CREATION OF NORMATIVE AND TECHNICAL BASE FOR QUALITY CONTROL OF REINFORCING COATINGS USED IN THE REPAIR AND MANUFACTURE OF PARTS OF PRINTING MACHINES

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The main direction of modern printing engineering is to improve the quality and reliability of machines and mechanisms. Therefore, the issue of ensuring the specified durability of parts, the service life of which is often determined by the quality of their surface layers.

In recent years, there have been many new ways to ensure the specified characteristics of the working surfaces of parts and which are called technological methods of surface hardening.

But the widespread use of these methods in industry is largely limited by two factors. First, the method of assessing the quality of the surface-reinforced layer is imperfect, and secondly, the regulatory and technical documentation on the basis of which the calculation and feasibility study of the feasibility of using certain control methods requires a new approach to solving these problems.

At the Department of Machines and Units of Printing Production of the Educational and Scientific Publishing and Printing Institute of the Kyiv Polytechnic Institute named after Igor Sikorsky conducted research that allows us to analyze existing methods for

assessing the quality of the coating. The analysis showed that in order to assess the quality of coatings, it is necessary to standardize the methods of their testing. Unfortunately, today there is no single, reliable and standard method of quality control of coatings. The analysis also showed that in most cases, the quality of the coating is characterized by adhesive and cohesive strength [1]. Despite the fact that in some countries some methods are standardized, almost every review article contains the conclusion that today there is no separate methodology that meets modern requirements [2 - 5].

Numerous studies on the performance of coating parts have shown that, despite the fact that the surface layer of the coating is affected by the external environment, the main reason for their destruction is the lack of connection between the coating material and the base.

That is why the assessment of the adhesive strength, or the bond strength of the coating to the substrate, is one of the most important characteristics of the strength of the coating. In most cases, the bond strength is determined experimentally, which is due to the fact that the adhesive strength is influenced by many factors related to the properties of the bonded materials and the parameters of the technological modes of coating.

It should be noted, however, that the attempt to assess the quality of the applied coating by the properties of only the adhesive contact is not complete enough. On the other hand, the application of data only on the cohesive strength of the coating does not allow to draw a conclusion in general about the strength characteristics of the composition.

Taking the cohesive strength as an additional characteristic of the strength properties of the coating, it should be recognized that it can be realized only under conditions of sufficient adhesive strength. That is why, as it makes no sense to create a cohesive coating, which remains unrealized due to its detachment from the base, it is impractical to create a composition with a sufficiently high adhesive strength [6].

It should be noted that most of the methods used to assess the strength of coatings are not regulated by any regulations.

The Japanese standard JIS H8504 "Metal coatings. Methods for determining adhesion" provides methods for measuring the adhesion of metal coatings [7]. The standard covers the areas of application and restrictions on the use of methods for assessing adhesive strength: indentation method, scratching method, evaluation method, shear method, heating method, heat shock method, adhesive tape method, separation method, tensile test method, bending test method.

It should be noted that these methods allow to measure the adhesive strength (quantitatively or qualitatively), but none of them allows to measure the cohesive strength, modulus of elasticity and Poisson's ratio. In addition, each of the above methods applies only to a specific type of coating and has restrictions on the thickness of the coating.

ASTM C-633, "Standard Method for Controlling the Adhesion or Cohesion Strength of Plasma Sprayed Coatings" (USA), uses a tensile strength method to determine the adhesion strength of a coating to a substrate or the cohesive strength of a coating [8]. This method is limited to testing plasma-sprayed coatings with a

thickness of more than 0.38 mm. Thin coating cannot be tested by this method. This method allows to determine either the adhesive or cohesive strength, however, does not allow to determine the elastic properties of coatings.

In ГОСТ 9.304-87 "Unified system of protection against corrosion and aging. Gas-thermal coatings. General requirements and control methods" [9] describes a method of separation tests, which allows to determine the adhesion strength of the coating. The method consists in uniform separation of the coating applied to the end of the sample, which is glued to the counter-sample without coating.

To determine the strength of adhesion, pre-glued samples (Fig. 1) are fixed in a special centering device that ensures alignment when applying the load, and placed in a test machine. The test result is taken into account if the separation of the bonded samples takes place between the coating and the base metal on the coating. In case of rupture during the test on the adhesive layer, it is necessary to measure its strength, adjust the bonding technology and conduct additional tests

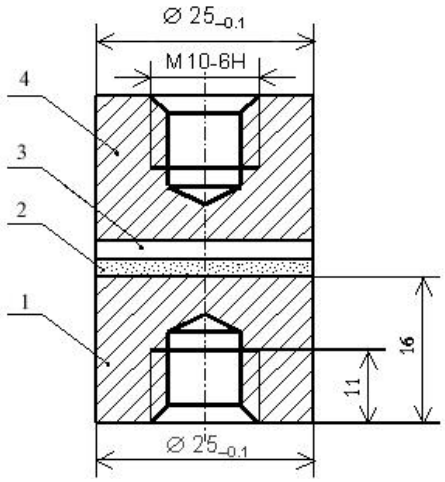

Fig. 1. Test scheme: 1 - sample, 2 - coating, 3 - adhesive layer, 4 - counter-sample.

The bond strength of the coating in a single test and the actual adhesive is determined by the formula:

$$\sigma = \frac{F}{S},$$

where σ - is the bond strength, MPa; F - breaking force, H; S is the cross-sectional area of the samples, cm^2.

The bond strength of the test coating is determined as the arithmetic mean of the results of the five test specimens.

ГОСТ 9.302 - 88 "Metallic and non-metallic inorganic coatings. Control methods" [10] applies to metallic and non-metallic inorganic coatings obtained by electrochemical, chemical and hot (tin and tin alloys) methods and establishes control methods in accordance with ГОСТ 9.301- 86 [11].

The standard defines: the appearance of the coating; coating thickness; porosity of the coating; adhesion strength of the coating; protective properties of non-metallic

inorganic coatings; chemical composition of coatings; oil content of coatings; completeness of washing of non-metallic inorganic coatings; protective properties of metal coatings; filling of anode-oxide coatings on aluminum and its alloys; functional properties of coatings; methods for determining the internal stresses of metal electrochemical coatings; method for determining the relative elongation of the nickel coating.

To determine the control of the bond strength of coatings, the standard provides for the use of the following methods: polishing method; cutting method; bending method; winding method; stretching method; method of applying a grid of scratches (dash method); heating method; method of changing temperatures; sawing method; method of extrusion (stamping); wiping method.

ГОСТ 9.304-87 and ГОСТ 9.302-88 allow to determine only the adhesive strength of the coating, and the latter does not describe the test method.

ГОСТ 9.301-74 "Unified system of protection against corrosion and aging. Coating of anode-oxide semi-finished products of aluminum and its alloys. General requirements and control methods" [12] applies to protective and protective-decorative anode-oxide coatings applied to the surface of semi-finished products of aluminum and deformed aluminum alloys and articles thereof, in cases where the initial surface is preserved or partially treated to improve the appearance.

This standard establishes general requirements for the appearance of the coating, the thickness of the anode-oxide surfaces, the degree of filling of the anode-oxide coating, the protective properties of the coating.

ДСТУ 2831-94 (ГОСТ 28617-95) “Coatings of metal and non-metallic inorganic bicycle products. General requirements and control methods” [13] applies to metallic and non-metallic inorganic protective and protective-decorative coatings of parts and assemblies of bicycles, motorcycles, mopeds (hereinafter - bicycle products), designed for operating conditions in accordance with ГОСТ 15150 [14].

The standard establishes: general requirements for the surface of the base metal; general requirements for the choice of types and thicknesses of coatings; general requirements for coatings; rules of acceptance and methods of control.

The appearance of the parts that determine the appearance of the product is controlled by comparison with samples and standards.

ДСТУ 2639 - 94 “Unified system of protection against corrosion and aging. Gas-thermal coatings. The method of determining the strength of adhesion of the coating to the base of the normal separation at temperatures up to 1770 K” [16] establishes a method of static tests of the strength of the gas thermal coatings of normal separation at temperatures on the surface of the sample up to 1770 K.

The requirements of this standard are mandatory for testing the adhesion strength of gas-thermal coatings operating at temperatures above 400 K. For coatings operating at temperatures of 400 K and below, it is permissible to use the method of separation tests according to ГОСТ 9.304 [9].

The essence of the method is to determine the force by which the end face of the sample pin is torn off in the normal direction from the coating layer previously sprayed on the common end face of the pin and the matrix (Fig. 2).

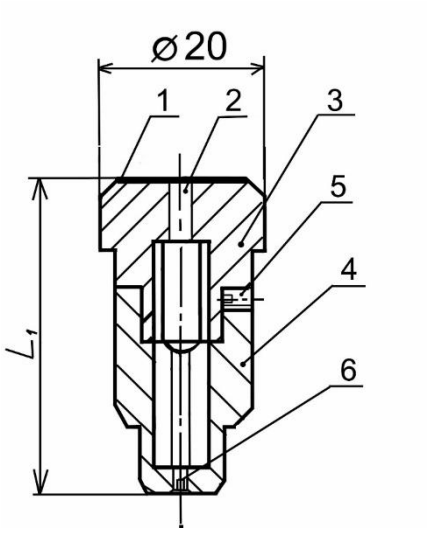

Fig. 2. Sample for testing: 1 - coverage; 2 - pin; 3 - matrix; 4 - cover; 5, 6 - locking screws

Tests are carried out using samples of special design (Fig. 2). The coating is applied to the common end of the pin and matrix. The difference in the thickness of the coating layer by the area of spraying should not exceed 0.01 mm. For the manufacture of the pin and matrix using the material used for the manufacture of specific parts to be coated. In the absence of a suitable range of material for the manufacture of pins and matrices, these parts of the samples may be made composite, with plates welded to them from the material from which specific parts are made with a protective coating.

The adhesion strength of the coating to the substrate in a single test is calculated using the formula

$$\sigma_{as} = \frac{P_{\max}}{F} \quad ,$$

where σ_{as} - adhesion strength, MPa; $P_{\max}$ - the maximum force recorded during the separation of the end of the pin from the coating layer, H; F is the area of the end of the sample pin, mm^2.

The value of adhesion strength obtained in this test is a conditional characteristic used to compare the quality of coatings and determine the impact of technological factors on them.

If the fracture during separation occurs completely at the interface between the coating and the substrate, the test result is considered as the strength of adhesion of the coating to the substrate during normal detachment.

If the fracture during separation occurs on the coating layer, the test result is counted as the strength of the coating, assuming the strength of adhesion is higher than the strength of the coating in this experiment.

If the fracture has a mixed appearance, that is the fracture occurs partly at the interface between the coating and the base, and partly along the coating layer, it is

considered that the adhesion strength and coating strength are equal to the value obtained.

ДСТУ 3366-96 (ГОСТ 30431-96) "Gas-thermal wear-resistant coatings. Tribotechnical test methods. General requirements" [17] establishes general requirements for the method of tribotechnical tests of gas-thermal wear-resistant coatings intended for operation in the mode of mixed friction, to the conditions of production and testing of gas-thermal wear-resistant coatings samples and evaluation of the obtained results.

The standard contains codification rules and corresponding code designations of morphological features of gas-thermal wear-resistant coatings surfaces, which provide systematization of the results of tribotechnical tests during the creation of databases.

Thus, the analysis of existing methods of testing coatings used to strengthen the surfaces of printing machines and the normative documents created on their basis shows that there is a need not only to create a specialized standard to assess the properties of the entire range of existing coatings, but also to achieve its joint use with ДСТУ on equipment, technology, compliance with labor protection and environmental requirements.

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