

Technological Aspects of Forming the Surface Microrelief of Low-Wear Coatings after Electro-Diamond Grinding

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Abstract. The results of electro-diamond grinding of coatings based on the WC25 powder material are presented in the paper. It is shown that after electro-diamond grinding of the WC25 coating, an obtained magnitude ($R_a=2.02\mu\text{m}$) of surface roughness doesn't meet the qualifying standards to parts surface working in wear-out conditions. The forming of the obtained microrelief is probably connected to the features of electrochemical dissolution of the WC25 coating material in the electrolyte being used. Based on the polarization studies, it is revealed that the electrochemical dissolution character of the indicated coating in the water solution of 10%NaNO₃ is determined by the dissolution character of cobalt (Co) component. The intensive cobalt (Co) dissolution during the electro-diamond grinding of the WC25 coating leads to the tungsten carbide chipping by the grinding disk particles that increases the roughness. One of the way to improve the surface quality of low-wear coatings after electro-diamond grinding is an introduction of an additional step in a technological process, carrying out with the switched off source of technological current. For realization of the process according to this scheme a technological dimension chain is made which takes into consideration the dissolution value of the most active coating composition element while the calculating of the operating dimensions of a detail.

1. Introduction

It is known that a failure of parts and construction elements is mainly caused by a wear and corrosive damage of their surface layers. The methods of a chemical-thermal impact and of surface hardening based on a deformation impact and also various ways of a low-wear coating application [1,2,3,4] are used to increase both the wear and corrosive resistance of parts surfaces. The application of such high-performance coating technologies as a detonation-gas and a plasma spraying, and an electro-beam surface welding allows to form the surface layers with high hardness [5,6,7,8]. The appearance of a new class of powder materials, consisting, as a rule, of a number of components and having a complex of unique properties, improves the technological processes of a preparation of backing material surface before coating and a final surface treatment after coating and welding operations. These technologies of the backing material surface preparation and the final machining influence greatly on the formation of the physical-mechanical characteristics and therefore, on the product reliability and longevity [9, 10]. As a rule, abrasive and diamond grinding are used for the final mechanical surface treatment after coating. It often results in the degradation of physical-mechanical surface layer characteristics obtained while the low-wear coating. The cause of the surface layer degradation is that hardness of the powder based coating is often comparable with abrasive tool hardness [11]. The significant perspectives for solving this problem are seen in using the technologies for low-wear coating treatment based



on the combination of processes of electrochemical dissolution and mechanical cutting. The beneficial effects of using the specified technologies, providing the quality of the surface layer were obtained while forming the surfaces of the tough high-resistance steel alloys [12, 13].

2. Materials and procedure of the experiments

The experimental studies of the part machining with the powder based coating were carried out on an experimental facility for electro-diamond grinding (Figure 1).

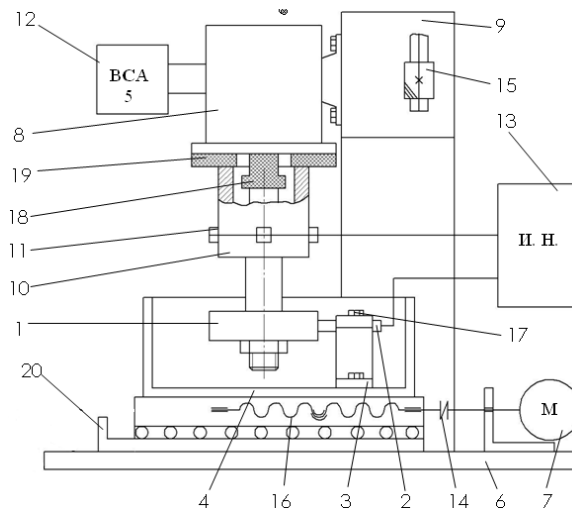


Figure 1. The scheme and appearance of an experimental facility for electro-diamond grinding. 1 – diamond disk on a metal alloy; 2 – test specimen; 3 – strut for fixing the test specimen; 4 – electrochemical cell; 5 – ball bearing ways; 6 – pedestal base; 7 – feed motor; 8 – primary motor; 9 – carriage; 10 – spindle; 11 – contact-wiper facility; 12 – DC source–VSA 5; 13 – voltage source; 14 – joint box; 15 – cleat; 16 – lead screw; 17 – fixing screw; 18 – isolating joint box; 19 – textolite washer; 20 – cell limit stop.

The supplied technological voltage was $U=8$ V. The voltage limit is 8 V due to a probability of an erosion processes initiation while the electro-diamond grinding. It decreases the quality of the machined surface. A rate of motion was 15-17 m/c. The value of the longitudinal table feed was 45 mm/min. The diamond disk on a metal alloy ACB 80/63 100% M1 was used as a tool. The machining of the coated test specimens was carried out during one cut with the cutting depth $t=0.1$ mm.

A powder composition containing tungsten carbide is used as material for parts protection from abrasion wear [14]. The WC25 powder composition belongs to this material class. The coatings made of this composition have high wear resistance and they are used to restore movable and static joints. A detonation-gas sprayed coating based on the WC25 powder composition was chosen as the material for the research.

The quality of the machined surface was assessed by a roughness parameter. After the electro-diamond grinding the surface roughness of the coated test specimens was measured with the help of a complex New View 7300 Surface Profiler.

The research of electrochemical dissolution of the WC25 coating containing Cobalt (Co) and Tungsten (W) was carried out on potentiostat P5827M. The anode potential changed from 0 to 8 V. The water solution of neutral salt NaNO_3 was used as an electrolyte.

3. Results and discussion

In the results of the experiments on the electro-diamond grinding of the coatings based on the WC25 powder composition it was found that the obtained surface roughness magnitude $R_a = 2.02 \mu\text{m}$ (Figure 2). It should be noted that higher quality demands are made to the working surfaces, specifically to the surface roughness, of the coated parts relating to a wear-resistant class.

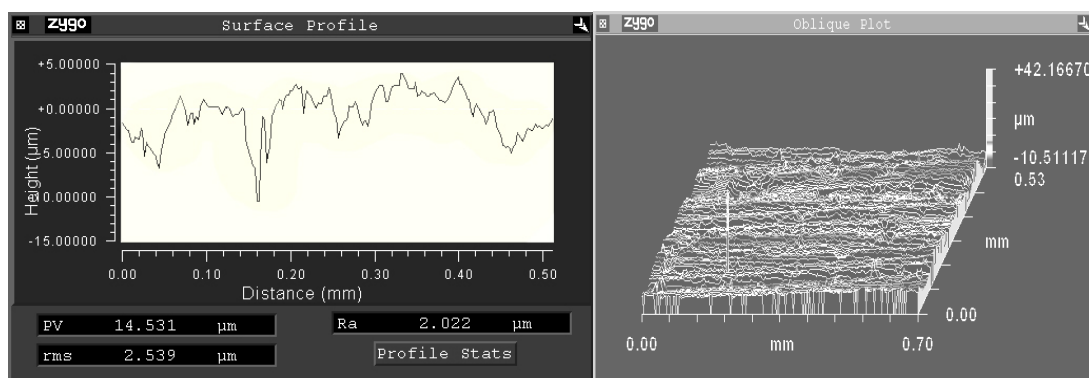


Figure 2. The surface roughness of the test specimen with the WC25 coating after electro-diamond grinding

Probably, the forming of the microrelief received after electro-diamond grinding is caused by the features of the electrochemical dissolution of the WC25 coating material in the electrolyte used. These features are stipulated by the different behavior of the WC25 components, tungsten carbide and cobalt alloy, during the electrochemical dissolution. Specifically, an active cobalt (Co) dissolution in the water solution of 10% NaNO_3 occurs in the potential range from $\phi = 0 \text{ V}$ to $\phi = 8 \text{ V}$, which is indicated by a current density increase with the anode potential rise. (Figure 3)

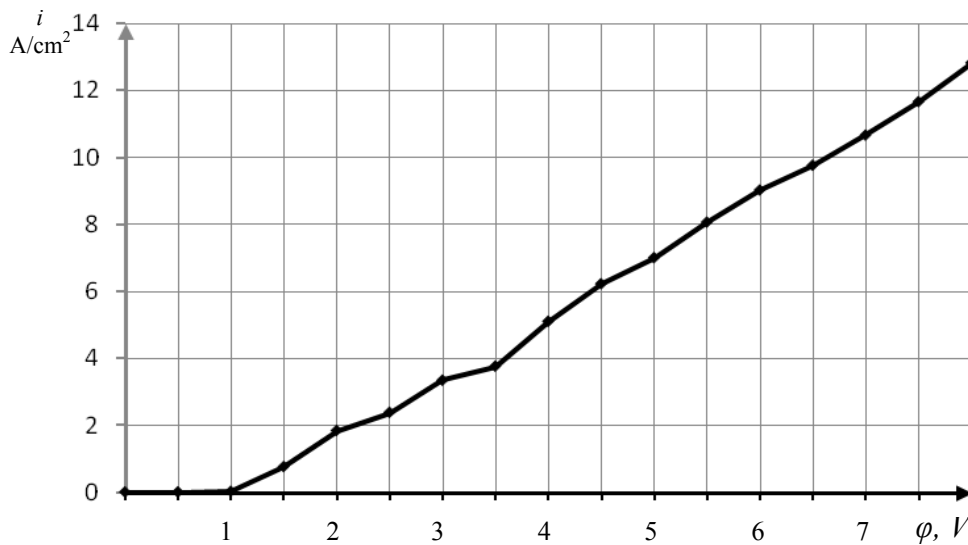


Figure 3. Polarization curves of anode dissolution of cobalt (Co) in water solution of neutral 10%NaNO₃

The feature of tungsten (W) electrochemical behavior in the water solution of 10% NaNO₃ is that the dissolution in an active state is only observed until the potential $\phi = 1.5$ V (Figure 4). Further anode potential rise results in the current density decreasing practically till 0. Probably, in the potential range from 1.5 V to 8 V it is caused by the formation of an oxide film (Figure 5) on the anode surface in the result of tarnishing. This film retards the anode dissolution and results in a surface passivation.

The analysis of the received results of electrochemical dissolution of cobalt (Co) and tungsten (W) allows to make an assumption that the character of the anode behavior of the WC25 coating in the water solution of 10% NaNO₃ (Figure 6) is determined by the character of cobalt (Co) component dissolution.

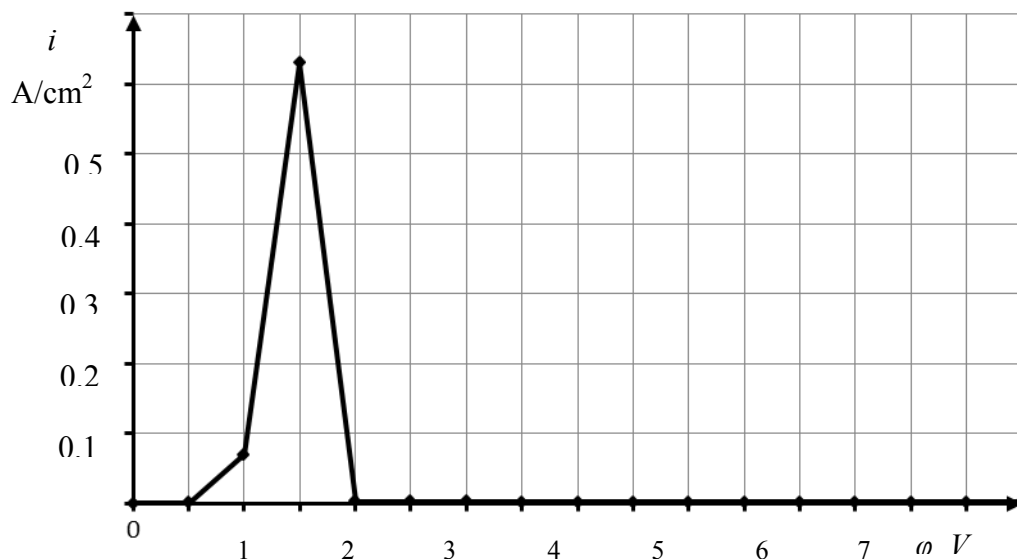


Figure 4. Polarization curves of anode dissolution of tungsten (W) in water solution of 10% NaNO₃

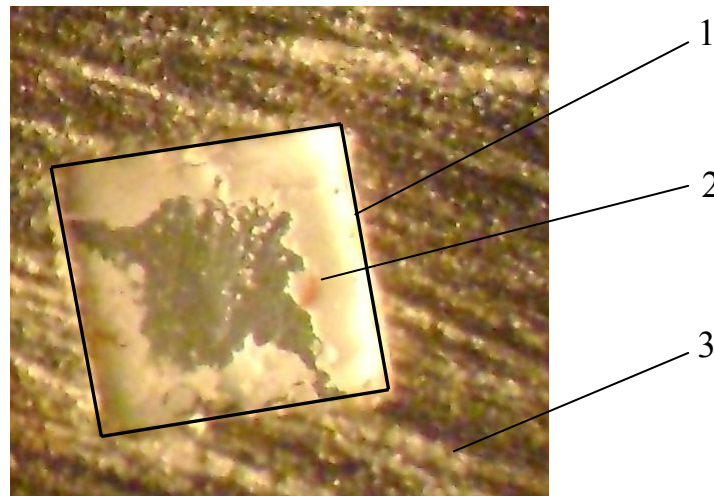


Figure 5. Surface morphology of tungsten (W) specimen after electrochemical dissolution in 10% NaNO_3 water solution: 1 – specimen; 2 – passivating film; 3 - arbor

Thus, we can observe an intensive dissolution of cobalt (Co) in the water solution of 10% NaNO_3 which causes the exposure of the particles of tungsten carbide and results in their chipping out during the process of cutting by a diamond grinding disk. The similar mechanism of forming the surface microrelief was observed while the electro-diamond grinding of hard alloys [15].

Probably, the value reduction of surface roughness after electro-diamond grinding is possible by the choice of a passivating electrolyte composition. However, the application of a similar variant for the reduction of surface roughness in case of the electro-diamond grinding of low-wear coatings based on powder compositions is problematic because of the complexity of a composition choice of a passivating electrolyte for all elements.

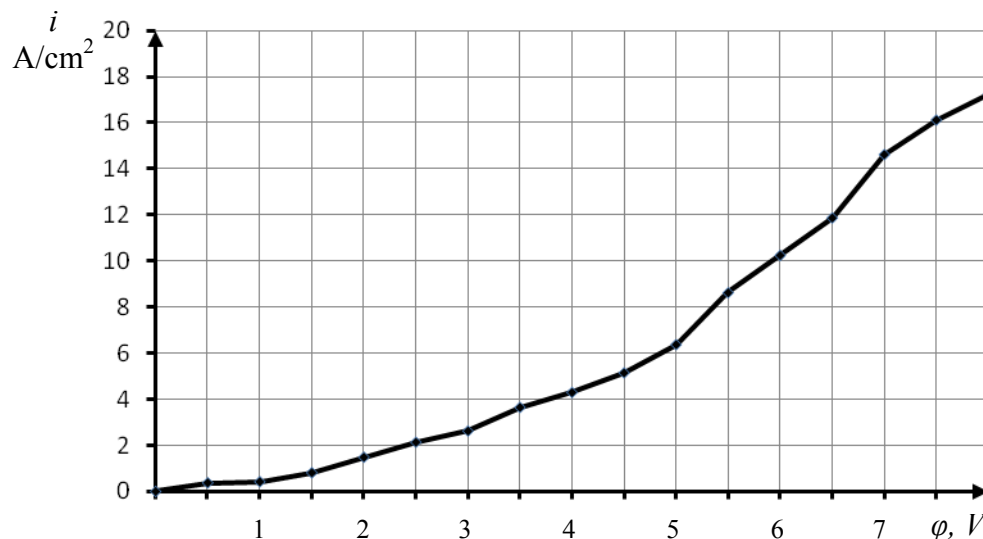


Figure 6. Polarization curves of anode dissolution of the VK25 powder composition in a water solution of 10% NaNO_3

One of the way to improve the surface quality of low-wear coatings after electro-diamond grinding is an introduction of an additional step in the technological process, carrying out with the switched off source of technological current. However, for realization of the process according to this scheme it is

necessary to take into consideration the dissolution value of the most active composition element while calculating the operating dimensions of a detail. A technological dimension chain made up, subject to a possible dissolution value of the coating surface based on the WC25 after electro-diamond grinding is shown in Figure 7.

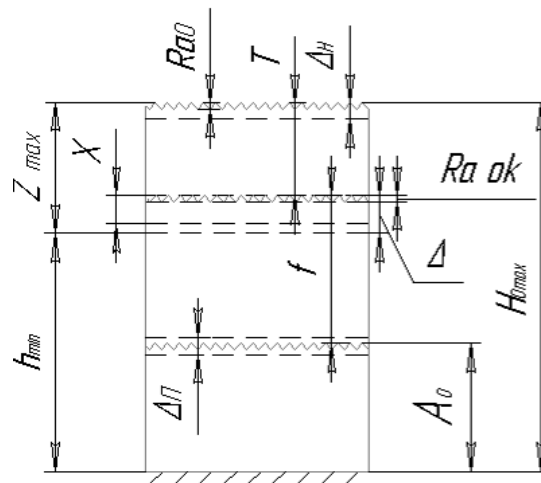


Figure 7. Technological dimension chain for a value definition of the minimal total grinding amount for machining the WC25 coating, subject to a possible value of dissolution of the coating surface after electro-diamond grinding.

H_{0max} – maximum coating dimension before machining; Z_{max} – maximum machining allowance; Δ – allowance for a final part dimension; h_{min} – minimal coated part thickness after machining; ΔH – allowance for coating thickness before machining; $\Delta \Pi$ – thickness of a transition layer; A_0 – thickness of a backing material; f – minimal sufficient coating value for part exploitation; Ra_0 – coating surface roughness before machining; Ra_{0K} – final surface roughness X – value of the coating surface dissolution after electro-diamond grinding.

3. Conclusion

These studies showed that an increased surface roughness value ($Ra=2.02\mu m$) is observed after the electro-diamond grinding of the coating based on the WC25 powder composition. The forming of the surface microrelief after electro-diamond grinding is connected to the features of the electrochemical dissolution of the WC25 coating elements in the electrolyte under study. The character of the dissolution of the indicated coating is determined by the character of the electrochemical dissolution of cobalt (Co). We observe an intensive dissolution of cobalt (Co) in the water solution of 10% $NaNO_3$ which causes the exposure of the particles of tungsten carbide and results in their chipping out during the process of cutting by a diamond grinding disk. To improve the surface quality of low-wear coatings after electro-diamond grinding is possible by an introduction of an additional step in the technological process, carrying out with the switched off source of technological current.

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