Mathematical Modeling of the Technology of Processing Metal Products with a Vapor-Gas Discharge

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Abstract. **Currently, the development and research of new technologies for surface treatment of metal products is being actively pursued. One of these methods is the processing of a metal surface with a vapor-gas discharge. The work is devoted to the development of a mathematical model of the part processing process. This approach is relevant for use at the stages of preparation and planning of experiments, for describing the results of technology, as well as for monitoring changes in the parameters of technological blocks.**

In the simulation, **an arbitrary macroscopic volume of liquid is considered directly under the discharge region, bounded by the surface (Fig. 1). It is assumed that chemical reactions and phase transitions do not occur with the liquid in this volume. Then the change in the mass of the liquid in the volume occurs due to its loss from this volume in small portions and at low speeds. Evaporation at the electrolyte-gas (air) interface and mixing of liquid layers can be considered as mechanisms for the loss of liquid mass.**

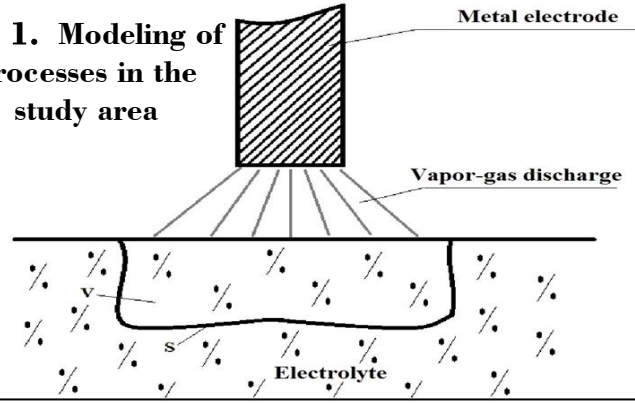

Fig. 1. Modeling of processes in the study area

continuity equation

$$\frac{\partial \rho}{\partial t} = \nabla(\rho \vec{v}) = 0, \quad (1)$$

Euler's equation

$$\rho \frac{\partial \vec{v}}{\partial t} + \rho(\vec{v}, \nabla)\vec{v} = -\nabla P + \rho \vec{g}, \quad (2)$$

conduction equation

$$\rho C \frac{\partial T}{\partial t} = Q + \nabla(a \nabla T), \quad (3)$$

The mathematical model **of the metal processing process is a system of equations for physical quantities such as the temperature of the electrolyte, the density of the liquid and the rate of loss of the mass of the electrolyte from a certain volume**

Substitution **of all the parameters characterizing the state of an aqueous solution of salicylic acid (or electrolytes of a different composition) into equations (1) - (3) makes it possible to construct in MATLAB a primary model of changing the parameters of the processing of a part with a vapor-gas discharge.**

In the conditions of the considered process, difficulties arose taking into account the large number of variable parameters, which are sometimes quite costly to control from the hardware point of view and from the point of view of time costs. These difficulties led to the need to use the capabilities of a *three-factor experiment* to create a *mathematical model* of the studied process of processing metal products

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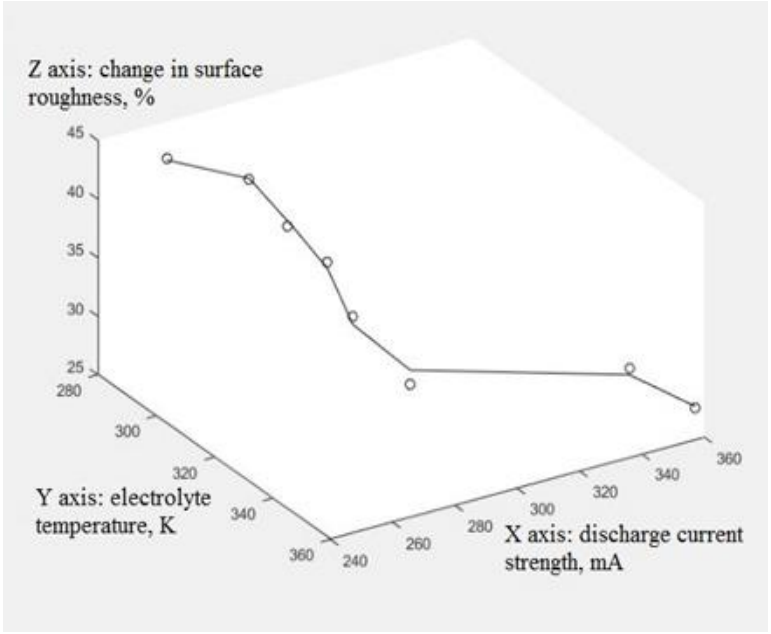

Fig. 2. Dependence of roughness surface on the temperature of the electrolyte and the strength of the discharge current

The search for a mathematical description of the process under consideration was carried out in the form of a response function:

$$y = f(x_1, x_2, \ldots, x_n).$$

To describe the dependence of the change in surface roughness on the current in the discharge, the discharge voltage and the temperature of the electrolyte, the response ***function is obtained***:

$$\delta R_a = f(I_p, U, T) = 739{,}006 - 0{,}863 I_p - 0{,}594 T - 0{,}254 I_p T + 0{,}198 I_p^2 + 0{,}325 T^2 + 0{,}159 U^2.$$

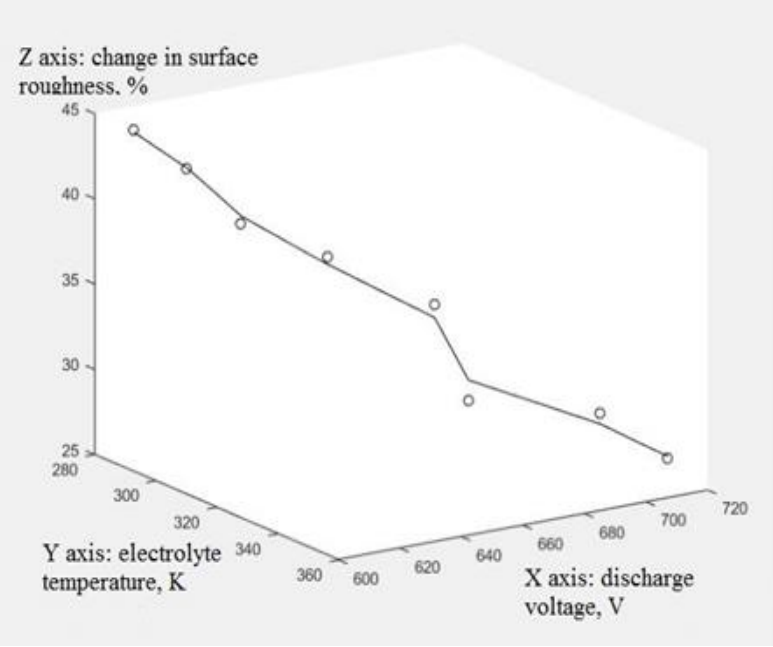

Fig. 3. Dependence of roughness surface on electrolyte temperature and discharge voltage

The methodology for the mathematical description of the technology for reducing the roughness of metal surfaces under the conditions of the experiments carried out will make it possible to use information on the influence of processing factors for further research and optimization of the processes under consideration.

Thank you!

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