CONTRIBUTIONS ON ELECTRO-CHEMICAL PROCESSING OF INTERIOR SURFACES

Dr. Paraschiv, I. Sârbu, C. Ciofu
Technical University "Gh. Asachi" of Iaşi

1. GENERAL CONSIDERATIONS

The electro-chemical processing allows the solving of many problems concerning the complex machine parts processing, made of materials with high physical-mechanical properties (refractory steels, magnetic materials, anticorrosive alloys, metal carbides, etc.). Adopting a procedure in working up machine parts with complex interior surfaces ensures both enhanced technological characteristics and a better economic efficiency, in the terms of correct setting of working conditions and a knowledge of some intimate phenomena which accompany anodic dissolving.

2. THE STUDY OF SPEED DISTRIBUTION

When processing a nozzle with a profile in the shape of a truncated cone (figure 1a) or a parabola (figure 1b), which takes two phases, a rough cutting one and a finishing one, there must be provided such an electrolyte flow and choosing of working parameters, so that processing should be made with a maximum productivity, at a minimal cost, in the technical conditions imposed to the machine part.

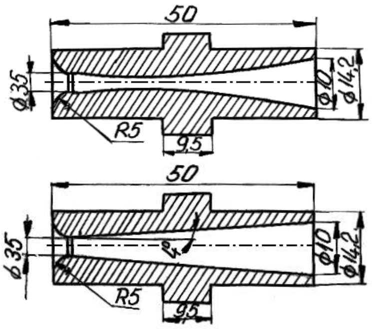

Figure 1a,b.

The study of speed distribution is made taking into account that the movement is of Hagen-Poisseuille type.

Applying the Newton's law, it follows that the electrolyte speed is:

$$V(r)=\frac{p_1-p_2}{4.\mu.l}r^2+c \qquad (1)$$

where $p_{2,}$, p_1 represent the pressures that work on the electrolyte particle (N/m$^{2)}$; l – the processing length (m); r – the distance from the surface of the tool-electrode to the particle. The C constant is determined applying the annulment condition of the speed on the surfaces of the tool-electrode and the machine part; therefore:

$$c=\frac{p_1-p_2}{4.\mu.l}\left(\frac{x}{2}\right)^2 \qquad (2)$$

where x represents the working interstice (mm).
Thus one obtains the formula of the electrolyte speed, which shows, in a normal plane section at the interior surface of the machine part, a distribution after a revolution parabolic of the speed vectors heads.

$$V(r)=\frac{p_1-p_2}{4.\mu.l}\left(R^2-r^2\right) \qquad (3)$$

The determination of movement equations of the fluid through the pipe is made using the Navier-Stokes equations [1]. The integration of these equations is made along a current line, using the simplifying hypothesize characteristic to these equations: the movement is permanent; the mass forces derive from a potential, resulting the following expression:

$$\frac{V_1^2}{2.g}=\frac{1}{2.g}\frac{p_1-p_2}{16.\mu.^2 l^2}.R^4.+\frac{1}{\gamma}\left(p_1-p_2\right)+h_{r_{1-2}}-l.\cos\alpha \qquad (4)$$

when h_{r1-2} represents the laminar loss of pressure; α – the inclination angle of the interior surface of the nozzle.

The electrolyte flow type is determined applying the theory of similitude, according to which the Reynolds coefficient is proportional to the speed and the equivalent diameter, an inversely proportional to the kinematic viscosity:

$$R_e=\frac{V_1.d_e}{\xi} \qquad (5)$$

The importance to determine the Reynolds coefficient comes from the necessity to impose either a laminar flow (providing a moistening of all parts of the anode and the cathode, but failing to eliminate properly the anodic dissolving products) or a turbulent flow, which provides this kind of elimination at high speed.

The rough cutting phase must be executed with a high productivity, thus requiring a turbulent flow and a high dissolving rate. It is known that the dissolving rate is given by the following formula:

$$V_d = \frac{U.k}{\rho \cdot \chi} \qquad (6)$$

where *U* represents the terminal voltage (V); *k*– the electro-chemical coefficient (mg/C); ρ – the electrolyte resistivity (Ω·cm); χ– the working interstice (m).

Thus, it is necessary that, during the rough cutting phase, to work with high electrolyte concentrations and temperatures as close as possible to the vaporization temperature.

During the finishing phase there is the problem of the uniform current density distribution on the whole surface of the tool-electrode. In these conditions, it is necessary that upon the tool-electrode with a profile conjugated with the machine part to be obtained to apply a piece of insulator.

The analytical determination of the shape of the insulated surface is made taking into account two elementary surfaces, which have an insulated portion, imposing that the non-insulated portions should have the same area.

Taking into consideration that one of the edge of the insulation is in the vertical plane (xOz), the equation of the other edge of the insulation can be determined calculating the θ angle under which the insulated portion is seen in the xOy plane, depending on the z distance, measured on the height:

$$\Theta = \frac{m.z + n - r}{m.z + n} \qquad (7)$$

where r represents the radius of the surface element, and m and n the coefficient of the straight line representing the equation of the generatrix of the tool-electrode cone, projected in the plane (figure 2), or, in the case of a paraboloidal surface:

$$\Theta = \pi \frac{a.z^2 - r}{az} \qquad (8)$$

where a represents the parabola diameter, resulting

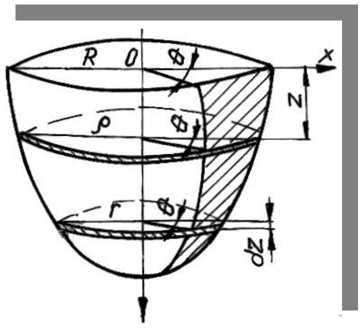

Figure 2.

rom the intersection of the parabolic with the xOz plane (figure 3).

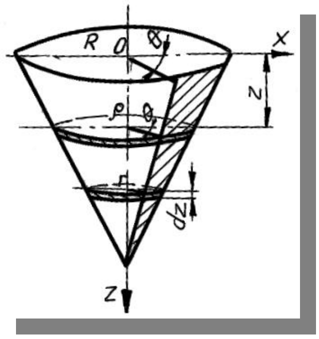

Figure 3.

Due to the decrease of the passage section of the electrolyte along the machine part axis, there is an increase of the electrolyte speed, and accordingly an intensification of the anodic dissolving process.

Therefore, between the current density and the electrolyte speed should exist a close interdependence, in order for the processing to be uniform.

For processing the nozzle from figure 1a there has been used a NaCl 10% solution, with a flow capacity of 8 l/min, a current density of min. 20 A, at a voltage of 17 V and a temperature of 44 ºC. The processing time was of 7,6 minutes.

It follows that electro-chemical processing makes it possible to obtain complex revolution interior profiles, with a high economic efficiency, providing a fair dimensional accuracy and quality of the machine part.

References

1. ***Devouche, A.*** *Prelucrarea electrolitică, Machine outil Francaise, nr. 22/1987, France.*

Recomandată pentru publicare: 30.04.04.