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EXPERIMENTAL INVESTIGATIONS CONCERNING THE EXTRACTION OF CONE MENISCUS ON METAL SURFACES WITH ELECTRICAL DISCHARGE MACHINING (EDM) ADHIBITION

BY

TOPALA PAVEL*, RUSNAC VLADISLAV**

Abstract: The paper presents the results of experimental investigation concerning cone meniscus formation on innard surfaces with impulse discharge adhibition. The aim of surface micro geometry modification is to increase their absorption capacity of radiation and the emission of elementary particles.

It is shown that the size of the formed meniscus depends on the energy processing regime, device size, electric discharge in impulse duration and thermo – physic properties of executive innard material.

1. Introduction

The works on electrical discharge machining (EDM) adhibition for technologic purposes can be divided into two vast groups: the first states the results concerning dimensional processing of the innard (cutting, puncture, grinding) [1-3] and the second group reflects the researches concerning the formation of deposit layers (from compact or dusty materials or their combination) [4-11].

If the main aim of dimensional processing is the formation of the innard with a certain geometry, the accuracy and high productivity of the roughness then the main aim of deposit formation is the innard surfaces conferring exquisite properties, such as: wear and corrosion resistance, high hardness, low friction coefficient and, finnaly, the lowest roughness.

The main aim of these two cases is low roughness, but this parameter is the one that determines the durability of the processed innards with (EDM) adhibition and used in cinematic couples that action on the action of friction powers. It results from the conclusions of experimental researches shown in some papers [1-4], the roughness size of the processed surface depends on the

energy processing regime and the properties of executive innard materials or those of the deposit realization.

The roughness parameter of the processed surfaces can be treated as beneficial and the main goals are modified on innard surface formation with (EDM) adhibition. It is known that in case of some physical phenomena such as heat exchange between bodies, radiation capacity of the surfaces and the capacity of particle emission (vapors, electrons and ions) and the absorption of different radiation types, the effects develop more intensively if the respective surfaces possess a more developed roughness.

The determination of the surface area of the piece when its roughness is determined by some callosities with accidental geometry is very difficult, that is why the well – determined callosity geometry formation and its distribution on the above mentioned piece according to certain laws.

In case of processing processes with (EDM) adhibition when no matter what kind of method was applied, be it the dimensional processing [5, 6] or the formation of deposit layer melting and the melting of the material from electrode surface with spherical calotte craters formation.

Three types of craters were registered by the authors of the works [8] all of them having the shape of spherical calotte; the first with a smooth profile; the second with a hard profile and the third having a meniscus in the middle. The different hight of menisci was registered both in case of dimensional processing and in conditions of (EDM) adhibition on deposit formation [4].

A number of works have been recently published [8, 11] where it is shown that the appearance of the meniscus in the middle of craters results from a new physical picture of electro-erosion and namely of the liquid metal surface perturbation under the action of highly intensive electric fields, superficial tension powder of melted metal and that of the weight.

The following are the results of experimental researches concerning the modification of micro-geometry surfaces with (EDM) adhibition on underexposure regime with meniscus extraction from the processed innards surfaces confectioned from different materials.

2. Experimental method of research

Experimental researches were accomplished in the normal condition of the air at medium temperature. Experimental researches were elaborated using RC pulse generator confectioned under laboratory conditions [4]. During the attempts the frontal device was measured with a dial with 0,01mm precision and was permanently controlled with a measurement microscope MPB-2.

Meniscus sizes (Taylor cones) acquired on electrode surfaces on hermit discharges were measured with the MBS – 9 microscope. Voltage drop on the device, current variations in pulse, pulse duration as well as energy applied on hermit discharge were determined by oscilloscopation [4, 11]. W wire and

W+10%Re alloy with d = 2mm served as electrodes. Electric discharges were held in an electrode system made of the same material. The size of the device was equal to S = 0,2mm, condenser battery capacity was modified on steps (with a step equal toll 100μF) limited to 100 ... 600μF.

The modification of battery capacity induced the accumulated energy variation on it and the pulse duration. The top meniscus angles measurement was elaborated with an optic apparatus.

3. Experimental results and their interpretation

The influence of accumulated energy on the condenser battery was analyzed during the researches as well as pulse duration on meniscus formation on the anode surface when anodes are positioned and connected to the discharge circuit of circuit pulse (fig.1).

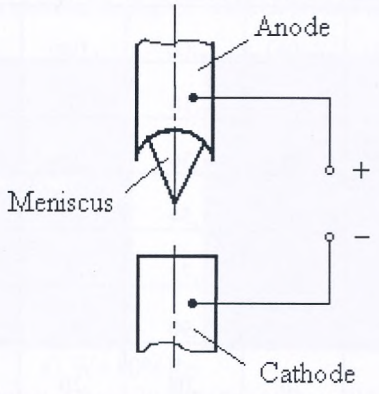


Fig.1 Scheme of electrodes position and their connection in discharge circuit of current pulse generator.

The researches were elaborated under conditions of electric discharges in pulse in under-excitation regime for the thermo interaction with processed surface. It was stated that in conditions of electric discharges in pulse when the electric field intensity applied to clearance is only $10^4 \ldots 10^5$V/m, the meniscus extraction takes place which, at the first sight, appears to be a contradiction to the conditions stated by scientist D. Gabovici for dangerous intensities of inhibited electric discharges for this intension ($E_{cr} \approx 10^8$V/m).

The possibility of surface perturbation under the influence of dig intensity of electric fields with development of capillary waves and cone meniscus extraction is confirmed and by both theoretical and experimental results obtained by some authors [9, 10, 11]. In the case when voltage drops perturbation of liquid metal surface with meniscus extractionis considered the drop of anode voltage (in accordance with work [11]), this condition is fulfilled.

The testing experiments demonstrated the veracity of this hypothesis through meniscus acquirement on electrode surfaces executed from titanium alloys, constructional metal, zirconium, wolfram, etc [4, 8, 11].

Further on some experimental results dealing with meniscus formation on anode surfaces executed from W and W+10%Re alloy will be presented and analysed.

It was observed that for electrode – anodes executed from W+10%Re alloy with increase of accumulated energy on condenser battery from 0,18J till 1,08J and impulse duration from 100 till 220μs the meniscus height varies from 49μm till 126μm (tab.1). For electrode anodes executed from W subjected to processing under similar conditions, their height varies from 28μm till 70μm (tab.2).

Table 1

Base meniscus diameter and its height in the role of condenser battery capacity and impulse duration for anodes made of (W+10%Re) alloy.

r.	, (μF)	$_c$, (V)	$_m$, (A)	$_c$,(J)	, (μs)	h $_m$, (μm)	$d_{b.m}$., (μm)
.	00	0	3	,18	00	4 9	84
.	00	0	26	,36	25	7 0	84
.	00	0	50	,54	60	8 4	112
.	00	0	66	,72	80	9 8	140
.	00	0	70	,90	00	1 12	168
.	00	0	76	,08	20	1 26	196

Table 2

Base meniscus diameter and its height in the role of condenser battery capacity and impulse duration for anodes made of (W).

r.	, (μF)	$_c$, (V)	$_m$, (A)	$_c$,(J)	, (μs)	h $_m$, (μm)	$d_{b.m}$., (μm)
.	00	0	00	,18	00	2 8	56
.	00	0	46,6	,36	25	3 5	84
.	00	0	66,6	,54	60	4 2	112
.	00	0	80	,72	80	5 6	140
.	00	0	86,6	,90	00	6 3	168
.	00	0	00	,08	20	7 0	182

Figures 2 and 3 represent oscillograms obtained in the research process for W+10%Re alloy and W and meniscus extracted from these surfaces.

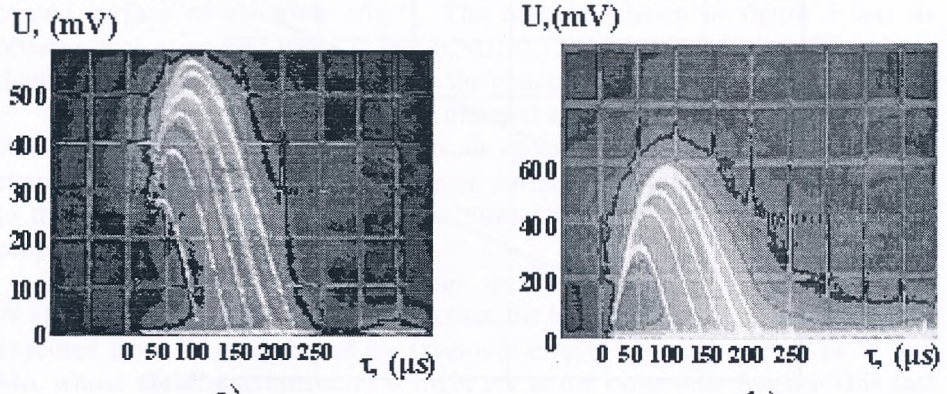
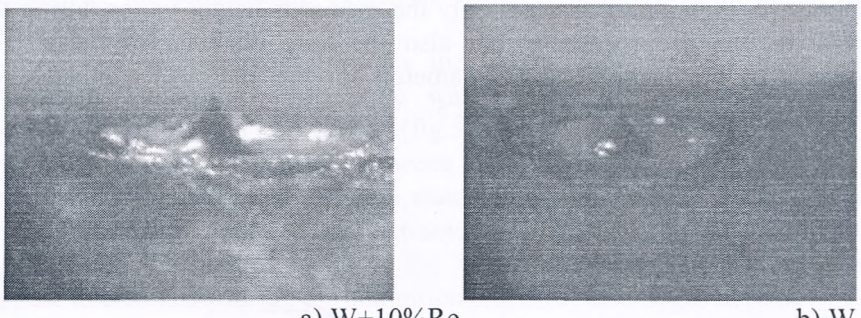


Fig.2. Oscilograms obtained during the research process (a-W+10%Re; b-W).



a).W+10%Re b).W

Fig.3 The meniscuses extracted from (W+10%Re) surface, (W) in laboratory conditions.

Performing the analysis of obtained results, we can present the dependence of meniscus height on energy accumulated on condenser battery for processed materials (fig.4).

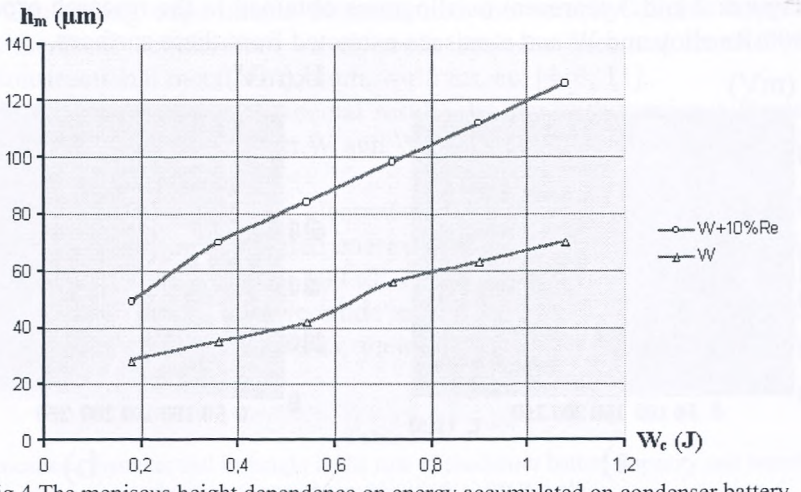


Fig.4 The meniscus height dependence on energy accumulated on condenser battery.

It is worth mentioning that not only the meniscus height varies during the energetic regime of processing, but also the base diameter of these. The dependence of the meniscus base diameters on the energy accumulated on condenser battery is presented in figure 5.

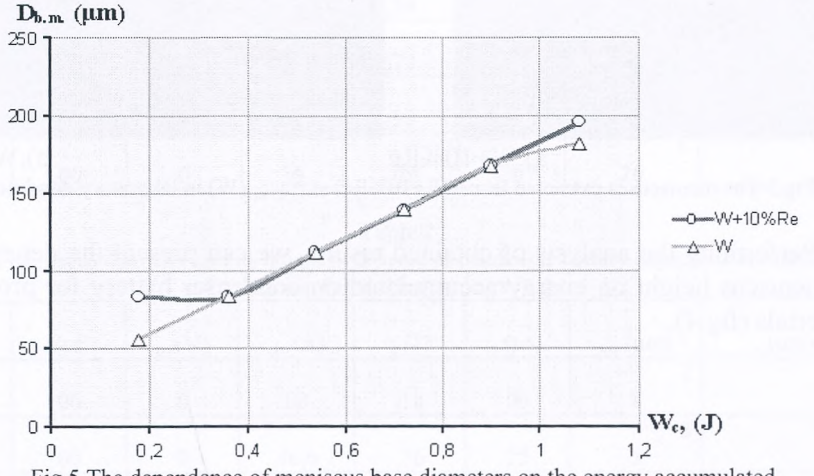


Fig.5 The dependence of meniscus base diameters on the energy accumulated on the condenser battery.

As we can observe from the presented dependence in fig.4 and 5, the meniscus height and their base diameter depends in its major part on the energy accumulated on the condenser battery. Thus, energy is a very important parameter which influences the meniscus formation metal surfaces.

The above mentioned can be explained only by the fact that the quantity of released energy in clearance is the direct amount of material quantity melted on busted surface of electrode (fig.5). The material shown in figure 5 lets us observe that at energy value 0,36J; 0,54J; 0,72J and 0,90J the meniscus base diameters grow in direct proportion to the quantity of applied energy.

They are practically the same for material execution of these. These results can be explained by the fact that electrode spots through which the conductivity channel of EDM contacts with processed surface, it is placed on special height to this and the increase of discharge current is a kind of processed material properties (fig.2).

The acquirement of the meniscus on electrode surface executed from W+10%Re alloy with a greater height than the height obtained on anode surface executed from W is explained by {rhenium effect} [7], such metals as W and Mo, whose melting temperature is high, are at the same time fragile. This fact limits their application in pure state in practice.

The alloying of these metals with Re leads to plasticity increase, wear resistance, the temperature decreases while crossing to liquid state, electric proprieties, etc.

During researches, besides the height and meniscus base diameter measuring, some new measuring was under taken with the purpose of determination of their top angles (fig.3). It was stated that the top angle for meniscus measuring is situated between $88^0 - 92^0$ limits.

Besides this, some cases were stated when the presence of a crystallized metal sphere drop is noticed on meniscus top. This fact confirms the hypothesis dealing with metal erosion under the influence of high electric fields which appear in clearance during the adhibition electrical discharges in pulse.

4. Conclusions

Analyzing both experimental results and theoretical results realized by other scientists as well as our our experimental results we can conclude the following:

1. in conditions of adhibition electric discharges in pulse on the metal surface some necessary conditions appear which are sufficient for the extraction and congelation of the meniscus;
2. the extracted menisci have a con form with the top angle between 88^0 - 92^0;
3. the linear dimension of menisci (the diameter of the base and height) are the regime processing functions, the duration of physical-mechanic properties of materials for electrode execution;
4. in the function of processing regime some micro-geometric modifications can be created on metal surfaces.

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