INCREASE OF ELEMENTS LIFE BY MEANS OF PLASMA ELECTROLYTIC OXIDATION

ПОВЫШЕНИЕ РЕСУРСА ДЕТАЛЕЙ ПЛАЗМЕННО-ЭЛЕКТРОЛИТИЧЕСКИМ ОКСИДИРОВАНИЕМ

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Abstract: *Micro arc oxidation (MAO) is one of the advanced methods of obtaining thin-layer oxide ceramic coatings on the elements of machines of different functionality, allowing considerably increasing their life. The work is devoted to investigation of wear resistance and microhardness of coatings formed by micro arc oxidation on aluminium alloys in different electrolyte types. MAO is recommended for application at different engineering and maintenance technical enterprises, that produce, restore and harden elements.*
KEYWORDS: *MICRO ARC OXIDITION, LIFE, WEAR RESISTANCE, MICROHARDNESS, ELECTROLYTE, OXIDE CERAMIC COATING.*

1. Introduction

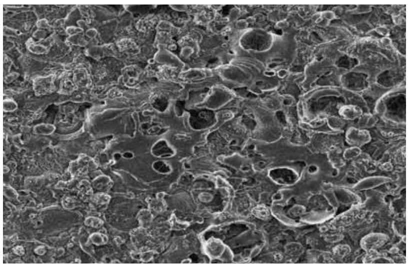
Increase of elements life by means of their restoration and hardening is the principle reserve of material saving, reduction of techniques repair expenses and one of the most important problems in the conditions of raw-material and energy resources price rise. One of the advanced methods of allowing considerably increasing the life of elements produced from aluminium alloys (pistons of internal combustion engines, bodies of hydraulic gear-type pumps, etc.) is micro arc oxidation.

The essence of micro arc oxidation is in forming thin-layer high-strength wear resistance ceramic coating mainly from solid phase aluminum oxides on the element surface under the influence of micro plasma discharges [1].

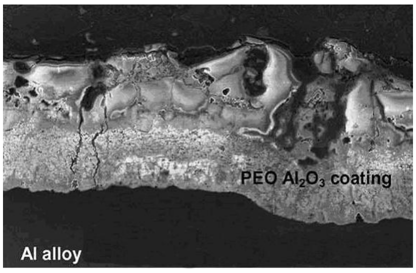
To the main advantages of plasma electrolytic oxidation (PEO) can be referred [2-3]:

- possibility to apply coatings on complicated specialized articles, internal surfaces and hidden cavities;
- obtaining of coatings with thickness to 0,3 mm with adhesion compared with base material hardness;
- low price and availability of chemical agents and materials;
- environmental safety.

Fig. 1, as an example presents morphology and typical microstructure of coatings obtained by MAO on aluminium alloys.



a)



b)

Fig. 1 *– Morphology (a) and microstructure (b) of coatings obtained by MAO. Enlargement 600^X and 400^X.*

At present many aspects of mechanism of MAO passing are under-investigated: there is no systematic information on the influence of internal and external factors on this process, many new electrolytes are not tested yet, etc.

The results of investigations of wear resistance of coatings being obtained by MAO on different aluminium alloys in electrolytes of type «KOH-Na_2SiO_3» and «KOH-H_3BO_3» are presented below.

2. Experimental procedures

Aluminium alloys of marks: ENAB-42000, 5251, 1235, 2017A and bronze C60800 were taken as material for sample production.

Coatings on aluminium casting alloy ENAB-42000 were formed in electrolyte of type «KOH-Na_2SiO_3» with the following concentration of components per 1 liter of distilled water: KOH – 2 g/l, Na_2SiO_3 – 10 g/l.

Electrolyte of type «KOH-H_3BO_3» with components concentration: KOH – 5 g/l, H_3BO_3 – 20 g/l starch – 10 g/l was used to form the coatings on deformed aluminium alloys ENAB-42000, 5251, 1235 and 2017A. Duration of sample oxidation was 100 min.

Relative wear resistance of sample surfaces was investigated in the conditions of boundary lubrication on the friction test machine ИИ 5018 according to scheme «stone-holder-roller». Boundary lubrication conditions at tests of coatings on alloy ENAB-42000 were provided with uniform feeding of spindle oil to friction surface. For wear speeding the abrasive prepared from siliceous sand with dispersion 3 μm was added into power fluid. Abrasive material concentration was 0,14 % according to oil mass. As working environment at tests of coatings obtained on deformed aluminium alloys 3 % solution of milk acid was used. Values of stone-holder and roller were determined by gravimetrical method. Micro hardness of coatings was measured by device ПМТ-3.

3. Results and discussion

In the course of the done investigations it was stated that wear rate of oxide-ceramic coatings obtained in electrolyte of type «KOH-Na_2SiO_3» is in 3-4 times lower than wear rate of aluminium surfaces that were not hardened Fig. 2 (a).

Working surfaces of samples without coatings after tests were covered with numerous deep parietal lines and scratchers – wear tracks resulting from the influence of abrasive particles on metal. Working surfaces of friction pairs with hardened samples in a less degree were subjected to abrasive particles influence. Rollers with coatings actually did not have scratchers and notches. It is conformation of their high hardness and wear resistance. General view of working surfaces after tests for wear is presented in Fig. 2 (b, c).

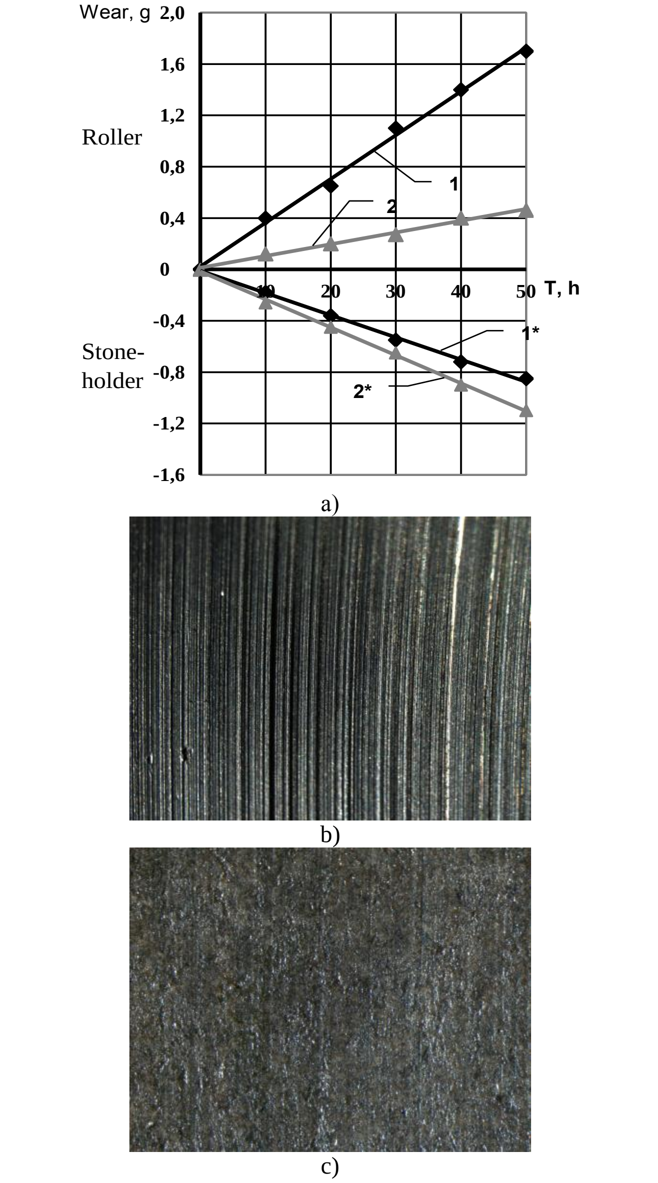


***Fig. 2** – Results of tests for wear: a) influence of duration of tests on wear of friction pairs: 1 – roller from alloy АК7ч without coating; 2 – roller from alloy ENAB-42000 with coating. 1*, 2* – stone-holder (Steel 18 ChGT, HRC 58-62); b) surface of roller without coating after tests; c) surface of roller with coating after tests.*

Special interest was paid to tests of wear resistance of coatings obtained by MAO on aluminium deformed alloys in electrolyte of type «$KOH-H_3BO_3$». In this case bronze samples were considered as transfer standard. At that wear intensity of reference surface was in 2-3 times higher than wear intensity of aluminium deformed alloys being hardened by MAO (Fig. 3).

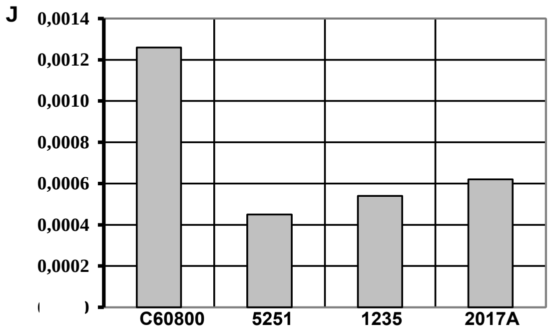


***Fig. 3** – Intensity of wear J samples from aluminium alloys with oxide-ceramic coating in comparison with C60800*

Reasons of high wear resistance of oxide-ceramic coatings are connected with their structural state [3, 4]. Apparently, those structural modifications of alumina oxide in coatings form the strongest type of intermolecular bounds between each other [4-6]. The number of authors [1-3] is sure that the oxide-ceramic coating obtained by MAO, as a matter of fact, is a composition material, at the same time coating wear resistance can be compared with wear resistance of composition materials on the ground of tungsten carbide, traditionally applied against abrasive wear.

Coatings obtained by micro arc oxidation differ with high hardness. Thus, for example, average value of microhardness of hardened layers, obtained on aluminium deformed alloys is 14-17 GPa, on casting alloy ENAB-42000 – 6-8 GPa. At the same time microhardness of aluminium alloys without coatings is in the limits – 0,86…0,99 GPa. It is necessary to stress that microhardness by thickness of the formed coatings is not uniform (Fig. 4). Maximum value of microhardness falls on the definite layer of coating, higher or lower which its values decrease. The area with maximum values of microhardness is at the distance of 30…50 μm from nominal size of oxidize sample. The decrease of microhardness is observed along the whole thickness of outside hardened layer of coating.

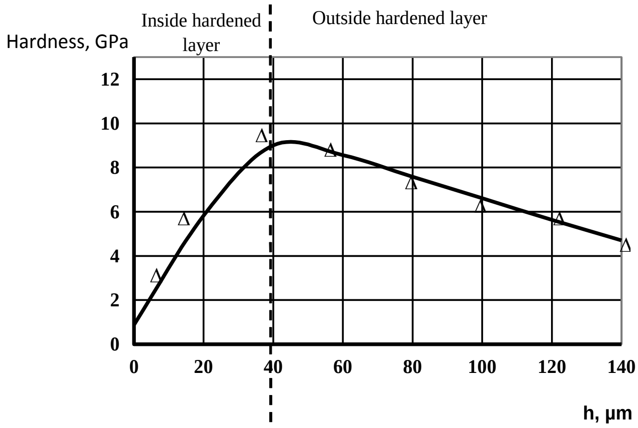


Fig. 4 – Alternation of microhardness of coating obtained by MAO in electrolyte of type «$KOH-Na_2SiO_3$» by thickness on aluminium alloy ENAB-42000

Increased microhardness of oxide-ceramic coatings obtained by MAO and its nonuniformity by thickness of the hardened layer are acknowledged by other investigators [2, 3]. At the same time it is stressed that in the inside layer contains more of solid phase α- and γ- phases of alumina oxide, than in the outside layer because of higher temperature in coating breakdown paths. Microhardness of coatings also depends on chemical composition of oxidize alloy.

4. Conclusion

The complex of investigations of oxide-ceramic coatings obtained by MAO on aluminium alloys proved that they possess high microhardness and wear resistance. This method can be recommended for application at engineering and maintenance technical enterprises, that produce, restore and harden elements. The anticipated increase of hardened elements life will be not less than 150-200% in relation to new elements.

5. Literature

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