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MASS EROSION AND MATERIAL TRANSFER AT THE DEPOSITION OF LAYERS BY INVERSE ELECTROEROSION

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ABSTRACT

The deposition and alloying of the superficial layers by inverse electroerosion or by electric spark given by a vibrating electrode permits to obtain a large scale of properties at the surface of metallic materials from tools, machines organs, electric contacts, etc. During the inverse electroerosion, the evaporated and ionizated material from electrode (+) under the influence of temperature and electric field, is transferred and deposed on the surface of the part (-). The intensity of material transfer depends on the parameters of the electrical discharge between electrodes, on the time of work and on the nature of the electrodes. This paper work wants to establish the type of evolution in time of the quantity of erodated material from electrode and deposed on the surface of the part. The experimental results are in accordance with the theory of the phenomena of erosion by temperature mixed with the phenomena of massic erosion. The results show that the deposed mass increases by the specific time of deposition until it reaches maxim value, then it decreases.

KEYWORDS: erosion, spark, discharge, electrode

1. Introduction

The electric erosion or processing by electric sparks based on the erosion of metals during the electric discharge by impulses.

When the electric current is pulsatory with direct polarity (the part = anode) and the interelectrodic space is a dielectric liquid (oil, kerosene) takes place the processing by electroerozion of the parts (on their surfaces appear cavities, profiles, etc).

If it is used an inverse polarity (part = cathode) and the interelectrodic space is a gas, it takes place a deposition of electrode material (anode) by the surface of the part.

In contrast with other superficial processings (superficial thermal treatments, thermo-chemical treatments, deposition with thermal spray, deposition by PVD and CVD, etc.) the deposition by electric spark given by a vibrating electrode ensures a very resistant union of the deposed layer with the basic material and permits the deposition with pure metals and with metallic alloys and the alloying of the sublayer with the electrode material.

Under the influence of the temperature from the electric spark (5 000 – 11 000^{0}C) and the electric field, take place on the electrodes some physical phenomena as: electrical discharges in impulse and electrothermical process which have as final result the electric erosion.

B.R. Lazarenko proposes the following succession of the phenomenon which takes place at the electric erosion in impulse. After the piercing of the space between electrodes, a fascicle of electrons emitted by the cathode (the part) interacts with the surface of the anode (the electrode) given their breaking energy and causes a micro explosion which makes a micro cavity on the surface. Because of the explosion, the evaporated material melted is plunged by the electrodynamic field, the hydrodynamic pressure and the gasocinetic pressure from the discharge on the surface of cathode (the part) and the result is the deposed (white) layer which is very hard and has other special properties.

The most important characteristic of the processing is the discharge energy of the electric spark in the interelectrodic space, which depends on the voltage and medium intensity of the electric current, the nature and the thickness of the deposed layer on the cathode, the nature and the thickness of the electrode (anode). At the medium values of the current (0.2 ÷ 80 A) and voltage 15 ÷ 220 V are obtained 8 ÷ 18 J energy. When the discharge energy

in impulse is lower, the quantity of material transferred between electrodes will be smaller.

The total energy W_i produced in the electrodic space during an electric impulse is:

$$W_i = \int_0^{\tau_i} U(t) \cdot I(t) \cdot dt \quad (1)$$

τ_i – total time of the impulse
U(t) – the voltage of the impulse
I(t) – the intensity of the impulse

The total energy (W_i) is given by electrodes (W_{el}) and by the channel of the discharge (W_k).

$$W_i = W_{el} + W_k \quad (2)$$

The energy who is transmitted to the electrodes which is turned into heat has as result the melting, the local vaporization and in the end the erosion of electrodes.

$$W_{el} = \int_0^{\tau_i} U(t) \cdot I(t) \cdot dt - S\int_0^{\tau_i} \varepsilon(t) \cdot I(t) \cdot dt \quad (3)$$

S – the distance between electrodes (3 ÷ 500 μm)

I(t) – the variation of electric potential by the channel of discharge.

2. Experimental method

In order to establish the time evolution of the mass erosion and the transfer of material from the electrode to the part, were made samples with thin strip form (55x10x1 mm) of two steels OLC 55 and 42 MoCr11.

The chemical composition of the two steels is given in table 1. On the samples which are in the initial stage normalized (N), quenched and tempered were successively deposed four layers with a wolfram carbide electrode (WCo8), with 2.2 mm ϕ.

The deposition was made on a single face with specific times of 1.25 minutes/cm^2. At every deposition was used a discharge energy in impulse of 0.3 J.

Table 1

Type of steel	Chemical composition, %									
	C	Mn	Si	P	S	Cr	Mo	Ni	Cu	
OLC55	0.52-0.60	0.50-0.80	0.17-0.37	0.04	0.045	-	-	-	-	STAS 880-88
	0.57	0.74	0.25	0.022	0.025	0.24	0.03	0.16	0.23	determinated
42MoCr11	0.38-0.45	0.6-0.9	0.17-0.37	0.035	0.035	0.9-1.2	0.15-0.3	-	-	STAS 791-88
	0.41	0.62	0.27	0.02	0.04	0.98	0.25	0.22	0.32	determinated

The deposed mass on the slide (cathode) or the massic erosion was determined by weighing the thin strip before and after each deposition.

The thermal treatment parameters applied before deposition by electric spark for the two steels, were:

- OLC 55 – normalizing from 850^{0}C/air
- quenching from 840^{0}C/oil
- tempering to 600^{0}C/air
- 42MoCr11 – normalizing from 870^{0}C/air
- quenching from 850^{0}C/oil
- tempering to 600^{0}C/air

3. Experimental dates

After deposition and alloying of four successive layers, when the specific time of the deposition was 1.25 ÷ 5 min/cm^2, were measured by weighing the masses before and after each deposition Mo, M1, M2, M3 and M4, and the masses for each deposed layer Δ M1, ΔM2, ΔM3, and ΔM4 and the total mass of the final layer $\sum_{i=1}^{4} \Delta M_i$. The values resulted by weighing at the analytical balance are given in table 2.

Table 2. *The deposed weight on the sample after DASE*

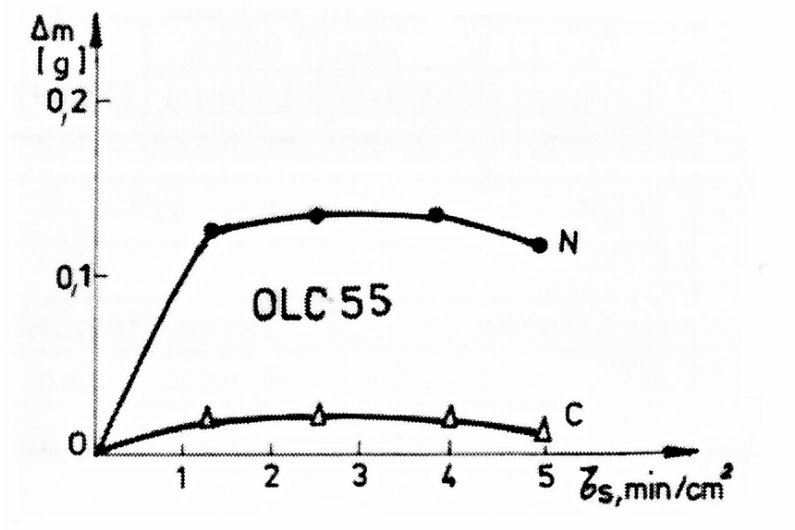
The part	**Initial state**	**Mo**	**M1**	**M2**	**M3**	**M4**	**Δ M1**	**ΔM2**	**ΔM3**	**ΔM4**	**ΣΔMi**
OLC55	N	4.1541	4.2804	4.2841	4.2848	4.2775	0.1252	0.0037	0.0007	-0.0073	0.1223
	C	4.3218	4.3319	4.3401	4.3409	4.3381	0.0101	0.0082	0.0008	-0.0028	0.0163
42MoCr11	N	4.2080	4.3405	4.3430	4.3439	4.3405	0.1325	0.0025	0.0009	-0.0034	0.1325
	C	4.3511	4.3654	4.3718	4.3791	4.3702	0.0143	0.0064	0.073	-0.0089	0.0189

Obs. Mo – initial weight; M1…M4 – weight of the samples after each; ΔM1 …ΔM4 – weight of each deposed layer; N – normalized; C – quenched.

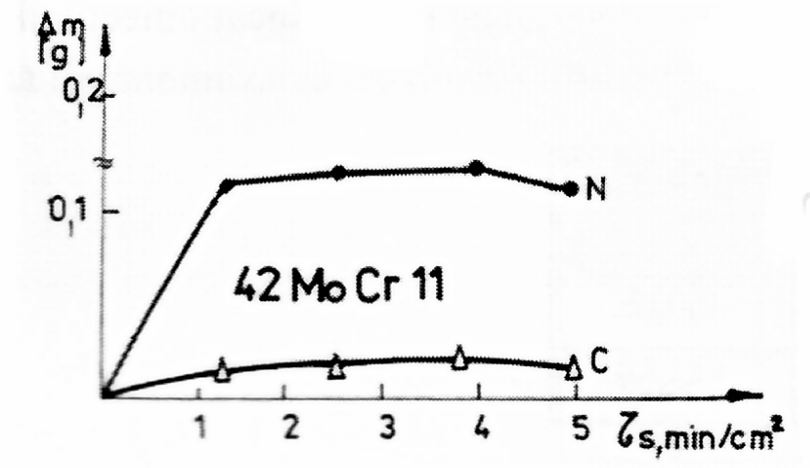
By knowing the measured contribution (ΔMi) after each deposition, the density of WCo8 electrode (ρ) and the surface of deposition (L.l) it is possible to calculate the thickless of each deposed layer:

$$e_i = \frac{\Delta Mi}{\rho \cdot L \cdot l}, \text{ mm} \qquad (4)$$

The thickest layers are the same as those measured with the micrometric ocular of the device hardness measurement PMT 3.



a.



b.

Fig. 1. *The variation of the deposed mass with the specific time of the WCo8 electrode on the steel layers with the specific time of deposition. a) OLC55; b) 42MoCr11*

From table 2 and figure 1, it results that the biggest weight is obtained at the deposition of the first layer. The weight of the other layers is smaller, and after the fourth deposition, with the specific time of 5 min/cm^2, the massic contribution is even negative. From these data results that for deposed layers with a certain weight are necessary just 1÷3 successive depositions. Also, it has been pointed out that (τ_s = 1.25 min/cm^2) the deposed weight by the two steels, with the initial state normalizing is almost ten times larger after the first deposition as the weight deposed on the same steels in quenching and tempering state. After the second and third depositions (τ_s = 2.5 şi 3.75 min/cm^2) the massic contribution is very small; after the fourth deposion (τ_s = 5 min/cm^2) the weight increasey because the pulverization of the material deposed before. The pulverization of the deposed material after a large

specific time has as result the appearance in the layers of some stretch stress with higher values.

It has been shown that if after 1÷2 deposition, the layers are remove the stress by knocking with the vibrating electrode without voltage, the massic contribution will increase making possible the obtaining of layers with larger thickness.

4. Conclusions

* The quantity of eroded material from electrode (+) and deposed on the part surface (-) depends on the discharge energy in impulse; so this quantity also depends on the intensity of the work system and on the physical and geometrical constants of the electrodes.

* The deposed weight on the cathode (the part) is larger on the normalized steel than on the quenched and tempered steel.

* The deposed weight on the cathode increase swith the specific time of deposition to the 2 ÷ 3 min/cm^2 and after made it decreases because of the pulverization of the layers deposed before.

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