Wear-resistance investigation of electro-screen coatings obtained using electroerosive powders of micro and nanofractions

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Abstract. The results of the wear resistance investigation of electro sparking coatings, applied using electrode material from electroerosive powders of hard alloy VK-8 (90%) with the addition of powder of high-speed steel of grade R6M5 (10%), are presented. Electro spark coatings were formed on samples of 30KhGSA steel using these electrodes and installation UR-121. The coefficient of friction and the wear rate of the surface of the sample and counterbody were measured on an automated friction machine "Tribometer" (CSM Instruments, Switzerland), controlled by a computer, according to the standard "ball-disk" test scheme.

1. Introduction

The development of modern machine building requires improving the quality, reliability and durability of parts, components and mechanisms. One of the effective ways to solve these problems is the use of various functional coatings obtained by the method of electrospark alloying (ESA), the advantages of which are the simplicity of the process, high adhesion of coatings, low energy intensity and high environmental friendliness. The main electrode materials are mainly sintered hard alloys, the cost of which, because of the presence of expensive tungsten, is relatively high. To solve this problem, as an electrode material, it is proposed to use VK-8 (90%) hard alloy powder as the main fraction and add 10% of high-speed steel powder of grade R6M5 [1-9]. One of the progressive and industrially unused methods of obtaining a micro powder and nanofraction from any conductive material that is characterized by low power consumption and no pollution of the environment is the method of electroerosion dispersion (EED) [10, 11].

The purpose of this work was to assess the wear resistance of electro-spark coatings obtained with the electrode material from electro-erosion powders of a hard alloy with the addition of high-speed steel powder.

2. Materials and methods

To obtain the micro powder and nanofraction from solid carbide and high-speed steel wastes, a device for electroerosive dispersion of conductive materials was used.

In the first pressing step, the powder was placed in a flexible rubber mold and preliminarily manually compacted to a density of 3,1847 g/cm^3. Then the samples were placed in a working

chamber of the press at a temperature of 18 ° C, the pressure was pumped to the required value, at this pressure the sample was held for 2 minutes, after which the pressure was dropped to atmospheric and the compacted samples were removed from the rubber mold. The following isostatic pressures of 250 MPa were used. The compacted samples in a Nabertherm VHT 8/22 furnace were sintered for 2 hours at a temperature of 1250 ° C in argon. The first electrode was obtained by mixing the powders in the ratio of VK-8 (90%) + R6M5 (10%), and the second electrode - by mixing powders in the ratio of VK-8 (70%) + R6M5 (30%). Electro spark coatings formed by such electrodes were obtained on samples of steel 30KhGSA on the UR-121 (manufactured by PELM, Podolsk)

The coefficient of friction and the wear rate of the surface of the samples and counterbody were measured on an automated friction machine (Tribometer, CSM Instruments, Switzerland) controlled by a computer (Fig. 1), according to the standard test procedure "ball-disk" (Figure 2). These tests allow one to use the Hertz model; they correspond to international standards ASTM G99-959 DIN50324 and can be used to evaluate the wear resistance of the sample and the opposing member.
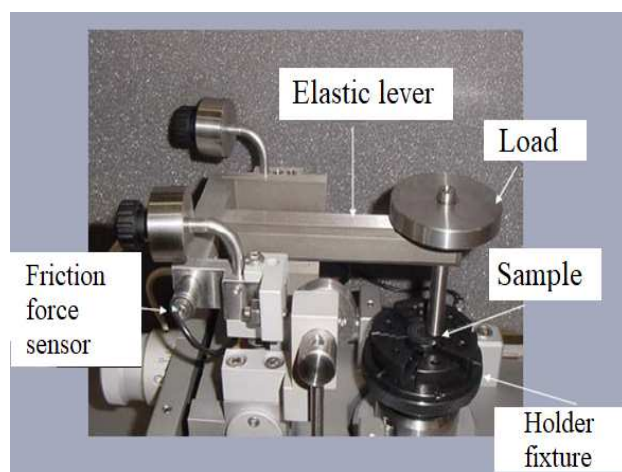

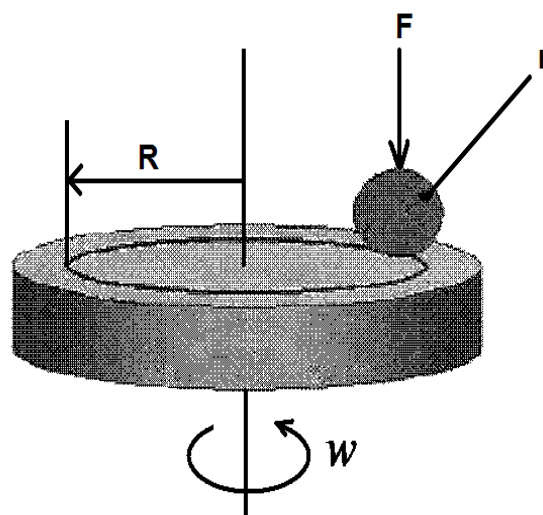**Figure 1.** Diagram of an automated friction machine (Tribometer, CSM Instruments, Switzerland)

Figure 2. Standard test scheme "ball-disk", R - the radius of curvature of wear; r - the radius

The samples were mounted in a holder; a rod was attached perpendicular to the plane of the sample, at the end of which there was a ball with a diameter of 6 mm made of Al_2O_3 (aluminum oxide). By adjusting the displacement sensor, the radius of wear curvature was selected; another sensor compensated for the frictional force and allowed one to set the value of the friction coefficient at a certain time.

Preparation for the test included:

A) three types of calibration

1) calibration of speed and rotation of the motor; 2) calibration of the tangential displacement of the sensor; 3) calibration of the radius.

B) setting test parameters using special software (Instrum X for Tribometer program). The following information required for the test was specified:

1) the frequency of the sensor interrogation; 2) data on the environment; - temperature, - humidity; 3) the value of the load at which the test will be carried out, 4) the linear velocity, cm / sec; 5) mileage in meters or number of cycles; 6) information about the substrate: - coating material; - substrate material; - type of preliminary cleaning of the sample before testing; 7) information on the counter (ball): - coating material; - material of the counterbody; - type of preliminary cleaning of the counterbody before the test; - the size, mm; - geometry.

The tests were carried out in air at a load of 5 N and a linear velocity of 10 cm / sec, a curvature of

the wear curvature of 5-6 mm, the friction path was 1000 meters.

As a result of the tests, the wear resistance of the sample and the statistical partner (ball) was estimated from the wear factor by the formula:

$$W = V/(P \cdot l),$$ (1)

where W – the wear rate, $mm^3 \cdot N^{-1} \cdot m^{-1}$; V – volume of deleted material, mm^3; P – load, N; l – friction path, m.

Having determined the wear diameter of the ball with the Olympus GX 51 optical inverted microscope, the volume of the removed material on the ball was calculated by the following formula:

$$V = \pi \cdot h^2 \cdot (r - (1/3)h),$$ (2)

where $h = r - (r^2 - [d/2]^2)^{1/2}$, d - wear diameter, mm; r - ball radius, mm; h – segment height, mm.

The volume of the removed material was determined from the section of the wear track on the surface of the sample using an automated precision contact profilometer "Surtronic 25" manufactured by Taylor Hobson. The volume of the removed sample material was determined by the formula:

$$V = s \cdot l,$$ (3)

where l – circumference, mm; s – cross-sectional area of the wear track, mm^2.

3. The study of assessing the wear resistance of electro-spark coatings

An optical image of the wear spot of the counterbody (ball) after multiple passes through the experimental surface of the experimental sample (electric spark coating based on VK-8 hard alloy powders (90%) with the addition of powder of high-speed steel grade R6M5 (10%) and 30KhGSA steel is shown in Figure 3.

The images are taken with the OLYMPUS GX51 inverted optical microscope, Al_2O_3 counter body (aluminum oxide).

The groove profile of the surface of the electric spark coating was investigated on an automated precision contact profilometer "SURTRONIC 25" (Fig. 4).
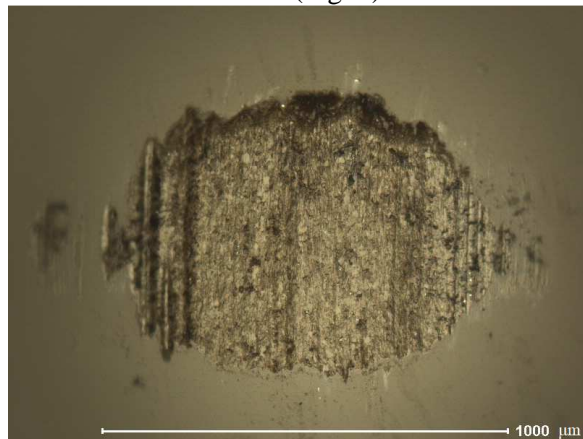

Figure 3. An optical image of the wear spot of the counterbody (ball) after multiple passes through the investigated sample surface, VK-8 (90%) + R6M5 (10%)
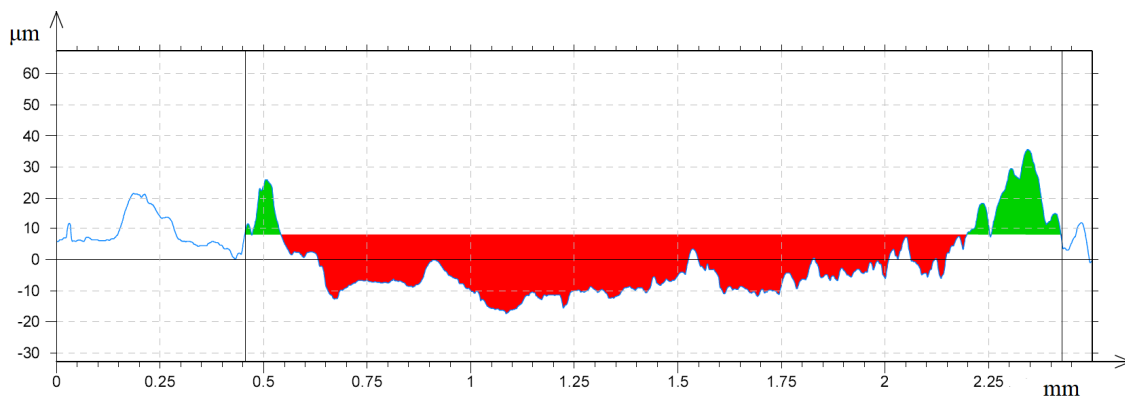
Figure 4. Surface groove profile of the sample surface

The values of the coefficient of friction (μ) and wear factor (w), established in tests of electrospark coating using electrodes made of sintered powders mark VK-8 + R6M5 on steel samples using 30KhGSA UR-121 settings, are given in Table 1.

Table 1. Tribological characteristics of electrospark coatings

Coefficient of friction (μ)				The wear factor of the statistical partner , $mm^3 \cdot N^{-1} \cdot m^{-1}$ x10^{-6}	Wear factor of the sample, $mm^3 \cdot N^{-1} \cdot m^{-1}$ x10^{-6}
Initial	Minimum	Maximum	Average		
0,143	0,143	0,695	0,435	1,704	131,3

4. Conclusion

Based on the evaluation of the wear resistance of electro sparking coatings obtained with the help of electrode material from electroerosive powders of micro and nanofraction of hard alloy VK-8 (90%) with the addition of powder from high-speed steel grade R6M5 (10%), the friction coefficient (initial, maximum and average) was determined. The values of the wear factor of the statistical partner and the wear factor of the electrospark coating were also obtained. The optical image of the wear spot and the groove profile of the wear of the electric spark surface are shown.

5. Acknowledgments

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