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Copper-Coated Electrodes for Electrical Discharge Machining of 38X2H2MA Steel

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Abstract—The use of copper-coated aluminum electrodes in the electrical discharge machining of 38X2H2MA steel is assessed. Such electrodes prove effective. The use of coated electrodes improves the economics of electrical discharge machining by permitting the use of cheaper materials in the electrode core.

Keywords: electrical discharge machining (EDM), electrodes, productivity, coated electrodes, efficiency
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The manufacturing costs of electrodes for electrical discharge machining depend on the material employed and its manufacturing technology.

In selecting the electrode material, we take account of its erosion resistance, electrical conductivity, technological expediency (the possibility of manufacturing a tool of the required form), cost, strength, corrosion resistance, and the lack of harmful emissions at high temperatures in the discharge [1, 2].

Copper is used for such electrodes. Copper electrodes are highly resistant to erosion and ensure stable electrical discharge machining. However, they are expensive.

Traditional production methods (such as milling and turning) for complex electrodes involve considerable consumption of material, which increases their production costs [3, 4].

One method of reducing the production cost is to use electrodes with erosion-resistant coatings [5]. The coating may be applied on metallic or polymer cores.

The electrode cores may be produced by casting or by fast prototyping.

In the present work, we investigate the use of aluminum electrodes with a copper coating in the electrical discharge machining of 38X2H2MA steel.

MATERIALS AND METHODS

A workpiece made of 38X2H2MA structural steel (State Standard GOST 4543–71) is machined on an Electronica Smart CNC electrical discharge system. The working fluid is I-20A oil. Table 1 presents the machining conditions: T_{on} is the time to switch on the pulses, μs; T_{au} is the pulse's operational cycle, %; U is the voltage, V; I is the current, A; T is the machining time, h; S is the machining area, mm^2.

We select three electrodes for the experiment (Fig. 1): (1) M1 copper (State Standard GOST 1173–2006); (2) AK12 aluminum alloy (State Standard GOST 1583–93) with a copper coating; (3) AK12 aluminum alloy (State Standard GOST 1583–93).

The copper coating on electrode 2 is applied galvanically in a sulfuric-acid electrolyte (with a current of 1 A/dm^2). The electrolyte is preheated to 60–70°C. The coating thickness is 1.3 mm (Fig. 1b).

The machining depth and wear of the electrode are measured by means of a Carl Zeiss Contura G2 system. To improve the accuracy of the measurements, the machining of 38X2H2MA steel by each electrode is repeated three times.

RESULTS AND DISCUSSION

In Fig. 2, we show the electrode wear after machining with the parameters in Table 1.

We see that the wear of aluminum electrode 3 is greatest: 0.7 mm. The wear of copper electrode 1 is comparable with that of coated electrode 2: no more than 0.1 mm.

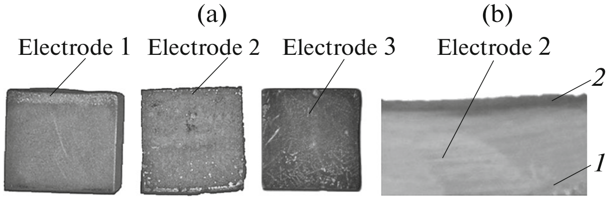

Fig. 1. Electrodes produced from different materials: (1) copper; (2) copper-coated aluminum alloy; (3) aluminum alloy: (*1*) aluminum core; (*2*) copper coating.

Table 1

Parameter	I, A	T_{on}, μs	U, V	T_{au}, %	T, h	S, mm^2
Value	3	50	50	26	1	120

Table 2

Electrode	Experiment	Machining depth, mm	Mean productivity, mm/h
Aluminum	1	0.53	0.52
	2	0.55	
	3	0.48	
Copper-coated aluminum	1	0.88	0.89
	2	0.90	
	3	0.89	
Copper	1	0.92	0.92
	2	0.94	
	3	0.90	

Table 2 presents the machining depth in the electrical discharge machining of 38X2H2MA steel in accordance with Table 1.

The productivity is least when using the aluminum electrode 3 and greatest for the copper electrode 1. The difference in productivity of the copper electrode 1 and coated electrode 2 is no more than 4%.

Analysis of the economic efficiency in manufacturing the copper electrode and the copper-coated aluminum electrode shows the benefit of the coated electrode. Electrode production is 2.5 times more economical for the coated electrode.

CONCLUSIONS

(1) In machining 38X2H2MA steel, it is expedient to use a copper-coated aluminum electrode.

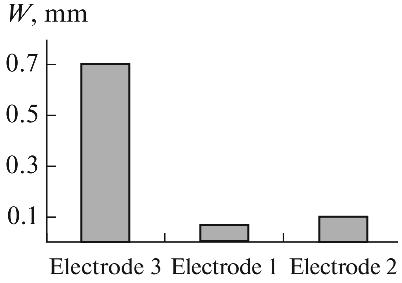

Fig. 2. Wear W for copper electrode 1, coated electrode 2, and aluminum electrode 3.

(2) The use of a coated electrode permits the use of an inexpensive core, with obvious economic benefits.

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