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## STRUCTURE FORMATION IN THE ZONES OF CONTACT OF LAYERS OF CLAD STEEL OPERATING IN ARCTIC CONDITIONS

P.A. SALEI, G.D. MOTOVILINA, Cand. Sc. (Eng), G.Yu. KALININ, Dr Sc. (Eng)

*NRC "Kurchatov Institute" – CRISM "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

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**Abstract**—The paper studies structure formed in the zone of contact of the cladding and base layers of steel grades F500WArc-P and E500W-P, produced by batch rolling and explosion welding, respectively. It has been revealed that the technology of applying the cladding layer determines the structure and dimensions of the contact zone of the bonded layers.

*Keywords:* clad steel, stack rolling, explosion welding, corrosion-resistant steel, contact zone of cladding and base layers

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**EXPRESS METHOD FOR DETERMINING THE CONTENT OF DIFFUSIVE HYDROGEN IN DEPOSITED METAL**

V.V. GEZHA, Cand. Sc. (Eng), V.A. MOGILNIKOV, P.V. MELNIKOV, Cand. Sc. (Eng)

*NRC "Kurchatov Institute" – CRISM "Prometey", 49, Shpalernaya St, 191015, St Petersburg, Russian Federation. E-mail: mail@crism.ru*

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**Abstract**—An express method has been developed that makes it possible to determine the content of diffusive hydrogen in the deposited metal for 1 hour, which is important for adjusting the technological parameters of welding high-strength steels.

*Keywords*: high-strength steels, heat input of welding, deposited metal, diffusion hydrogen, express method

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# RESTORATION AND MODIFICATION OF PRODUCTS WITH HIGH-ENTROPY ALLOY $CoCrFeNiMnW_{0.25}$ USING ADDITIVE TECHNOLOGIES

D.V. MASAILO, Cand Sc (Eng), N.G. RAZUMOV, Cand Sc (Eng), E.V. VOLOKITINA, A.A. POPOVICH, Dr Sc. (Eng)

*Peter the Great St Petersburg Polytechnic University, 29 Polytekhnicheskaya St, 195251 St Petersburg, Russian Federation*

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**Abstract**—The results of a study of the possibility of restoring and modifying the surface of products by direct laser growth using a powder of a high-entropy $CoCrFeNiMnW_{0.25}$ alloy are presented. In the course of the work, a powder was obtained, the phase composition of which is represented by a single-phase solid solution with a face-centered cubic lattice, and the process of direct laser growth on a product prototype was studied. The applied coating is characterized by a higher hardness of 217.6 HV than the product material and a 22% lower weight loss during the anodic solubility test.

*Keywords*: direct laser growth, high-entropy alloy, powder metallurgy, restoring and modifying, corrosion-resistant coating

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## DEVELOPMENT OF BIOACTIVE COMPOSITE MATERIAL BASED ON BAMBUSURIL AND POROUS TITANIUM NICKELIDE

V.R. LUCHSHEVA, A.A. BAKIBAEV, E.S. MARCHENKO (Dr Sc. Phys-Math)

*National Research Tomsk State University, 36 Lenin Ave, 634050 Tomsk, Russian Federation.*
*E-mail: kuscherbaeva_venera@mail.ru*

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**Abstract**—At the Tomsk State University, a composite material was developed based on porous titanium nickelide and bambus[6]uril which was deposited on the surface of porous titanium nickelide under vacuum. Bambusuril surface occupancy has been assessed, and the biological response of cells to modified samples has been studied. Using scanning electron microscopy, it was possible to establish that the surface of porous titanium nickelide is unevenly covered with bambusuril island-shaped agglomerates size 0.3–3 μm. Bambus[6]uril is localized both on the surface and in the pores. The developed material has high biocompatibility in vitro and low toxicity.

*Keywords:* bambusuril, titanium nickelide, composite material, biomaterial, MTT- test

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## OBTAINING CARBON MATERIALS FOR THE ADSORPTION OF GREENHOUSE GASES

A.E. MEMETOVA, Cand Sc. (Tech.), N.R. MEMETOV, Cand Sc. (Tech.), A.D. ZELENIN,

A.V. BABKIN[2], Cand Sc. (Tech.), N.A. CHAPAKSOV[1], E.S. MKRTCHYAN[1]

[1]*Tambov State Technical University, 106/5, room 2 Sovetskaya St., Tambov, Russian Federation*

[2] *Lomonosov Moscow State University, Department of Chemistry, Leninskiye Gory-1, 119991 Moscow, Russian Federation. E-mail: anastasia.90k@mail.ru*

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**Abstract**—Coffee-based carbon adsorbents are promising adsorbents for greenhouse gases, in particular methane, due to the possibility of creating a precision porous structure. Microporous and micromesoporous samples with a narrow pore size distribution up to 7 nm have been obtained. A study was made of methane adsorption in carbon adsorbents obtained by chemical activation at different ratios of KOH to coffee precursor. The highest adsorption of the greenhouse gas methane, equal to ~18 mmol/g at 100 bar and a temperature of 298 K, is achieved on a sample with a ratio of activating agent to carbonized precursor of 6:1 (6AKP).

*Keywords*: porous structure, activation, greenhouse gas, adsorption, methane, carbon adsorbent

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**CREATION AND STUDY OF INTERMETALLIC COATING OF THE Ni–Ti SYSTEM REINFORCED WITH TUNGSTEN CARBIDE TO INCREASE WEAR RESISTANCE OF TITANIUM ALLOY**

D.A. GERASHCHENKOV[1], Cand. Sc (Eng), A.A. IVANOVSKY [2], A.M. MAKAROV[1], S.Yu. EVDOKIMOV[2]

*[1] NRC "Kurchatov Institute" – Central Research Institute of Structural Materials "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

*[2] JSC Silovye mashiny, 3/2 Vatutina St, 195009 St Petersburg, Russian Federation*

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**Abstract**—The results of studying the intermetallic coating of the Ni–Ti system with the addition of tungsten carbide are presented. The coating was synthesized on the surface of titanium alloy VT6 using an integrated approach – preliminary deposition of a precursor coating from monometallic nickel by cold gas-dynamic spraying and subsequent laser processing. It is shown that the introduction of tungsten carbide into the intermetallic matrix provides an increase in hardness by a factor of three or more, as well as a decrease in wear intensity by a factor of 80 compared to the wear resistance of VT6 titanium alloy. A technology has been developed and a batch of steam turbine blades with a wear-resistant coating on the surface of shrouds has been manufactured.

*Keywords*: titanium alloy, intermetallic coating, TiNi alloy, reinforcement, tungsten carbide, wear resistance

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# STRENGTH ANALYSIS OF CARBON FIBER REINFORCED PEEK COMPOSITES WITH HEAT RESISTANT SIZING AGENTS

D.S. ALEKSANDROVA[1,2], M.V. KOMAROVA[1,2], A.S. EGOROV[1,2], Cand Sc. (Chem), A.L. ANDREICHEV[3], A.A. SHUMAKOV[3]

[1] *National Research Center "Kurchatov Institute", 1 Akademika Kurchatova Sq, 123182 Moscow, Russian Federation. E-mail: gudeeva@irea.org.ru*

[2] *National Research Center "Kurchatov Institute" – IREA (Institute of Chemical Reagents and High Purity Chemical Substances), 3 Bogorodsky Val, 107076 Moscow, Russian Federation*

[3] *R&D Department, JSC UMATEX, 42/Bldg 13 Volgogradsky Ave, 109316 Moscow, Russian Federation*

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**Abstract**—Continuous Fiber Reinforced Thermoplastic Composites (CFRTPCs) are known for their demand in high-tech industries due to their excellent mechanical, thermal and chemical performance. However, poor adhesion interaction between carbon fiber (CF) and high-performance polymers such as PEEK tend to influence the mechanical modulus of the composite parts in a negative way. In the current work, a number of PAA-based sizing agents modified with various fillers were used for CF surface treatment in order to improve adhesion. Thus, the wettability of the sizing agents was studied, as well as the free surface energy using the Owens-Wendt method. The calculated energy values were used to determine the work of adhesion between the sizing agents and PEEK. The adhesive connection between the CF treated with the sizing agents and PEEK was examined by the single fiber *pull-out* testing. Furthermore, the most promising samples were used for CF, on the basis of which towpreg composites samples were obtained to study its physico-mechanical properties. Results suggested that the values of the strength characteristics of the composites are comparable to the values measured for composites based on commercially available materials.

*Keywords*: carbon fiber, surface treatment, sizing agents, PEEK, Continuous Fiber Reinforced Thermoplastic Composites

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## DEVELOPMENT OF EXTRUDABLE COMPOSITES BASED ON UHMWPE

O.V. GOGOLEVA, Cand. Sc. (Eng), P.N. PETROVA, Cand. Sc. (Eng), A.L. FEDOROV, Cand. Sc. (EnG),

M.N. KONDAKOV, Cand. Sc. (Eng), E.S. KOLESOVA

*Institute of Oil and Gas Problems, Yakutsk Scientific Center of the Siberian Branch of the Russian Academy of Sciences, 20 St Avtodorozhnaya, 677007 Yakutsk, Russian Federation.*
*E-mail: ipog.ipng@ysn.ru*

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**Abstract**—A comparative analysis of hot pressing and extrusion for obtaining polymer composite materials based on UHMWPE was carried out. The paper describes physical-mechanical and tribological studies of the developed composite materials. It was found that samples obtained by extrusion have high wear resistance and significantly better deformation and strength properties compared to samples obtained by hot pressing. On the basis of the performed studies, the possibility of processing composites based on UHMWPE by extrusion by adding a low-viscosity grade of PE and stearic acid has been shown.

*Keywords*: ultra high molecular weight polyethylene (UHMWPE), extrusion, low-pressure polyethylene, stearic acid, physical and mechanical properties, coefficient of friction, wear resistance

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## RELATION BETWEEN THE RESULTS OF A BENDING TEST AND THE CRITICAL DEFORMATION OF THE TESTED METAL

A.V. ILYIN, Dr Sc. (Eng), A.V. MIZETSKY, Cand. Sc. (Eng), V.V RIABOV, Ju.V. VERETENNIKOVA

*NRC "Kurchatov Institute" – CRISM* "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federatio*n. E-mail:* mail@crism.ru

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**Abstract**—The features of sample deformation during bending tests using numerical methods of investigation – FEM are considered. Formulas are presented for determining the critical deformation of a metal based on the results of a bending test. With formulas, it is possible to predict the minimum diameter of the mandrel, which provides a satisfactory result, depending on the ability of the material to work hardening.

*Keywords*: bending test, deformation capacity, deformation diagram, plastic deformation, critical deformation, work hardening

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## ANODIC BEHAVIOR OF Zn22Al ALLOY DOPED WITH GALLIUM IN CORROSION-ACTIVE ENVIRONMENTS

J.H. SHARIPOV, F.A. ALIEV, I.N. GANIEV, Dr Sc (Chem), Z.R. OBIDOV, Dr Sc (Chem)

*Institute of Chemistry named after V.I. Nikitin of the National Academy of Sciences of Tajikistan, 299/2 St Aini, 34063 Dushanbe, Tajikistan. E-mail:* obidovzr@gmail.com

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**Abstract**—The paper presents results of an experimental research of anodic behaviour of Zn22Al alloy doped with gallium in corrosion-active environments HCl, NaCl and NaOH. The electrochemical potentials of corrosion, pitting formation and repassivation of gallium-doped alloys are shifted towards positive values compared to the basic Zn22Al alloy. Alloys, containing 0.01–1.0 wt% gallium, in the pH range from 3 to 9 are the most resistant to pitting corrosion. The corrosion rate of alloys micro doped (0.01–0.1%) with gallium is 1.5–2.5 times lower than that of the basic Zn22Al alloy. The corrosion products of the studied alloys consist of protective oxide films of ZnO, $Ga_2O_3$, $ZnAl_2O_4$, $Al_2O_3 \cdot Ga_2O_3$.

*Keywords:* Zn22Al alloy, doped, gallium, corrosion-active environment, corrosion rate, potentials of corrosion, anodic behavior

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## EFFECT OF SENSITIZATION ON SERVICE PROPERTIES OF WELDED JOINTS OF AUSTENITIC PIPELINES UNDER OPERATION CONDITIONS OF RP RBMK 1000

N.V. VASILIEV, Cand. Sc (Eng), Yu.V. STEPANOV, Cand. Sc (Eng), M.I. ZUEVA, P.I. BORKIN, E.A. IVANENKO, V.A. PETROV, Cand. Sc (Eng)

*NRC "Kurchatov Institute" – Central Research Institute of Structural Materials "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

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**Abstract**—In order to assess the effect of metal sensitization of welded joints of pipelines Du300 from austenitic steel on their service characteristics under the operating conditions of the RP RBMK 1000, samples were tested from steel grade 08Kh18N10T with a constant strain rate from $10^{-7}$ to $10^{-3}$ $s^{-1}$ in high water parameters and analysis of changes in their properties.

*Keywords*: austenitic steel, RBMK 1000 reactor plant pipelines, welded joints, sensitization, strain rate, service characteristics

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## RADIATION-INDUCED STRUCTURE OF AUSTENITIC STEELS WITH DIFFERENT NICKEL CONTENT UNDER NEUTRON IRRADIATION IN SM-3 AND BOR-60 REACTORS

E.A. KULESHOVA[1, 2], Dr Sc. (Eng), S.V. FEDOTOV[1], Cand. Sc. (Eng), D.A. MALTSEV[1], Cand. Sc. (Eng), A.S. FROLOV[1], Cand. Sc. (Eng), D.V. SAFONOV[1], Cand. Sc. (Eng), N.V. STEPANOV[1], G.M. ZHUCHKOV[1], B.Z. MARGOLIN[3], Dr Sc. (Eng), A.A. SOROKIN[3], Cand. Sc. (Eng)

[1] *National Research Center Kurchatov Institute, 1 Sq Academician Kurchatov, 123182 Moscow, Russian Federation*

[2] *National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe shosse, 115409 Moscow, Russian Federation*

[3] *NRC “Kurchatov Institute” – CRISM “Prometey”, 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

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**Abstract**—Comparative studies of the radiation-induced structure of austenitic steels with a nickel content of 10, 20 and 25 wt.%, irradiated sequentially in the SM-3 and BOR-60 reactors, as well as to higher damaging doses in the BOR-60 reactor, have been carried out. The phase composition, dislocation structure, pores, and radiation-induced segregations at grain boundaries were studied by high-resolution analytical methods of transmission electron microscopy, scanning electron microscopy, and atomic probe tomography. The formation of radiation-induced phase precipitates based on nickel has been established, and its volume fraction correlates with the level of radiation-induced segregations, and increases, the higher the nickel content in the steel. The values of barrier strength factors for radiation-induced structural elements in the studied steels are adjusted by calculation and experiment, which makes it possible to determine their contribution to radiation hardening.It is shown that the largest contribution to radiation hardening as a result of neutron irradiation in BOR-60 at high irradiation temperature up to 29 dpa is made by large radiation-induced precipitates of (G + γ') phases. It is shown that with an increase in the damaging dose, the main factor limiting the performance of internal devices will be radiation swelling, since the contribution to the change in properties from radiation-induced phases and radiation defects will not increase due to their density reaching saturation. Steel with 25 wt.% Ni exhibits the lowest level of swelling at high radiation doses, which makes it possible to consider it as a material-candidate for internals for promising VVER reactors with higher temperatures and longer service life.

*Keywords*: austenitic stainless steel, neutron irradiation, porosity, swelling, phase composition, radiation-induced segregations, scanning electron microscopy, transmission electron microscopy, atomic probe tomography

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## TOOL LIFE AND TRANSVERSE-LONGITUDINAL EXTRUSION IN THE HOLLOW AXISYMMETRIC PARTS MANUFACTURING

M.S. KALUGINA[1, 2], S.A. ZHUKOV[2], E.E. AGAMIROVA[3], A.V. BOGDANOV[2]

[1] *JSC Concern “Okeanpribor”, 46 Chkalovsky Ave, 197376 St. Petersburg, Russian Federation*

[2] *Baltic State Technical University Voenmekh named after Dmitry Ustinov, 1, 1st Krasnoarmeyskaya, 119005 St Petersburg, Russian Federation*

[3] *Dagestan State Technical University, 70 Imam Shamil Ave, 367026 Makhachkala, Republic of Dagestan, Russian Federation*

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**Abstract**—The paper studies fundamental possibilities of using the transverse-longitudinal extrusion scheme for improving the technologies for manufacturing hollow axisymmetric parts from metal bars.

*Keywords*: hollow axisymmetric parts, transverse-longitudinal extrusion, stress-strain state, movable punch, steel matrix, tool life

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## INFLUENCE OF HEAT-TREATMENT MODES ON THE STRUCTURE AND PROPERTIES OF BAINITIC-MARTENSITIC STEEL

E.V. MISHURINSKAYA, V.A. BELYAEV, M.V. GOLUBEVA, Cand Sc. (Eng),
G.D. MOTOVILINA, Cand Sc. (Eng)

*NRC "Kurchatov Institute" – CRISM "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

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**Abstract**—Modeling of the stages of production technology of high-strength bainitic-martensitic steel is carried out: of hot plastic deformation, hardening and high-temperature tempering. The dependence of the structure and properties of steel on the modes of hot plastic deformation and heat treatment has been established.

*Keywords*: Gleeble-3800 modeling, low-carbon chromium-nickel-molybdenum steel, rolling, quenching and tempering, structure, mechanical properties

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## CHANGES IN THE STRUCTURE AND PROPERTIES OF THE THICK SHEETS OF BAINITIC/MARTENSITIC STEEL AT A CROSS-SECTION

K.Yu. KURTEVA, G. D. MOTOVILINA, Cand. Sc. (Eng), E.V. ZABAVICHEVA

*NRC “Kurchatov Institute” – CRISM “Prometey”, 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

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**Abstract**—To expand the grade of rolled low-carbon low-alloy steels chrome-nickel-molybdenum composition. The analysis of changes the mechanical properties and structure in the thickness of rolled sheets of 15, 50 and 60 mm produced using quenching with furnace heating and high tempering was performed.

*Keywords*: thick-sheet rolling, low-carbon low-alloy cold-resistant steel, microstructure, heat treatment, mechanical properties, dislocation rack martensite, granular bainite, rack bainite.

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## EFFECT OF HEAT TREATMENT MODES ON THE STRUCTURE AND MICROHARDNESS OF A Ni–W NANOCOMPOSITE COATING

M.V. MERKULOVA[1,2], A.V. KRASIKOV[1], Cand. Sc (Chem), M.S. MIKHAILOV[1]

*NRC "Kurchatov Institute" – CRISM "Prometey", 49 Shpalernaya St, 191015 St Petersburg, Russian Federation. E-mail: mail@crism.ru*

*[1]Peter the Great St Petersburg Polytechnic University, 29 Polytekhnicheskaya St, 195251 St Petersburg, Russian Federation*

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**Abstract**—The effect of heat treatment (annealing temperature and duration) on the structure and properties of coatings of the Ni–W system obtained by electrodeposition has been studied. It has been found that annealing results in an increase of microhardness due to hardening of the alloy matrix and precipitation of $Ni_4W$ and NiW intermetallic phases. A heat treatment mode was selected to provide maximum microhardness of 1350 HV for Ni–W coatings with a tungsten content of 44 wt %.

*Keywords*: electrodeposited coatings of the Ni–W system, heat treatment, microhardness, intermetallic compound, solid solution of tungsten in nickel

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## OPERATIONAL MONITORING OF THE METAL OF SOLUTION PRESSURE VESSEL REACTORS AT NRC "KURCHATOV INSTITUTE"

T.V. BOIKOVA, Yu.O. KOCHNOV, S.V. MYASNIKOV, N.V. PETRUNIN, S.S. TERASHKEVICH

*NRC "Kurchatov Institute", 1 Sq. Academician Kurchatov, 123182 Moscow, Russian Federation. E-mail: Boykova_TV@nrcki.ru*

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**Abstract**—The paper considers experience of using witness samples for monitoring the state of the metal of the Argus reactor pressure vessel with fuel in the form of an aqueous solution of uranyl sulfate–at a nuclear facility at the National Research Center "Kurchatov Institute". Tests for resistance to intergranular corrosion were carried out in order to establish the actual state of the material. The main objective of the research was to identify corrosion defects. The approach involves the study of witness samples made of steel grade 08Kh18H10T, interconnected by welding wire St 04Kh19H11M3. Witness samples are examined. Extraction of samples for analysis is carried out approximately once every 10 years, or when an energy release (more than $5 \cdot 10^5$ kWh) is reached. The high resistance of the materials used in the corrosive environment of the fuel solution is shown on the basis of experimental results.

*Keywords:* operational monitoring, Argus solution reactor, uranyl sulfate, witness samples, intergranular corrosion, metallographic studies, control sample, corrosion resistance, residual life

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## ON THERMOPHYSICAL PARAMETERS OF ION-THERMAL PLASMA TECHNOLOGY FOR SPENT NUCLEAR FUEL PROCESSING

A.S. PETROVSKAYA[1], Cand Sc (Phys-Math), A.B. TSYGANOV[1], Cand Sc (Phys-Math), S.V. SUROV[2], D.A. BLOKHIN[2]

*[1] InnoPlasmaTec LLC, 4–6/letter B, 17th line V.O., 199034 St Petersburg, Russian Federation. E-mail: anita3425@yandex.ru*

*[2] "Science and innovations", scientific division of the State Atomic Energy Corporation "Rosatom", 32/2, bdg 1 Kadashevskaya Embankment, 115035 Moscow, Russian Federation*

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**Abstract**—The paper describes the development of the Ion Sputtering – Thermal Separation (IS-TS) technology for closed nuclear fuel cycle and spent nuclear fuel (SNF) reprocessing. The atomization of the SNF pellet is performed by the plasma discharge in an inert gas or hydrogen medium, sputtered SNF atoms in the gas flow move along the separating diffusion tube and deposite separately on selected sections of the tube due to differentiation by saturated vapor temperatures. Based on the numerical calculation of the temperature field and the velocity field of the carrier gas, the values of the thermophysical parameters of the technology are obtained, which make it possible to design a prototype of a diffusion separation system with the optimal mode of sputtering and separate collection of SNF elemental components.

*Keywords:* nuclear fuel cycle, spent nuclear fuel reprocessing, structural materials, nuclear materials science, high-pressure plasma discharge, thermophysical parameters, temperature field

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