About Modeling Kinematic Parameters of Deposition from Composite Electrochemical Coatings for Restoration of Details for Agricultural Machines

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Abstract. Theoretical aspects of process of drawing of composite galvanic coverings on the basis of a chromic matrix on current-carrying surfaces are considered by method of galvanic contact plating (GCP). The analytical dependences connecting parameters of physic mechanical characteristics of a covering with technological modes of sedimentation of coverings and design features of the equipment, used in process are resulted.

1. Introduction

Standard galvanic reduction of parts restored by chromium plating, successfully used for such a long time, despite its ease of use in recent years does not meet the requirements of modern technology and technologies for the quality of coatings used in the restoration of agricultural machinery parts [1, 2]. In this regard, in recent years have been widely developed and implemented in the production of modernized methods of restoration of chrome plating parts.

Taking into account the above, and based on the existing theoretical and practical groundwork on the problem of restoring parts by chromium plating with simultaneous activation of the cathode, a previously developed method for restoring parts was proposed, which consists in combining the process of galvanic coating and its simultaneous machining during deposition with the possibility of regulating the rate of recovery of a particular part surface area, depending on its wear [1]. The method is called galvanic contact deposition (GKO).

2. Materials and research methods

There was a research to determine the operating parameters of the processing method applicable for experimental sleeves. They were conducted on experimental shells, made of steel 30 HGSA TU 14-1-950-74.

Axial residual stresses in chromium coatings was determined by the method of backgroundmaterial with continuous grazing of intense layers from the surface which was carried out on the machine UKOONT [3, 5]. The unit is designed to measure the relative strain and consists of a strain gauge
amplifier 8ANCH-7M and recording potentiometer KSP-4. Primary transducers were strain gages 2FKPA-10-200 V.

Residual stresses in the studied layer were represented as the following sum [1]:

\[ \sigma_h = \sigma_{hv} + \sigma_{hs} \]

where \( \sigma_{hv} \) – linear component determined by the deformation of the sample which cuts from the part; \( \sigma_{hs} \) – nonlinear component, calculated according to the curve of deformation during the etching of the sample in the study depth.

3. Results and discussion

Plastic deformation of the deposited coating crystal is always accompanied by its elastic deformation [4, 9]. Consequently, the dimensions of the body at the final moment of its loading differ from its dimensions determined when the load is removed.

To represent the logarithmic degree of deformation it is necessary to calculate the integral of an infinitely small increment of the considered size of the body or its element related to its value at each given moment of deformation

\[ \delta_x = \int_{x_i}^{x_d} \frac{dx}{x} = \ln x \bigg|_{x_i}^{x_d} = \ln \frac{x_d}{x_i} \]  (1)

On the other hand, the expression of the degree of deformation as the ratio of the size increment to the initial size is of great interest [8].

Due to the fact that the tool forces under its influence on the deposited coating is extremely small compared to the mechanical properties of the coating, it can be assumed that in this case there is a small deformation [3] (the degree of deformation is less than 0.01). For small deformations:

\[ \delta = \varepsilon \]  (2)

and, accordingly

\[ \varepsilon_x + \varepsilon_y + \varepsilon_z = 0 \]  (3)

Multiplying all the terms of the equation for the degree of deformation by the volume \( V \) of the deformable body, we obtain

\[ V \delta_x + V \delta_y + V \delta_z = 0 \]  (4)

and for small deformations:

\[ V \varepsilon_x + V \varepsilon_y + V \varepsilon_z = 0 \]  (5)

Thus, the sum of the multiplication of volume by logarithmic degrees of deformation (crumpled volume) in mutually perpendicular directions is zero.

The elementary displaced volume is defined by the expression:

\[ dV_c = F_z dz \]  (6)

where \( F_z \) – the area of normal cross sections of the deposited coating at each specific moment of the deformation process. Then

\[ V_c = \int_{z_i}^{z_d} F_z dz \]  (7)

In the case of plastic deformation of elementary volume \( F_z = V/z \) [1]. Then

\[ V_c = V \int_{z_i}^{z_d} \frac{dz}{z} \]  (8)

where \( Z_i \) – is the initial height of the deposited layer;

\( Z_d \) -the height of the deposited layer after deformation.

After integrating, we can obtain:

\[ V_c = V \ln \frac{z_d}{z_i} = V \delta_z \]  (9)

Such algorithm of layer-by-layer deformation to determine the degree and rate of deformation was’t chosen by chance. It was presented in [1, 2] and experimentally tested in [3].

From the expression above (7), taking into account, that \( Y_i Z_i = F_{ih} \) and \( Y_d Z_d = F_{dh} \) follows:

\[ \frac{x_d}{x_i} = \frac{Y_d Z_i}{Y_i Z_d} = \frac{F_{ih}}{F_{dh}} \]  (10)
where $F_{ih}$ and $F_{dh}$ are the areas, respectively, normal to the x-axis of the body sections before and after deformation.

Taking into account the above, it is possible to express the degree of deformation and displacement volumes not only through the linear dimensions, but also through the cross-sectional areas normal to the coordinate axis, in the direction of which the degree of deformation and displacement volume is considered:

$$\delta_x = \ln \frac{x_d}{x_i} = \ln \frac{F_{ih}}{F_{dh}} = -\ln \frac{F_{dh}}{F_{ih}}$$

$$\varepsilon_x = \frac{x_d - x_i}{x_i} = \frac{\Delta x}{x_i} = \frac{F_{ih} - F_{dh}}{F_{dh}} = -\frac{\Delta F_x}{F_{dh}}$$ (11a)

Similarly, we can get expressions to calculate the degrees of deformation in the directions of the coordinate axes Oy and Oz.

In general, we can write:

$$\delta = -\ln \frac{F_d}{F_i}; \quad \varepsilon = -\frac{\Delta F}{F_d}$$ (12)

**Conclusion**

Theoretically developed and experimentally investigated the dependence of tool pressure on the stages of recovery, implemented by GKO technology, which allows to obtain high-quality thick coatings (in particular chrome) with a given physical, mechanical and, as a consequence, operational properties.

**References**

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