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## STRUCTURE AND PROPERTIES OF HIGH STRENGTH LOW ALLOYED COLD-RESISTANT STEEL AFTER REHEAT AND DIRECT QUENCHING WITH TEMPERING

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**Abstract**—The paper shows comparative investigations of structure of rolled plates from low alloyed cold-resistant steel 08CrNi2MoCuNb with guaranteed yield strength 750 MPa after traditional reheat quenching and quenching from rolling heat (direct quenching) with subsequent high temperature tempering. The research is carried out by means of optical metallography, SEM and TEM. The peculiarities of parameters of bainite-martensite structure, which influence the strength level in initial (quenched) state, are revealed. Also, the impact of tempering on structure and properties of rolled plates after reheat and direct quenching is shown.

**Keywords:** high strength steel, reheat quenching, direct quenching, tempering, structure, bainite, martensite, parent austenite grain, Grain Average Misorientation (GAM), EBSD, TEM

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## RESEARCH OF MATERIAL OF DAMAGED POLY-V PULLEYS FOR INCREASING THE SERVICE LIFE OF PROMISING AUTOMOTIVE GENERATORS

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**Abstract**—The material of the deteriorated poly-V pulleys made of cold-rolled steel strip 08kp and 08ps was studied using electron microscopy with an X-ray microanalyzer and the causes of their fatigue failure were determined. The main reasons for their destruction can be heterogeneous structure and properties and non-optimal mode of annealing and, as a result, the low hardness on the transitional zone of the pulley, through which they are damaged in service. So, to avoid pieces deterioration, cold-rolled

tape made of 035Yu steel with a homogeneous structure and properties was developed. The study also proposes a new mode of its recrystallization annealing, which increases the hardness at the transition zone of the poly-V pulley and the service life of promising automotive generators.

**Keywords:** poly-V belt, pulley, generator, expansion, annealing, fatigue failure, cold-rolled tape, homogeneous structure

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## THE INFLUENCE OF HEAT TREATMENT ON THE FORMATION OF THE STRUCTURE AND THE LEVEL OF MECHANICAL PROPERTIES OF HIGH-ALLOYED TITANIUM ALLOY

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**Abstract**—The paper investigates the possibility of increasing the strength of the experimental high-alloyed titanium alloy due to various methods of thermal action, leading to a change in its phase composi-



tion and intragrain structure. Changes in mechanical properties in correlation with the change in structure in the annealed, tempered and heat-hardened state are reviewed. It is shown that by controlling phase transformations in high-alloyed two-phase titanium alloys, it is possible to realize high-strength state with satisfactory plastic characteristics. The optimal complex of mechanical properties is provided by heat treatment, which leads to the creation of a two-phase heterogeneous structure with a developed bimodal intragrain structure.

*Keywords:* titanium alloys, heat treatment, structure, properties

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## STRUCTURE AND PROPERTIES OF NICKEL-BASED ALLOY EP718 IN THE PROCESS OF MANUFACTURING

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**Abstract**—The influence of the semi-finished products manufacturing process (forging, solution annealing and ageing) on the structure and corrosion properties of the EP718 nickel-based alloy (KhN45MVTYuBR) used in the oil and gas industry is investigated. The corrosion-electrochemical properties of the alloy were determined using gravimetric and electrochemical techniques. Microstructure was studied by optical and transmission electron microscopy. It is shown that the EP718 alloy in the delivery state (without heat treatment) has the highest corrosion resistance, and corrosion properties degrade during subsequent solution annealing at 1080°C.

**Keywords:** nickel-based alloys, oil and gas industry, alloy EP718, corrosion, non-metallic inclusions, precipitation hardening, carbides

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## SYNTHESIS OF NANOCOMPOSITE COATING OF ELECTRODEPOSED AMORPHIC LAYERS OF THE Ni–P–W SYSTEM

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**Abstract**—The processes of the formation of the nanocomposite coating of Ni–11.5% P–5%W were studied during the heat treatment of amorphous electrodeposited layers. Using the method of differential scanning calorimetry, the temperature of the onset of crystallization of the nanocrystalline phase  $\text{Ni}_3\text{P}$  was determined. X-ray diffraction analysis showed that heat treatment produces  $\text{Ni}_3\text{P}$  phosphides and, presumably,  $\text{Ni}_5\text{P}_2$ , the size of which, according to electron microscopy, is 5–50 nm. The influence of the duration of heat treatment on the phase composition and microhardness of coatings is investigated.

**Keywords:** nanocomposite coating, heat treatment, microhardness

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## FORMATION OF ANTI-FRICTION COATINGS ON TITANIUM BY ELECTROSPARK ALLOYING WITH METAL CERAMIC ANODES

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**Abstract**—The paper presents the results of experimental studies in the field of the formation of anti-friction coatings on VT-1.0 titanium alloy by electrospark alloying.

**Keywords:** tribology, electrospark alloying, anti-friction coating, titanium, roughness parameter, tungsten carbide, titanium carbide, silicon carbide

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## ON THE ANTIFOULING NON-BIocide COATING WITH LOW SURFACE ENERGY. PRELIMINARY RESULTS OF TESTING UNDER NATURAL CONDITIONS

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**Abstract**—The study describes antifouling coatings with low surface energy designed to prevent marine biological fouling. The non-biocidal enamel has been synthesized from film-forming epoxy made on the basis of aromatically conjugated hydroxyphenylene and modified with pre-fluoropolyester fluids. The results of laboratory and field tests are presented; a pilot-industrial production of enamel is organized.

**Keywords:** antifouling coating, surface energy, non-biocidal enamel, laboratory and field tests

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## STOICHIOMETRIC COMPOSITION OF THIN-FILM SURFACE STRUCTURES AND ITS INFLUENCE ON THE FUNCTIONAL CHARACTERISTICS AS REGARDS GYROSCOPIC DEVICES

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**Abstract**—This article considers the research results of the effect of stoichiometry on the properties of titanium nitride thin-film coatings of the float and electrostatic gyroscopes. It presents the results of tests of such mechanical and optical characteristics of titanium nitride thin-film structures as microhardness, resistance to wear and friction, and image contrast determined by the reflection coefficients of a titanium nitride base surface and a raster pattern formed by local laser oxidation. When making a rotor of a cryogenic gyroscope, the prospects of use and technological methods for the formation of functional surface structures of niobium carbide and nitride are considered. It is shown that during the formation of coatings of the required composition, the most important is the thermodynamic estimation of possible interactions. These interactions allow us to accomplish the structural-phase modification of the material, which is determined by the complex of possible topochemical reactions leading to the formation of compounds, including non-stoichiometric composition.

**Keywords:** titanium nitride, niobium carbide, niobium nitride, sputtering, stoichiometry, wear and friction resistance, raster pattern, contrast, rotor, gas bearing, X-ray phase analysis.

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## PRODUCING CLAD POWDER BY DISINTEGRATOR WITH NEW ROTOR DESIGN

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**Abstract**—The article presents the results of the development of technology for producing composite materials, in particular the production of clad powder materials for wear-resistant coatings. In the proposed method, a clad powder is processed by disintegrator with a new design of the working rotor. Powder particles consist of solid nuclei – core of micron size, surrounded by a cladding layer of soft components. A modified rotor design was used to develop a technology for producing clad powders with desired properties for example Stellite–Aluminum composition. The thickness of the cladding layer is 1.0–2.0  $\mu\text{m}$ , and the firm adhesion of the hard and soft components required for the coating is confirmed. The necessary fraction of the composite powder 50–60 microns for gas-dynamic spraying has been achieved. The obtained experimental set of the plated powder was tested to obtain functional protective coatings using supersonic cold gas-dynamic spraying. Studies have shown that the adhesive strength of the coating was less than 75 MPa and the porosity less than 1.0%. The coating is recommended to protect some components and parts of precision machine-building and power engineering.

**Keywords:** clad powder, composite material, rotor disintegrator, microhardness, adhesion, porosity.

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## INTERMETALLIC COMPOUNDS OF THE Ti–Al–Ni SYSTEM SUITABLE FOR HYDROGEN ACCUMULATION

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**Abstract**—The paper studies how intermetallic compounds of the titanium-aluminum-niobium system could be used as a getter. It was found that with an increase in the niobium content in the alloy from 16 to 40 at.%, the volume of absorbed hydrogen increases from 0.47 to 2.2 wt.%. It is shown that the maximum amount of absorbed hydrogen is observed in alloys with a dendritic structure. Recommendations are given for future directions of research.

**Keywords:** intermetallic compound, hydrogen, getter, hydride

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## BORON NITRIDE FOR MODIFICATION OF RUBBER BASED ON ISOPRENE ELASTOMER

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**Abstract**—The work studies vulcanization characteristics of elastomers based on isoprene rubber filled with carbon black N330 and boron nitride (BN). The influence of the boron nitride (BN) concentration on technological, dynamic, physical and mechanical properties of elastomers has been researched. The application of boron nitride for producing rubber with good properties has been considered. With a gradual increase of the inert filler BN concentration up to 35%, a decrease in the curing rate by 33% and polymer cross-link density by 26% is observed. Moreover, the start time of vulcanization increases by almost 300%, the optimal curing time by 200%.

*Keywords:* boron nitride, rubber, vulcanization, filler, properties.

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## PRODUCTION OF POLYMERIC NANOCOMPOSITES BY NATURE-LIKE METHOD AND STUDY OF THEIR PHYSICAL AND CHEMICAL PROPERTIES

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**Abstract**—At the NRC “Kurchatov Institute” – GOSNIIGENETIKA, NpCdS nanocrystals were obtained by microbial synthesis. They were stabilized with proteins, which composition is determined by the strain used for biosynthesis of nanoparticles. Biogenic nanoparticles were studied and described by size, shape, hydrodynamic diameter,  $\zeta$  potential, luminescence level, and defined as quantum dots applying methods of electron microscopy, dynamic light scattering, and spectrofluorimetry. The influence of temperature, pressure and solvents on the stability of biogenic nanoparticles and the luminescence intensity was evaluated in collaboration with IREA (NRC “Kurchatov Institute”). The luminescence intensity of the aqueous suspension of NpCdS was determined depending on the range of nanoparticle concentrations.

The possibility of introducing and identifying NpCdS in epoxy resin, polyimide, and polyvinyl alcohol was assessed. Polymer nanocomposites are used for optoelectronic, biomedical and agricultural applications.

**Keywords:** biogenic NpCdS, protein capping agents, quantum dots, luminescence, polymer matrix, nanocomposites

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#### RESEARCH OF WELDABILITY OF TITANIUM PSEUDO- $\beta$ ALLOY VST 5553

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**Abstract**—The welding properties of argon-arc and electron-beam welding of titanium pseudo- $\beta$ -alloy of VST 5553 grade are investigated. It is shown that to increase the level of mechanical properties of welded joints, it is necessary to apply heat treatment after welding.

**Keywords:** titanium alloys, welding, heat treatment, welded joints, mechanical properties.

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#### PROTECTION OF WELDED JOINTS FROM OXIDATION AT WELDING OF TITANIUM ALLOYS

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**Abstract**—This paper considers the protection of welded joints from oxidation during welding of marine hull structures from titanium alloys. The requirements for welding equipment and protective devices are defined. Technological measures are considered to ensure reliable protection of welded joints from ambient air and, accordingly, to ensure high quality welding.

**Keywords:** titanium alloys, welded joints, gas impurities, gas protection devices

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## COMPARATIVE ANALYSIS AND VERIFICATION OF ENGINEERING METHODS OF SHALLOW CRACKS EFFECT FOR FRACTURE TOUGHNESS PREDICTION FOR REACTOR PRESSURE VESSELS

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**Abstract**—The main features of shallow cracks fracture are considered, and a brief analysis of methods allowing to predict the temperature dependence of the fracture toughness  $K_{JC}(T)$  for specimens with shallow cracks is given. These methods include DA-method, (JQ)-method, (J-T)-method, "local methods" with its multi-parameter probabilistic approach,  $G_P$  method uses power approach, and also two engineering methods – RMSC (Russian Method for Shallow Crack) and EMSC (European Method for Shallow Crack). On the basis of 13 sets of experimental data for national and foreign steels, a detailed verification and comparative analysis of these two engineering methods were carried out on the materials of the VVER and PWR nuclear reactor vessels considering the effect of shallow cracks.

*Keywords:* reactor pressure vessels, fracture toughness, shallow cracks, brittle fracture resistance, engineering forecast methods

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## CALCULATION OF TEMPERATURE CONDITIONS OF A PLASMA SPUTTERING CELL FOR DECONTAMINATION OF NUCLEAR POWER PLANT CONSTRUCTIONS

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**Abstract**—We are developing a technology for the “dry” deactivation of nuclear power plant constructions by ion sputtering of surfaces with micro-sized radioactive contaminants, our technology is implemented by plasma discharge in an inert gas medium with mass transfer of sputtered material and its deposition in diffusion mode on the anode substrate. Unlike traditional radiochemical methods, in our technology, radionuclides do not transfer into liquid radioactive waste, but condense in a compact solid form, which makes possible to use them. Because our technology can be applied both during decommissioning nuclear power plants (including deactivation of neutron-irradiated nuclear graphite), and during routine operation and scheduled repairs of nuclear reactors, so it is possible to extract the necessary isotope concentrate in the required quantities, due to intense neutron flux in nuclear power plant. The design of plasma sputtering cell to remove radionuclides from the irradiated graphite and NPP construction surfaces involves ignition of a direct current plasma discharge in an inert gas (for example, argon) at the pressure of  $P \sim 0.1\text{--}1$  atm and control of the temperature conditions of the sputtering material deposition. In this paper temperatures of the anode (tantalum collector) and the cathode (sputtered graphite) were calculated depending on the input power to the argon plasma discharge. Data on temperatures of cathode and anode (collector) surfaces make it possible to control the elemental composition of the sputtered atoms and to form nanoscale layers of radionuclide concentrate on collector for using in radiation medicine and new beta-voltaic batteries. Thus, the technology is important not only for the deactivation of nuclear power plants, but also for the formation of nanoscale layers of beta-active materials.

**Keywords:** nuclear power plants, decontamination, ion sputtering, plasma sputtering cell, temperature mode, calculation method

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## TECHNOLOGY FOR PRODUCING VESSEL STRUCTURES OF THE MAIN CIRCULATION PUMP FOR BREST REACTOR

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**Abstract**—One of the important joints of a liquid metal fast reactor is the main circulation pump. In the course of the present research, a preproduction model of the pressure chamber, the most labor-consuming unit of the main circulation pump, was manufactured. This complex welded structure was made of 10Kh15N9S3B3 (EP-302Sh) steel sheets; fixtures and accessories were also manufactured, and as a result the metal consumption of the structure decreased. Technological documentation was made for bending, stamping of parts of the pressure chamber, welding of components, their heat and mechanic treatment, and its assembling. According to the results of this work, the existing technological documentation was adjusted in the context of the new data for pressure chamber of the main pump.

**Keywords:** reactor, main circulation pump, pressure chamber, bending, stamping, welding, assembling

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### ON THE EXPERIMENTAL LEAD-COOLED INSTALLATION

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**Abstract**—Extensive experience in operating nuclear power plants convincingly proves that fast liquid metal cooled reactors are among the most promising. The advantages of using liquid lead coolants in nuclear power industry are shown. In Russia, lately, much attention has been paid to the natural safety of fast reactors. At the stage of testing materials for components of reactor plants, a number of problems arose for basic systems. An experimental lead-cooled installation was developed for testing large structures, continuous monitoring and maintaining specified technical parameters. For reliable coolant circulation (lead coolant circulation speed up to 200 kg/s), a magnetohydrodynamic pump (MHD pump) has been developed, which is distinguished by high efficiency and reliability, it is also ease in operation and maintenance. Currently, the experimental setup is successfully used in scientific research of materials for RU BREST-OD-300. All its systems showed high reliability, maintainability and the possibility of further modernization.

**Keywords:** nuclear power, lead, installation, liquid metal coolant, magnetohydrodynamic pump, safety, reliability, advanced reactor technologies

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## METHODICAL APPROACH FOR STUDYING KINETICS OF SHORT AND LONG FATIGUE CRACKS GROWTH FOR IRRADIATED REACTOR MATERIALS.

### Part 2. Construction of fatigue propagation rate diagram on the basis of test of precracked charpy specimens

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**Abstract**—The finite element technique has been used for estimating the stress intensity factors (SIF) for short cracks emanating from a notch of single-edge bend specimen (SE(B)) and also weight function for this type of the specimen have been determined. On the basis of the received results the uniform equation for calculations SIF for short and long cracks in a specimen such as SEB (at  $h/W = 0.3$ ) has been offered. The technique of construction of full kinetic diagrams of growth of the short and long fatigue cracks, initiated from the notch, is developed and approved. Full kinetic diagrams of growth of fatigue cracks (short and long) in steel X18H10T and in weld metal in initial and irradiated (up to 40 dpa) conditions were built.

**Keywords:** stress intensity factors, short and long fatigue crack, cyclic crack resistance, fatigue crack growth, austenitic steel, neutron irradiation.

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