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NEW EPISODES AT THE PHYSICAL PHENOMENA OF ELECTROEROSION

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ABSTRACT

In this work is proposed a new model of analyzing the physical portrait of the process of electric erosion in normal conditions. Based on analysis of the bibliographic sources of nowadays and based on the result of the personal researches, the authors propose a model, based on capillary waves appearing and their developing on surface of the electric field.

KEYWORDS: electric erosion, capillary, waves, field.

The work is consecrate to the solving of problems about difficulties of implementation in practice of no conventional technologies especially of processing by method of electro erosion. These find their application at the dimensional processing (the obtain of processing, debiting, rectification) [1,2,3] and superficial treatment (deposition from compact material, powder, powder composition etc.)[4], but in the present the application domain and the spreading of this type technologies in the industry of machine construction, electronics, chemical and alimentation is limited. What are the reasons? We can evidence two of them: reduce productivity and big spending of energy.

Was effectuate a lot of researches to increase this method's productivity: more frequency of work of generator, the utilization of multi contour generators and those that have as base transistors, the application of electric and magnetic fields, the application of ultrasounds etc., but the obtain results permit to increase the situation, but not sufficient to confer to this method a new impulse of development and to increase the diversity of the domains of applicability.

As another technological method, it has on the base physical phenomena named electro erosion.

The classics of this technology B. Lazarenco, N. Lazarenco, B. Zolotîh, V. Zingerman etc. [2] elaborated a physical interpretative picture of this phenomenon for conditions of electric discharges in impulse in dielectrically liquid environment. This can be show like this: at the beginning between electrodes appear the channel of conductibility by strimer effect, in the second faze is discharge the energy from battery of condenser, the channel dilate very quick and around it appear gas bubble and it's volume becomes bigger because of the inertness – and because of this appear the depression of it, and because of this the smelt material from the electrodes surface it is expulse in gap, here we can not exclude the action of electrodynamics forces on the more of the material. If electro erosion phenomenon it is developed after the productivity it will be a direct function of frequency and the energy of the impulses, but this doesn't happened.

These disadvantages are characteristic and for the case of allying with electric spark, that is produced in normal atmospherically conditions and for which the forming of a big depression is practically excluded. In all works about electro erosion we can see that this phenomenon is together with the appearance on the surface of electrodes craters. Traditional it is said that they have a spherical form, and others forms are not important, even if they appear. From the analysis of the research made by the authors of the work [4, 7, 8] we can say that there are three types of spherical craters: first is smooth; the second is rugged and the third has in the middle a meniscus (fig.1).

Meniscuses was observed on the surface of cathodes craters, too, as well as on the anode from different metals [4, 6]. Meniscuses from fig.2 are characteristic for the process of forming depositions din from compact materials [12,13].

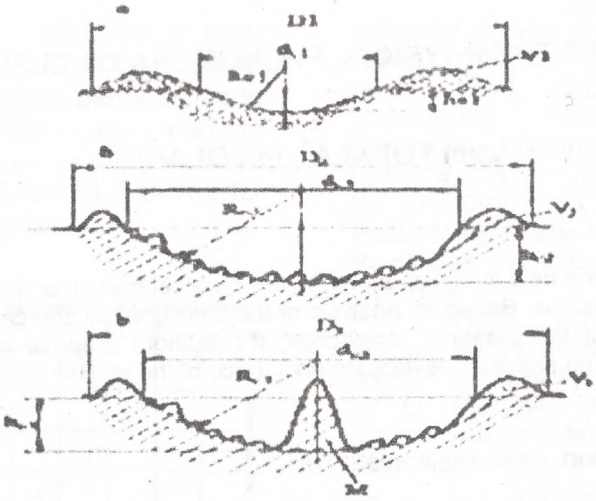

Fig.1 Types of craters obtain during the dimensional processing by electro erosion (D_1, D_2, D_3) – crater diameters together with the wave; d_{c1}, d_{c2}, d_{c3} – diameters of three crater types; h_{c1}, h_{c2}, h_{c3} –crater depth; M – menisc; V – val.[8].

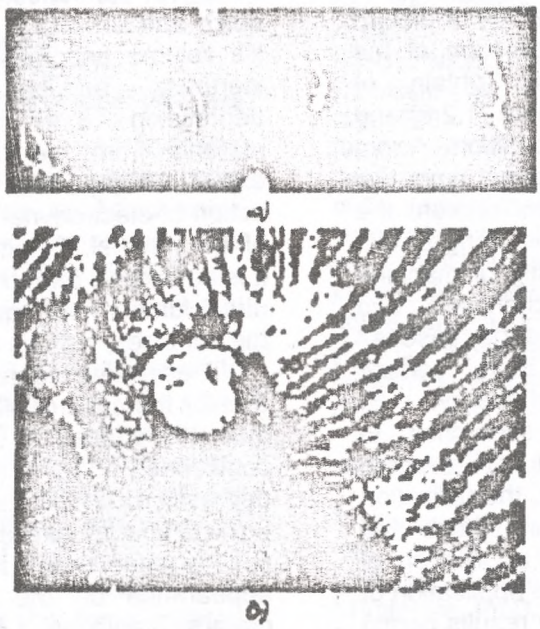

Fig.2 Meniscuses from metal:
a) from the wolfram anode,
b) formed in crater on the anode surface of titanum

If we analyze the fig.3 then we can see that, meniscuses can come from
practice on all types of metals throw which can go the electricity .Their observation on the electrodes surfaces made from material strong fusible it is easy, because the quantity of it is small and the process of freezing is more favorable.
The appearance of the meniscuses, their orientation, and different dimensions for the case of the solitary discharge, as for dimensional process, as for the forming of depositions, shows directly the fact that, they can not appear from the reason of depression from plasma channel and can not confirm the poly - channel of plasma spot from gap.

During some works [4, 5, 7, 9] that it is possible that on the surface of the liquid metal in electric field to develop capillary waves that make the appearance of a conic

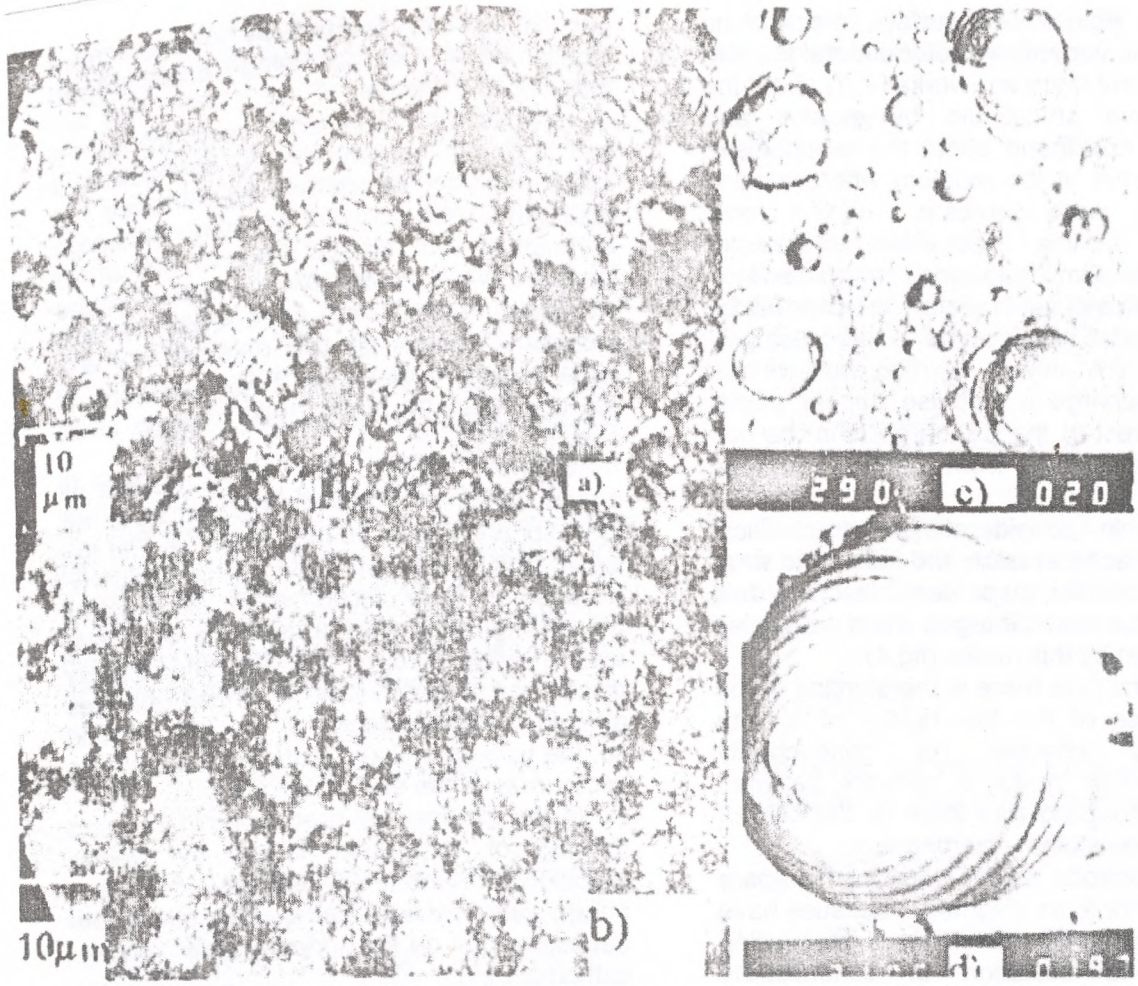

Fig. 3. Microstructured surface of electrodes processing with aid of electrodischarge machining: a) Ge (U=100V, C=200pF), b) Si (U=150V, C=550pF), c) portion surface electrode from W and one protuberance here and surface (d)

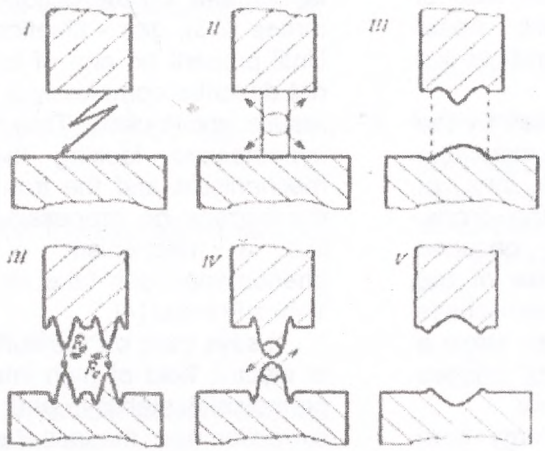

Fig 4 The model of electro erosion process proposed

meniscus, from which surface are broking drops or the vaporization of the metal like ion. In the present there are works [4, 7] about the technological processing by erosion and where we can found about this mechanism. So, indifferent of the medium where electric discharged were produce, the most important in this mechanism of electro erosion are some capillaries which develop on the surface of liquid metal in electric field.

In the case of dimensional processing in liquid medium only in starting faze of the electric discharge in impulse appear partial liquid, the rest of the discharge is in the gas medium (a bubble from vapors of liquid dielectric).

Taking in consideration the classical picture of electro erosion and looking to what was said earlier, we can describe this process like an integral and complex phenomenon by this model (fig.4):

In the first faze there is the piercing of the gap because of the low rigidity of it, with forming of channel (or conductibility channels). This make a network between electrodes coupling with them by the help of cold electrode stains – starting faze.

Cold electrode stains warm and prepare the surface for force discharge, because have as suport micro unregulerities of processing surface. The dilatation of conductibility channel is together with the shock wave and luminoziy;

In the second faze apear warm electrode stains that steal the electrodes' metals making a bath of liquid metal by the action of electric field the surface of liquid metal of electrodes is perturbating, here apear capillary waves with forming of meniscus like con Taylor;

In the next faze from meniscuses by the action of electric field are extracted extractors that serv as a transmitter od ions or electrodes or from where breking drops. When are more channels simultany, because there are paralel streams, because of the lentile effect they can blend and meniscuses blend too, and in some cases it can make a short circuit in gap by the help of bridges formed;

In the las faze when the energy from condensers is finished, the intensity of electric field goes to zero and on the action of weigh force and superficial tension the liquid goes in oposite direction by inertion from smelt metal bath forming craters and "freezing"like a wave.

If we talk about meniscuses from fig. 1c and from fig.2b then we can mention that these from on the surface of cathodes not during the direct faze of the electric discharge in impulse, but during the process of re loading of condenser battery, because the discharge circuit is an oscillate one. Meniscuses from fig. 2a obtained on the surface of wolfram anode at the repeating of the discharge go bigger until make a short circuit in gap.

Until present we observe that practice all craters obtained in electro erosion have an ideal spherical form. In this model we find the explication of this effect, too. This happens, because in micro discharges (in dimensional processing) take part a massive electrode and a wire - form one but the energy discharged it is distribute on those surfaces after the intensity vector of the electric field so, the volume of liquid metal bath copies the vector raze of the electric field.

In the dimensional processing [1,2,3] and forming of deposition layers by electro erosion [5] the material from the electrode – anode surfaces is broking with or with out deposition of it on the surface of electrodes – cathodes.

In special literature there are different models of mechanisms of electro erosion in the case of dimensional processing and deposition of material on the surface of processing piece (in the case of forming layers) like: on the action of electro dynamic forces [2,3], gas - kinetics and other forces. Until present no one of knowing models can not describe completely a lot of experimental results accumulate. This goes to some new hypothesizes looking the electro erosion mechanisms and the transfer of material on the surface on processing piece. Last time like a mechanism of electro erosion phenomenon can take as a base the effect Tonks-Frenkel [4].

It says that: on the surface of liquid metal in electric field of high intensity develop a a periodical instability, and this condition the extraction from the last of some tops (fig.2) of considerable height. In the case of forming deposition layers, extracted tops from micro bath of smelt metal from the surface of anode

- electrode can cause the forming of a bridge of movement of the gap, or o the transfer of the smelt metal by the form of brake drops from the tops under action of electric field on the surface of electrode - cathode.

The first time in specialty literature this presupposition was made by the authors of the works [4,12], that observe the appearance of sharp tops in condition of electric discharge in impulse to increase the gap $S > 0,3mm$ and the tension of loading of condenser generator equal with $U_c = 240V$. The same tops were obtained in case of bombing the smelt metal surface with plasma by the authors of the work [5, 6].

The excitation of capillary waves make the perturbation of liquid metal surface. To demonstrate that this effect is possible in conditions of processin by elctro erosion we can write the relation of surface perturbation of liuqid metal in metric system[11]:

$$\omega^2 = \frac{k}{\rho}\left(g\rho - 4\pi\sigma^2 k + \alpha k^2\right) \quad (1)$$

where ω – ciclic frequency; α –superficial tension value; ρ – metal density; $k = 2\pi/\lambda$ / number of wave; λ – length of wave; σ – superficial density; g – the acceleration of free fall.

To make the liquide metal surface to be in equilibrium, ω –it is necessary always to be a real number , for all values of k, for the right side of the equation(1) to be more then zero. So, the metal surface will be perturbate in all cases when will be:

$$\frac{k}{\rho}\left(g\rho - 4\pi\sigma^2 k + \alpha k^2\right) < 0, \quad (2)$$

with condition that the excitation can be write like this:

$$g\rho - 4\pi\sigma^2 k + \alpha k^2 < 0. \quad (3)$$

According with [6] critical density can be determinate with the raltion:

$$\sigma_{cr} = \sqrt[4]{g\rho\alpha/4\pi^2}. \quad (4)$$

In metric system the intensity of electric field can be calculate like this:

$$E = \frac{4\pi\sigma}{\varepsilon} = 4\pi\sigma. \quad (5)$$

For air $\varepsilon \approx 1$.

Relations (4) and (5) alowes us to establish relative for intensity the critical electric field necessary to apear perturbations:

$$E_{cr} = \sqrt[4]{64\pi^2 \rho g \alpha}, \quad (6)$$

The perturbation of liquid metal surface in conformity with the effect Tonks-Frenkel can be inly when the intensity of eiectric field in gap will be more that critical value:

$$E \geq E_{cr}. \quad (7)$$

To obtain the value of E_{cr} in system SI, it is necessary in case of measurings:

$$g = cm/s^2,$$

$$\rho - g/cm^3, \ \alpha - dine/cm$$

to transform the equation (6) like this:

$$E_{cr} = \sqrt[4]{64\pi^2 \rho g \alpha \cdot 3 \cdot 10^4} \ [V/m] \quad (8)$$

The intensity of electric field for allaying by electro erosion constitue $E \approx 10^7 - 10^8 \ V/m$, and this is more then E_{cr} at smelt temperature $T = T_{top}$ (T_{top} – the temperature of smelt of different metals) where can be the perturbation of types Tonks-Frenkel.

From (2) this develope for k situated in limits:

$$\frac{E^2 - \sqrt{E^4 - E_{cr}^4}}{8\pi \cdot \alpha} \leq k \leq \frac{E^2 + \sqrt{E^4 + E_{cr}^4}}{8\pi \cdot \alpha} \quad (9)$$

So, for different metals we can calculate the length minim of wave for which we can develop the perturbation taking in

consideration the properties of liquid metals in smelt temperature [10].

Analyzing the results of theoretical calculations made in conformity of earlier relations and experimental measuring conform to minimum length of wave for electrodes made from such materials as : W, Ta, Zr,Ti etc. A big analisis of interaction processes of electric discharge plasma in impuls with metal liquid surface, permit to conclude that:

-liquid metal is perturbate by the acton of electric field of discharges; on the surface of liquid metal an apear capillaries;from the surface of metals can be extract conic meniscuses Taylor;this is the transmiter for metal particulies(ions and electrodes) and vapours; theoretical calculation are confirm by experimental results obtained by different authorsthe time of discharge is sufficient to develope perturbations and to spread capillary waves.

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