ABSTRACT AND REFERENCES

MATERIALS SCIENCE

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THE INFLUENCE OF THE PACK DECARBURIZING PROCESS WITH PINCTADA MAXIMA SHELL POWDER AGENT ON THE PROPERTIES OF HIGH CARBON STEEL (p. 6-13)

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In the present study, ductility enhancement of high carbon steel AISI 420 was conducted by pack decarburizing method to improve mechanical properties of this steel. This specimen was placed in a rectangular box containing pinctada maxima shell powder (PMSP) mixed with the carburizing agent with different percentage variations and heat treated in an oxygen atmosphere at different temperatures and soaking times. Phase analysis results indicated that the pack decarburizing process at a temperature of 900 °C, for soaking time 3 hours and an additional 30 % PMSP in the carburizing agent causing the martensit microstructure, the surface hardness number and thickness of carbon layer decreased but the impact energy of high carbon steel AISI 420 increased. The surface hardness number, carbon layer thickness each respectively decreased by 63 % and 60 %, but impact energy or impact strength increased by 33 %. This phenomenon indicates that the pack decarburizing treatment causes carbon diffusion from the surface of the specimens to the carburizing agent or reverse carbon diffusion occurs, because the concentration of carbon in the carburizing agent is higher than the surface of the specimen. The addition of PMSP in the carburizing agent increases the occurrence of carbon diffusion from the surface of specimens to the carburizing agent or reverse carbon diffusion occurs, because differences in concentration and influence of PMSP contains elements of Ca which function as catalysts or energizers. The results show–that the pack decarburizing process with an additional PMSP in the carburizing agent accelerates the diffusion of carbon atoms out the surface of the specimens (reverse carbon diffusion process), thus decreasing the thickness of the surface carbon layer, surface hardness number and increasing the impact energy.

Keywords: steel AISI 420, Pinctada maxima shell powder, pack decarburizing, diffusion process, surface hardness number, carbon layer thickness, impact energy.

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CHANGE IN THE PHYSICALMECHANICAL AND DECORATIVE PROPERTIES OF LABRADORITE UNDER THERMAL EXPOSURE (p. 14-20)

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We have experimentally investigated samples from the four fields of coarse-grained labradorite, which is extracted in Ukraine. The samples of labradorite were tested at high temperatures of 200, 300, 400, 500, 600, 700, 800, 900 °C.

Red spots at the surface of samples is the result of oxidation of the metal Fe2+: at different fields of labradorite they cover a different area of the sample's surface of natural stone: it ranges from 39 to 60 %. An analysis of the polished labradorite surface after heating revealed that red inclusions are evenly distributed over the surface of labradorite samples. Oxidation of minerals, which is visually observed on all the samples of labradorite, starts at a temperature of 300 °C. One of the features in the research described in this paper is the application of digital image processing in order to quantitatively assess the Fe oxidation area (red spots) at the polished surface of labradorite samples. To a temperature of 500–600 °C, there is a gradual increase in the oxidized area of the samples' surface. At temperatures above 700 °C, there is a sharp increase in the oxidized area at the samples' surface. In general, the oxidized spots of metals cover between 40 to 60 % of the surface of labradorite samples.

When heated, the labradorite samples become 50 % brighter than the original value for indicator L in the color system Lab.

A decrease in the velocity of ultrasonic wave propagation in labradorite samples occurs evenly, without surges. The reason for a decrease in the ultrasonic wave velocity is the formation of defects and cracks in labradorite samples due to an uneven thermal expansion of minerals. At a temperature of 700 °C ° or higher, there is a decrease in the velocity of ultrasound wave propagation in the samples of natural stone.

At heating, there is a decrease in the indicators for gloss in all labradorite samples. In general, when labradorite was heated up to 900 °C, the samples from the Ocheretyansky deposit lost 11.21 % of their gloss, from the Neviryvsky deposit – 4.03 %, from the Osnikivske deposit – 33.57 %, from the Katerinovsky deposit – 15.3 %.

Keywords: labradorite, high temperatures, labradorite gloss indicators, decorativeness of natural stone, ultrasonic wave propagation.

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DEFINITION OF THE INFLUENCE OF OBTAINING METHOD ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF Ni $(OH)_2$ POWDERS (p. 21-27)

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Four types of hydroxide were chosen for the study. Two of them were synthesized using the industrial method and are used in alkaline batteries. The other two nickel hydroxide powders were synthesized according to the method described in modern literature. The first hydroxide was synthesized using the hydrolytic method from a solution of nickel salt and urea. The other was synthesized from a solution containing a mixture of nickel and aluminum salts in a 4:1 ratio and was precipitated with a solution of alkali. As a result, all chosen hydroxide powders differ in physico-chemical parameters: structure, phase composition, morphology. Thus, it was revealed that the synthesis method of nickel hydroxide, and in turn, differences in structure and morphology, have a significant impact on electrochemical and other physico-chemical properties of powders.

As a result of measuring specific surface area using the dye absorption method, the measured values of the studied hydroxide were found to be 2.52 m^2/g to 15.44 m^2/g. The measured values were used to calculate diffusion coefficients. The diffusion coefficients were calculated for both anodic and cathodic processes, along with their averaged values. The obtained values of proton diffusion coefficients varied from $9.86 \cdot 10^{-15}$ to $9.87 \cdot 10^{-17}$ cm^2/s.

Comparison and analysis of electrochemical characteristics, specific surface area values and diffusion coefficients allowed making recommendations for hydroxide application.

A mechanism was proposed; that explains the values of specific parameters, and the relation between the structure, synthesis method and physico-chemical parameters was revealed.

Keywords: $Ni(OH)_2$, nickel hydroxide, synthesis method, cyclic voltamperometry, specific surface area, proton diffusion coefficient.

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IMPROVING A RESOURCESAVING SURFACING TECHNOLOGY USING TWO RIBBON ELECTRODES WITH A CONTROLLED TRANSFER OF ELECTRODE'S METAL (p. 28-34)

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This paper reports results of research into a resource-saving technology of surfacing with two ribbon electrodes with a controlled transfer of the electrode's metal from the end sides of ribbon electrodes and with an adjustable ratio between the ribbon electrodes' feed speed. To implement the proposed technology of surfacing, we designed a device that makes it possible to change the ratio between feed speeds of the first and second electrodes in a wide range. That provides for a controlled heat-mass transfer to the welding bath. As well as, accordingly, a controlled fusion of ribbon electrodes and the distribution of thermal energy throughout a welding bath. This makes it possible to improve quality of the surfaced products using a simple and reliable resource-saving device.

A given design makes it possible to optimize parameters for a pulsed mechanical transfer and prevent the deformation of ribbon electrodes, to ensure an alternating reciprocation motion of the ribbon electrodes' end sides at optimal frequency and amplitude. That provides for the optimal size of the surfaced bead while making it possible to reduce the consumption of an electrode's metal for loss and overheating, and, accordingly, the consumption of energy for melting, as well as ensure a resource saving technology of surfacing.

The process of surfacing with two electrodes, even when using fluxes recommended for arc welding, occurs partially similar to the electroslag process, because a certain percentage of current is shunted by the molten slag. This helps reduce the depth of welding and lowers the share of the base metal in the surfaced metal. The main advantage of surfacing with two ribbon electrodes is obtaining the surfaced metal with the required chemical composition as early as in the first or second layer, in contrast to the single-electrode surfacing where it is necessary to apply from 3 to 5 layers.

Results of research into the influence of oscillation frequency of ribbon electrodes have revealed that the maximum increase in a melting coefficient occurs at oscillation frequency in the range of 45–55 Hz regardless of other mode parameters.

Keywords: surfacing, ribbon electrode, resource-saving technology, controlled heat-mass transfer.

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STUDYING THE AUTHENTICITY OF THE GOLDEN ELEMENT FROM A MONGOLIAN WARRIOR'S ARMOR BY PHYSICALCHEMICAL METHODS (p. 34-40)

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We report results from an expert study into the historical artifact of the XIV–XV centuries – the golden armor element of a Mongol warrior. The obtained results allowed us to establish signs of authenticity in the historical values made of gold in a given chronological period.

The microstructure of the object was investigated at a magnification of 10–20 times, revealing significant fragility and frailty of the metal. At magnification by 150–200 times, we found the system of cracks with triple points, individual caverns, and a cavernous character of the fracture. Furthermore, we have revealed many dislocations of fractures and traces of the metal flow at the surface of the item, as well as traces of tools that had been used to clean it. At magnification by 2,000 times, we found an extremely complex morphology of the metal with numerous caverns, as well as the surface of partially dissolved metal, which retains the contours of ancient scratches.

We have established that the deeper parts of the alloy partially retained their chem ical composition, and the concentration of gold in them is only 62–80 %, while the alloy was refined at the surface in a natural way, therefore, the gold content in it was determined to be within 81–98 %. In addition, in the deeper parts of the alloy, silver concentrations are larger compared with the surface layers, because silver compounds are chemically more active and are carried away from the surface under the action of external factors.

We have determined a list of features that indicate the authenticity of the object, and which are unambiguously detected using an electron microscope, as well as based on the results of studying the chemical composition of the surface of the artifact by emission method. In our opinion, it is efficient to use electron microscopy in experts' work in order to confirm authenticity, to identify signs of forgery and traces of restoration of artifacts made from gold alloys.

Keywords: electron microscopy, alloy microstructure, signs of authenticity, historical values made of gold.

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DESIGN AND EXAMINATION OF THE NEW BIOSOLUBLE CASTING ALLOY OF THE SYSTEM Mg–Zr–Nd FOR OSTEOSYNTHESIS (p. 40-48)

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We have performed a comparative analysis of existing materials for the fabrication of implants and report their physical-mechanical properties; their advantages and disadvantages have been defined. It is shown that magnesium alloys are among the most promising biosoluble materials. They are bioinert and biocompatible, but their use in osteosynthesis is limited mainly by their inadequate mechanical properties due to the high rate of biodegradation, which requires improving them by changing the chemical composition of the alloy.

In order to develop a new magnesium-based biosoluble alloy, we have selected the most suitable doping systems in accordance with the established criteria.

Employing the methods of experiment design, we studied the separate and joint influence of zirconium, neodymium and zinc on structure formation and mechanical properties of magnesium alloy. Mathematical models have been constructed that describe the influence of the examined alloying elements on the mechanical properties of the metal. Using the regression equations derived, we have carried out the optimization of the chemical composition of magnesium alloy.

The industrial and pre-clinical tests of implants made from the designed biosoluble alloy have been performed. Experiments on animals confirmed the absence of toxic effect from the products of degradation of the devised magnesium alloy on a living organism. Studying the influence of the designed alloy on reparative osteogenesis during experiment on rabbits has shown the positive dynamics of bone tissue regeneration without noticeable changes in its structure, which ensures reliable merging of elements in bones at osteosynthesis.

It was established that the implants made from the designed alloy possess the necessary level of mechanical properties that match the mechanical properties of bone tissue. At the same time, they are non-toxic and provides a secure bone tissue healing until the complete fracture consolidation. Positive results of the experiments conducted allow us to suggest a favorable prognosis on the possibility of using implants made from the devised biosoluble alloy of the system Mg–Zr–Nd in humans.

Keywords: alloying elements, experiment design, tensile strength, relative elongation, chemical composition, optimization.

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DETECTING THE INFLUENCE OF HEAT SOURCES ON MATERIAL PROPERTIES WHEN PRODUCING AVIATION PARTS BY A DIRECT ENERGY DEPOSITION METHOD (p. 49-55)

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Quality of the material obtained by the method of direct energy deposition using three heat sources (plasma arc, electric welding arc and welding arc with cold metal transfer) was studied. AlMg5 alloy wire was used as the filler material.

The study was conducted to establish at what heat source the deposited material will have the highest physical and mechanical characteristics and performance. It was also necessary to assess quality, size and uniformity of distribution of the deposited layers since these indicators determine accuracy of the resulting product and make it possible to reduce machining allowance.

Influence of heat sources on formation of surface of deposited plates was revealed: the specimens obtained by the method of plasma surfacing had protrusion height of the deposited layers on the side surface up to 2 mm, the specimens obtained by the method of electric arc and CMT surfacing had protrusion height of 0.5 mm. The obtained data will enable determination of the minimum allowable machining allowance.

Analysis of chemical composition has shown that each heat source ensured chemical composition of the finished product corresponding to chemical composition of original material. Distribution of alloying elements was uniform among the deposited layers. However, the CMT process provided the most accurate distribution of alloying elements.

Physical and mechanical properties of the plates obtained by the direct growth method were approximately at the same level with the materials obtained using conventional methods of casting and pressing.

The specimens obtained by the method of plasma surfacing had the highest values of mechanical properties: σ_t=28 MPa; $\sigma_{0.2}$=15 MPa; δ=30.4 % which can be explained by a more dispersed structure and a high level of fusion of the deposited layers.

The obtained data will make it possible to determine which heat source is more expedient to use in order to obtain properties necessary for a concrete technological process. They also make it possible to evaluate applicability of the method of direct growth using arc heat sources in mass production of parts.

Keywords: additive technologies, plasma surfacing, direct growth, cold metal transfer.

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