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STUDIES ON THE INFLUENCE OF EVACUATING EROSION PRODUCTS ON THE PRODUCTIVITY AT THE ELECTRO-DISCHARGE MACHINING PROCESS

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ABSTRACT

It has been noticed that during the evacuation of solid particles from the active area with the help of the dielectric liquid at the electro-discharge machining process, these particles are slower than the liquid current. The difference is higher when the particle dimensions are higher and when the flowing speed is lower.

A device fitted with an auxiliary basin has been conceived in order to ensure a precise steering of the dielectric liquid and it was used for carrying out experiments for the accurate determination of the influence on the productivity.

Keywords: electro-discharge machining, productivity, erosion products

1. GENERAL CONSIDERATIONS

The presence of dielectric liquid is imperatively necessary at the EDM process.

At the backing-off movement of electrode, a swirling motion of dielectric liquid appear into the technological gap, which allows the particles detachment from the stored layer on the part's surface near the working space. In addition, there have been stored layers of the solid particles into the technological gap, which can completely interrupt the EDM process because of the dielectric properties of these layers.

During its movement it will carry away the liquid and gaseous materials, since the solid particles tend to trail. This tendency to trail is increased when the particles are bigger and the leaking speed and viscosity is low. The trail phenomenon during the fluid movement is made into a laminar flow, natural evacuation evolving in compliance with the dielectric liquid’s incompressibility conditions.

The appearance of these phenomena can be avoided through the forced evacuation of the solid particles by moving the particles from the technological gap, assured by the forced circulation of dielectric liquid.

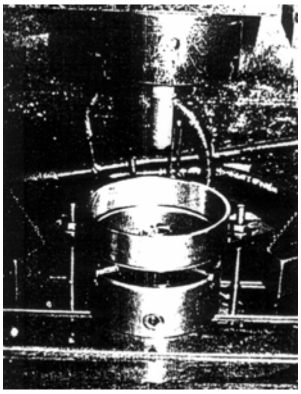

Figure 1. The cleaning device with forced evacuation of the dielectric liquid.

To assure an optimal cleaning process of the technological gap between the electrode and the part, it was conceived a simple device made of a concentric jaw for simultaneous lighten, hand-driven according to the standard STAS 1655/2-87 cylindrical pan (vase type) used as a working auxiliary tank, which has a bore to allow the working part to be tighten into the concentric jaw a working part, which has a central technological hole.

The optimal cleaning process is assured by a driven motion of the dielectric liquid into the working auxiliary tank into a circular motion as shown in fig. 2.

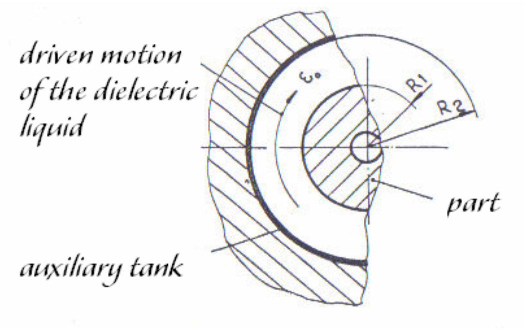

Figure 2. The circular motion of the forced evacuated dielectric liquid inside the auxiliary tank

This way the cleaning process between the technological gap and the part is assured by the centrifugal force which force the solid particles to move to the exterior of the working pan, the swirl that attract a small part of solid particles into the interior of the working part and forced evacuation through the technological bore.

The circular motions lake place inside the working auxiliary tank by a continuous filling with a Diesel fuel jet, under a tangential direction to the interior wall.

The part has a cylindrical configuration with ϕ30 mm and 30-mm height and is made of 50VCr11 steel with a control bore of ϕ5 mm, which assures the forced circulation of dielectric liquid,generating a rotation movement (in ε_0 direction). The cleaning process is achieved by means of the centrifugal force, which allows the solid particles to be evacuated through the technological bore.

The graphite electrodes have a cylindrical configuration. They were previous weighed with an analytic balance and measured with a micrometer.

This equivalency of the active (frontal) surface of the working electrode is necessary because in the natural evacuation case it's a circular surface, but in the forced evacuation case the surface is a circular crown wheel. The average value of difference between those two active surfaces is 0,398 mm^2, which means 0.4%, which is low enough to be ignored. Therefore the electrode's diameters which assure the active (frontal) surface equivalency for these two evacuation cases are shown below:

– natural evacuation –

1. Φ_E = 10 [mm]; 2. Φ_E = 15 [mm]; 3. Φ_E = 20 [mm]; 4. Φ_E = 25 [mm]

– forced evacuation –

1'. Φ_E = 11.6 [mm];2'. Φ_E = 16.1 [mm];3'. Φ_E = 20.8 [mm];4'. Φ_E = 25.7 [mm]

Their dimensions have been made for natural evacuation of ϕ10, ϕ15, ϕ20, ϕ25 and ϕ11.6, ϕ16.1, ϕ20.8 and ϕ25.7 for forced evacuation.

The electrode's wear has been estimated with the formula:

$$Q_E = \frac{m_{E1} - m_{E2}}{tpr} = \frac{\Delta mE}{tpr} \left[\frac{\text{g}}{\text{min}}\right] \tag{1}$$

where: m_{E1} – initial weight; m_{E2} – final weight

The estimation of the dimension variation Δ_D has been made with the formula:

$$\Delta_D = \Phi_D - \Phi_E \tag{2}$$

where: Φ_E – initial diameter; Φ_D – bore diameter

The EDM process was performed on an ELER01-GEP50F machine and the dielectric used was a winter Diesel fuel.

2. PERFORMED EXPERIMENTS

The experimental tests were performed on groups of parts, in sets, in the table being presented the computed average values. The variables have been modified one bye one, the others being kept constant.

Productivity variation (Q_{OP}), as a function of processing depth (H) is presented in fig. 3 for the natural evacuation case (Φ_E = 10), in fig. 4 for the forced evacuation case (Φ_E = 11.6), while the corresponding values, that have been prior measured and computed, are presented in table 1 and table 2 according to these two cases.

Table 1. Technological parameters for the natural evacuation case.

	m_1 [g]	m_2 [g]	Δm [g]	tpr [min]	Q_{OP} [g/min]	H [mm]	I [A]	U [V]	Φ_E [mm]
P1	171.005	167.746	3.258	40	0.081	5	7.5	20	10
P2	175.524	169.437	6.580	152	0.043	10	7.5	20	10
P3	167.147	157.180	9.967	237	0.042	15	7.5	20	10
P4	173.270	160.109	13.161	331	0.039	20	7.5	20	10

Table 2. Technological parameters for the forced evacuation case.

	m_1 [g]	m_2 [g]	Δm [g]	tpr [min]	Q_{OP} [g/min]	H [mm]	I [A]	U [V]	Φ_E [mm]
P1’	181.401	178.205	3.195	17	0.187	5	7.5	20	11.6
P2’	168.252	161.925	6.327	36	0.175	10	7.5	20	11.6
P3’	181.705	172.119	9.585	56	0.171	15	7.5	20	11.6
P4’	181.371	168.337	13.034	82	0.158	20	7.5	20	11.6

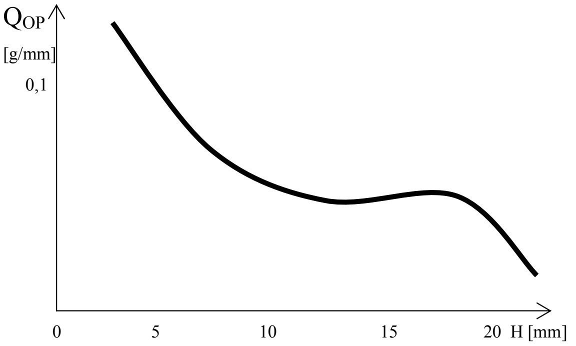

Figure 3. Productivity variation with depth.

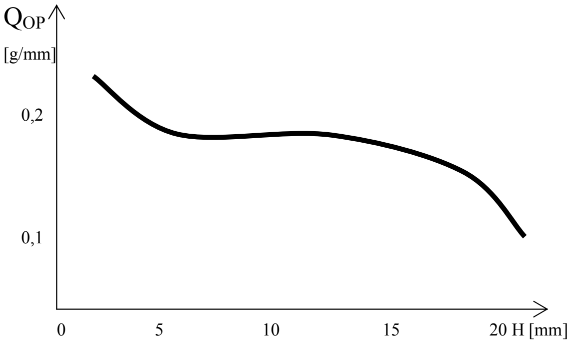

Figure 4. Productivity variation with depth

The results of experimental tests revealed that increasing the absorption depth (H) and the concentration of processed material over a optimal value into the technological gap, lead to a decreasing part of processing impulses that are useful, the rest of useless impulses being consumed for disintegrating the absorbed material. This way, exceeding the optimal absorption depth, the process productivity (Q_{OP}) is decreasing.

If there is an excessive concentration of processed material it will appear a carbonization phenomenon. It can be observed that process productivity in forced evacuation case is superior to natural evacuation case. The variation of process productivity (Q_{OP}) with the processed surface of material (S) is shown in table 3 and fig. 5 for the natural evacuation case, in table 4 and fig. 6 for the forced evacuation case, according to the electrode’s diameter [3].

$$\left(S = \frac{\pi \cdot \phi_E^2}{4} \right) \tag{3}$$

Table 3. Technological parameters for the natural evacuation case.

	m_1 [g]	m_2 [g]	Δm [g]	tpr [min]	Q_{OP} [g/min]	Φ_E [mm]	I [A]	U [V]	H [mm]
P5	169.650	166.423	3.226	40	0.081	10	7.5	20	5
P6	166.312	159.004	7.307	98	0.074	15	7.5	20	5
P7	171.589	158.745	12.844	188	0.068	20	7.5	20	5
P8	181.401	161.312	20.088	358	0.056	25	7.5	20	5

Table 4. Technological parameters for the forced evacuation case.

	m_1 [g]	m_2 [g]	Δm [g]	tpr [min]	Q_{OP} [g/min]	Φ_E [mm]	I [A]	U [V]	H [mm]
P5’	174.065	190.901	3.163	17	0.186	11.6	7.5	20	5
P6’	179.990	172.729	7.260	40	0.181	16.1	7.5	20	5
P7’	174.474	161.693	12.781	72	0.177	20.8	7.5	20	5
P8’	176.090	156.080	20.009	118	0.169	25.7	7.5	20	5

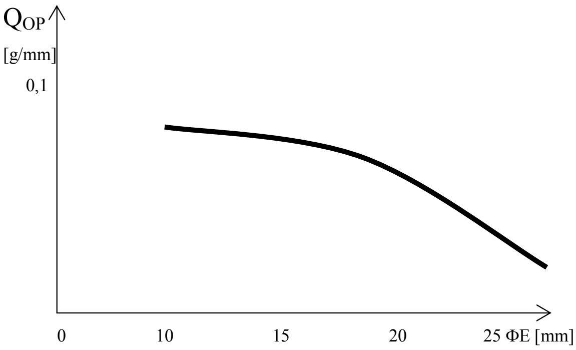

Figure 5. Productivity variation with the processed surface of material

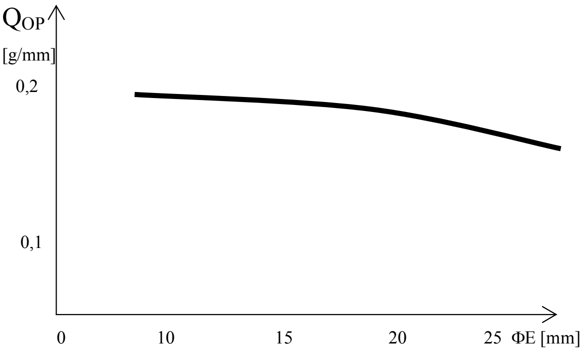

Figure 6. Productivity variation with the processed surface of material

It can be concluded, after a precise examination of experimental results, that the forced evacuation of processed material is superior to the natural evacuation, regardless the variable parameters of the process (H, Φ_E, I).

6. REFERENCES

[1] Gavrilaş, I, ş.a. Prelucrări neconvenţionale în construcţia de maşini, vol. I, Editura Tehnică, Bucureşti, 1991.

[2] Nichici, A. Prelucrări prin eroziune în construcţia de maşini, Editura Facla, Timişoara, 1983.

[3] Petrescu, V. Cercetări privind prelucrarea alezajelor prin eroziune electrică, Tehnomus IX, 1998.

[4] Petrescu, V., Ştefănescu, D.P., Nemeş, T. Study Regarding the Optimisation of the Washing Process at Electro-Discharge Machining, Conferinţa Internaţională Tehnologii Moderne, Calitate, Restructurare, Chişinău, Rep. Moldova, 2003.