Technology support for the supply of an element of the coating material during cladding with a flexible tool

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Abstract. The article considers the issue of improving the quality of machining of engineering products when using the method of deformation cladding with a flexible (wire) tool (wire brush). The essence of this method is to combine the processes of plastic deformation from impacts of wire brush with coating for various functional purposes. The design of the feed device has been developed, which allows controlling the necessary clamping force of the coating material element (MCE) to the wire tool. The control of clamping force provides temperature stabilization in the contact between the MCE and the tool and allows to increase the uniformity of coating formation on the workpiece. The coating material is set with eccentricity relative to the axes of the brush, which makes it rotate about its axis during operation, ensuring its uniform wear. This feed device is easily dismantled, which provides a quick replacement of the MCE.

1. Introduction

The introduction of a new high-performance method of combined surface treatment of products by cladding with a flexible tool has recently gained more and more popularity. This method is technologically simple, environmentally friendly, cost-effective and allows you to get high quality coatings with good adhesion to the workpiece. Increasing the new advanced technologies part in the total share will accelerate the growth of industrial production.

Friction cladding is performed as follows. The coating material should initially exist in the form of a rod or a similar item. The major production tool is a rotating cylindrical metal brush. The brush rotates at high speed, and it is pressed against the processed surface. In another place, the brush is pressed against the rod of the coating material. Each one of the wires of which the brush consists removes a material particle, some fraction of a micron in size, and transfers it to the processed surface. The high rotational speed of the brush results in a significant force of impingement between a particle and the surface; the particle is fused to the processed surface. The large number of wires in the brush and the high rotational speed provide high efficiency and uniformity of material transfer from the rod to the processed surface [1].
2. Relevance
The deformation cladding with a flexible tool (DCF) allows you to apply coatings for various functional purposes: corrosion-resistant, wear-resistant or decorative. The study of various aspects of this method goes to new levels [1-7, 9].

For example, to increase the adhesion level in the production of bimetallic wire by passing a steel core through molten metal, the authors [2] suggest to form a thin sublayer of non-ferrous metal with a rotating metal brush.

The results of comparative tests of copper coatings formed by electroplating and deformation cladding with a flexible tool at ultimate loads are presented in [3]. DCFT coatings, unlike electroplated coatings, did not peel off the base material at all load cycles during the peel adhesion test. The authors [4] found that it is advisable to use sectional brushes that have not only a frictional effect, but also impact effect for hardening and nanostructuring of the surface layer.

Studies [5] prove that the bearing capacity of prestressed joints can be increased due to plastic deformation of the surface with a flexible tool and simultaneous coating on this surface. The authors [1] study the effect of electric current on the rate of the process and the formed coating thickness.

The study [6] found that the use of donor metals (material coatings) capable of strain hardening comparable with the hardening of the substrate causes mutual mass transfer to the mating surfaces, and the conditions of the interaction in the contact zone with the tool promote formation of a coating from the donor metal on the surface of the specimen or of a layer represented by a layered mixture of iron with the donor metal, which is formed as a result of mechanical alloying of the surface of the steel substrate with the donor metal. A similar mass transfer occurs in the case of electric discharge alloying [8].

The problems of increasing the adhesion of the coating to the substrate of the workpiece are considered [9]. The thermo-mechanical parameters of DCFT are modified to increase adhesion in this work.

One of the main factors when applying the coating is the tightness of the tool to the MCE or, in other words, the clamping force of the MCE pressure on the tool. Reducing the tightness leads to a decrease in temperature in the contact zone of the MCE with the wire tool. The sizes of the coating droplets will change accordingly, which are transferred at the ends of the wire elements to the workpiece, which leads to an unevenly formed coating on the product.

Automating the process of controlling the pressure of a MCE on a wire tool is quite difficult due to the large number of constituent parts. Also, high accuracy requirements are imposed on the feed device, which leads to a serious increase in the cost of the process.

We offer a feed device whose design will reduce processing errors to a minimum and it is cost-effective.

3. The design of the feed device
During the design process, a device was created for coating the surface of the workpiece (figure 1). The clamping force of the MCE to the wire tool is regulated, which is maintained at a certain level during processing in this feed device. This ensures uniform wear of the MCE and its quick replacement.

The device comprises a brush with a metal pile 1, which is pressed by its periphery to the workpiece 2, and MCE 3 in contact with it. The element is made in the form of a bar of cylindrical shape and is installed in the guide bushing 4 with a small gap, giving it the ability to move and rotate. The MCE clamping mechanism is equipped with a manual regulator in the form of a hold-down screw 5 interacting with the MCE end face through the compression spring 6 with the upper 7 and lower 8 spring supports. The screw 5 is installed through a threaded connection in the upper plate 9, in which (as in the guide bushing), the slideways 10 are fixed (3 slideways evenly spaced around the circumference relative to the axis of the screw 5) using nuts 11 based on the washers 12. On slideways 10 carry out the movement of the bush 13, mounted in the plate movement 14. Slideways 10 can eliminate the effects of inevitable structure vibration and increase the stability of fixation with screw 5.
The guide bushing 4 is installed, screwed into it by pins 15 into the grooves of the supporting sleeve 16, having a V-shape and is fixed in the working position by the force of the spring 17, acting through the washer 18 on the pins 15. The supporting sleeve is part of the wire tool casing (not shown). The device is installed with eccentricities $e_1$ and $e_2$ relative to the axes of the wire tool, which ensures periodic turning of the MCE during processing. The device is equipped with a measuring scale 19, by which it is possible to determine the amount of compression of the spring, i.e. to control the clamping force of the MCE.

4. The principle of operation of the MCE feed device

The MCE 3 is placed in the guide bushing 4 and installed by means of the pins 15 into the grooves of the supporting sleeve 16 which is part of the casing of the wire tool 1. The pins 15 are fixed in working position by the force of the spring 17 acting through the washer 18. The clamping force is regulated by a screw 5, which compresses the spring 6, creating the necessary force. The wire tool 1 is brought into rotation to form a coating on the surface of the workpiece, which makes the MCE rotate due to the eccentricities $e_1$ and $e_2$. The friction force arising between the interacting surfaces of the tool and the MCE leads to its heating. The temperature of the heated surface of the MCE reaches approximately 0.7-0.8 the melting temperature of the coating material. The heated particles of the coating material adhere to the ends of the pile of the wire tool and are transferred to the surface to be
treated, grasping with it and forming a layer of coating material on the surface. Impacts of a metal pile on a part provide its surface hardening simultaneously with coating.

5. Conclusions
The uniformity of the formation of the coating layer is increased due to the installation of a compression spring in the design of the device, which provides uniform MCE clamping force and does not allow a sharp change in it. The clamping screw is provided to enable adjustment of the clamping force in the structure. The coating material is set with eccentricity relative to the axes of the brush, which makes it rotate about its axis during operation, ensuring its uniform wear. The device has the ability to quickly dismantle, which allows for quick replacement of the MCE.

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