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EFFECT OF CELL VOLTAGE ON ELECTROCHEMICAL MACHINING PARAMETERS

Abstract: *The analysis of parameters of the electrochemical machining of the hole when the cell voltage changes from 10 to 30 V was performed in the article.*

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Language: *English*

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Introduction

Electrochemical machining is a method of processing electrically conductive materials, which consists in changing the shape, size, and roughness of the surface of the workpiece due to the anodic dissolution of its material in an electrolyte under the action of an electric current [1-6]. This method produces complex elements on the surfaces of difficult-to-process materials [7-8]. Compared with electric discharge machining, electrochemical machining has the advantage of maintaining the geometric shape of the electrode tool.

Electrochemical machining is performed at direct current using various electrolytes, such as mineral acids, aqueous solutions of salts and others. The electrolyte is pumped under pressure into the created gap between the workpiece and the electrode, thereby ensuring non-contact processing that does not lead to electrode wear. The voltage is assumed to be 10...30 V, depending on the type of electrochemical machining.

Thus, due to the absence of electrode wear, the influence of the voltage value on performance and other qualitative indicators of electrochemical machining is subject to consideration.

Materials and methods

Electrochemical machining of a conical hole in a metal was modeled using the COMSOL program. Models of the workpiece (anode) and the tool (cathode) were constructed and constant and variable parameters of electrochemical machining were set [9-10]. The element in the metal workpiece was obtained by removing a volume of material to form a cone having a diameter of 165 microns larger base and a diameter of 128 microns smaller base. The conductivity of the electrolyte was 7 S/m. Other constant parameters of electrochemical machining were: deformation seed layer thickness – 0.001 mm, molar mass of dissolving species – 54.94 g/mol, density of dissolving species – 7.77 g/cm^3, number of electrons per dissolving species – 2.4, threshold current density for dissolution – 10 A/cm^2. Three experiments were performed to determine the changes in some electrochemical machining parameters when the cell voltage changes in the range of 10...30 V.

A primary current distribution model with a threshold current density value was used for the calculation. The process of electrochemical machining of the hole was simulated for 1 s.

Results and discussion

The results of the experiment are shown in the Figs. 1-8. The following electrochemical machining parameters were analyzed: electrochemical reaction boundary heat source, total power dissipation density, overpotential, local current density, normal electrolyte current density, total mass reaction rate, total electrode growth velocity and stoichiometric coefficient. The values of all studied electrochemical machining parameters increase with increasing cell voltage values.

Electrochemical reaction boundary heat source acts more evenly at a lower cell voltage and less stably at a higher cell voltage. A similar phenomenon can be observed when the overpotential changes from the value of the cell voltage. The deviation of the electrode potential is marked by five peak values at a cell voltage of 10 V, and the peak values become more than 30 at 30 V.

Total power dissipation density and local current density vary by almost the same function with some nuances. There is a phase of an instant peak value and a gradual decrease to a minimum value not equal to zero. At the same time, in the phase of gradual decrease, there is a phase of repeated increase in the parameter at a cell voltage of 10 V, and at 30 V this phase is absent. Normal electrolyte current density, total mass reaction rate and total electrode growth velocity vary according to the same functions as total power dissipation density and local current density. Thus, it can be said that the considered indicators are interrelated and the greatest influence on the process of electrochemical machining is carried out by the value of the cell voltage, which is in the range from 10 to 20 V.

The graphs of the stoichiometric coefficient demonstrate numerical values indicating the amount of the reagent substance entering into a chemical reaction, as well as the amount of the reaction product substance formed as a result of this chemical reaction.

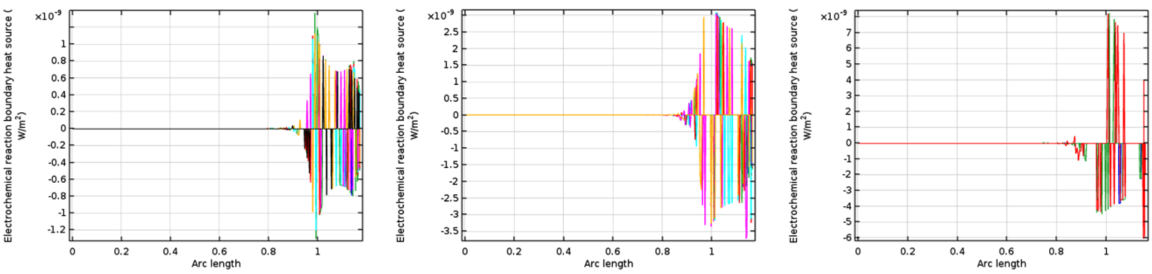

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Figure 1 – Electrochemical reaction boundary heat source: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

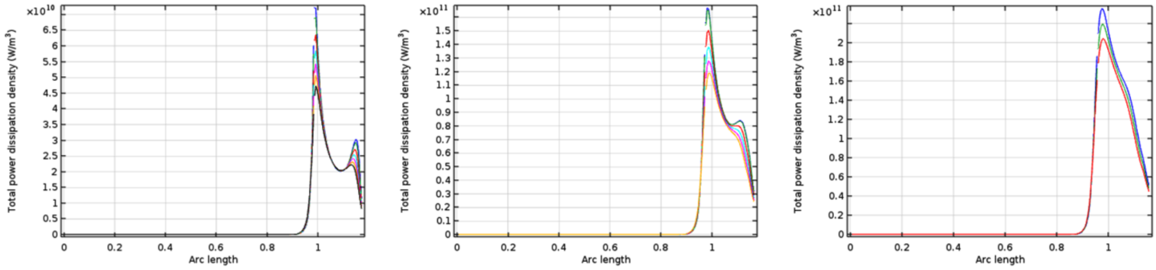

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Figure 2 – Total power dissipation density: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

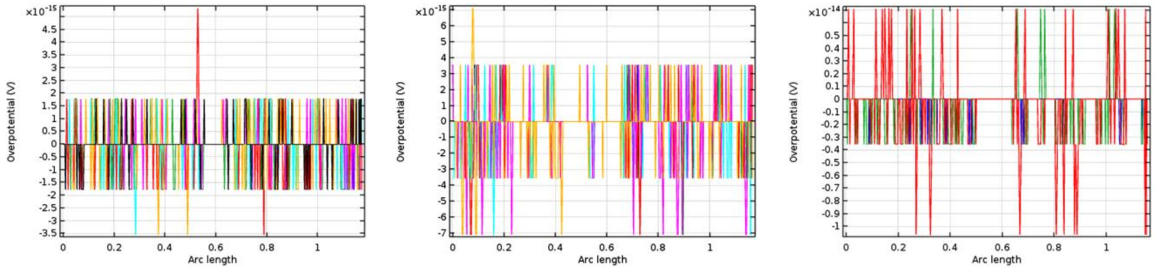

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Figure 3 – Overpotential: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

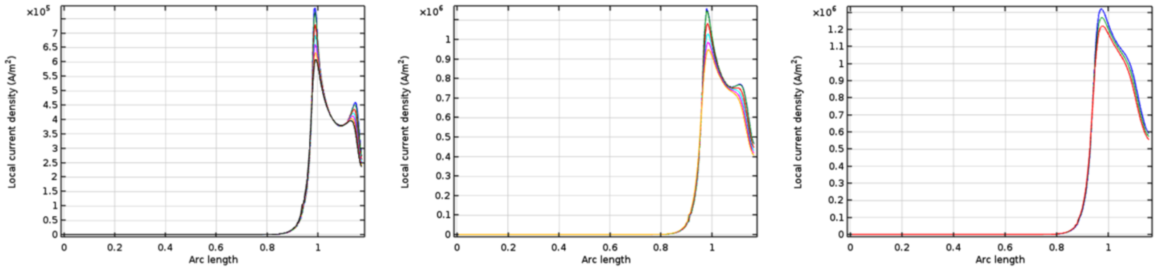

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Figure 4 – Local current density: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

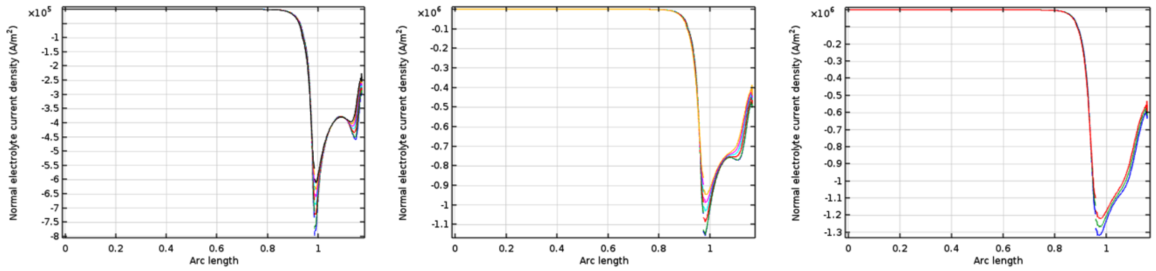

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Figure 5 – Normal electrolyte current density: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

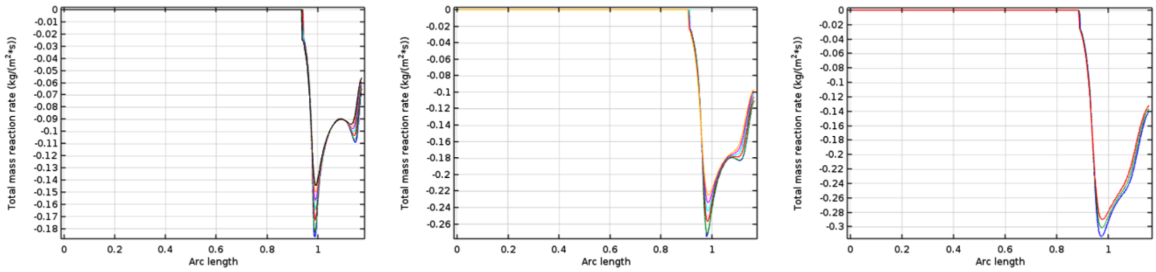

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Figure 6 – Total mass reaction rate: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

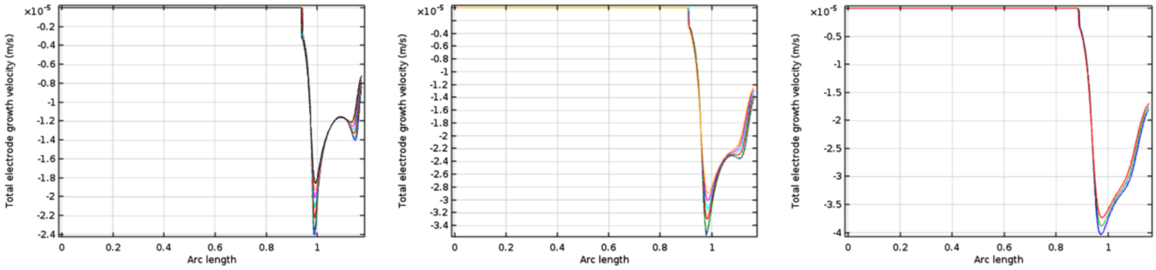

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Figure 7 – Total electrode growth velocity: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

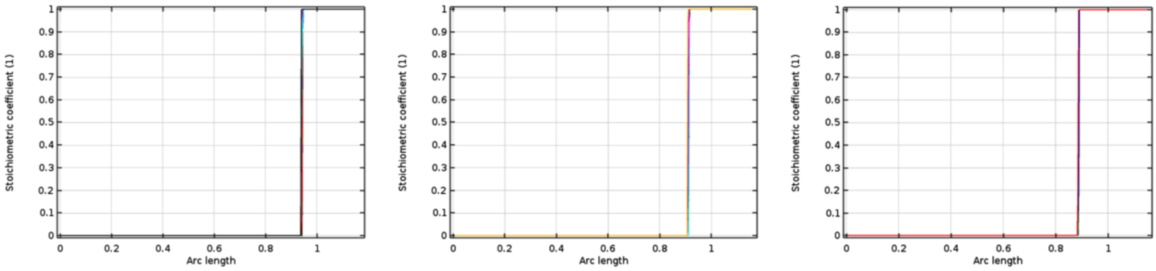

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Figure 8 – Stoichiometric coefficient: a) cell voltage – 10 V, b) cell voltage – 20 V, c) cell voltage – 30 V.

It can be seen that at different cell voltages, the coefficient values are the same, i.e. the electrochemical machining process proceeds in the same way in all cases.

Conclusion

Based on the analysis of the experimental results, the following conclusions can be drawn:

1. With increasing cell voltage, the calculated values of the studied electrochemical machining parameters increase.

2. Total power dissipation density, local current density, normal electrolyte current density, total mass reaction rate and total electrode growth velocity vary in almost the same function. At the same time, with increasing cell voltage, the values of the indicators change according to a more linear law.

3. When the cell voltage is 10 V, the change in electrochemical reaction boundary heat source and overpotential occurs more proportionally over the entire measured surface.

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