The quality study of composite galvanic coatings, obtained using electroerosive powders

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Abstract. Actual is the task of creating the so-called composite galvanic coatings (CGC), introducing hardening additives in the form of finely dispersed powder into the solution. During the experiments, a coating was applied using a standard composition, and then a coating with the addition of EED powder in an amount of 5 g/l of solution. The microstructure of the obtained coatings was investigated using a Quanta 200 3D scanning electron microscope. Testing the hardness of the samples along the transverse section was carried out using the DM – 8 automatic microhardness analysis system. It was experimentally established that the composite galvanic coating has a clear boundary with the substrate and a transition friable layer of up to 30 μm. In this case, the presence of vertical cracks up to 50 μm in size was noted. It was shown that a composite coating obtained with the addition of an electroerosive powder in an amount of 5 g/l of solution has a microhardness 12% higher than a coating using a standard electrolyte composition.

1. Introduction
Restoration of parts is the process of bringing a worn part to a healthy state by restoring its mass, as well as geometric and physical properties. The main part of the parts fails under the action of friction. As a result of friction, the material of the part is destroyed, it delaminates, and residual deformations also accumulate. Together, all of the above phenomena lead to the loss of a detail of its original geometric parameters, making its further use impossible. Parts restoration is a resource-saving technology, in some cases material costs can be reduced by up to 70% compared with the manufacture of a new part. It is generally believed that the average cost of materials in the manufacture of parts is 38%, and in the recovery of 6,6% of the total cost. Also, in the restoration of parts, a much smaller number of technological operations is used in comparison with the manufacturing process of a new part. In comparison with other methods of reconditioning parts, the ironing process does not require the use of sophisticated equipment, or expensive reagents. The necessary reagents can be prepared on site and have a low cost. The advantage of ironing is also that strong and dense precipitation can reach a thickness of up to 1–1,5 mm, and after intermediate machining of the part, the ironing process can be repeated. Thus, it is possible to restore parts with strong wear. The resulting coatings can have a hardness of 150 to 650 HB, and, if necessary, can be subject to surface hardening. The wear resistance of high-quality solid iron deposits can reach values not lower than that of hardened steel. The deposition process is particularly attracting attention with the high deposition rate of the metal, which is explained by the high current efficiency. The current efficiency for various electrolytes is 75–95%, and the maximum deposition rate is up to 1–1,2 mm/h per diameter. The high productivity of the
process, combined with the low cost of equipment and consumables, as well as the ability to achieve small allowances for further machining, combined with the ability to obtain solid and dense sediments, both small and large thickness, make this process competitive with vibration arc surfacing for a sufficiently wide item nomenclature. The ironing process is variable. By varying parameters such as current density, electrolyte composition or its temperature, the properties of the resulting precipitate can be changed. So, for example, you can get a coating with high hardness, or vice versa a viscous coating.

Actual is the task of creating the so-called composite galvanic coatings, introducing hardening additives in the form of finely dispersed powder into the solution. In this case, the iron in the coating is a connecting link (the so-called matrix), which includes powder particles. Composite galvanic coatings have higher exploitative qualities, and when using them, parts can be given new physical properties uncharacteristic of ordinary galvanic coatings [1-9].

In this work, electroerosion powders are proposed as a hardening additive [10-12].

The aim of this work was to study the quality of composite galvanic coatings using electroerosive powders.

2. Materials and methods
In accordance with the goal, a series of experiments were carried out on the coating of samples using sulfate electrolyte. The sample is a metal circle with a thickness of 5 mm and a diameter of 50 mm. The area of the side on which the coating was 0,1963 dm².

During the experiments, a coating was applied using a standard composition, and then a coating with the addition of EED powder in an amount of 5 g/l of solution.

When selecting the anode etching current, the properties and composition of the material from which the workpiece is made, highly alloyed, and also hardened steels require large anode etching currents.

The microstructure of the obtained coatings was studied using a Quanta 200 3D scanning electron microscope (Figure 1).

This device is equipped with a tungsten cathode, the accelerating voltage of which can vary from 200 eV to 30 kV, the resolution (with optimal WD) of 3,5 nm at 35 kV; 3,5 nm at 30kV in the natural environment.

Testing the hardness of the samples along the transverse section was carried out using the DM – 8 automatic microhardness analysis system. The hardness was measured by the micro-Vickers method with a load on the indenter of 100 g on five prints with a free choice of injection site. This measurement procedure complies with GOST 9450–76 (Measurement of microhardness by indentation of diamond tips). Indenter loading time 10 s.

3. Results and discussion
The microstructure of the coating studied using a Quanta 200 3D scanning electron microscope is shown in Figure 1.

The results of microhardness measurements for samples No. 1 and No. 2 are shown in table 1.
Figure 1. The microstructure of the galvanic coating

| Imprint number | Vickers microhardness |  |
|----------------|-----------------------|--|
|                | Electrolyte with EED  | Standard electrolyte |
| 1              | 704                   | 644                   |
| 2              | 673                   | 665                   |
| 3              | 729                   | 673                   |
| 4              | 747                   | 673                   |
| 5              | 824                   | 681                   |
| Average value (units) | 735                   | 667                   |

It was experimentally established that the composite galvanic coating has a clear boundary with the substrate and a transition friable layer of up to 30 μm. In this case, the presence of vertical cracks up to 50 μm in size was noted.

It was shown that a composite coating obtained with the addition of an electroerosive powder in an amount of 5 g / l of solution has a microhardness 12% higher than a coating using a standard electrolyte composition.

Conducted experiments on the deposition of CGC showed that even a small addition of a dispersed phase in the form of a solid powder material can improve the exploitative qualities of the resulting coating. The method compares favorably with simplicity of coating directly on the part. The low cost of consumables and equipment make this process even more attractive for industrial implementation.

As a practical application of the composite galvanic coating based on ferrous sulfate electrolyte and electroerosive powder material, the piston pin was restored.

4. Conclusion
An important scientific and practical problem has been solved in the work, aimed at improving the quality of parts restored by galvanic coatings.

Thanks to the study of the used powder samples, as well as the study of the properties of the deposited coatings on modern devices, results were obtained showing the high potential of this
recovery method. It was found that even a small addition of electroerosive powder to the electrolyte (5 g/l), allows to improve the exploitative qualities of the deposited coating. The availability of the reagents and equipment used in this process, combined with the high deposition rate of the material on the part, makes this method promising for industrial implementation.

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