Control of electrochemical dimensional processing on the basis of synergy of controllable factors

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Abstract. The article considers the factors that influence the electrochemical dimensional processing, which have synergistic connections. It is revealed that the size of the interelectrode gap is of great importance for ensuring the quality of processing, and methods for adjusting the gap during processing are proposed.

Introduction

Quality indicators of automatic and semi-automatic lines for electrochemical surface treatment are separated into groups of indicators according to:
- their purpose (productivity, specific output of products from the occupied area);
- reliability (trouble-free operating time, life before the first major overhaul, shelf life, service life);
- on the economical use of materials, electricity and labor resources (specific consumption of electricity, water);
- for ergonomics (sound pressure at the workplace, the volume of sucked air);
- on the manufacturability (mass and specific gravity of the line);
- on standardization (coefficient of applicability);
- on patent law (indicators of patent protection);
- safety (protection of electrical equipment).

The performance of automatic and semi-automatic lines for electrochemical surface treatment can be viewed from various aspects: technical, theoretical and operational. Technical productivity is the main technical and economic indicator that characterizes the capabilities of the line, due to the technological process and the design of the equipment. In addition to productivity, the process quality of the electrochemical dimensional processing includes the processing accuracy and roughness of the treated surface.

Analysis of indicators and factors of electrochemical dimensional processing

The carried out investigations on sectional samples of steel 12x13 with dimensions 10 * 10 * 20 mm by electrochemical dimensional processing using a brass cathode from L62 with dimensions of 3*3 mm and electrolyte NaNO3 made it possible to compose the regression equations for the above indices of the quality of the technological process of electrochemical dimensional processing:

\[ Y_1 = 142.23 - 16.69X_1 - 6.59X_2 + 20.31X_3 + 18.21X_4 + 97.75X_5 + 110.53X_6 + 84.41X_7 - 56.39X_1X_5 + 72.08X_5X_6 + 56.73X_5X_7 + 61.27X_6X_7; \]

\[ Y_2 = 1160.77 + 271.71X_1 + 21.21X_2 + 136.29X_3 + 39.66X_4 + 79.52X_5 + 404.59X_6 + 426.38X_7 + 193.49X_1X_5 + 90.62X_1X_6 + 151.51X_1X_7 + 84.27X_2X_3 - 71.23X_2X_5 + 67.82X_6X_7; \]
У3=54,49-9,47*Х1-5,73*Х2-4,99*Х3-7,40*Х4-7,13*Х5+7,16*Х6-4,69*Х7+6,32*Х1*Х2+6,68*Х1*Х4+6,63*Х1*Х5+7,18*Х3*Х4-6,27*Х5*Х6-6,21*Х6*Х7.

In these equations У1 - efficiency of process, У2 - accuracy of processing, У3 - the surface roughness after processing, Х1 - initial interelectrode gap, Х2 - electrolyte pH value, Х3 - electrolyte concentration, Х4 - electrolyte temperature, Х5 - electrolyte speed, Х6 - treatment time, Х7 - operating voltage. [1]

In these equations the variables Х1 и Х5, Х5 и Х6, Х5 и Х7, Х6 и Х7 (for У1); Х1 и Х5, Х1 и Х6, Х1 и Х7, Х6 и Х7 (for У2); Х1 и Х2, Х1 и Х4, Х1 и Х5, Х3 и Х4, Х5 и Х6, Х6 и Х7 (for У3) have a synergistic effect. To analyze the synergistic influence of factors, a connection diagram was used. Figure 1 shows the factors by which, according to the regression equation for productivity, there is a synergistic effect.

The increase in productivity is significantly affected by the processing time, but the speed of the electrolyte due to synergistic bonds has a greater impact. Similarly, Figure 2 shows the factors by which, according to the regression equation for accuracy, there is a synergistic effect.

The increase in accuracy is significantly affected by the operating voltage, but due to synergistic relationships, the initial interelectrode gap exerts a greater influence.

Figure 3 shows the factors by which, according to the regression equation for roughness, there is a synergistic effect.
affecting the roughness of electrochemical processing

The decrease in roughness is significantly affected by the temperature of the electrolyte, but due to synergistic bonds, the initial interelectrode gap exerts a greater influence.

Thus, in order to achieve a given level of performance indicators, accuracy and roughness, synergistic factors, different for each indicator, are involved. To ensure the required performance and accuracy, it is necessary to establish factors at the upper levels, with the exception of the hydrogen index of the electrolyte. To reduce the roughness, all factors should also be set at the upper level, except for the processing time.

In modern industry, traditional, for example, mechanical processing, as well as new types, such as ultrasonic, laser, plasma, etc., are used to process natural-deficient, hard metals. At the same time, laser and plasma cutting of materials are the most modern, promising methods and increasingly find practical application in the manufacture of products from hard-to-process materials. These methods provide high productivity of the production process, but they also have a number of disadvantages that do not allow their application in the case of stringent quality processing requirements. [2]

Electrochemical dimensional processing of materials has a number of unique features that allow it to compete with other methods of dimensional shaping. An increase in the level of quality of electrochemical dimensional processing is possible due to the choice of appropriate processing regimes or through the introduction of new technical solutions.

Corresponding treatment regimes should first of all be aimed at achieving the required quality of the treated surface, the performance parameter is, although important, but secondary. Processing modes can be selected in such a way as to ensure that the requirements for both surface quality and productivity are met. Consider the connection diagram for the system of equations under consideration; Figure 4 shows the factors by which the regression equations for performance, accuracy and roughness have a synergistic effect.

![Figure 4 Diagram of the relationships of synergistic factors affecting the productivity, accuracy and roughness of electrochemical processing](image)

The main criteria affecting the process of electrochemical processing with fixed electrodes are the electrolyte velocity, the voltage at the electrodes and due to the synergistic effect, the magnitude of the initial interelectrode gap plays a large role. To improve the quality of the surface, the initial interelectrode gap should be set at the upper level, but in the process of processing, when it increases, the productivity decreases. Maintaining the required value of the interelectrode gap is provided, for example, by the mobility of the tool electrode; as it is realized in the patent RU (11) 2 277 034 (13) C2 Method of electrochemical processing. [3]

In addition, an example of a technical solution is the design of a new electrode tool, which uses nanomaterials and composites. In the proposed embodiment, there is no constant uncontrolled electrical contact between the tool electrode and the workpiece to be machined, so that the side surfaces of the cut channel are plane-parallel. A positive result of the new tool electrode is the
elimination of additional processing operations to eliminate the non-parallelism of the surfaces of the cutting channel. [4]

Conclusions
The results of the studies allow controlling the electrochemical treatment and providing the required technological parameters. Priority should be given to the accuracy and purity of the treated surface, and then performance. An analysis of the synergistic effect of the regression equations revealed the dependence of the quality indices on the value of the interelectrode gap, which simplifies the control of the electrochemical processing.

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