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BEHAVIOR OF LOCALIZED STRAIN UNDER HOT COMPRESSION OF CAST SPECIMEN FROM Mg–Al–Zn ALLOY

A.Ya. KOCHUBEY, Cand Sc. (Eng), P.L. ZHURAVLEVA

Federal State Unitary Enterprise "All-Russian Scientific Research Institute of Aviation Materials" –
National Research Center "Kurchatov Institute", 17 Radio St, 105005 Moscow, Russian Federation.
E-mail: zhuravlevapl@gmail.com

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Abstract—Axisymmetric hot compression experiments of Mg–Al–Zn specimens in intervals of temperature 250–450 °C and deformation rate (10-3-5)·10^{-1} s^{-1} were carried out. Structure formation was studied by optical microscopy. Macroscopically localized strain of cylindrical specimens depending on temperature, strain rates and initial grain size (400 μm and 1400 μm) are investigated. Localized strain diagrams for different initial grain size can be used for development and optimization of hot processing technology parameters are plotting. It is shown that increase of the grain size direct to strain localization increment tendency.

Keywords: localized strain, hot plastic deformation, axisymmetric compression, grain size, twinning, dynamic recrystallization, diagrams

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INVESTIGATION OF THE SURFACED METAL OF THE Fe–Cr–Ni–Mn–Mo–Ti–Nb–C SYSTEM FOR OPERATION UNDER HIGH-TEMPERATURE GAS-ABRASIVE WEAR

D.V. PRIYATKIN, A.A. ARTEMYEV, Cand Sc. (Eng), V.I. LYSAK, Acad. RAS

Volgograd State Technical University, 28 Lenin Avenue, 400005 Volgograd, Russian Federation

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Abstract—Compositions of flux-cored wires for electric arc surfacing of alloys of the Fe–Cr–Ni–Mn–Mo–Ti–Nb–C alloy system, resistant to high-temperature gas-abrasive wear, were developed. The deposited alloys were studied by optical and electron microscopy, X-ray mi-crospectral and X-ray diffraction analysis. The influence of the carbon content in the alloy on its structural-phase composition, hardness, and wear resistance at normal and elevated temperatures up to 600°C was revealed. It was established that increasing the carbon content in the alloy from 1.2 to 2.8 wt. % leads to increasing the volume fraction of $(Cr, Fe)_xC_y$ carbides involved in the formation of the eutectic austenite-carbide matrix of the alloy at 6 times. Their morphology also changes from $(Fe, Cr)_{23}C_6$ to $(Fe, Cr)_7C_3$. In this case, the content of $(Ti, Nb, Mo)_xC_y$ and Mo_xC carbides in the alloy changes insignificantly, and their average size increases by 10%. It has been established that the formation of a composite structure in the alloy contributes to its high resistance to gas-abrasive wear at a temperature of 600°C. The wear resistance of the developed alloy is comparable to a foreign industrial analogue at a much lower cost.

Keywords: arc surfacing, hardfacing alloys, wear resistance, high temperature gas abrasive wear, hardening phases, abrasive particle, sclerometry

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ANALYSIS OF TECHNOLOGICAL PROCESSES OF PRODUCTION OF SPHERICAL POWDERS AND GRANULES OF NiAl NICKEL MONOALUMINIDE FOR THE NEEDS OF DOMESTIC ENGINE BUILDING

M.V. ZHAROV, Cand Sc. (Eng)

Moscow Aviation Institute (National Research University). 4 Volokolamskoe shosse,
125993 Moscow, Russian Federation. E-mail: MaximZharov@mail.ru

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Abstract—The article is devoted to the study of the features of various methods for obtaining granules of nickel aluminide NiAl. The problems hindering the widespread use of nickel aluminide NiAl in modern aircraft and engine construction are analyzed. It has been revealed that the main problems hindering the widespread industrial use of nickel aluminide NiAl are practically zero plasticity of the material during pressure treatment and difficulties in machining parts made of this material. However, this problem can be solved with the use of pellet metallurgy technologies, when by sintering the granular material, an almost finished product is obtained that requires minimal amounts of subsequent machining. Within the framework of the conducted studies, the quality criteria of the obtained granules were determined, which include the sphericity of the granules, the stability of the obtained dimensions of the granular material, the absence of defects in the form of pores, the absence of satellites on the surface of the granules, the presence of a finely dispersed dendritic structure of the granule material. Several methods of obtaining granules of nickel aluminide NiAl have been investigated from the point of view of obtaining the highest quality raw materials, namely: the method of spraying the melted billet with a high-temperature inert gas flow (gas atomization method), the method of centrifugal spraying of the melted electrode (PREP method), the method of centrifugation of the melt using a perforated crucible. It is determined that the optimal way to obtain a high-quality granulate of NiAl material is the method of centrifugal spraying of the melted electrode. In the course of the conducted research, it was proved that the main parameter of the process of centrifugal spraying of the melted electrode, affecting the quality of the obtained granules, their diameter and the value of the dendritic parameter of the microstructure of the granules, is not so much the current strength I as the rotation speed of the melted electrode n. The optimal values of the electrode rotation speeds are determined, which are $n \approx$ 15000–16000 revolutions per minute at a current strength $I \approx$ 1000–1500 A. A technology for obtaining high-quality NiAl material granulate has been developed and tested, which includes operations for obtaining initial NiAl blanks by self-propagating high-temperature synthesis, subsequent remelting of semi-finished products, heat treatment, separation of granules and subsequent granulation by the PREP method.

Keywords: granules, nickel aluminide, metallurgy of granules, crystallization, quality of granules, sphericity, porosity, satellite sticking, melt drop, phase composition, hereditary structure, gas atomization, atomization of the electrode, the speed of rotation of the electrode

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SYNTHESIS OF NANOPOROUS FUNCTIONAL MATERIALS FOR THE CHEMICAL INDUSTRY

A.E. MEMETOVA, Cand Sc. (Eng), A.D. ZELENIN, N.R. MEMETOV, Cand Sc. (Eng),
T.V. PASKO, Cand Sc. (Eng), A.V. GERASIMOVA, Cand Sc. (Eng), D.V. TAROV, Cand Sc. (Eng)

Tambov State Technical University, 106/5, bdg 2, St Sovetskaya, 392000 Tambov, Russian Federation

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Abstract—In this study, we synthesized samples of nanoporous carbon materials (NCM) from polymer raw materials. The influence of the conditions of the synthesis process (the mass ratio of the activating agent to the precursor) on the structure of the obtained samples has been studied. Varying the mass ratio of the activating agent to the precursor made it possible to obtain microporous, micromesoporous, and mesoporous carbon materials. Methane adsorption has been researched in a wide pressure range. The highest adsorption of methane, equal to ≈ 20 mmol/g at 100 bar and 298 K, is achieved on a sample with a ratio of the activating agent KOH to carbonized precursor 6:1 (6NCM).

Keywords: structure, activation, potassium hydroxide, adsorption, methane, carbon adsorbent

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STRUCTURE AND PHASE CONSTITUTION OF GRAPHITE-LOADED REACTION-BONDED SiC

O.Yu. SOROKIN, Cand Sc (Eng), I.O. BELYACHENKOV, A.S. CHAINIKOVA, Cand Sc (Eng),
S.V. ZHITNYUK, Cand Sc (Eng), P.N. MEDVEDEV, Cand Sc (Phys-Math)

All-Russian Scientific Research Institute of Aviation Materials NRC “Kurchatov Institute”, 17 St Radio, 105005 Moscow, Russian Federation. E-mail: lab13@viam.ru

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Abstract—The influence of porous SiC preforms densities for the siliconizing process on the structure and phase constitution of graphite-loaded reaction-bonded SiC (G-SiSiC) was studied. It was found that varying the densities of porous SiC preforms containing artificial graphite of similar grain size with the dimensions less than 25 mm (in height or diameter) can lead to the G-SiSiC samples with low free Si content (less 4 wt.%.). It was also shown that reaction sintering of G-SiSiC samples with the optimized densities during the siliconizing process results in the formation of a dense fine-grained SiC layer. Moreover, during the siliconizing process, a dense SiC gradient matrix is formed in which graphite and Si inclusions are uniformly dispersed in bulk.

Keywords: reaction-bonded SiC, siliconizing, graphite, gradient structure

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INVESTIGATION OF THE INFLUENCE OF NATURAL SHUNGITE ON THE PROPERTIES AND STRUCTURE OF POLYTETRAFLUOROETHYLENE

A. P. AMMOSOVA, A.A. USHKANOV, S.A. SLEPTSOVA, Cand Sc (Eng),
A.A. OKHLOPKOVA, Dr Sc (Eng), N.N. LAZAREVA, Cand Sc (Eng)

Ammosov North-Eastern Federal University, 58 Belinskogo St, 677000 Yakutsk, Republic of Sakha (Yakutia), Russian Federation. E-mail: alexanderushkanov@mail.ru

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Abstract—The paper presents the results of physical-mechanical and tribological studies of composites based on polytetrafluoroethylene and natural shungite. It has been established that the introduction of shungite leads to an increase in the wear resistance of the material by 114 times compared to an unfilled polymer. Electron microscopy has shown that a secondary layer is formed on the friction surface of the composites, which protects the material from wear. Using IR spectroscopy, it has been established that during the wear of composites, tribochemical reactions occur with the formation of oxygen-containing functional groups and subsequent structuring of the surface layer. The results of the study obtained by differential scanning calorimetry show that the presence of natural shungite in the PTFE matrix leads to ordering of the structure of the composites.

Keywords: polytetrafluoroethylene, polymer composite, fillers, wear resistance, friction coefficient, structure, friction surface.

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ARAMID ORGANOPLASTICS WITH INCREASED RESISTANCE TO CLIMATIC FACTORS

G.F. ZHELEZINA, Cand Sc. (Eng), G.S. KULAGINA, Cand Sc. (Eng), A.S. KOLOBKOV, Cand Sc. (Eng), P.M. SHULDESHOVA

All-Russian Scientific Research Institute of Aviation Materials (VIAM) – National Research Center “Kurchatov Institute”, 17 Radio St, 105005 Moscow, Russian Federation.
E-mail: admin@viam.ru

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Abstract—The article describes the stage-by-stage development of Russian aramid fibers. The differences between the third generation of Rusar NT fibers and CBM and Ruslan fibers are described. In this work, we studied the resistance of a structural organoplastic based on the third generation of Russian aramid fibers to various climatic factors in order to justify the possibility of using the material in all climatic conditions. For structural organoplastics reinforced with aramid fibers capable of absorbing moisture, the humidity of the environment is a particularly significant factor of influence. When developing all-climatic organoplastics, the key issue is to increase the resistance to moisture absorption and ensure the stability of mechanical characteristics during water and moisture absorption. For the first time for a Russian aramid organoplastic, it has been shown that due to high moisture resistance and a high level of preservation of physical and mechanical properties after exposure to a wide range of climatic tests, organoplastic grade VKO-25 can be considered for use in aviation products operating in all climatic conditions.

Keywords: aramid fibers, organoplastic, moisture absorption, water absorption, polymer composites, climatic aging

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ANODIC BEHAVIOR OF GALLIUM DOPED Zn55Al ALLOY IN ACID, NEUTRAL AND ALKALINE ENVIRONMENTS

M.E. SIROJIDINOV, I.N. GANIEV, Dr. Sc. (Chem), J.H. SHARIPOV, Z.R. OBIDOV, Dr. Sc. (Chem)

V.I. Nikitin Institute of Chemistry of the National Academy of Sciences of Tajikistan,
299/2 Aini St, 734063 Dushanbe, Tajikistan. E-mail: obidovzr@gmail.com

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Abstract—The paper presents results of potentiostatical and potentiodynamical research of anode behaviour of gallium-doped Zn55Al alloy in acid, neutral and alkaline environments of electrolytes HCl, NaCl and NaOH, at various pH values. Gallium additives (0.01–1.0 wt%) lead to displacement of corrosion electrochemical potential, pitting formation and repassivity to positive values. The results indicate a decrease in the corrosion rate of gallium doped alloys by 2–3 times compared to the base alloy. Such dependence is observed in all investigated corrosion environments.

Keywords: Zn55Al alloy doped with gallium, electrochemical research methods, corrosion potentials, medium pH, corrosion rate, anodic behavior

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ANALYSIS OF THE INFLUENCE OF AGGRESSIVE FACTORS AND CONDITIONS ON THE COMPOSITION OF CORROSIVE PRODUCTS

R. K. VAGAPOV, Cand Sc. (Chem)

Scientific-Research Institute of Natural Gases and Gas Technologies – Gazprom VNIIGAZ,
15/1 Proektiruemy proezd No 5537, Razvilka, Leninsky urban district, 142717 Moscow region,
Russian Federation. E-mail: R_Vagapov@vniigaz.gazprom.ru

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Abstract—Data on the use of the X-ray diffraction method in the analysis of the composition of corrosion products are presented. Such knowledge makes it possible to obtain information on the mechanisms of corrosion development and the protective properties of corrosion products, being either dense (with certain protective properties against corrosion) or loose (with a low level of protection against corrosion), which doesn't prevent the penetration of corrosive media to steel surfaces. Under H_2S conditions, a layer of mackinawite (tetragonal FeS) is formed on the surface of steels, and in acidic environments of formation water imitations, it was found that, in addition to it, cubic FeS is formed. Iron sulfide with a cubic crystal structure, being metastable, reduces the protective properties of the sulfide film in aggressive acidic H_2S media. During carbon dioxide corrosion of steel, the main product is siderite ($FeCO_3$), characterized by the phenomenon of isomorphism (i.e. changes in the chemical composition of the phase while maintaining its crystal structure). It is established that in the formation water model, sediments of non-stoichiometric composition $Ca_xFe_yCO_3$ and $(X\mathrm{Fe})CO_3$ are formed, where $X = (Ca^{2+}, Mg^{2+}, Mn^{2+})$. Both of them are poorly crystallized and have defects in the crystal structure, which reduce their protective properties relative to the stoichiometric $FeCO_3$ formed in a 3%NaCl solution. A corrosion inhibitor in aqueous media promotes the adsorption of the inhibitor film, preventing the formation of corrosion products.

Keywords: carbon dioxide corrosion, hydrogen sulfide corrosion, corrosion products, siderite, mackinawite

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CORROSION RESISTANCE OF COMPOSITE Ni–P COATINGS IN VARIOUS AGGRESSIVE MEDIA

D.S. POLUKHIN[1], Yu.N. GOIKHENBERG[2], Dr Sc. (Eng), E.G. BODROV[1]

[1] *LLC RDC-Konar, 8 Yeniseiskaya St, 454010 Chelyabinsk, Russian Federation.*
E-mail: polukhin.dmitriy@konar.ru

[2] *South Ural State University (National Research University), 76 Lenin St, 454080 Chelyabinsk,*
Russian Federation. E-mail: goikhenbergyn@susu.ru

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Abstract—The paper studies corrosion resistance in highly aggressive media of composite nickel-phosphorus coatings after isothermal annealing at different temperatures accompanied by crystallization. The phase composition of chemically deposited Ni-P coating containing about 1% dispersed SiC was analyzed. Gravimetric method was used to determine the mass loss of the samples as a result of daily exposure to various acids and in a solution of nitric acid with a concentration from 5 to 65%, which is extremely aggressive for Ni-P coatings. At each heat treatment, the steel witness samples were used to determine the microhardness by the Vickers method at a load of 100 g. The dependence of the parameters of the corrosion process on the presence of a dispersed additive and the phase composition of the coating has been established. At low holding times the dispersed phase exhibits a barrier effect reducing crystalline phosphide Ni_3P formation during annealing and corrosion resistance; meanwhile, prolonged holding at lower temperatures produces about 70% Ni_3P, stable high hardness values and improved corrosion resistance values. Lowering the coating heat treatment temperature in an oxidizing environment reduces the intensity of phosphorus burn-off from the surface and decreases all coating properties. The concentration of nitric acid in the solution at the level of 5–15% is critical and contributes to the dissolution of all coatings, regardless of their composition.

The conducted research and revealed regularities made it possible to determine the contribution of the phase composition and presence of the dispersed additive to the formation of the main service characteristics of the nickel-phosphorus coatings – microhardness and resistance to aggressive media, as well as to determine the technological modes of heat treatment that allow the formation of optimum properties of products used in the oil and gas industry.

Keywords: nickel-phosphorus coating, dispersed phase, microhardness, thin coatings, Vickers method, phase composition, intermetalide Ni_3P, numerical values of the corrosion, nitric acid, gravimetric method

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STABILITY OF THE Y–Ti–O OXIDES IN REACTOR MATERIALS UNDER NEUTRON IRRADIATION AT HIGH TEMPERATURES

A.S. FROLOV[1], Cand Sc. (Eng), E.A. KULESHOVA[1,2], Dr Sc (Eng), B.A. GUROVICH[1], Dr Sc (Eng),
A.A. NIKITINA[3], D.A. MALTSEV[1], Cand Sc. (Eng), S.V. FEDOTOVA[1], Cand Sc. (Eng),
D.V. SAFONOV[1], Cand Sc. (Eng)

[1] *National Research Center "Kurchatov Institute", 1 Akademika Kurchatova Square, 123182 Moscow, Russian Federation. E-mail: frolov_as@nrcki.ru*

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

[3] *A.A. Bochvar High Technology Scientific Research Institute for Inorganic Materials (VNIINM), 5a Rogova St, 123098 Moscow, Russian Federation*

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Abstract—The paper presents the results of electron microscopic studies of ferrite-martensitic steel samples hardened with Y–O oxides, EP-450 DUO in the initial state and after neutron irradiation in the BN-600 reactor at 1000°C to a damaging dose of 77.5 dpa. These studies showed that the main types of oxide phases were $Y_2(Si, Ti)_2O_7$ and $Y_2(Si, Ti)O_5$. These precipitates at sizes less than 10–20 nm were semi-coherent with a ferritic matrix of steel EP-450 DUO with the ratio $(110)_{matrix}//(221)_{particle}$. Some of the Y–Ti–O oxides in the initial state were $Y_2Ti_2O_7$-type with some deviations from the stoichiometric composition.

However, after neutron irradiation under BN-600 conditions at temperature ~ 1000°C, oxide particles could not be described by the indicated stoichiometry. Besides, after irradiation, silicon and aluminum were found in the oxide's composition. In the case of taking these elements into account during the construction of a triple composition diagram, it was shown that the oxide phases had $Y_2(Ti, Si, Al)_2O_7$ and $Y_2(Ti, Si, Al)O_5$ types. It was established that in samples of EP-450 DUO steel in the initial state with oxide particles up to 20 nm in size, the yttrium content is generally lower than the titanium concentration. The titanium and yttrium concentrations corresponded to the stoichiometric composition $Y_2Ti_2O_7$ (1:1) with a further increase in the average diameter of these phases. After irradiation, the situation changed somewhat: the yttrium content in most oxide phases exceeds the total concentration of titanium, silicon, and aluminum.

The paper also presents the analysis of porosity and evolution of grain structure in EP-450 DUO steel after neutron irradiation.

Keywords: DUO-steels, oxide phases, neutron irradiation, steel EP-450 DUO

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CORROSION RESISTANCE OF 12% CHROME STEEL UNDER THE OPERATION CONDITIONS OF A STEAM GENERATOR OF A REACTOR PLANT WITH SODIUM COOLANT

A.S. KUDRYAVTSEV, Cand. Sc. (Eng), S.A. SUVOROV, D.A. ARTEMIEVA,
R.M. RAMAZANOV, 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—The influence of an aqueous medium and superheated steam on the corrosion resistance and resistance to corrosion-mechanical destruction of 07Kh12NMFB steel in various operating modes of a steam generator of a promising high-power sodium-cooled reactor plant has been studied. Steel of this grade meets the requirements for the operation of heat exchange pipes and vessel elements of direct-flow steam generators of a reactor plant in terms of corrosion resistance and corrosion-mechanical strength.

Keywords: chromium steel, steam generator, sodium coolant, corrosion resistance, resistance to corrosion-mechanical destruction.

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FEATURES OF THE BEHAVIOR OF THE DISPERSION FUEL METMET UNDER IRRADIATION

L.A. KARPYUK[1], Cand Sc. (Chem), A.M. SAVCHENKO[1], Cand Sc. (Eng),
Yu.V. KONOVALOV[1], Cand Sc. (Eng), G.V. KULAKOV[1], Cand Sc. (Eng), S.V. MARANCHAK[1],
S.A. ERSHOV[1], E.V. MAYNIKOV[1], A.V. KOZLOV[1], Cand Sc. (Eng), A.L. IZHUTOV[2], Cand Sc. (Eng),
V.Y. SHISHIN[2], Cand Sc. (Eng), A.A. SHELDYAKOV[2], V.V. YAKOVLEV[2]

[1]*A.A. Bochvar High Technology Scientific Research Institute for Inorganic Materials (VNIINM), 5a Rogova St, 123098 Moscow, Russian Federation. E-mail: sav-alex111@mail.ru*

[2]*State Scientific Center "Scientific Research Institute of Atomic Reactors" (JSC "SSC RIAR"), 9 Zapadnoe shosse, 433510 Dimitrovgrad, Ulianovsk region, Russian Federation*

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Abstract—The paper considers the behavior under irradiation of the METMET fuel composition, which consists of particles of uranium-molybdenum alloy in a matrix of zirconium alloys. Post-reactor investigations confirmed the satisfactory performance of pilot fuel elements irradiated in the MIR reactor to a burnup of 61 MW day/kgU under significant thermal loads. The structural stability of the fuel under irradiation, good compatibility of the fuel rod components with each other could be noted. Fuel rods with METMET fuel composition have good prospects for use in reactors of floating nuclear power units and low-capacity nuclear plants, as well as a tolerant fuel.

Keywords: atomic energy, fuel element, Zr-based alloys, UMo alloy, MIR reactor

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