MICRO-ARC DIELECTRIC COATINGS ON ALUMINUM ALLOYS OF GRINDING WHEEL FRAMEWORKS

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Abstract: *It is presented the development of local electrically insulating coatings for tool of the technologies of high-efficient processing with the introduction the energy of electrical discharges into the cutting zone to maintain a working capacity of grinding wheels with diamond-metal composition of the working part. Development is an alternative to the electrical insulation upgrade of spindle units of universal grinding machines. The dielectric properties of micro-arc oxide coatings on deformable aluminum alloys formed on an alternating current in the regime of an arbitrarily falling power in alkali-silicate solutions have been studied. Information about the features of practical implementation of development is given.*

Keywords: grinding, diamond wheel, aluminum framework, deformable alloy, electro-protective oxidation, micro-arc oxide coating, specific volume resistivity, electric strength.

1. Introduction

Today's interest to investigate the dielectric properties of micro-arc oxide coating on the aluminum alloys is associated with the instrumental applications of such alloys in diamond grinding wheel frameworks that require electrical protection in high-performance technologies with direct current lead to the processing zone [1-3]. The aim of the work is to investigate the technological possibilities of microarc oxidation with regard to deformable aluminum alloys and to evaluate the dielectric properties of the obtained oxide coatings.

2. Experimental research

Experimental samples were made of two types of deformable aluminum alloys, which are used as constructional materials for carrying parts in instrument engineering – D16T and AK6. Formation of coatings was carried out at anode-cathode (alternating) current in the regime of randomly falling power during 1 hours at the initial current density 20 A/dm^2. Three solutions were used as the investigated electrolytes: silicate – 12 g/l technical solution of liquid sodium glass with density 1.4 g/dm^3 (0:12), alkali-silicate – 2 g/l KOH + 12 g /l solution of the same liquid glass (2:12) and more dilute 1 g/l KOH + 6 g/l solution of the same liquid glass (1: 6). The thickness of the coatings was measured by a non-destructive method by vortex-current thickness gauge NOVOTEST TP-1. Volumetric resistance was evaluated using a terameter E-13 at an operating voltage of 100 V. The breakdown voltage (respectively, the electrical strength) was measured at alternating current (50 Hz).

Analysis of the thicknesses of oxide coatings formed under identical electrolysis conditions shows (Table 1) that it depends on the alloy grade and the composition of the electrolyte. In general, the thickness of coatings on D16T alloy is greater than on AK6 ones. The advantage increases with the transition to more "aggressive" electrolytes containing in its composition caustic alkali – with growth from electrolyte medium without KOH (0:12) to electrolyte medium with KOH. The probable reason of this is the different etching rate of intermetallic compounds entering into alloys [4].

The subsequent measurement of the coatings dielectric characteristics, its specific

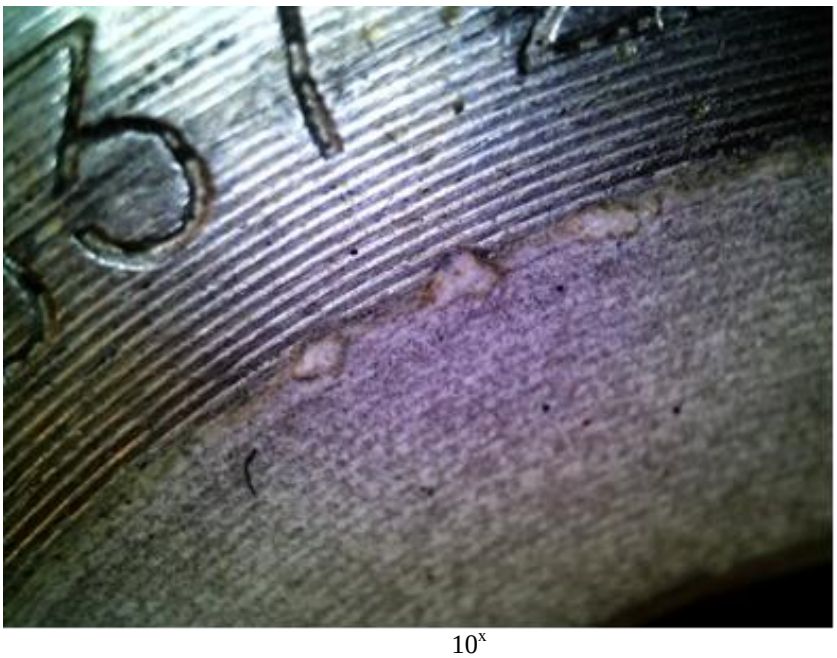
volume resistivity and the electrical strength indicate (Table 1) the predominant effect of thickness on their values.

Table 1: Characteristics of micro-arc oxide coatings on deformable aluminum alloys

Characteristic	Alloy	Electrolyte composition		
		0:12	2:12	1:6
Thickness, μm	D16T	80	100	70
	AK6	60	55	40
Specific volume resistivity, Om·m	D16T	$3,2\cdot10^{9}$	$1,0\cdot10^{9}$	$4,3\cdot10^{9}$
	AK6	$7,4\cdot10^{9}$	$5,2\cdot10^{9}$	$8,9\cdot10^{9}$
Electric strength, $V\cdot\mu m^{-1}$	D16T	12,7	13,1	13,8
	AK6	10,2	10,0	13,1

The fact that the dielectric properties of micro-arc coatings deteriorate with increasing thickness (from AK6 to D16T, see Table 1) can be explained by the increasing heterogeneity of the phase- structure composition, by improving the conditions for migration and diffusion of alkali metal ions (K, Na) under the influence of temperature, by "capturing" current-carrying ions into the composite porous structure of the oxide layer [5].

On both alloys the best index of specific volume resistivity provide coatings formed in alkali-silicate electrolyte 1:6, the lowest – in a solution of 2:12. The electrical strength of the coatings (see Table 1), like the specific resistivity, unambiguously decreases with increasing thickness. The latter is associated with a decrease in open porosity (Fig. 1) and end-to-end defects, which are a “trouble spot”, since the electrical strength of the air in them is only 3 V/μm.



10^{x}

100^x

Fig. 1. *Microphotographs of the framework surface of the experimental grinding wheel with a local micro-arc oxide coating on aluminum alloy AK6*

The reasons for the electrical strength deterioration with increasing the coatings thickness are the same, which lead to deterioration of specific resistivity – heterogeneity, the presence in the composition of aluminum oxides of different structures, mullites, sillimanites and other compounds with lower dielectric properties.

The electrical strength index is less dependent than specific resistivity on the alloy grade and the electrolyte composition, but a slight advantage is observed in oxide coatings formed in a 1:6 electrolyte solution.

3. Conclusion

Investigations of the dielectric properties of micro-arc oxide coatings formed on AC6 and D16T alloys with alternating current in the regime of random falling power were carried out. It is shown that the value of the specific volume resistance and electrical strength is mainly influenced by the thickness of the coatings, as well as the alloy grade and the electrolyte composition. It is established that the best results of the dielectric properties on both alloys provides alkali-silicate electrolyte 1 g/l KOH + 6 g/l technical solution of liquid sodium glass.

The achieved characteristics of the dielectric properties of micro-arc oxide coatings on deformable alloys AK6 and D16T make it possible to use them as insulation layers for parts, structural elements, integrated microcircuits in instrumentation, including for aluminum frameworks of diamond grinding wheels for the technologies of high-efficient processing with the introduction the energy of electrical discharges into the cutting zone.

References

[1] *Machine-building faculty. 125 years as part of KhPI.* Ed. by **A. I. Grabchenko and M. S. Stepanov**. Kharkov, Cursor, 2010, 212 p. – In Ukrainian and Russian.
[2] **Gutsalenko, Yu. G.** *Diamond-spark grinding of high functionality materials* [Online resource]. Kharkov, Cursor, NPU «KhPI», 2016, 272 p. [3,75 Мб], access code: http://web.kpi.kharkov.ua/cutting/dsghfm-monograph.pdf. – In Russian.
[3] **Gutsalenko, Yu. G., C. G. Iancu, E. K. Sevidova, and I. I. Stepanova**. Local electrical insulation solutions for tools from superhard materials for their enhanced adaptation to diamond-spark grinding. *Physical and Computer Technologies. Proceedings of the 22nd International Scientific and Practical Conference, December 7-9, 2016, Kharkov.* Dnepropetrovsk, Publishing house "Lira", pp. 56-59. – In Russian.
[4] **Bakovets, V. V., O. V. Polyakov, I. P. Dolgovesova.** *Plasma-electrolytic anodic processing of metals*. Novosibirsk, Publishing House "Nauka" – Siberian Department, 1991, 168 p. – In Russian.
[5] **Pavlyus, S. G. et al.** Dielectric properties of anodic-sparked silicate coatings on aluminum. *Electronic material processing.* 1987, No. 3, pp. 34-36. – In Russian.