ABSTRACT AND REFERENCES
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THE EFFECT OF EXTERNAL MAGNETIC FLUX FIELD IN THE QTS WELDMENT ON THE CHANGE OF FATIGUE CRACK PROPAGATION BEHAVIORS (p. 4-11)

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This investigation discusses fatigue crack propagation behaviors on the welded joint of Hot Rolled Quench Tempered Steel (QTS) in which during welding process the fusion zone of the joint was subjected to magnetic flux field. The QTS weldability is not really excellent due to the change of microstructure into tempered martensite, and the possibility of microcrack defect on the welding area is still high. The purpose of the investigation is to know the effect of External Magnetic Flux (EMF) field during welding process on fatigue crack propagation behaviors. The external magnetic flux is applied transversely from two sides of the workpiece using a DC powered solenoid of 0, 3, 6, 9 and 15 Amperes. The effect of EMF is more sensitive to decrease the tensile strength and the fatigue crack propagation rate of the weld area. The result shows that the electromagnetic force on the weld pool increases. It causes the liquid metal circulation rate to increase and welding defects to decrease. This indicates that the liquid metal and filler metal are easily mixed, the release of gas from liquid metal to surface before solidification easily happens. The finding shows that the effect of EMF is more efficient.

Keywords: crack propagation rate, crack resistance, external magnetic flux, martempering, martensite, QTS, weldability.

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STUDY OF THE INFLUENCE OF OXIDIZING PARAMETERS ON THE COMPOSITION AND MORPHOLOGY OF $Al_2O_3{\cdot}CoO_x$ COATINGS ON AL25 ALLOY (p. 11-19)

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The influence of operating parameters of plasma-electrolytic oxidation in diphosphate cobalt-containing electrolyte on the process of formation of oxide coatings on alumosilicon alloy AL25 (GOST 1583) was studied. It was shown that inclusion of cobalt into the composition of surface oxide layers leads to a change of morphology and topography of the surface. Variation of current density and PEO time allows flexible control of the process of incorporation of the catalytic component into the matrix of oxide of basic metal. It was shown that at an increase in oxidation time, cobalt content in the surface oxide layer increases.

The rational mode of plasma-electrolytic treatment of piston alloy in diphosphate electrolyte for obtaining oxide coatings, enriched with cobalt, was substantiated. It is advisable to perform formation of PEO-coatings on AL25 with developed globular-mosaic surface, maximum cobalt content, with minimizing impurities in the range of current densities of 3–5 A/dm^2 within 20–40 min. The obtained cobalt-containing oxide coatings can be used in the air and water purification systems, specifically, for intracylinder catalysis of gas emissions of internal combustion engines.

Keywords: piston silumin, AL25, plasma-electrolytic oxidation, oxide coating, surface morphology.

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EFFECT OF HEAT TREATMENT AND CRYOGENICS ON HARDNESS OF DUCTILE CAST IRON MICROSTRUCTURE (FCD50) (p. 20-26)

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The results of researches of possibilities of increasing the mechanical properties of pig iron with ball-bearing graphite of brand FCD-50 by the combined heat treatment are described. The scheme of multistage heat treatment, the characteristic feature of which is the operation of cooling in liquid nitrogen, is proposed. The use of such a scheme allows for increased HRC hardness characteristics. The study of the microstructure of cast iron treated with this scheme has proved the efficiency of the cryogenic heat treatment stage and determined its rational regimes.

To match or approximate the properties of steel, the mechanical properties of this ductile cast iron 50 (FCD-50) must be enhanced by methods such as ACTDI (austemper cryogenic and temper Ductile Iron). In this procedure, the FCD-50 specimen is inserted into the electric kitchen heater at 350 °C (room temperature), heated to 600 °C and held at this temperature for 45 minutes. Next, the specimen is heated to 900 °C and held at this temperature for 1 hour (temperature austenisation). Then, the specimen is placed in furnace 2 at 3,000 °C for 45 minutes (austempering process). The specimen subsequently is cooled in liquid nitrogen. In this study, additional specimens were obtained for hardness and microstructure tests. The as-cast test yielded a hardness value of 18.39 HRC. In the hardness test for the ACTDI process, 12 hours of submersion yielded the highest hardness result of 24.25 HRC. In terms of the changes in microstructure after soaking changes, the amount of perlite present in the specimen was greater than that of ferrite, and the arrangement of graphite nodules was better than that of the as-cast material.

Keywords: FCD-50, spheroidal graphite cast iron, thermal treatment, cryogenic treatment, hardness, microstructure.

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DETERMINING THE PATTERNS OF PHASE AND STRUCTURAL TRANSFORMATIONS AT CARBONTHERMAL REDUCTION OF MOLYBDENUM CONCENTRATE (p. 27-32)

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We have studied patterns in the influence of O/C in the charge on the content of C, O_2, and Mo in metallized molybdenum concentrate after different temperatures of thermal treatment. it was determined that O/C at 1.75–2.00 in the charge after treatment at 1,223–1,423 K provides for the content of Mo in metallized molybdenum concentrate at 74.6–78.0 % by weight. The content of C and O_2 was 0.5–2.0 % by weight, and 0.6–5.5 % by weight, respectively. At O/C in the charge at 2.50, the products of reduction after heat treatment at 1,323 K consisted of Mo and MoO_2. The residual molybdenum-containing oxide component is due to the insufficient amount of a reducing agent. The presence in the phase composition of carbide Mo_2C together with Mo was found at O/C in the charge at 1.33, indicating a certain excess of the carbon reducing agent. The most favorable conditions for reduction were ensured at O/C in the charge at the level of 1.83 with a transition of most of the oxides to the metal phase of Mo. We have obtained a spongy structure of the metallized product, which ensures an increased rate of dissolving the obtained molybdenum-containing additive in a liquid metal at alloying. We did not identify in the phase composition any compounds susceptible to sublimation, which predetermines a reduction in the losses of Mo when using an alloying additive.

Keywords: molybdenum concentrate, carbothermal reduction, phase analysis, microscopic study, carbide formation, alloying.

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SIMULATION OF STRUCTURE FORMATION IN THE Fe–C–Cr–Ni–Si Surfacing Materials (p. 33-38)

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The paper investigates the formation of equilibrium phase state in the surfacing materials 300Cr25Ni3Si3 and 500Cr40Ni40Si2BZr, obtained by electric arc surfacing that employs powder tapes PL AN-101 and PL AN-111. This makes it possible to determine the relationship between chemical composition of the tape and the structure of the formed coating. To examine the patterns of phase transformations during crystallization, we applied thermodynamic simulation using the "Thermo-Calc Software". Phase diagrams of the system Fe-Cr-Ni-Si-C were constructed and analyzed; it was established that the alloys in equilibrium belong to the hypereutectic alloys. Their crystallization starts with the formation of primary carbides M_7C_3 with a hexagonal lattice and ends with the eutectic transformation "Liquid → Austenite + M_7C_3". The alloy 500Cr40Ni40Si2BZr at a temperature below 1,081 °C undergoes carbide transformations $M_7C_3 \leftrightarrow M_3C_2$. In the alloy 300Cr25Ni3Si3, austenite partially transforms into ferrite in a temperature range below 830 °C. At 600 °C, the alloys consist of the following phases: the alloy 300Cr25Ni3Si3 – austenite, ferrite, and carbide M_7C_3; the alloy 500Cr40Ni40Si2BZr – austenite and carbides M_7C_3 and M_3C_2. It was established that the molar fraction of carbides in the alloy 500Cr40Ni40Si2BZr is considerably higher than that in the alloy 300Cr25Ni3Si3 (56 mol. % and 41 mol. %, respectively). We analyzed a change in the volumetric fraction and phase chemical composition of the alloys depending on temperature. The data obtained make it possible to predict the behavior of alloys under specific operating conditions.

Keywords: wear-resistant coating, thermodynamic simulation, equilibrium crystallization, chromium carbides, chromium eutectic, austenite.

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INFLUENCE OF THE THERMAL FACTOR ON THE COMPOSITION OF ELECTRONBEAM HIGHENTROPY ALTiVCrNbMo COATINGS (p. 39-46)

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This paper reports results of studying the element and phase compositions of electron-beam coatings based on the high-entropy alloy AlTiVCrNbMo, depending on the deposition temperature (in the range of 300...700 °C).

The high-entropy alloys were melted in an arc furnace in an atmosphere of high-purity argon. Vacuum condensates of the high-entropy alloy (AlTiVCrNbMo) with a thickness of 3–5 μm were obtained in the vacuum setup UVN-2M-1 at a working vacuum of $5 \cdot 10^{-5}$ mTorr. The alloy evaporation was performed from the water-cooled ingot mold using an electron-beam gun with a power of 5 kW. Condensation of vapors of all the elements of the alloy was performed onto copper substrates at temperatures of 300, 500, 700 °C.

Based on analysis of the element composition of materials of the target made of the high-entropy six-element alloy AlTiVCrNbMo and electron-beam coatings, based on it, we established the critical parameter (specific heat of vaporization of an element) that defined a selective change in the element composition. In accordance with a characteristic change in the composition of coatings of the multi-element high-entropy alloy, 3 groups of elements were distinguished: with a specific heat of evaporation of 280...350 kJ/mol (group 1), 420...460 kJ/mol (group 2), and 590...680 kJ/mol (group 3). It was shown that the formation of a single-phase coating of the high-entropy alloy (based on BCC of the crystalline lattice) occurs at the higher deposition temperature of 500...700 °C when the coating consists of not less than 5 elements.

It was established that based on the conditions for an electron-beam process of materials formation, the results obtained can be divided into two types: those determined by the condition of evaporation of the target and those determined by the conditions of coating deposition. The density of flows of elements, evaporated from the target, is determined by their specific heat of evaporation. However, the ratio of atoms in the flow, derived in this way, may not be retained in the formed coating due to the secondary evaporation of elements from the growth surface. The obtained results allow us to substantiate principles for the selection of components for achieving the optimal element and phase compositions of high-entropy alloys.

Keywords: high-entropy alloy AlTiVCrNbMo, electron-beam coating, thermal factor, element composition, phase composition.

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PREDICTION OF SPECIFIC ELECTRICAL RESISTIVITY OF POLYMERIC COMPOSITES BASED ON CARBON FABRICS (p. 46-53)

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We have proposed an improved approach to forecasting electrical resistivity of composite materials based on carbon fabrics by using a finite element method that takes into consideration a deformation of the reinforcing material during molding. Electrical characteristics of homogenized reinforcing fibers are determined by using known dependences for unidirectional composites. Based on the developed approach, we calculated values of electrical resistivity of composite materials based on the carbon fabric of twilled weaving and the weft-knitted carbon fabric. To account for a change in the thickness of the weft-knitted carbon fabric during molding, we simulated its deformation under the action of vacuum pressure. The obtained calculated values of electrical resistivity of the examined materials are in good agreement with the results of experimental study. Divergence between the calculated and experimental results for a material based on the carbon fabric of twilled weaving is 10 %. For materials based on the weft-knitted carbon fabric, divergence is 11 % towards the weft and 32 % in the direction of the base of the fabric.

Given that the volumetric fiber content in a material from the weft-knitted carbon fabric was determined based on the results of modeling its deformation at molding, as well as the results of similar studies, reliability of the simulation can be considered quite satisfactory. The proposed approach could be applied when choosing a rational scheme for weaving a fabric in order to estimate specific resistivity in the absence of information about volumetric fiber content and the actual structure of the material after its fabrication.

Keywords: composite material, carbon fiber, specific electrical resistivity, finite element method.

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DEFINITION OF THE AGING PROCESS PARAMETERS FOR NICKEL HYDROXIDE IN THE ALKALINE MEDIUM (p. 54-60)

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The parameters of the aging process of nickel hydroxide in the alkali medium, depending on aging time and presence of cobalt hydroxide additive, have been determined. It was revealed that the aging process is governed by re-crystallization of nickel hydroxide and it also occurs through the ordering of crystal lattice defects, including in the direction along (001) plane. It was determined that aging results in a significant decrease of the utilization coefficient of nickel hydroxide. It was also revealed that the aging rate is high initially, but decreases overtime. It was determined that the utilization coefficient for nickel hydroxide with and without cobalt hydroxide had decreased by 37 % and 47 %, respectively, after aging in 4.5M KOH for 56 days. The mechanism describing the change of the average discharge potential for the aged samples with cobalt hydroxide has been proposed. It is assumed that aging of nickel hydroxide with cobalt hydroxide leads to the formation of a layered double hydroxide film on the surface of nickel particles.

Keywords: aging, nickel hydroxide, $Ni(OH)_2$, $Co(OH)_2$, alkaline accumulator, utilization coefficient, defect, crystal lattice

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