ELECTROCHEMICAL DISCHARGE MACHINING (ECDM) – THE PRINCIPLE OF PROCESSING

Nioaţă Alin, *lecturer PhD. eng., "Constantin Brâncuşi" University of Târgu-Jiu, Romania*
Ciofu Florin, *lecturer PhD. eng., "Constantin Brâncuşi" University of Târgu-Jiu, Romania*

ABSTRACT: The Working through electrochemical discharge machining is a process of removal of the excess of working through repeted action of electrical discharges within the impulse, in the limited space between an electrode connected at one pole and the object of working connected at the other pole, of a tension impulses generator. The paper presents the study of the elementary processes which unfold simultaneously within the elementary working space, as well as the knowing and mastering of the physical mechanism of the drawing material .

KEYWORDS: erosion, cathode, anode, electrode, thermal effect

The processing through complex, electrochemical discharge machining represents a superposition and a sequence in time and space in the working areas of the activities for processing through electrical erosion and electrochemical erosion.

In order that this superposition to be possible, a different structure of the elementary working area is necessary and also an adjustment determined by the necessary working conditions, specific to each and every activity.

The structure of the elementary working area is presented in the figure 1. Thus, the material drawing is the consequence of the simultaneous action of two erosive agents. On the one hand the working environment, ML, the electrolyte formed of the aqueous solution of the ions R_AR_B, which we find in the electrical field of I intensity and which determines a partial electrochemical dissolving of the anode (the object to be processed OP), and on the other hand the electrical discharges in impulses generated by the breaking of the micro-contacts crossed by the current, constituted at the level of the micro-asperities, of the anode (OP) and respectively of the cathode (the object to be transferred), and which determine the thermal component of the drawing. Both the erosive agents are of "bridge" type. The process is influenced by the formation on the anode of a passive film PF, insoluble, with dielectric properties and high mechanical resistance, by the existence of a pressure *p* between the electrodes, combined with a relative tangent movement v_r of OT and OP, with the aim of generating impulses of current and forced mechanical de-passivation for reactivating the anode and evacuation of the waste processing outside of the working area. As a result of these actions, mainly the erosion OP takes place through the dislocation of the elements of material, as a consequence of the electrical discharges DE and of the effect of anodic dissolving.

The cathode is subject to erosion, in a smaller extent, through the dislocation of the elements of material, of the object to be transferred. Also, there is a possibility for the electrical discharges to appear through the local penetration of the anodic film, which dislocates supplementary particles of material

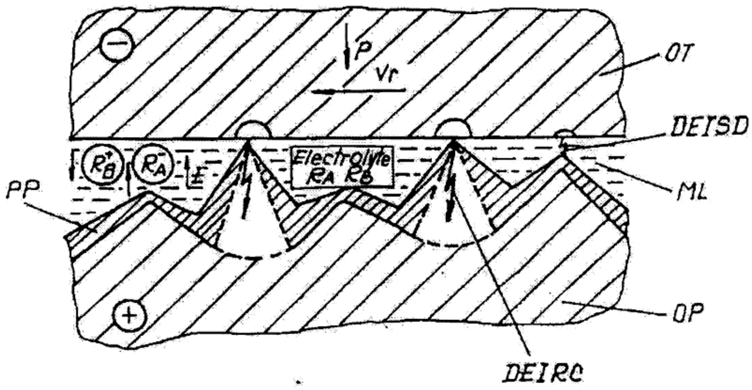

Figure1: The fundamental scheme of processing through electrochemical discharge machining

Taking into account different values of the determinative factors of the working conditions (tension, current, pressure and the relative velocity between OT and OP) there is a possibility to become preponderant either the electrochemical phenomenon of dissolving, or the thermal phenomenon of erosion as an effect of the electrical discharges. In case the specific power introduced within the working area is low and the drawing takes place especially based on the anodic dissolving, the productivity is reduced, but the precision of processing and ruggedness of the surface are of superior levels. In increasing the specific power, the erosion of the material is owed almost exclusively to the thermal effect of electrical discharges. In this case a drawing of material takes place, which is owed to the anodic dissolving, simultaneously with the drawing of electrical impulses, but outside the surface affected by these discharges.

Under the circumstances of the preponderance of the effect of electrical erosion, the local concentrations of energy may lead to high temperatures within the channel of electrical discharges with values of $10^4 \ldots 10^5$K, and may lead beside smelting and local vaporization of the material in the surface layer of OP, to decomposition of the electrolyte. The results of dissolving and decomposing of the electrolyte work together to form a passive film as well to determine their properties ($M_e^+ + R_A^- = M_e R_A$; $R_B^- + e^- = R_B$; see figure 1).

Reactivation of the anode through forced removal of the film enables the maintenance of some simultaneous discharges or partially superposed and consequently also a well- marked Joule thermal effect is possible due to the concentration of the current on small surfaces. Densities of $10^3 \ldots 10^5$ A/cm^2 are reached, whereas the duration of a discharge is of $10^{-3} \ldots 10^{-5}$s. The greatest part of these energy is transmitted to the anode, which otherwise is subject to an intense erosion, erosion which constitutes the main effect of technological interest.

These local concentrations of energy put the material to great stresses and as a result, beside a well- marked global erosive effect, certain metallurgical phenomena take place which lead to some layers thermally modified to emerge, having special characteristics, as well as some micro-fissures in these layers. These alterations testify for the nature preponderantly thermal of the processing through electrochemical discharge machining.

Nevertheless most of the scientists agree with the theory of the thermal drawing, appraising as determinative the thermal effect caused by:

- the energy unfolded through Joule- Lenz process due to the reduction in area phenomenon of the current lines at its crossing to the electrode which presents a larger section for the discharging channel with small section and then to the semi-finished product, also with a larger section(figure 2,a)
- the kinetic energy of the charges in motion (electrons and ions) in the discharging channel of the un-stationary electrical resort, suddenly given way at the surface of the semi-finished product and electrode (figure 2,c).

Due to the interaction of the dissociated elements with the smelted metal, on the surface of the semi- finished product (figure 2,b) and the electrode, a film of oxide will be formed. Consequently, electrical discharges in impulse may take place, caused by the easy penetration of the oxide film (figure 2,d) with low dielectric rigidity, or of the areas with impurities.

The special literature estimates that for the processing through electrochemical discharge machining with breaking contact, the drawing of material is the consequence of unfolding two preponderant elementary processes such as:

1. the electric contact;
2. the un-stationary electric resort;

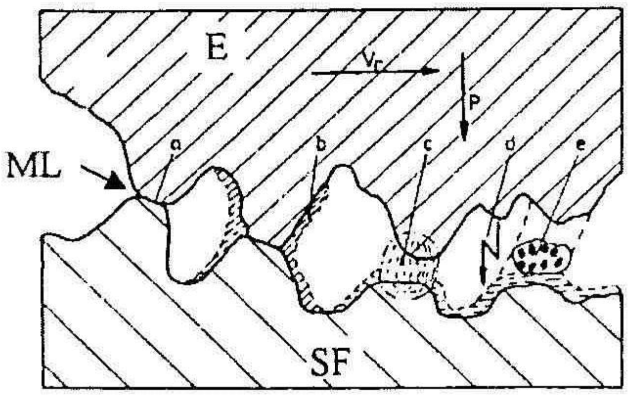

Figure 2: The elementary working area
a-electric contact; b-oxide film;
c-discharge in un-stationary electric resort; d-discharge through penetration;
e-erosive particle

THE ELECTRIC CONTACT, as a thermal source in the process of processing through electrochemical discharge machining, starts the moment when the physical contact is realized between the most prominent micro- asperities, one of them pertaining to the processed object (OP), and the other to the transferred object (OT) (figure 1). The contact is realized in a kinetic way by the relative velocity between the two bodies, by the pressure of contact, as well as by the depth of processing.

THE UN-STATIONARY ELECTRIC RESORT. The breaking of the bridges is important because it represents the previous stage of the electric resort, if the operating conditions allows its start, that is if the tension applied overcomes the potential of ionization of the metal vapours (9V). This method of starting the resort, through breaking the contact between the metallic bodies crossed by the current, has a large applicability in practice since it has the advantage not to need the penetration of the environment between the electrode- tool and the semi-finished product. Thus, the sources of supply are no longer needed to provide high tensions, but only values to start and support the resort. Although, it is necessary for the same polarity to be maintained for at least the same interval of time as for ions displacement toward the cathode. Consequently in order to realize the processing reduced sources of tension are enough (to smelt the metal) and low inductive circuits (low self-inductance to realize short time heating).

The un-stationary electric resort as a thermal source of process represents the second stage of unfolding of the process. This stage is formed and developed when the electric contact is broken, when the free electrons in the peripherical area of the metal accumulated supplementary energy, due to the thermal effect of heating (Joule-Lenz effect leads to temperatures of 5000…6000 ^{0}C), which is sufficient to overcome the energetic necessity of leaving the metal and to produce the thermo- electronic emission. Then classical processes of forming the conductor channel take place in an electric field between two irregularities with the emergence of the micro- resort, a strong ionization (the metal vapours being present) and eventually the emergence of the thermal plasma in the column of discharging dependent of the local conditions and the resort length. The un- stationary electric resort is formed the moment when the distance cathode- anode is of 10^{-4} cm or less (of the size of medium way of the electrons which displace freely without collision, between the cathode and anode to whom are given way energies), having the duration of between 10^{-3} and 10^{-5}s and is characterized by high tensions of current of 10…200A/mm^2 and temperatures of 10^4…10^5K. The relative movement between the semi- finished product and the electrode-tool will lead to the elongation of the resort and consequently to modifying of the discharging parameters, lending to the phenomenon the character of limited impulse in time and space, having as a result the compression of the resort the moment when the speed of the ionization process of the resort space is higher than that of the process of ionization itself.

If the processing conditions are changed, this unfolding of the elementary processes of erosion are modified, too: for instance, if the tension is too low, then the contact may be interrupted without the consequence of discharging in the resort, or if the smelted metal is not removed in the elementary working area, then the interruption of a single process is followed by a new discharging in the resort.

Consequently, there are three main possible types of erosion:

- contact erosion, at low tensions: U = 6…10V;
- resort- contact erosion, at medium tensions: U 10..20V;
- erosion through resort, at high tensions: U =20…30V.

In conclusion, during the process of processing using the electrochemical discharge machining proceeding, heating and evacuation of the metal at the level of the irregularities represents the result of accumulating the elementary processes, dependent directly on the local conditions and the way of distributing the energy between the semi- finished product and the electrode.

REFERENCES

[1] Nagîţ, Gh., , Tehnologii neconvenţionale, Universitatea Tehnică „Gh. Asachi", Iaşi, 1998.

[2] Herman, R.I.E., Prelucrarea prin eroziune electrică complexă, Editura Augusta, Timişoara, 1998.

[3] Herman, R.I.E., ş.a., Prelucrarea prin eroziune complexă electrică-electrochimică, Editura Augusta, Timişoara, 2004.

[4] Nioaţă, A., Cercetări teoretice şi experimentale privind optimizarea unor parametri ai prelucrării prin eroziune complexă, Teză de doctorat, Sibiu, iulie 2007.