WEAR OF TOOL ELECTRODES IN ELECTROMACHINING

A. V. Paustovskii

Both technically and economically, electromachining must be regarded as a potentially useful technique for the surface hardening of machine and mechanism components and, at the same time, imparting to them a high surface finish (up to Class ν 9 of GOST 2879-59 standard) [1].

The principle of the electromachining process is that a high-intensity, low-voltage current is supplied to the point of contact between a tool electrode and the part being machined, as a result of which all protruding surface irregularities are subjected to strong local heating, enabling the pressure exerted by the tool to deform them and level them down.

The standard VK and TK sintered hard alloys* are normally used for the manufacture of the leveling plates of tool electrodes. However, no information is available in the literature on their wear in the course of electromachining.

In view of this, the present investigation was undertaken with the aim of determining the relative wear resistance of sintered hard alloys during electromachining and the effect of carbon concentration in steel on the magnitude of wear. VK2, VK3, VK3M, VK4, VK6, VK6M, VK8, VK15, and VK20 tungsten carbide hard alloys and T5K10, T14K3, T15K6, and T30K4 titanium--tungsten carbide hard alloys were chosen for investigation. Armco iron, and steels type St. 3, 45, and U8 were used as workpiece materials. For comparison, electromachining tests were carried out also on ShKh15 ball-bearing steel†, which is frequently used in industry and machined with the same grades of hard alloys.

The standard hard alloys to be investigated were chosen so as to include materials which would make it possible to evaluate the influence of the most important factors on their wear resistance. Thus, for ex-

---

*Typical VK alloys are VK6 (6% Co, balance WC), VK15 (15% Co, balance WC), etc.; typical TK alloys are T5K10 (10% Co, 5% TiC, balance WC), T15K6 (6% Co, 15% TiC, balance WC), etc. —Transl.
†1% C, 1.5% Cr—Transl.

---

Fig. 1. Wear of hard-alloy tool electrodes as function of ratio of their elastic moduli to those of steels. Hard-alloy groups: a) VK; b) TK.
Wear of hard-alloy tool electrodes as function of ratio of their thermal conductivities to those of steels. Hard-alloy groups: a) VK; b) TK.

Specimens of the hard alloys,† 18 x 16 x 8 mm in size, were ground on a carborundum wheel to radii of R = 40 and r = 15 mm and polished on a synthetic diamond wheel to a Class V 10 finish on their working surfaces. Steel specimens, used in the as-supplied condition, were machined before electromachining experiments to a diameter of 38 mm and a length of 100 mm, the following finish-machining parameters being employed: \( V = 75.4 \text{ m/min}, \) \( S = 0.21 \text{ mm/revolution}, \) and \( t = 0.8 \text{ mm}. \) The tool geometry was: \( \alpha = 10^\circ, \gamma = 5^\circ, \varphi = 45^\circ, \varphi_b = 20^\circ, r = 1.0 \text{ mm}. \) The following electromachining parameters were employed in all experiments: \( V = 12 \text{ m/min}, \) \( S = 0.21 \text{ mm/revolution}, \) \( P = 30 \text{ kg}, \) \( I = 500 \text{ A}, \) and \( U = 2.3 \text{ V per pass}. \)

The surface area of the elliptical imprint forming on the plate specimen during machining was used as a tool-electrode wear criterion. For each grade of hard alloy, five experiments were conducted and the mean contact-spot area was determined.

It must be assumed that the wear of hard alloys during electromachining depends primarily on strength characteristics and heat transfer, which may be expressed by the ratios of the elastic moduli and thermal conductivities of the tool and workpiece materials. Figures 1a and b and 2a and b show the wear of the hard alloys as a function of the ratios of these characteristics.

It will be seen from these figures that, generally speaking, the best results were shown by the VK group alloys, while the least wear was recorded for VK8 alloy. Of the TK type alloys, the highest wear resistance was recorded for T5K10 alloys, which, however, was on the average 55% less wear-resistant than VK8 alloy. An examination of the effect of grain size on the wear resistance of VK3, VK3M, VK6, and VK6M alloys leads to the conclusion that, as the mean grain size is reduced, the wear of the alloys increases. This is evidently due to the fact that, with decrease in grain size, the electrical resistivity of hard alloys rises (0.180 \( \Omega \cdot \text{mm}^2/\text{m} \) for VK6 against 0.205 \( \Omega \cdot \text{mm}^2/\text{m} \) for VK6M [2]); this produces a more intense Joule heat-evolution effect in the contact zone and, accordingly, greater Joule electrode wear (the wear of VK3M and VK6M alloys is 20–30% higher than that of VK3 and VK6 alloys).

Although the relationship between the wear of tool electrodes and the ratio of the elastic moduli and thermal conductivities is quite complex, there is a distinct similarity between curves representing the machining of various steel grades. The graphs show that the wear of any given hard alloy increases on transition from Armco iron to steels 3, 45, and U8, while decreasing for ShKh15 steel (the data for ShKh15 steel have been reproduced to provide a basis for comparison).

It must be assumed that when the ratio of elastic moduli and thermal conductivities is high, as is the case with VK2 hard alloy, the temperature in the contact zone of the two materials is low, as a result

*In the alloy designation, M denotes a small grain size—Transl.
†The alloys were kindly made available for the investigation by I. M. Mukha, G. V. Plyushch, and M. M. Babich.