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TECHNOLOGIES OF STRENGTHENING AND RESTORATION BY ELECTRODEPOSITION OF COMPOSITE COATINGS

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The technology of restoration and surface strengthening of machine parts with composite electrochemical coatings, which include a dispersed phase in the form of molybdenum disulfide and a matrix of iron-phosphorus alloy, which provides a significant increase in the level of operational properties, is substantiated.
Key words: *electrolysis, concentration, electrolyte, wear, strength.*

Problem. Electrodeposition of wear-resistant coatings from electrolyte suspensions (ES) with subsequent electrothermal treatment is a promising direction in the development of the technology of restoration and improvement of wear resistance. It is promising, both in the field of increasing the KEP, which will allow creating materials with high wear resistance, and in the field of obtaining new materials with unique properties with a full remelted coating.

Analysis of research and publications. Currently, electrolytic fertilizing is most widely used in repair production to restore a wide range of steel parts of auto-tractor machinery, parts of agricultural machines, machine tools, and many others [1]. To restore worn parts, electrolysis modes are used, which provide increased hardness of iron precipitates, which provides them with a fairly high wear resistance. The highest hardness are the coatings obtained in the so-called "hard" modes of electrolysis, which are characterized by low temperature (20-30 ° C) and high density of the cathode current (50 A / dm2 and more).

Research results. The process of electrodeposition of composite coatings is carried out on asymmetric alternating current, which allows to increase the speed of deposition in comparison with the stationary mode. The quality of electrodeposition of coatings depends on the electrolysis regimes (acidity, cathodic current density, asymmetry coefficient, concentration of particles of the second phase in the electrolyte and the speed of the electrolyte flow relative to the cathode surface) [2]. Zrostannya tverdosti kompozytsiynykh pokryttiv dosyahayet′sya i za rakhunok zmitsnennya matrytsi dyspersnymy tverdymy chastynkamy. Mikrostruktura matrytsi kompozytsiynykh pokryttiv v bil′shosti vypadkiv kharakteryzuyet′sya podribnennyam zerna. Chastynky druhyy (tverdoyi) fazy pre- pereshkodzhaye rostu zerna, tak yak zaymayut′ v osadi chymali obsyahy i stvoryuyut′ navkolo sebe defektni zony i polya napruzhen′, po suti nadayut′ mekhanichnyy vplyv na zrostayuchi shary osadu. Dyspersni chastynky nadayut′, v zv'yazku z tsym, znachnyy vplyv na zminu tonkoyi struktury osadzhuyuchohosya metalu, tobto zmenshuyut′ rozmiry blokiv mozayiky, zbil′shuyut′ mikroposhkodzhenya krystalichnoyi reshitky i shchil′nist′ dyslokatsiy. Tse spryyaye zrostannyu mikrotverdosti metalevoyi matrytsi i intehral′noyi tverdosti vs′oho kompozytsiynoho pokryttya. V protsesi elektroosadzhenya pokryttya zminyuvaly shchil′nist′ katodnoho strumu i pokaznyk asymetriyi - holovni chynnyky, shcho vplyvayut′ na tverdist′ osadu. Na mikrotverdist′ vplyv mayut′ umovy elektroosadzhenya, a same: kontsentratsiya soli zaliza v elektroliti, temperatura elektrolitu i shchil′nist′ strumu. Pry riznykh znachennyakh tsykh parametriv mikrotverdist′ pokryttiv znakhodyt′sya v diapazoni 1350-6470 Mpa. Naybil′sh m'yaki pokryttya vykhodyat′ pry vysokiy kontsentratsiyi zaliza v elektroliti, vysokiy temperaturi i pry nyz′kiy shchil′nosti strumu. Zbil′shennya shchil′nosti tka, znyzhennya temperatury i zmenshennya kontsentratsiyi suprovodzhuyet′sya posadi- pinnym zrostannyam mikrotverdosti. Naybil′shyy vplyv nadaye kontsentratsiya soli lehuyuchoho elementa. Dlya provedennya doslidiv vykorystovuvaly elektrolit nastupnoho skladu (k·h / m3):- sirchanokysle zalizo - 350 ... 380; - hipofosfit natriyu - 9 ... 10; - kyslotnist′ elektrolitu - 0,9 ... 1,0. V tsey elektrolit vvodylysya rizni kil′kosti poroshku dysul′fidu molibdenu, otrymana suspenziya intensyvno peremishuvalasya propelernoyi mishalkoyu. Na tverdist′ kompozytsiynykh elektrokhimichnykh pokryttiv znachnyy vplyv mayut′ rezhymy elektrolizu: shchil′nist′ katodnoho strumu i, v menshiy miri, vid velychyny pokaznyka asymetriyi. Kontsentratsiya dysul′fidu molibdenu v elektroliti - suspenziyi, a otzhe i zmist yoho v elektroosadzhenykh pokryttyakh, na tverdist′ takykh pokryttiv praktychno ne vplyvaye (kryva 2 na rys. 4.1). V yakosti dyspersnoyi fazy vykorystovuyut′sya m'yaki chastynky dysul′fidu molibdenu, a v yakosti matrytsi - vysokomitsnyy zalizo - fosfornyy elektrolitychnyy splav, tobto rozpodil tverdosti mizh dyspersnoyu fazoyu i matrytseyu maye zvorotnyy kharakter, v porivnyanni z tradytsiynymy kompozytsiynymy elektrokhimichnymy pokryttyamy. M'yaki chastky v tverdiy matrytsi predstavlyayut′ soboyu, po suti, pory, yaki povynni znyzhuvaty mitsnist′ (tverdist′) pokryttya. Pry nevelykomu zmisti dyspersnykh chastynok v pokrytti (<10%), yak tse maye mistse v nashomu vypadku, i pry yikh nevelykykh rozmirakh, nespryyatlyvyy vplyv m'yakykh chastynok na tverdist′ pokryttya shche ne proyavlyayet′sya i tsya kharakterystyka odnoznachno vyznachayet′sya mekhanichnymy vlastyvostyamy matrytsi. An increase in the hardness of composite coatings is also achieved by strengthening the matrix with dispersed solid particles. The microstructure of the matrix of composite coatings in most cases is characterized by grain grinding. Particles of the second (solid) phase prevent grain growth, as they occupy considerable volumes in the sediment and create defective zones and stress fields around them, essentially exerting a mechanical influence on the growing layers of the sediment. Dispersed particles have, in this regard, a significant influence on the change in the fine structure of the deposited metal, that is, they reduce the size of the mosaic blocks, increase the microdamage of the crystal lattice and the density of dislocations. This contributes to the growth of the microhardness of the metal matrix and the integral hardness of the entire composite coating. In the process of electrodeposition of the coating, the density of the cathode current and the asymmetry index were changed - the main factors affecting the hardness of the deposit. Microhardness is influenced by electrodeposition conditions, namely: iron salt concentration in the electrolyte, electrolyte temperature, and current density. With different values of these parameters, the microhardness of coatings is in the range of 1350-6470 MPa. The softest coatings are obtained with a high concentration of iron in the electrolyte, high temperature and low current density. An increase in tissue density, a decrease in temperature, and a decrease in concentration are accompanied by a gradual increase in microhardness. The greatest influence is exerted by the concentration of the salt of the alloying element. For conducting experiments, the electrolyte of the following composition was used (kg / m3): - iron sulfate - 350 ... 380; - sodium hypophosphite - 9 ... 10; - electrolyte acidity - 0.9 ... 1.0. Different amounts of molybdenum disulfide powder were introduced into this electrolyte, the resulting suspension was intensively mixed with a propeller stirrer. Electrolysis regimes have a significant influence on the hardness of composite electrochemical coatings: cathode current density and, to a lesser extent, the value of the asymmetry index. The concentration of molybdenum disulfide in the suspension electrolyte, and therefore its content in electrodeposited coatings, has practically no effect on the hardness of such coatings (curve 2 in Fig. 4.1). Soft particles of molybdenum disulfide are used as the dispersed phase, and a high-strength iron-phosphorus electrolytic alloy is used as the matrix, i.e., the hardness distribution between the dispersed phase and the matrix is reversed compared to traditional composite electrochemical coatings. Soft particles in a solid matrix are, in fact, pores that should reduce the strength (hardness) of the coating. With a small content of dispersed particles in the coating ($<10\%$), as is the case in our case, and with their small sizes, the adverse effect of soft particles on the hardness of the coating is not yet manifested and this characteristic is clearly determined by the mechanical properties of the matrix. When studying the influence of electrodeposition modes on the internal stresses arising in the iron-phosphorus matrix, the following was found. When increased in the iron-phosphorus alloy, they increase significantly and at DK≈50 A / dm2 reach σvn≈600 MPa. At such high tensile stresses, cracking of iron-phosphorus coatings is observed. Internal voltages in iron-phosphorus coatings also increase when the acidity of the electrolyte decreases (by increasing the value of the hydrogen pH indicator). However, the influence of electrolyte acidity on internal voltages in electrolytic precipitation is much smaller than the influence of cathodic current density. An increase in the asymmetry of the electrolytic current has an ambiguous effect on the internal voltages in iron-phosphorus precipitates. When this indicator (β) increases from the minimum values to $\beta = 6\text{-}7$, a gradual increase in internal stresses is observed, which reach a maximum at the specified values of the asymmetry indicator. At the same time, iron-phosphorus precipitates have a fine-grained structure and have increased microhardness. In order to obtain regular dependences of internal stresses in composite electrochemical coatings based on an iron-phosphorus alloy with molybdenum disulfide particles on the content of the dispersed phase in it and on the electrolysis modes, an experiment was conducted using methods of mathematical planning of the experiment. The variable factors in this experiment were: concentration of molybdenum disulfide (CMoS2), cathode current density (DC), asymmetry index (β) and hydrogen index (pH). The value of internal stresses (σvn), determined by the flexible cathode method [3], is used as an optimization criterion. There are two main requirements for the technological process of applying electrolytic coatings, including composite electrochemical coatings: firstly, the process must ensure obtaining coatings with specified properties on the surfaces of parts and, secondly, ensure strong retention of these coatings on restored or reinforced parts. Both of these requirements can be ensured by the correct choice of electrolysis modes, and the second requirement is also by careful preparation of the surfaces of the parts on which electrolytic coatings are expected to be applied. Obtaining a strong connection of the electrolytic deposit with the metal of the base is possible only if the oxide films, which are always present on metal surfaces, are completely removed from the surface of the base, and if the coating is kept in an active (non-oxidized) state until the start of electrolysis.

Conclusions: The method of electrolytic deposition of KEP based on an iron-phosphorus alloy with the use of solid lubricant particles - molybdenum disulfide - as the substance of the second phase has been substantiated.

References

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