.** Likhansky V. V., Aliev T. N., Kolesnik M. Yu., Evdokimov I. A., Zborovsky V. G. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 57–66.

They determined criteria conditions in kinetic growth of oxide film on surface of zirconium alloys by means of power approach. The theoretical analysis made on basis of such approach upon establishment of parametrical conditions of crisis in kinetic growth of oxide film has shown qualitative correspondence with experimental data. Analysis testifies also that the crisis phenomenon is caused by evolution of mechanical stresses in oxide corrosive layer and in an adjoining layer of metal and is connected with formation of wavy structure on boundary of oxide/metal.

Keywords: zirconium alloys, kinetic oxidation, modelling of criterial conditions.

UDC 537.621:539.371

**Influence of elastic bending deformations upon magnetic and shielding properties of the roll magnetic screen.** Kuznetsov P. A., Manninen S. A., Vasilieva O. V. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 67–72.

The paper presents results of research of elastic deformations influence upon magnetic and shielding properties of the magnetic screens made of amorphous alloy AMAГ-172 strips. It is shown, that curves of magnetization of strip toroids essentially change at bending deformations of specimens. Measurements and calculations effected by method of final elements shielding efficiency of constant magnetic field by single-layered screens with different size of elastic deformations have shown their satisfactory coincidence.

Keywords: amorphous alloy AMAF-172, magnetic screens, shielding efficiency, elastic deformation.

UDC 666.792.32:621.762

**Planetary milling of silicon carbide powders.** Perevislov S. N. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 73–80.

The paper studies the production characteristics of a superfine powder of silicon carbide ( $d_{0,5} \leq 0,5$  mm) using a planetary milling and the optimum conditions for milling: 30% vol. milling bodies with diameter  $d = 10\text{--}11$  mm, 10% vol. powder, 20% vol. water. Due to the high dispersion of planetary milled SiC-powder a significant level of mechanical properties of liquid-phase sintered SiC-ceramic could be achieved.

Keywords: silicon carbide, planetary milling, liquid-phase sintering.

UDC 669.018.25:621.762.5

**Improvement of strength and hardness of submicron cemented carbide WC–8%Co–1%Cr<sub>3</sub>C<sub>2</sub> due to the carbonization during sintering process.** Dvornik M. I., Zaytsev A. V., Ershova T. B. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 81–88.

Under the conventional sintering of nanosized WC–8%Co–1%Cr<sub>3</sub>C<sub>2</sub> powder the submicron hard alloy is being formed. Due to carbon deficiency  $\eta$ -phase (6.5 vol.%) appears which reduces its strength down to 850 MPa. The authors offer methodology of controlled carbonization of the alloy in CO atmosphere during heating in sintering process. It is researched that CO decomposes nonuniformly that induces formation of free carbon inclusions in upper layers of sintered samples (2 vol.%). Additional homogenization process in gas atmosphere allows achieving the uniform carbon distribution and decreasing of  $\eta$ -phase and free carbon content in samples. Strength and hardness of these samples are 1640 MPa and 90.5 HRA accordingly.

Key words: submicron cemented carbide, carbonization, sintering, defect, strength

UDC 621.762:621.763:536.46

**Synthesis of materials on the basis of borides tungsten and zirconium in regime of burning.** Nikolenko S. V., Gostishev V. V., Lebukhova N. V. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 89–94.

The paper studies how powder composites could be produced on basis of  $W_2B_5$  and  $ZrB_2$  during burning, developing at aluminothermic restoration of reactionary mixtures. There are calculated adiabatic temperatures providing distribution of burning wave in mixtures including various initial reagents and at change of their ratio. The authors offer optimized regimes of electrospark cladding upon steel 45 synthesized powders on basis of tungsten boride ( $W_2B_5$  from 42 up to 55% of mass, the rest –  $Al_2O_3$ ) and zirconium borides ( $ZrB_2$  from 62 up to 66% of mass, the rest –  $Al_2O_3$  and  $SiO_2$ ). It is shown, that electrospark cladding from composite on the basis of  $W_2B_5$  increases wear resistance of steel surface in conditions of friction without greasing up to 18 times.

Keywords: aluminothermic synthesis, tungsten boride, zirconium boride.

UDC 661.685:621.762

**Metallothermal synthesis of chrome silicides.** Gostishev V. V., Komkov V. G. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 95–99.

The paper examines conditions of aluminothermic synthesis of cast chrome silicide containing phases of  $Cr_3Si$  and  $CrSi_2$ . Microhardness of silicide alloy makes 7450 MPa. It is shown that transition to magnesiumthermal synthesis in melt medium  $Na_2CO_3$  leads to receiving of chrome silicide  $CrSi_2$  in the form of a powder which specific surface constitutes  $7,28 \cdot 10^5 \text{ m}^{-1}$ . Chemical dispersion of powder increases a specific surface up to  $24,8 \cdot 10^5 \text{ m}^{-1}$ .

Keywords: metallthermy, chrome silicide, specific surface, microhardness.

UDC 661.862'002:621.762.2

**Microvawe synthesis of  $\gamma$ - $Al_2O_3$  nanopowder.** Wang Qingsheng, Koltsova T. S., Vasilyeva E. S., Popovich A. A. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 100–104.

The paper studies producing of gamma-alumina oxide nanoparticles from solution of  $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$  salt in PEG by microwave synthesis. Nanodisperse particles of amorphous phase had been annealed at the temperature from 850 to 1000°C. There were estimated dependencies of granulometric and phase composition of powder, annealing temperature and initial solution concentration.

Keywords: microwave synthesis, nanopowders, gamma-alumina oxide

UDC 621.791.754'293:621.039.536.4

**Thermomechanical analysis of multipass welding process for connection Дy300 of PBMK reactor by method of final elements.** Moschenko M. G., Rubtsov S. A., Korableva S. A. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 105–115.

Process of argon-arc multipass welding – one of the basic kinds of welding for austenite pipelines Дy300 of PBMK reactors is modelled. Calculation of temperature fields and residual stresses arising at multipass automatic welding has been executed by method of final elements by means of program complex Ansys 11.0. As a result of the decision thermal and mechanical problems satisfactory concurrence to experiment which specifies applicability of the offered method has been received. Results of calculation can be used as entry conditions for an estimation of actions upon decrease or inverting of tensile stresses, and also optimization of welding process.

Keywords: pipeline of PBMK reactor, automatic argon-arc multipass welding, temperature fields, residual stresses, modelling by a method of final elements.

UDC 669.14.018.8:620.193.4

**Features of hydrogenation of superficial layers of metal at corrosion of steel X18H10T in solution of hydrochloric acid at room temperature.** Malyshev V. N. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 116–123.

The paper determines quantity of hydrogen absorbed by metal upon 1 cm<sup>2</sup> of surface under the general corrosion of steel X18H10T in 1 N solution of HCl. There were used specimens of small thickness (0.025–0.185 mm). It is shown that saturation with hydrogen of superficial layers in some hundredth part of millimeter occurs in initial stage of corrosion (up to ~50 hours) and then its content in steel practically does not change during more than 1000 hours of corrosion attack. The estimation of hydrogenation kinetic could be made upon the equation offered in article.

Keywords: steel X18H10T, corrosion attack, kinetic saturation by hydrogen.

UDC 669.15–194.56:621.039.548.34

**Effect of stress on radiation swelling of austenitic steels.** Margolin B. Z., Murashova A. I., Neustroev V. S. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 124–139.

An analysis of experimental data on effect of type of stress state on radiation swelling of austenitic steels has been carried out. A constitutive equation for prediction of stress effect with regard for various contributions of hydrostatic and deviatoric stress components has been formulated. A physical interpretation of the formulated equation is suggested. For a calculating of stress-strain fields of components of reactor vessel internals it has been proposed to use radiation creep equation including swelling calculated with regard for stress effect. Coefficients in the formulated constitutive equation and in the equation of radiation creep have been determined.

Keywords: components of reactor vessel internals, austenitic steel, radiation swelling, radiation creep, constitutive equation, stress, stress state, hydrostatic and deviatoric stress components, hydrostatic stress, equivalent stress, effective stress.

UDC 669.296'293:621.039.531

**Computational determination of threshold displacement energies and study of atom displacement cascade evolution near extended Zr–Nb interface: molecular dynamics simulation.** Tikhonchev M. Yu., Svetukhin V. V. – Voprosy Materialovedeniya, 2011, N 4 (68), p. 140–152.

N-body potentials for Zr–Nb system have been prepared, potential for pure Zr and Nb were borrowed from the literature. The threshold atom displacement energies for single-component hcp-Zr and bcc-Nb crystals have been calculated as well as for Zr and Nb atoms that act as substitutional atoms in Nb and Zr matrices correspondingly. In this paper the extended hcp-Zr/bcc-Nb interface model has been offered. Interphase region of the boundary being considered involves 6 Zr layers and 2 layers of Nb. Part of Nb crystals lying in the interface keeps the structure similar to bcc while the structure of Zr part is considerably deformed. The quantitative estimations of the mean threshold displacement energy in the interface region have been obtained. The displacement cascade passage through interface has been simulated. When developing such cascades a considerable part of the generated point defects is captured by the interface region.

Keywords: zirconium-niobium alloys, molecular dynamics method, threshold displacement energy, atomic displacement cascade.