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INFLUENCE OF NIOBIUM MICROALLOYING ON THE KINETICS OF STATIC AND DYNAMIC RECRYSTALLIZATION DURING HOT ROLLING OF MEDIUM-CARBON HIGH-STRENGTH STEELS

T.V. KNYAZYUK, Cand Sc. (Eng), N.S. NOVOSKOLTSEV, A.A. ZISMAN, Dr Sc. (Phys-Math), E.I. KHLUSOVA, 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 temperature-strain conditions of dynamic and static recrystallization during hot deformation were determined at a rate of 1 sec–1 for medium-carbon steel microalloyed with titanium, boron, and vanadium containing different amounts of niobium. It was found that under hot rolling conditions niobium prevents the completion of dynamic recrystallization, and at temperatures below 970°C it drastically slows down static recrystallization in the pauses between successive reductions.

Keywords: niobium microalloying, medium-carbon high-strength steel, static and dynamic recrystallization, hot rolling.

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STUDYING THE INTERRELATION OF OPERATING CHARACTERISTICS AND STRUCTURE ZONES OF THERMAL INFLUENCE IN STEELS OF FERRITE-BAINITIC CLASS

S.V. KOROTOVSKAYA, Cand Sc. (Eng), O.V. SYCH, Cand Sc. (Eng), E.I. KHLUSOVA, 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 presents the results of study of changes in the structure, impact and crack resistance in two sections of the simulated heat-affected zone of low-carbon low-alloy steel with a guaranteed yield strength of 420 MPa (section with large grain and section of complete recrystallization). The simulation of various thermal welding cycles was performed on the Gleeble 3800 complex**.**

Keywords: heat affected zone, simulation, coarse-grained region, section of complete recrystallization, structure, ferrite, bainite, cooling rate, impact work, CTOD crack resistance.

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IMPROVEMENT OF THE COLD RESISTANCE OF THE 09G2S STEEL BY PROGRAMMED HARDENING COMBINED WITH ADDITIONAL MEDIUM-TEMPERATURE TEMPERING

M.I. OLENIN, Dr Sc. (Eng), V.I. GORYNIN, Dr Sc. (Eng), V.V. MAKHORIN

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

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Abstract—The article discusses a method of improving the cold resistance of steels of a ferrite-pearlite class. It has been established that the process of programmed hardening, combined with an additional medium temperature tempering, has a positive effect on the cold resistance of thermally improved 09G2S steel. The mechanical properties of steel grade 09G2S were determined before and after additional tempering at medium-temperature. It is shown that the new technology allows the critical temperature of brittleness, determined by the criterion of the energy intensity of failure, to be shifted to lower temperatures by 15°C, and at the same time to increase the impact strength of 09G2S steel three times more at a temperature of minus 90°C without changing its strength properties.

Keywords: ferritic-pearlitic steel, cold resistance, programmed hardening, medium temperature tempering, mechanical properties

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M.I. OLENIN, Dr Sc. (Eng), V.I. GORYNIN, Dr Sc. (Eng), V.V. MAKHORIN

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

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STRUCTURE OF WELDED JOINTS OF 15Kh2MFA STEEL COMPLETED WITH LOW CARBON SURFACING WITHOUT HEAT TREATMENT

M.N. TIMOFEEV, Cand Sc. (Eng), S.N. GALYATKIN, Cand Sc. (Eng), R.I. SAMOYLENKO, Yu.M. MARKOVA

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 the 15Kh2MFA steel structures at various sections of the welded joint performed without heat treatment after welding with low-carbon surfacing. It is shown that there are three zones in low-carbon surfacing, which differ in the content of chemical elements passing from the base metal to the deposited one, as well as in the tendency to form hardened structures during welding.

Keywords: automatic submerged arc welding, weld metal structure, low-carbon surfacing.

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ON THE CHEMICAL COMPOSITION, STRUCTURE AND MECHANICAL PROPERTIES OF ALLOY EP648 FABRICATED BY DEFORMATION, PROJECT DIE CASTING AND SELECTIVE LASER MELTING

O.G. OSPENNIKOVA, Dr Sc (Eng), P.G. MIN, Cand Sc. (Eng), A.M. ROGALEV, V.E. VADEEV

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

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Abstract—The paper studies chemical composition, structure and mechanical properties of the heat-resistant nickel EP648 alloy obtained by deformation, die project casting and selective laser melting. It is shown that the deformed material is characterized by low porosity, high impact strength and ductility, the cast material has large grains, high long-term strength and low-cycle fatigue. The material obtained by selective laser melting is characterized by an increased content of oxygen and nitrogen, fine-grain structure with large variation in grain size strongly expressed and heredity, and also high short-term strength.

Keywords: heat-resistant alloy, deformation, casting, selective laser melting, chemical composition, structure, strength, ductility, fatigue, impact strength.

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EFFECT OF COMBINING CONTINUOUS CASTING AND SIMULTANEOUS SOLID-LIQUID METAL DEFORMATION ON THE STRUCTURE AND PROPERTIES OF ALLOY V95 PRODUCTS

A.M. SERGEEVA[1,2], Cand Sc. (Phys-Math), N.S. LOVIZIN[1], Cand Sc. (Phys-Math),
A.A. SOSNIN[1], Cand Sc. (Eng)

[1] *Federal Research Center "Institute of machine science and metallurgy", Far Eastern Branch, RAS, 1 Metallurgov St, 681005 Khabarovsky Krai, Komsomolsk-na-Amure, Russian Federation, E-mail: mail@imim.ru*

[2] *Institute of scientific and technological innovation, Ltd (Skolkovo Community), 24, ap. 20, Kalinina St, 681007 Khabarovsky Krai, Komsomolsk-na-Amure, Russian Federation*

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Abstract—It is known that the solidification of melts under the influence of external factors leads to the formation of a fine-grained structure in the work pieces which improves the mechanical characteristics of finished metal products. The production of lengthy profiles with a high level of mechanical properties in a short production cycle is a complex interdisciplinary task of great practical importance. The paper presents results of research of the properties of products from aluminum alloy V95, which were obtained by continuous vertical casting combined with deformation in the solid-liquid state during solidification. A diagram of a device that implements such a process of combining is presented; its operation is reviewed. Also, a description is given of a method for producing flat work pieces and sample preparation for studying their mechanical characteristics and microstructure.

As research shows the metal products have a fine-grained structure with a dense directional arrangement of dislocations. The grain boundaries are wide, uneven, consisting of grids and dislocation plexuses. During the melt solidification a thin directional dislocation structure is formed in the crystallizer of the device providing increase of the mechanical characteristics of metal products without additional processing, and there are no shrinkage defects. The possibility of obtaining long metal products with high mechanical characteristics for a short production cycle with reduced power costs was shown.

Keywords: aluminum alloys, microstructure, continuous casting, mechanical properties, crystallization, deformation of a metal in the solid-liquid state.

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FIRST AND SECOND LAWS OF THERMODYNAMICS: RELATIONSHIP, "INCONSISTENCY", HIDDEN EFFECTS

A.M. SAVCHENKO, Cand Sc. (Eng), Yu.V. KONOVALOV, Cand Sc. (Eng),
A.V. LAUSHKIN, Cand Sc. (Eng)

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

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Abstract—The relationship of the first and second laws of thermodynamics based on their energy nature is considered. It is noted that the processes described by the second law of thermodynamics often take place hidden within the system, which makes it difficult to detect them. Nevertheless, even with ideal mixing, an increase in the internal energy of the system occurs, numerically equal to an increase in free energy. The largest contribution to the change in the value of free energy is made by the entropy of mixing, which has energy significance. The entropy of mixing can do the job, which is confirmed in particular by osmotic processes.

Keywords: thermodynamics, free energy, entropy, mixing entropy, configuration entropy, first and second laws of thermodynamics.

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NEW FEATURES OF ROCK-CUTTING TOOLS EQUIPPED WITH DIAMOND-CARBIDE CUTTING ELEMENTS

M.V. VOROBIEVA, Cand Sc. (Eng), S.A. PERFILOV, Cand Sc. (Eng),
A.A. POZDNYAKOV, Cand Sc. (Eng), R.L. LOMAKIN, V.D. BLANK, Dr Sc. (Phys-Math)

Technological Institute for Superhard and Novel Carbon Materials (TISNUM), 7a Tsentralnaya St, 108840 Troitsk, Moscow, Russian Federation. E-mail: vorobjeva@yandex.ru

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Abstract—The paper describes conducted feasibility study and scientific and technical basis for creation of technology for drilling tools with diamond-carbide cutting elements. The results of technological processes of production of diamond-carbide inserts (DCI) manufactured by Technological Institute for Superhard and Novel Carbon Materials (TISNUM), which are designed for operation and implementation in various drilling conditions were presented. The DCI differentiated physic-chemical and performance characteristics, depending on the physic-mechanical properties of rocks formations, the particular construction of wells and other drilling conditions. A complex of studies of physical and mechanical properties of DCI, their relationship with the structural and technological factors, performance of bits equipped with DCI, the nature of bits wear were conducted, including pilot testing of new polycrystalline diamond compact bits (PDC bits) with polycrystalline diamond cutters produced by TISNUM at the facilities of JSC Gazprom Neft. The possibilities of industrial production of DCI and premium drilling bits on the basis of TISNUM

technologies are shown, which will ensure demands of the Russian oil and gas industry, allowing import dependence elimination, and in future start of export. Ultimately, by 2025, with the help of new technologies, it will be possible to occupy up to 25–30% of the global market for drilling tools and equipment.

Keywords: diamond-carbide inserts, drilling tools, PDC bits, wear resistance.

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OPTICALLY ADJUSTABLE NANOCOMPOSITE ELECTROCHROMIC FILM WO_3/*r*GO TO CONTROL LIGHT TRANSMISSION AND PROTECTION FROM ELECTROMAGNETIC RADIATION

A.V. SHCHEGOLKOV, I.D. PARFIMOVICH, F.F. KOMAROV, Dr Sc. (Phys-Math),
A.V. SHCHEGOLKOV, Cand Sc. (Eng), E.N. TUGOLUKOV, Dr Sc. (Eng)

Tambov State Technical University, 106 Sovetskaya St, 392000 Tambov, Russian Federation
E-mail: tstu@admin.tstu.ru

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Abstract—The paper presents results of studies of the optical and electromagnetic properties of the WO_3/*r*GO electrochromic nanocomposite films obtained by mechanical spraying of a water-based dispersed solution with WO_3/GO particles and heat treatment (annealing) at a temperature of 300°C in an inert argon atmosphere for 24 hours. As a result, an electrically conductive phase of reduced graphene oxide *r*GO and crystalline WO_3 were formed.

Keywords: tungsten trioxide, electrochromic films, electromagnetic radiation, optical properties.

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TECHNOLOGY FOR PRODUCING COMPOSITE NANOSTRUCTURED POWDER FOR PROTECTIVE COATINGS

E.Yu. GERASCHENKOVA, A.F. VASILIEV, E.A. SAMODELKIN,
B.V. FARMAKOVSKY, 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—This article presents the results of the development of technology for producing clad powder and coatings based on it. The possibility of obtaining a clad powder using high-speed mechanosynthesis in disintegrator plants is shown on the example of the Hadfield steel–aluminum powder composition.

Keywords: clad powder, Hadfield steel, mechanosynthesis, disintegrator, supersonic cold gas dynamic spraying.

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NANOCOMPOSITE COATING WITH HIGH MICROHARDNESS BASED ON THE AGGLOMERATED Kh20N80-WC POWDER SYSTEM

T.I. BOBKOVA, Cand. Sc (Eng), A.F. VASILIEV, E.A. SAMODELKIN,

B.V. FARMAKOVSKY, 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—This article explores the characteristic and particular features of manufacturing nanostructured composite coatings with high microhardness from agglomerated powders of Kh20N80-WC system manufactured by high-speed mechanosynthesis. The properties of the functional coatings deposited by both supersonic cold gas-dynamic and microplasma spraying are studied.

Keywords: high-speed mechanosynthesis, shock disintegration, supersonic cold gas-dynamic spraying, microplasma spraying, microhardness.

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ELECTROCHEMICAL DEPOSITION OF NANOCRYSTALLINE Ni–W COATINGS FROM CITRATE ELECTROLYTES

A.V. KRASIKOV[1], Cand Sc. (Chem), A.D. BYKOVA[1], M.V. MERKULOVA[2], M.A. MARKOV[1], Cand Sc. (Eng)

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

[2] St Petersburg State Institute of Technology, 26 Moskovsky Prospect, 190013 St Petersburg, Russian Federation.

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Abstract—In this paper, requirements for wear-resistant coatings of Ni–40%W manufactured by electrochemical deposition are determined, and the electrolyte stability is studied. The influence of temperature and current density on the deposition of the Ni–W alloy from a citrate electrolyte was researched, and the optimal deposition mode was found. The maximum operating time of the electrolyte is established by the dependence of the current efficiency for the Ni–W alloy on the electric power transmission. The necessity of using membrane electrolyzers during the deposition of nickel-tungsten coatings is substantiated.

Keywords: wear-resistant Ni–W coating, electrochemical deposition, citrate electrolyte, processability of electrolyte, current efficiency.

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WEAR BEHAVIOUR OF METALS IN DRY SLIDING AGAINST MOLYBDENUM WITH CURRENT COLLECTION

M.I. ALEUTDINOVA, Cand. Sc. (Eng), V.V. FADIN, Cand. Sc. (Eng)

Institute of Strength Physics and Materials Science of Siberian Branch of Russian Academy of Sciences (ISPMS SB RAS), 2/4 Pr. Akademichesky, 634056 Tomsk, Russian Federation. E-mail: aleut@ispms.ru

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Abstract—The possibility of high electrical conductivity of dry sliding electrical contact against molybdenum counterbody was studied. It was found that metals W and Cu were not able to form a sliding electrical contact with high wear resistance at current density higher 100 A/cm^2. The characteristics of the contacts of iron containing metals were slightly better than the contact characteristics of non-ferrous metals due to weaker adhesion. Using X-ray phase analysis, it was shown the absence of oxides in the sliding zone of non-ferrous metals. This led to their strong wear and contact's low electrical conductivity. In the contact zone of iron containing samples the formation of FeO was observed that made it possible to reduce wear. This means that high electrical conductivity is unattainable in sliding with current collection against molybdenum.

Keywords: structure and phase composition of the surface layer, viscous plastic flow of the transfer layer, deterioration and wear of the sliding surface, sliding electrical contact, electrical conductivity of the sliding contact

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FIBER-BASED HYBRID POLYMERIC COMPOSITES FOR AVIATION: A review

E.D. KOLPACHKOV, A.O. KURNOSOV, A.P. PETROVA, Dr Sc. (Eng),

A.E. RASKUTIN, Cand Sc. (Eng)

Federal State Unitary Enterprise "All-Russian Scientific Research Institute of Aviation Materials" (FSUE VIAM), 17, Radio St, 105005 Moscow, Russian Federation. E-mail: admin@viam.ru

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Abstract—This article discusses the main classification criteria for hybrid polymer composite materials based on fibrous fillers. Their distinctive features are analyzed; examples of hybrid PCMs are given. The experience of FSUE VIAM in the creation of hybrid PCMs is considered.

Keywords: polymer composite materials, product aviation purpose, hybrid composite materials.

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ON THE DEFINITION OF FIRE-SAFETY CHARACTERISTICS FOR THREE-LAYER COMPOSITE POLYMERS IN SHIPBUILDING STRUCTURES

V.S. TRYASUNOV[1], Cand Sc. (Eng), I.V. LISHEVICH, Cand Sc. (Eng), G.I. NIKOLAEV[1], Dr Sc. (Chem), E.L. SHULTSEVA[1], V.E. BARUEV[2], A.V. MAKHANKO[2]

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

[2] Central Design Bureau for Marine Engineering "Rubin", 90 Marata St, 191119 St Petersburg, Russian Federation.

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Abstract—The article considers approaches and requirements for fire-safety characteristics definition of composite polymeric materials in shipbuilding. The results of experimental determination for such characteristics for three-layer composite polymeric material and fiberglass layer as an example are provided. The need for the development of domestic regulatory documentation on the correct requirements for testing multilayer PCM and data interpretation has been identified.

Keywords: fiberglass, three-layer composite polymer, fire-safety, combustibility, shipbuilding.

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THEORETICAL AND EXPERIMENTAL STUDIES OF COMPOSITE MATERIALS REINFORCED BY CARBON FABRICS.
Part 5: Simulation and experimental research of deformation of the carbon fabric structure

B.M. PRIMACHENKO[1], Dr Sc. (Eng), K.O. STROKIN[2], Cand Sc. (Eng)

[1]St Petersburg State University of Industrial Technologies and Design, 18 Bolshaya Morskaya St, 191186 St Petersburg, Russian Federation. E-mail: primbm@mail.ru

[2]Concern NPO Aurora, 15 Karbysheva St, 194021 St Petersburg, Russian Federation

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Abstract—Results of simulation and experimental research allowed us to obtain values of deformation characteristics of carbon fabric structure. Experimental data were processed according to methods of measurement of state system for ensuring the uniformity of measurements. Theoretical and experimental data have good coincidence, confirming high quality of mechanic-analytical model for deformation of the carbon fabric structure.

Keywords: carbon fiber, woven structure, reinforcing component, composite material, mechanical-analytical model.

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ESTIMATE OF EARLY STAGES OF DESTRUCTION DURING STRESS CORROSION CRACKING OF PIPE STEELS BY EDDY CURRENT METHOD

Ye.N. BUTUSOVA[1,3], V.V. MISHAKIN[2,3], Dr Sc. (Eng)

[1] *Shipbuilding company AEROKHOD Ltd., 37E Shcherbakova, 603003 Nizhny Novgorod, Russia. E-mail: Anelka13@yandex.ru*

[2]*Mechanical Engineering Research Institute of RAS – branch of Institute of Applied Physics of the RAS, 85 Belinskogo St, 603024 Nizhny Novgorod, Russian Federation, E-mail: imndt31@mts-nn.ru*

[3] *Nizhny Novgorod State Technical University named after R.E. Alekseev (NNSTU), 24 Minin St., 603950 Nizhny Novgorod, Russian Federation, E-mail: imndt31@mts-nn.ru*

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Abstract—The paper studies stress corrosion cracking (SCC) of low carbon low alloyed steels. It is shown that the use of eddy current method allows us to evaluate modifications of fine structures associated with the processes of initiation and growth of stress corrosion cracks. The dependences of the incubation time on the value of the macroelasticity limit σ_0 are given. It is noted that the increase in the value of σ_0 leads to an increase in the time before the initiation of the first crack. This can be explained: the limit of macroelasticity determines the beginning of microplastic flow in the material. On the basis of experimental data, the analytical dependence of the incubation period of the SCC on the value of the macroelasticity limit is obtained. The calculation error did not exceed 10%. A parameter is proposed for assessing the state of the material subject to SCC. It allows recording the passage of the stages of accumulation of microdamages and the moment of exhaustion of a significant part of the material resource before the appearance of multiple surface macro-cracks according to the data of eddy current measurements.

Keywords: low-carbon steel, stress corrosion cracking (SCC), eddy current method, crack, macroelasticity limit.

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EVALUATION OF CORROSION RESISTANCE OF MATERIALS UNDER CONDITIONS OF MOISTURE CONDENSATION IN THE PRESENCE OF CARBON DIOXIDE

R.K. VAGAPOV, Cand. Sc (Chem), D.N. ZAPEVALOV, Cand. Sc (Eng),

K.A. IBATULLIN, Cand. Sc (Chem)

Research Institute of Natural Gases and Gas Technologies Gazprom VNIIGAZ LLC, 15/1Projected passage No 5537, Razvilkovskoye rural settlement, Leninsky District,142717 Moscow Region, Russian Federation. E-mail: R_Vagapov@vniigaz.gazprom.ru

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Abstract—The paper investigates aspects of the development of corrosion processes under conditions of moisture condensation in the gas phase in the presence of carbon dioxide, which lead to the formation of local damage. The authors developed and tested a methodology for conducting steels corrosion testing. The causes of the formation and the corrosive effect of moisture condensation on steel under conditions of carbon dioxide corrosion at gas production facilities are analyzed. It was found that at elevated temperatures, when the temperature difference is higher, more moisture condenses on the surface of the steel, which leads to an increase in the rate of both general and local corrosion by 2–3 times, compared to room temperature. The increased localization of corrosion processes under conditions of moisture condensation and the presence of CO_2 makes the depth index of steel corrosion much higher than the general corrosion rate. When assessing the corrosiveness of environments with condensation of the aqueous phase, the rate of corrosion associated with the depth of the observed corrosion damage should be taken into account. According to the test results, it was determined that samples from the weld compared with the sample from the main body of the pipe differ in the degree of localization of corrosion in conditions of moisture condensation.

Keywords: corrosion resistance, moisture condensation, corrosion rate, local corrosion, carbon dioxide, local corrosion defects.

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