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APPLICATION OF THE METHOD ELECTRO-SPARK DEPOSITION WITH ADDITIONAL ULTRASONIC IMPACT TO EXTEND THE LIFE OF THE METALWORKING TOOL

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The article substantiates the possibility of using the method electro-spark deposition with additional ultrasonic impact to extend the life of the metalworking tool. Practical testing of this technology has been carried out. As a result, it was found that the number of articles manufactured using hardened tool and die tooling before their first regrinding increased 1.5-2.1 times.

Introduction. The operational wear of metalworking tools is a serious problem that can entail significant time and financial losses. Tool wear can be reduced by applying protective coatings. One of the most popular methods for creating wear-resistant coatings is the technology of electro-spark deposition (ESD) [1]. This is due to a number of its advantages: high adhesion of substrate and coating materials, the ability to carry out spot treatment of the surface, low thermal effect on the substrate, no strict requirements for surface preparation, high equipment reliability [1]. The undoubted advantage of electro-spark deposition is its suitability both for processing new and for restoring worn surfaces, which is very important for extending the service life of metalworking tools.

The disadvantage of this method is the impossibility of obtaining coatings of equal thickness and the high tension of their structure [2, 3]. Studies carried out by a number of authors [4] have shown that during electro-spark deposition there is also a problem of high roughness of the processed surface, which reduces the efficiency and quality of the tool with such a coating.

The elimination of these disadvantages is achieved through the use of an integral technology of electro-spark deposition with additional ultrasonic impact at various stages of coating creation: ESD with USI [5, 6]. The implementation of strengthening procedures is possible in two versions: according to the scheme ESD + USI and USI + ESD + USI. The choice of the processing scheme depends on the state of the worn out blade of the tool and the operating conditions of the product being processed with the hardened tool.

Methods of research. The principle of hardening the working edges of the tools by the proposed method is as follows. When a wear-resistant coating is formed according to the USI + ESD + USI option, at the initial stage, in the process of additional exposure to the surface with an alloying anode vibrating at an ultrasonic frequency, the processed material is activated, accompanied by an increase in its internal energy [5,6]. This causes the acceleration of physicochemical interactions, mass transfer processes in the anode - cathode system. During their vibro-shock high-frequency contact, a thin near-surface layer of plastically deformed metal is formed on the part cathode. The increased diffusion rate of atoms of alloying elements in the layer intensifies the process of saturation of the surface layer with them and leads, as a result of anodic-cathodic interactions, to a change in the structural-phase state of the coating being formed. Due to the reduced resistance of a metal to plastic flow under the ultrasonic impact [6, 7] and numerous vibration shock process for surface coating formation ESD method is more stable, with a stable and an active mass transfer, whereby the resulting coating has a higher thickness and a uniformity of thickness of the coating. In addition, under the influence of ultrasound, there is a redistribution, stabilization and relaxation of residual stresses over the section of the part [8]. As a result, the possibilities of controlling both the elemental composition of the hardened surface and the level and distribution of residual stresses over its cross section are expanded [9, 10].

The assessment of the thickness of the created coatings was carried out using a multifunctional device for measuring geometric parameters "Constant K-5" (TC 74.06.400.000.00). Measurements were carried out in accordance with the instructions attached to the device. The uniformity of thickness was determined by applying a grid on their surface with a uniform step, followed by precision measurement at the grid nodes of the coating thickness. After mathematical processing of the data obtained, curves were plotted that determine the change in thickness over the coating surface.

Research results. The protective coating on the surface of the cutting tool should, first of all, ensure its high performance under intense abrasive-mechanical effects.

Therefore, the processing of steel surfaces was carried out using hard-alloy electrodes of the VK (tungsten alloys), TK (tungsten-titanium alloys) groups and, for comparison, other compositions specially made for experiments, also capable of increasing the wear resistance of the treated surface.

Figure 1 shows the nature of the change in the thickness of the coatings formed by the T5K10 electrode over the entire surface of the samples according to three schemes: standard ESD - curve 1, scheme ESD + USI - curve 3 and scheme USI + ESD + USI - curve 2.

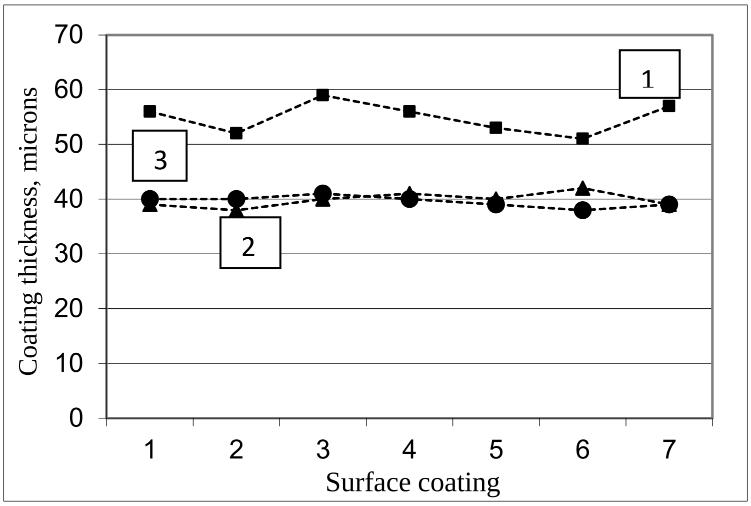

Fig. 1. – Change in the thickness uniformity of the hard-alloy coating depending on the processing scheme

The graph shows that the use of integral technology allows one to obtain a higher uniformity of thickness of the coatings created, which is very important for ensuring the required quality of the cutting edges of the tool. A similar picture of the change in the uniform thickness of the coating over the entire treatment area was also recorded when the surface was alloyed with other electrodes selected for research.

Then, according to the Knopp method, the microhardness of the obtained surfaces was measured, which is an indirect indicator of wear resistance (Figure 2).

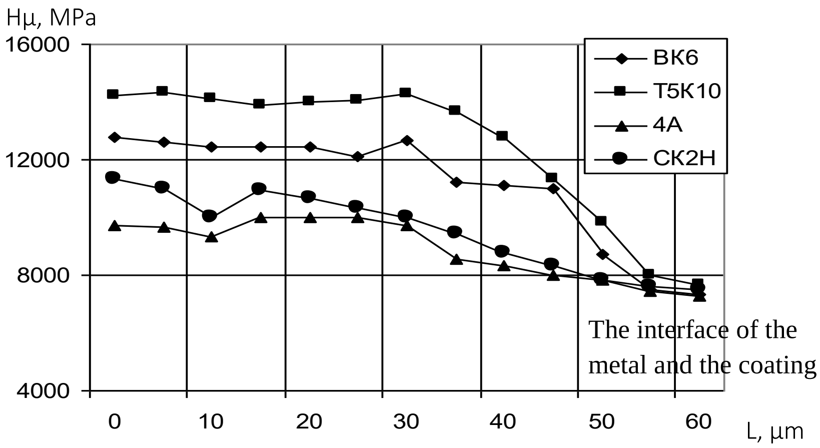

Fig. 2. – Distribution of microhardness over the cross section of the coating on R6M5 steel after its three-stage hardening with different electrode anodes

In the course of measurements, it was found that the most uniform change in microhardness along the depth of the hardened zone was recorded in the coating after three-stage hardening of the steel base with hard-alloy electrodes, in particular, with an alloying anode of T5K10 composition. It can be seen from this figure that the highest values of microhardness Hμ were observed when alloying the steel base with the T5K10 electrode. This is explained by more thermostats resistance of titanium carbide as compared to tungsten carbides and less intense carbon burn up for transfer carbides to the surface of the metal substrate.

In addition, it can be seen from Figure 2 that the composition of the electrode material also affects the depth of the hardened zone. The widest substantially commensurate with the thickness of the coating, hardened zone is formed by doping a steel cathode hard alloys by 25 - 30% less wide - in processing created by the electrode system, which, as noted above, were used for comparative tests order to optimize the formulations of reinforcing electrodes.

The roughness of the coatings was measured on a profilometer 296 in accordance with GOST 19300-86 at 5 - 8 points of the surface with control according to the criterion of the arithmetic mean deviation of the profile Ra, which is the average value of the distances of the points of the measured profile to its center line (Figure 3).

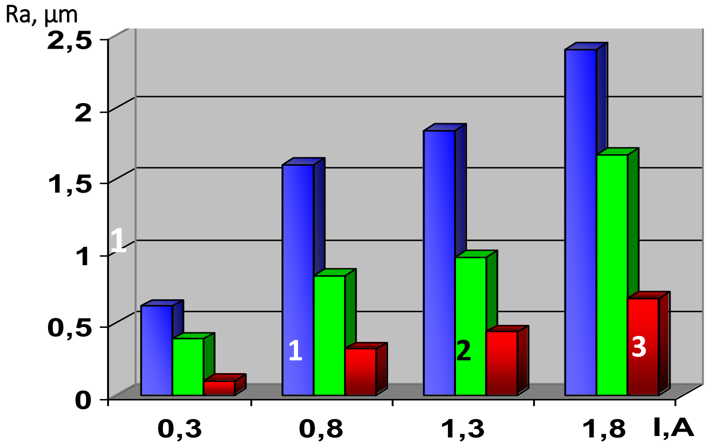

Fig. 3. – Change in surface roughness of coatings formed by methods:
ESD (1), ESD + USI (2), USI + ESD + USI (3)

Thus, the advantages of the integral method for obtaining coatings of the required quality are obvious. At the same time, it was found that the optimal variant of this technology for creating uniform-thickness coatings with a stable structure and low roughness of coatings is surface treatment according to the USI + ESD + USI scheme.

The possibility of creating high-quality wear-resistant coatings by the electro-spark deposition method with additional ultrasonic impact was tested on metal-cutting tools: cutters, cutters, drills, broaches, etc.; as well as the snap die: blanking, bending, and other dies (Figure 4).

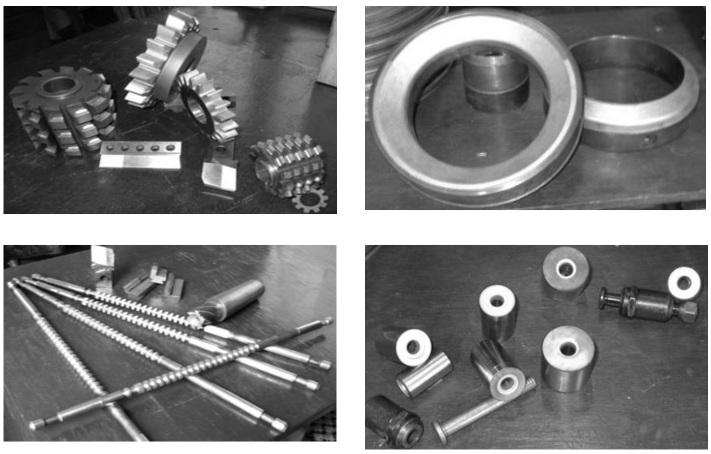

Fig. 4. – The restoration and strengthening of the integral method of electro-spark deposition with additional ultrasonic impact metal working tools and die tooling

By visual evaluation and control instrument hardened after its operation has been found the coating adhesion to the metal substrate and was maintained during the treatment and after its completion. Sticking of the product material to the coating surface was absent in all cases.

Production tests showed that the use of a hardened tool in comparison with a typical tool before the first regrinding allowed processing a larger number of parts (Table 1).

Table 1. - The number of products made with hardened and serial tools

The name of detail	Wear resistance		
	Number of parts made using standard tools, pcs.	Number of parts made using hardened tools, pcs.	Working resource increase (3 column):(2 column)
Scraper	113	200	1,77
Shell	62	116	1,87
Ring	2211	3952	1,78
Shaft	17	36	2,1
Plate	29	45	1,55

Conclusion. The hardening of the cutting surfaces of the listed tools by the ESD method with USI made it possible not only to extend the service life of the named parts, but also to return to the re-use of the product intended for disposal. As a result of the studies, it was found that the durability period of metalworking tools with a hardened coating exceeds the durability of serial ones by 1.5 times or more. It is shown that the number of articles manufactured using hardened tools and die tooling before their first regrinding increased 1.5-2.1 times. The data obtained confirm the reliability and stability of the processing of the working zones of the metal-working tool by the electro-spark deposition method with additional ultrasonic impact.

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