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THE ENERGY DISTRIBUTION IN THE GAP AT THE TECHNOLOGICAL APPLYING OF THE ELECTRICAL DISCHARGES IN PULSES

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ABSTRACT.

The paper present some author's considerations concerning the distribution of the energy delivered in the work gap, during the electrical discharge machining.

KEYWORDS: electrical discharge machining, energy distribution, gap size, voltage drop

1. INTRODUCTION

In the case of the applying the pulse electrical discharges to achieve dimensional machining where the gap size is of only some micrometers [1, 2, 3], pulse the electrical discharge energy is distributed between the electrodes and the work medium and certain sizes remain practically constant for all the machining cycle and also in the case of depositing layers of compact materials by the using of the contacts interrupting method [4].
In the case of the machining the materials by the applying of the pulse electrical discharge in sub-exciting work conditions, when the gap size is of about 0.03…2.5 mm, the size of the used energy and, respectively, its distribution between the electrical discharge plasma column and the electrodes surfaces has an important role on the thermal effects developing at the electrodes surfaces and, also, on the erosive effects. Due to this reason, the analysis of delivering energy and its distribution between the plasma column and the electrodes surfaces presents a special importance from the point of view of the establishing the work conditions and the design and elaborating of new processes and equipments for parts surface machining in case when the pulse electrical discharges are used as energy concentrated sources
In one of the first papers concerning this field, the authors proved [5] the fact that simultaneously with the increasing of the gap size, the quantity of energy delivered in the gap does not increase significantly and it is redistributed in the plasma channel and the electrodes surfaces.

2. CONSIDERATIONS CONCERNING THE ENERGY DISTRIBUTION IN THE WORK GAP

If we take into consideration the fact that the summary voltage drop (W_e) on the electrodes surfaces is a constant size (as the authors of the paper [7] experimentally established) and the summary size of the current intensity decreases due to the increasing the active resistance of the gap, then the quantity of energy delivered on the electrodes surfaces is proportionally reduced. If we try to write the relation corresponding to the energy delivered in the plasma channel as a function of the gap size, we will notice that it increase proportionally with the gap size or more correct with the size of its active resistance. This phenomena determine the increasing the dimensions of the plasma channel [6], the light intensity and the sonic intensity simultaneously with the increasing of the gap size for the same quantity of the energy accumulated on the capacitors battery (in this case, the discharge circuit can be considered as having constant the components *C* and *L*, while the component *R* increases).
In the case when we take into consideration that at the applying the pulses electric discharges two types of erosion appear as significant and generated by the types of the predominant active electrode spots on the electrodes surfaces, then the redistribution of the energy can help some technological aim, as the getting deposition layers of compact materials and powders [8, 10]
(when on the electrodes surfaces the liquid phase appears), grinding, thermal treatments

and chemical-thermal treatments [9] (when on the electrodes surfaces only cold electrode spots are generated, which are generated by the asperities and impurities and determine thermal effects in the surface layers of the machined parts).

Table 1. The modifying of the drop voltage, the accumulated energy and the energy delivered in the gap for a constant size of the pulse current amplitude

Exp. No.	*S* (mm)	W_c, (J)	W_s, (J)	$\int_0^\tau i_s(t)dt$	W_e, (J)	w_{cp}, (J)
1	0.1	6.57	2.94	0,147	2,82(J	0,12
2	0.3	6.75	3.04	0,1447	2,77	0,27
3	0.4	7.38	3.10	0,1347	2,58	0,52
4	0.5	7.38	3.17	0,1268	2,43	0,74
5	0.6	7.5	3.25	0,1120	2,15	1,1
6	0.8	7.68	3.33	0,111	2,13	1,2
7	1.0	7.68	3.40	0,0944	1,81	1,59
8	1.25	7.68	3.47	0,0913	1,75	1,72
9	1.5	7.87	3.58	0,0832	1,61	1,97
10	1.7	7.97	3.87	0,0841	1,61	2,26
11	1.85	8.1	3.82	0,0764	1,46	2,38
12	2.0	8.67	3.90	0,0722	1,38	2,52

The redistribution of the energy in the case of the pulse electrical discharges could be demonstrated in two modalities: the first, when knowing the summary drop voltage on the electrodes surfaces and on the plasma channel simultaneously with the increasing of the gap size and calculating the charge quantity which passes the discharge circuit, we can determine the charge quantity of delivered energy.
The second modality is based on the knowing the erosive effects at he electrodes surfaces and the charge quantity which passed the discharge circuit we can determine the voltage drop on the anodic and cathodic spots and the relation between them and we can establish the critical size of the current density necessary to generate both the warm and cold electrode spots and, respectively, we can determine the energetic work parameters for the parts surfaces machining.
Analysing the experimental results presented in the table 1, we can remark that simultanously with the increasing the gap size, the delivered energy increases too.
This fact is firstly due to the increasing of the active resistence size of the plasma channel. At the same time, an evident redistribution of the sumary energy delivered in the gap (*Ws*), the energy delivered between the electrodes (W_e) and plasma channel (W_{cp}) occurs.
If at the gap size of 0.1 mm on the electrodes a quantity of energy of about 95.9 % of the sumary energy is delivered, then at a gap size of about 2 mm, on the electrodes surfaces only 35.38 of summary energy is delivered and this fact essentially affects the the errosive and thermal effects occuring in the gap.
As proof of the above mentioned assertions, we can use the results of the researches concerning the deposition layers of metallic powdeers [8, 10], where we remarked that such phenomena are possible for gap sizes of 0.1...1.5 mm.

Table 2. The modifying of the drop voltage, of the accumulated energy and of the energy delivered in the gap as a function of the fap size and the voltage used to charge the capacitors battrery of the generator

S, (mm)	U_c, (V)	U_s (V)	W_c, (J)	W_s, (J)	$\int_0^\tau i_s(t)dt$	w_e (J)	w_{cp} (J)
0.1	160	21	7.68	3.04	0,144	2,76	0,28
	240	20.05	17.28	4.3	0,214	4,1	0,2
	320	20.55	30.72	4.8	0,233	4,47	0,33
	400	20.8	48	6.82	0,327	6,27	0,55
0.5	160	26	7.68	3.17	0,121	2,32	0,85
	240	25.2	17.28	4.5	0,178	3,41	1,09
	320	258	30.72	5.3	0,205	3,936	1,364
	400	26.1	48	7.2	0,275	5,28	1,92
1	160	30.5	7.68	3.4	0,111	2,13	1,27
	240	31.1	17.28	4.9	0,157	3,01	1,89
	320	30.0	30.72	5.5	0,183	3,513	1,987
	400	30.0	48	7.7	0,256	4,9	2,8
1.5	160	37.9	7.68	3.58	0,094	1,8	1,78
	240	38.2	17.28	5.3	0,138	2,64	2,66
	320	38.0	30.72	5.7	0,150	2,88	2,82
	400	38.5	48	7.01	0,182	3,49	3,52
2.0	160	49.5	7.68	3.9	0,078	1,49	2,41
	240	50.0	17.28	5.27	0,105	2,016	3,254
	320	51.3	30.72	7.9	0,153	2,93	4,97
	400	50.0	48	7.95	0,159	3,052	4,898

The results presented in the table 2 show the modifying the drop voltage, the summary energy delivered in the gap (for the capacitors battery of the generator with the capacity of 600 μF, and charging voltage of 160, 240, 320 and 400 V) and the energy delivered on the electrodes surfaces and on the plasma channel in comparison with the gap size. We can notice that the voltage drop on the gap is a function of the gap size and practically does not depend on the voltage of charging the capacitors battery.

Simultaneously with the increasing the gap size, the energy delivered in the gap (for a constant charging energy) increases of 1.14…1.16 times, due to the increasing of its active resistance. In the same conditions, we can notice the increasing of the energy using efficiency, if for U_c=160 V, the summary delivered energy W_s is of about 39.58…50.78 % and if for U_c=400 V, the efficiency is of about 14.20…16.56, the gap size being of 0.1…2 mm. If we take into consideration that the pulse duration is for all the cases of about 250 μs, then we can affirm that this is due to the increasing of the gradient energy delivered in a time unit and this generates a significant enhancement of the reactive component of the resistance of the equipment discharge circuit.

Analyzing the report between the energy delivered in the plasma channel and the on the electrodes surfaces, we can notice that this report decreases from 9.85 up to 0.61 (for U_c=160 V) and from 11.4 to 0.62 (for U_c=400 V) in the favor of the plasma channel.

It is important to mention that for a gap size of 1.5 mm, the quantity of energy delivered on the electrodes surfaces is practically equal to the energy delivered in the plasma channel and does not depend on the quantity of energy accumulated in the capacitors battery.

The redistribution of the summary energy quantity delivered between the electrodes surfaces and the plasma channel is due to the increasing of the gap active resistance size, and simultaneously with this phenomenon, to the decreasing of the current intensity in the discharge circuit of the generator and to the decreasing of the quantity of energy delivered on the electrodes active surfaces.

3. CONCLUSIONS

Analyzing the results of the experimental researches concerning the distribution of the energy delivered in the gap at the pulse electric discharges, we can formulate the following conclusions:

- The energy delivered in the gap is always smaller than the energy accumulated on the capacitors battery of the pulse generator;
- The energy accumulated on the capacitors battery can not be used as a technological parameter because only a part of it is delivered in the gap;
- The summary energy delivered in the gap is distributed among the plasma channel and the electrodes surfaces; for the gap sizes smaller than 0.1 mm, more than 90 % of energy is delivered on the electrodes surfaces and for the gap size of 1.5 mm, practically on the electrodes and in the plasma channel about 50 % of summary energy is delivered;
- From the point of view of the efficiency of the using the pulse electrical discharge energy, within the erosive phenomena, we recommend to use small gap sizes and small energies.

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