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ELECTROSPARK COATING FROM NANOCRYSTALLINE ALLOY

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Abstract: The article describes the properties of wear resistant electrospark coating made of nanocrystalline alloy of type 5БДСР (Finemet). It is proved that electrospark coating has nanocrystalline structure which is like amorphous matrix with nanocrystals α – Fe. Coating thickness is 33 µm, micro-hardness is 8461 - 11357 MPa, wear resistance is 0,55×104 s/g. Coating of nanocrystalline alloy of type 5БДСР can be used to increase wear resistance of machinery working surfaces.

Key words*: electrospark deposition, electrospark coating, nanocrystalline alloy, microhardness, wear resistance.*

INTRODUCTION

One of the promising trends of wear resistance increase of elements working surfaces is their hardening at the expense of formation of surface coating with high physical mechanical properties. Scientific and technical information analysis displayed that among widely-accepted methods of working surfaces hardening it is possible to differentiate thermal treatment, thermochemical treatment, laser and plasma hardening, etc. The promising method of hardening of working surfaces with complicated geometric form is electrospark treatment (EST) [1]. There are many different ways of development of EST method. One of them is usage of new materials with nanocrystalline structure. These materials usage allows to obtain multifunctional coatings that are able to increase elements working surfaces wear resistance [2-16].

Purpose of the work is to investigate the properties of hardening electrospark coating of nanocrystalline alloy (NCA).

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MATERIAL AND METHODS

Nanocrystalline alloy of type 5БДСР (Finemet) (Fe–70%, B – 9,2%, Si– 6,3%, Nb– 2,21%, Cu– 0,8%, Mo– 0,2%) was chosen as electrode material. The obtained coatings structure was investigated by means of scanning electron microscope Hitachi TM – 1000. Hardening coating was applied on steel samples 65Г by installation EST of type БИГ – 4 (mode: №2, K=0,8). The experimental electrospark coating thickness was measured at the sections. Measurements were done by microscope МИМ-8. The reference surface was the boundary of coating and base. Microhardness was measured at loading of 50 g by the diamond point pressing-in method using computerized microhardness tester ПМТ-3М-01. Mass transfer process was studied, investigated by geometric measuring of single erosive traces left by electrode the measurements were done with microhardness tester ПМТ-3М. The microhardness tester was equipped with ocular screw micrometer МОВ-1-16Х, and also with lens ОЭ-25 (epilens-plan-achromatic F=25,0 mm, A=0,17). Tribotechnical tests were done using, friction machine МТУ-01, at external loading 2,5 N, with resultant sliding velocity – 1,0 m/s. Steel of type 65Г tempered to HRC 58…60 was used as a material for counter-sample production. The wear was determined according to gravimetric method using balance Sartorius Competence CP64 with accuracy 0,0001 g.

RESULTS AND DISCUSSION

Scanning electronic microscopy allowed stating that electrospark coating, obtained by steel base treatment with the electrode made of nanocrystalline alloy (NCA) of type 5БДСР, has homogenious structure to level of 1 μm. However, there are microcrystalline inclusions of base material in transition section between coating and base (Fig. 1). X-ray tests displayed that the coating from alloy 5БДСР has nanocrystalline structure, which is like amorphous matrix with nanocrystals α – Fe. It is seen from Figure 2, wich presents the reflection from crystalline phases α–Fe [10].

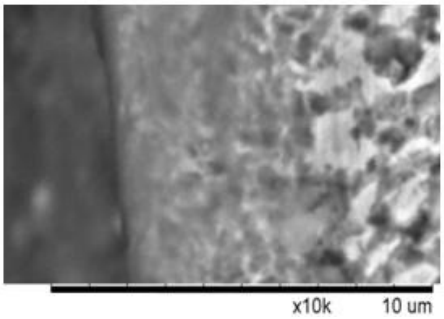

Figure1. Electrospark coating structure

Electrospark coating thickness varies nonlinearly. Experimental dependence of thickness from specific treatment time is presented in Fig. 3. Thereon fracture failure threshold equal to 2,1 min/cm^2 and fracture failure critical threshold equal to 5,2 min/cm^2 were set. At electrospark treatment (EST) with mode №2, K=0,8 maximum coating thickness from nanocrystalline alloy (NCA) of type 5БДСР is h = 33 µm, which is about 1,5 times more, than thickness of coating from alloy of type ВК6-ОМ, obtained with the analogous mode.

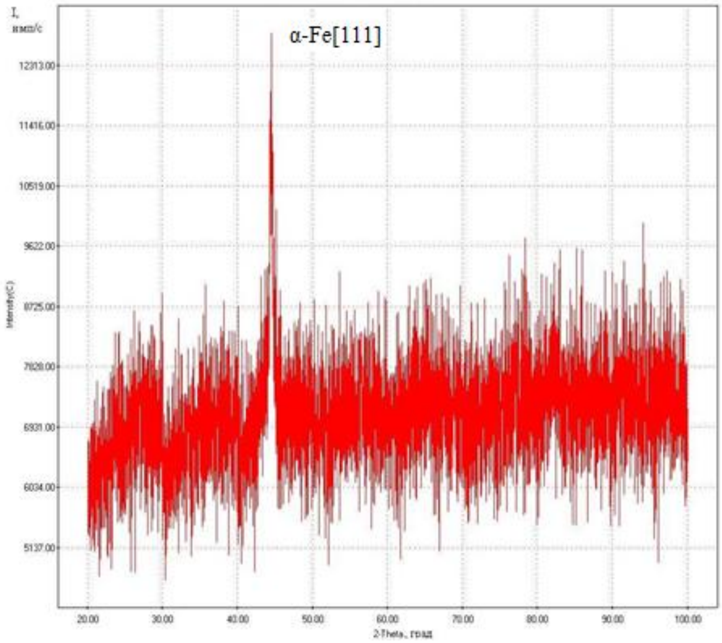

Figure 2. Electrospark coating diffractogram

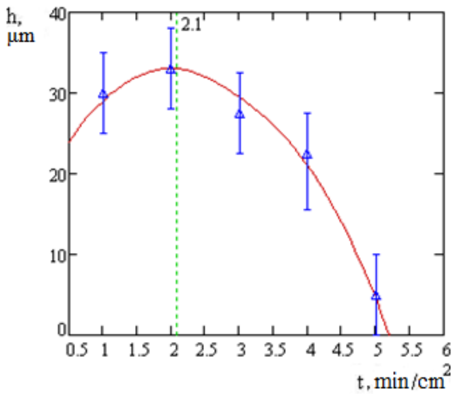

Figure 3. Coating thickness dependence from specific treatment time

Microhardness of hardening coating has dispersion in magnitude. Maximum value of coating microhardness from nanocrystalline alloy (NCA) of type 5БДСР is $H_{\mu max}$ = 11357 MPa, minimum is $H_{\mu min}$ = 8461 MPa. The distinctive feature indicating the coating plastic deformation is that there is a “crown” on indenter impresses [1, 8].

While mass-transfer investigations we determined the electrode material mass dependence being transferred from anode to cathode from initial potential – one of the main technological parameters of electrospark treatment (EST). Fig. 4 presents regressive power dependence which can be used to develop the technological process of elements hardness. By means of gravimetric method the mass-transfer direction and electrospark treatment (EST) efficiency were determined in whole. This method allowed determination of some parameters of mass-transfer which are essential for engineering support of electrospark treatment (EST) process (Tab. 1).

Table 1. Mass-transfer parameters

Mass-transfer average ratio	*Fracture failure threshold of coatings (t_x, min/cm^2)*	*Fracture failure critical threshold of coatings ($t_{кр}$, min/cm^2)*
0,54	*4,0*	*6,5*

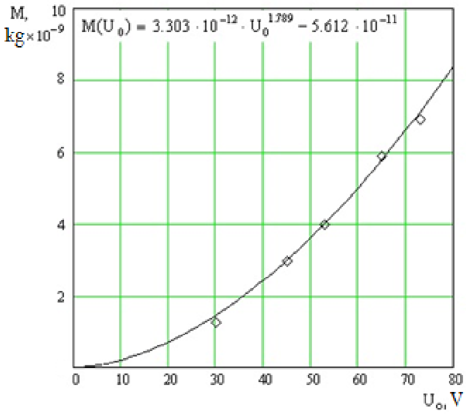

Figure 4. Mass dependence of electrode material being transferred from anode to cathode from initial potential at electrospark treatment (EST)

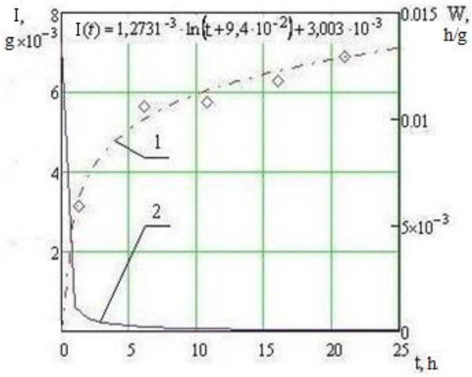

Figure 5. Dependence of wear (1) and u wear rate (2) of electrospark coating from test duration

Wear tests allowed obtaining the wear dependence from tests duration presented in the form of logarithmic regression function. After its differentiation the wear rate dependence from time was obtained (Fig. 5).

By means of tribotechnical tests it is proved that hardening electrospark coating from nanocrystalline alloy (NCA) of type 5БДСР has wear rate $W_{average} = 18\times10^{-5}$ g/s and wear resistance $U = 0{,}55\times10^{4}$ s/g. Low wear rate and high wear resistance testify that the examined electrospark coating should be reasonably used at hardening of machinery working surfaces.

CONCLUSIONS

Wear resistant electrospark coating from nanocrystalline alloy (NCA) of type 5БДСР has nanocrystalline structure, thickness 33 μm, maximum microhardness 11357 MPa, wear resistance 0,55×104 s/g. The coating from this alloy can be used to increase the wear resistance of machinery working surfaces.

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ELEKTROLUČNO PREMAZIVANJE NANOKRISTALNOM LEGUROM

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Sažetak: U radu su prikazane osobine otpornosti na habanje elektrolučnog premaza od nanokristalne legure tipa 5БДСР (Finemet). Dokazano je da elektrolučni premaz ima nanokristalnu strukturu koja izgleda kao amorfna matrica sa nanokristalima α – Fe. Debljina premaza iznosi 33 µm, mikrotvrdoća 8461 - 11357 MPa, otpornost na habanje 0,55×104 s/g. Premaz od nanokristalne legure tipa 5БДСР se može koristiti za povećanje otpornosti na habanje radnih površina mašina.

Ključne reči*: elektrolučna depozicija, elektrolučno premazivanje, nanokristalna legura, mikrotvrdoća, otpor habanju.*

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