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EROSION COMPLEX PROCESSING ASSISTED BY ULTRASOUND II

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ABSTRACT: Erosion complex processing supposes a complex process consisting of characteristic elementary processes developed simultaneously in the elementary operating space. The study of these elementary processes, that is knowledge and mastering of the physical mechanisms of material sampling is an important step in the generalization process of complex erosion processing.

1. GENERAL ASPECTS OF THE MACHINING BY COMPLEX, ELECTRIC AND ELECTROCHEMICAL EROSION

The physical and chemical processes/phenomena specific to this complex machining method are, in our case, especially thermal, electrochemical and mechanical, representing together a complex physical-chemical system depending on the nature of the used work liquid. Thus, considering its electric conductivity and chemical properties, the work liquid has an important role in initiating/developing the machining process. The choice of the type of work liquid may be made by considering the properties of the electrode-piece material, the complexity of the surfaces to be machined and also other technological parameters.

The phases specific to a machining by complex, electric and electrochemical erosion, using a semi-dielectric as a work liquid, are:

a) Forming/presence of an intense electric field around the asperities of the two surfaces of the electrodes;

b) Thinning and partial removal of the passivant layer, as a consequence of the relative movement between the two electrodes;

c) Constituting the metallic contact accompanied by an initial micro-discharge;

d) Stopping the contact with the development of an important electric discharge;

e) Ejecting in the work liquid certain micro-quantities of material detached from the surfaces of the two electrodes, stopping the electric discharge.

This type of machining is also called anodic-mechanical machining due to the fact that the material removal has a mechanical-electric feature.

2. FEATURES OF THE COMPLEX, ELECTRIC AND ELECTROCHEMICAL EROSION

The contribution of the anodic component in the material volume dissolved from the semi-fabricated is relatively reduced. In order to measure this contribution, it is defined a dissolving coefficient: $k_d=\frac{m_d}{m_t}=\frac{m_d}{m_d+m_{EDM}}$ [illegible], where m_d is the quantity of dissolved material due to the electrochemical processes, and m_t is the total quantity of sampled material, due to both of the phenomena: $m_t=m_d+m_{EDM}$, m_{EDM} being the quantity of sampled material as a consequence of the electric discharges.

Knowing that, by the spark, it is removed a quantity of material: $m_{EDM}=V\cdot\rho$, where *V* is the volume of the detached material, and ρ the material density, we may write the calculation expression of the quantity of material dissolved at complex erosion: $m_t=m_d+m_{EDM}=\frac{A}{zF}\cdot I\cdot t+V$

The electric energy of the hybrid process should be available in types adequate to each of the processes/methods involved in the machining process and these parameters specific to the individual processes are often very different. We may identify two possibilities: the first supposes the use of the sources available for each process, and the second consists in developing certain hybrid generators presented certain advantages such as reducing the number of constructive elements, reducing the volume, a high/good flexibility both for the development of certain individual/singular processes, and also in temporary sequences, reduced cost, a flexibility of the interface conditions etc.

3. ASPECTS REGARDING THE ULTRASONIC MACHINING USING THE CAVITATION PHENOMENON

Among the most applied proceedings based on the cavitation phenomenon generated by the ultrasonic vibration of a work liquid, there is cleaning, pickling and washing in an ultrasonic field.

The appearance of the cavitation spheres and the liquid penetration in spaces more difficult to access (figure 1, a) determine, in case of the mentioned proceedings, the detachment and the removal of the layers of adherent material, whose removal is required. Phenomena similar to the ones previously described are at the base of the ultrasonic cleaning of the abrasive tools; placing, near the abrasive tool, a pseudo-tool ultrasonically vibrated, in the presence of the usual cooling-greasing tool, easing the detachment of the metallic particles from the pores of the abrasive tool (figure 1, b) and recovering, as such, its chipping qualities.

The time of a cleaning operations of the usual pieces has values from 10 s (for removing the greases, the oils, the polyvinyl and alkaline inks, in organic solvents, at temperatures of 20…96 ° C), to 30 min (for example, for removing the accumulations of plumb and coal, in emulsions, at 55…80 ° C). Let’s emphasize the fact that, thus, there may be the removal, by means of ultrasounds, of the metallic impurities, of the powders, of the micro-chips, of certain protecting emails, of the greases of the polishing pastas, of the erosion products etc., and also the unclogging of the high accuracy pieces.

A high efficiency corresponds to an energy density of 5…10 W/cm^2; the powers of most of the usual installations are about 1…2,5 kW. The cleaning installation contains one or several tanks, on whose bottom the distributors are placed; if it is required a high productivity, the semi-fabricated are displaced in liquid, over the distributors, using a chain transporter (fig. 1, c). Figure 1, d schematically represents equipment for the ultrasonic cleaning of the thin bands and wires. There are relatively known the electrochemical coverings assisted by ultrasounds. The presence of the ultrasonic vibrations in a process of electrochemical covering has as a consequence an intense de-passivation, a facilitation of disengaging the hydrogen in the solution, a decrease of the possibilities to form the oxides on the cathode and of the thickness of the diffusion layer.

Thus, it becomes possible the increase of the electricity density, with the increase, as such, of the covering speed, the diminution of the operation time and the appreciable increase of productivity (deposing the chrome may be accomplished with a speed 5 times higher than in the absence of the ultrasounds, and the one of the cadmium and copper, about 30 times higher). The granulation of the deposited layer is smaller, the porosity, decreased, resulting from here more convenient physical-mechanical properties during the exploitation of the covered pieces.

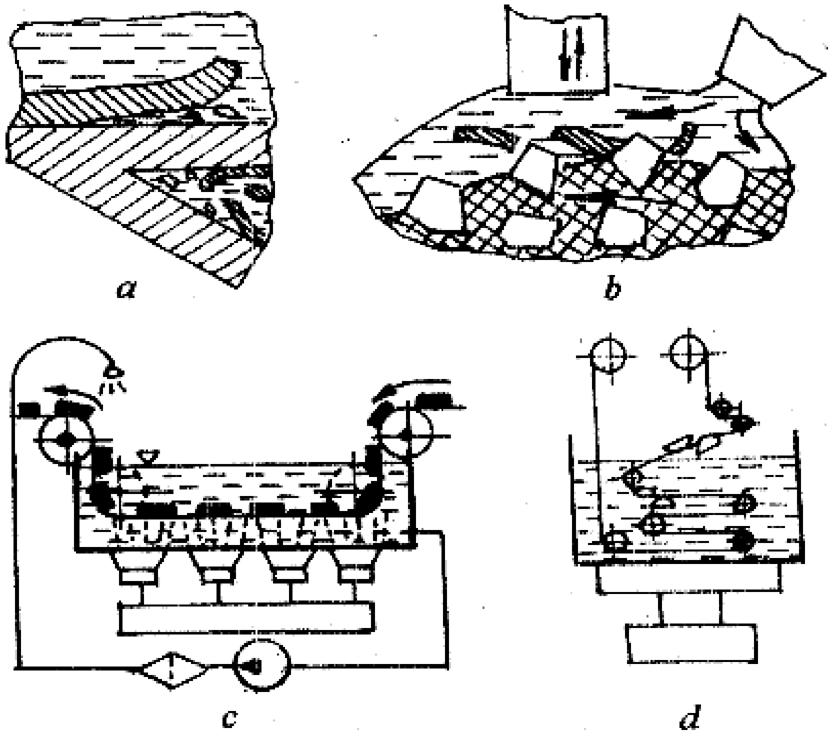

Figure 1 Cleaning by means of ultrasounds:
a-the cavitation spheres penetrate under the layer to be removed;
b-cleaning with an abrasive disk,
c-the cleaning installation with the displacement
of the individual semi-fabricated;
d-installation for cleaning the thin bands and the wires

The average speed of the vibrating movement is estimated by means of the relation:

$$v = 4 \cdot f \cdot A \qquad \text{[m/s]}, \tag{1}$$

where *f* is the oscillations frequency, in Hz, and *A* – the oscillations amplitude, in m.

If we consider a variation of the space crossed in a vibrating movement according to a sinusoidal law (a law which is not always appreciated by the specialists as being the most adequate for the dimensional machining, for example), we will be able to write:

$$y = A\sin\omega t \qquad \text{[m]}, \tag{2}$$

ω as the pulsation (or the angular frequency), and *t* - time, in s.

At its turn, pulsation *ω* may be expressed as:

$$\omega = 2\pi f \qquad [\text{s}^{-1}], \tag{3}$$

This allows us to write:

$$y = A\sin(2\pi f t) \qquad \text{[m]}, \tag{4}$$

Also, we may write the relation for the momentary speed v:

$$v = \frac{dy}{dt} = 2\pi f A\cos(2\pi f t) \qquad \text{[m/s]}, \tag{5}$$

The maximum value of speed $v_{\max}$ will be thus:

$$v_{\max} = 2\pi f A \qquad \text{[m/s]}, \tag{6}$$

The maximum kinetic energy of a corpus trained in a vibrating movement (semi-fabricated, port-semi-fabricated tank) will be determined by means of the relation:

$$E_{c\max} = \frac{m v_{\max}^2}{2} \qquad \text{[J]}, \tag{7}$$

The mechanical work accomplished by a radiant surface (by means of which a part of the energy is transferred to the environment), having the area S, in an elementary time dt, is:

$$dL = dt\iint_{S} pU_n dS, \qquad (8)$$

where U_n is the component of the normal speed on dS, and p – the pressure by means of which the environment opposes to the movement.

If we consider a distribution D_n of the speed on the surface, we will write:

$$dL = dt\iint_{(S)} pU_0 D_n dS \qquad (9)$$

The radiated energy will correspond to the relation:

$$E_r = \int_0^t U_0 F dt = \int_0^t U_0 F_r \sin\omega t\, dt + \int_0^t U_0 F_x \cos\omega t\, dt \qquad (10)$$

where F is the force exerted by the radiator, F_r – the active force, namely that component of the F force in phase with v_0 speed, F_x – the reactive force, namely that component of the F force in square with U_0. Successive replacements allow the reaching to the final relations in order to calculate the reactive energy (identical to the kinetic energy associated to a so-called additional mass m_r:

$$E_x = \frac{1}{2} m_r U_0^2 \qquad (11)$$

The developed power (the radiated power) is:

$$P_r = \frac{dL}{dt} = U_0 F \qquad (12)$$

4. CONCLUSIONS

The machining by complex, electric and electrochemical erosion, as a hybrid method of machining, is applicable where other machining methods become unsatisfying from the economical viewpoint or even impossible to apply: for the machining of some pieces of materials having exceptional properties (roughness, fragility, resistance at corrosion, etc); for machining with the work parameters placed at limits: very small speeds, very small or very high temperatures, very small or very high pressures and powers; machining at very small or very big sizes; machining imposing very strict accuracy and roughness; surfaces to be machined with complex configurations or configuration that are difficult to obtain by other means.

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