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Auto-adjusting of the gap at electro erosion processing

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Abstract. In this paper the authors studied the mechanism of materials' erosion when applying pulsed electrical discharge machining (PEDM) during the dimensional processing and the formation of deposition layers. It is known that during the processing the tool-electrode wear occurs. The practical part of the paper is of particular interest that describes design and the construction of a device intended for auto-adjusting of the gap size at the processing by applying PEDM. As a result, there is a stable amount of power released in the interstitial space, to avoid uncontrolled wear of the tool-electrode, for the homogeneous processing, free from defects leading to an increase in dimensional processing precision.

1. Introduction

The processing by means of electrical impulse discharge is conducted under the conditions of interaction of a multitude of phenomena with interconnected physical effects, which are difficult to individualize from the value perspective and to guide through the process parameters of processing equipment.

In these circumstances, the general technological characteristics: the productivity of processing, the relative volumetric attrition of the electrode and the quality of the processed surfaces are able to provide only an incomplete overview of the evolution and the global technical and economic efficiency of the processing procedures by means of electrical impulse discharge.

Succeeding the electrical impulse discharges in the size of the gap the energy is created, which is capable of doing some work. The value of this energy can be modified by directing the energy parameters: the electrical voltage, the electrical capacity, the frequency and the size of the gap. In specific cases of production, the electrical voltage values, the electrical capacity and the frequency of impulses are initially established as fixed values depending on the processed material and depending on the applied process. The value of the gap size is also set at the beginning of the production process and the work advance is afterwards adjusted manually. This is inconvenient and requires the presence of a specialist throughout the execution of the technological process involved in the production process.

2. The research methodology

In case of electrical discharge applied to dimensional processing and to the formation of contact-breaking deposits, the size of the gap is about (5...10) μm for which reason its influence on the erosive effects occurring on the surfaces of the electrodes cannot be appreciated.

There are only a few works [1-4] which attempt to define the influence of the size of the gap on electro erosion and which observe that the increase in the gap value causes a decrease in the crater diameter and its depth, and, correspondingly, the reduction of the mass quantity of the sampled material.
The investigations in this field, with the application of electric discharges in under-excitation regime [5, 6, 8], have allowed to find out that on the surfaces of the electrodes there is evidence of electro-erosion marks, consisting of two zones: the central one that is caused by the melting of the material and the formation of the crater and the marginal one, which separates the first zone from the rest of the processed surface and has the colour of recently treated metal. It is noted that, with the increase of the gap size, at the beginning the central zone increases in diameter reaching the maximum value then decreases after an exponential function up to a certain value, after which the division of the integral crater into a few craters of smaller dimensions is observed. In the same conditions for the marginal area, it is attested the increase of its dimensions by reaching and maintaining its constant size when the central zone takes values close to the maximum ones and the further increase after an exponent, as for certain values of the gap to be certified and the division of this into separate zones. For different energy processing regimes, the critical measures change their value proportionally, the character of erosion remaining the same.
The quantitative research regarding the change in the mass intensity of the electro erosion have confirmed the above-described facts for both the anode and the cathode electrode, with the difference that for a series of metals, the intensity of erosion is more significant for the anode, while for the electrodes made of graphite, things are not the same, in addition, fort he electrodes made of metals, the erosion in the state of vapour and liquid is attested, while the graphite also attests the solid erosion [1].
Depending on the applied procedure (deposit formation) or surface treatment (thermal, chemical-thermal), besides the properties of the material and the energy processing, the size of the gap plays an important role.

The energy density on the surface of the plasma channel is determined by the equation (1):

$$Q = qp \tag{1}$$

where: Q - the energy density on the surface of the plasma channel, q and p are respectively the specific heat of melting and the density of the item material.

The right part of the equation (2) is applied to the case of thermal processing, and the left side – for the formation of deposits and the melting of surfaces in various other processes.

$$\frac{4W}{\pi d^2 S} \geq Q_{top} \geq \frac{4W}{\pi d^2 \cdot S} \tag{2}$$

where: W - the energy released in the gap, d –the diameter of the plasma channel and S - the size of the gap.

In order to mechanise the processing procedures, the problem of automatically directing the size of the gap has emerged. At first glance, this problem can be solved quite simply, but trying to find the solution, things get complicated. Difficulties arise during the phase of automatic motion of the tool-electrodes in order to direct the gap size. The question arises: What are these difficulties? For example: by means of which method to measure the size of the gap; how to build the routing electrical scheme of the mechanical part; how to maintain the optimal value of the gap size in the actual processing practice. The questions are finishing and the answer becomes clear when there are alternatives to solving these uncertainties.
By elaborating such an automatic routing device for increasing the gap between the electrodes, it would be possible to obtain a stability of the amount of electrical energy emitted in the gap, to avoid the uncontrolled attrition of the tool-electrodes, to improve the process, to automatically determine the

size of the gap, resulting in a homogeneous processing, without defects, leading to increased processing accuracy.

3. The mechanical part of the device

The mechanical part of the device is made up of several mechanisms that are presented in figure 1.

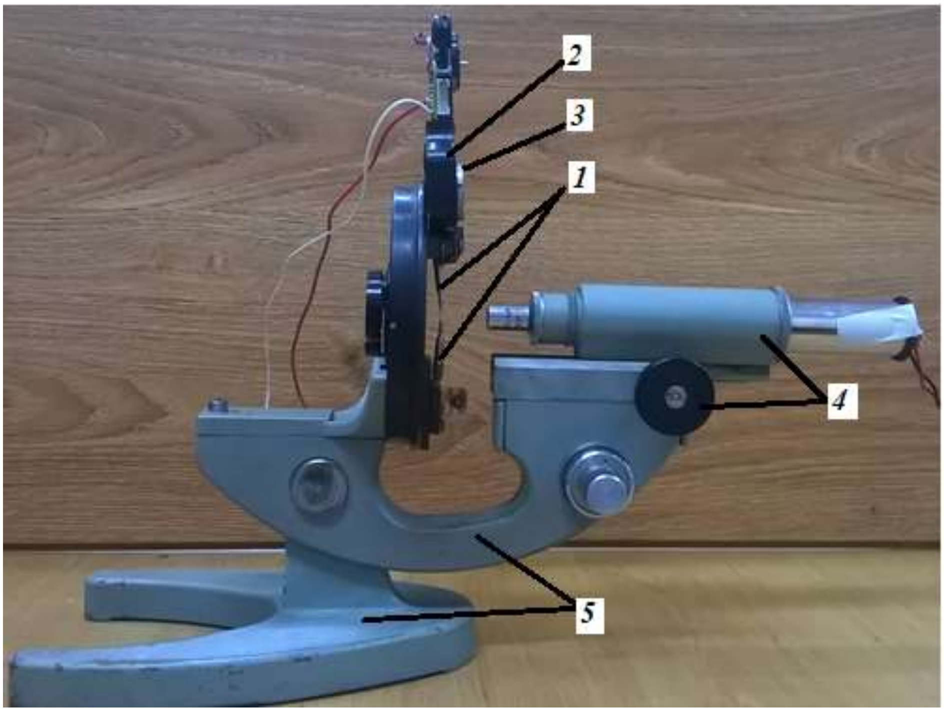

Figure 1. General overview of the mechanical device intended for automatic adjustment of the gap between the electrodes: 1 –electrode fixing mechanism; 2 –The mechanism of transformation of the rotation motion into the translational one; 3 –The electric motor; 4 –The focusing mechanism of the luminous flux; 5 –The base of the device.

The general overview of the mechanical device intended for the automatic adjustment of the gap between the electrodes is presented in figure 1. As it is observed, all the mechanisms listed above are fixed on the basis of the device, which served as a microscope. The use of the microscope has simplified the problem, and, consequently, has increased the accuracy in the operation process of the given device.

The mechanism for setting the electrodes allows fixing the electrodes with diameters from 0.5 mm to 2 mm. One of the electrodes is static and the other one is mobile. The mobile electrode is powered by an electric motor, which already receives commands from the electrical part of the device. The rotation motion of the engine is transformed into a rectilinear motion with the help of the system consisting of circular toothed surfaces (1) and rectilinear one (2) presented in figure. 2. The fixing system of the mobile electrode slides on a rectilinear orientation axis (3).

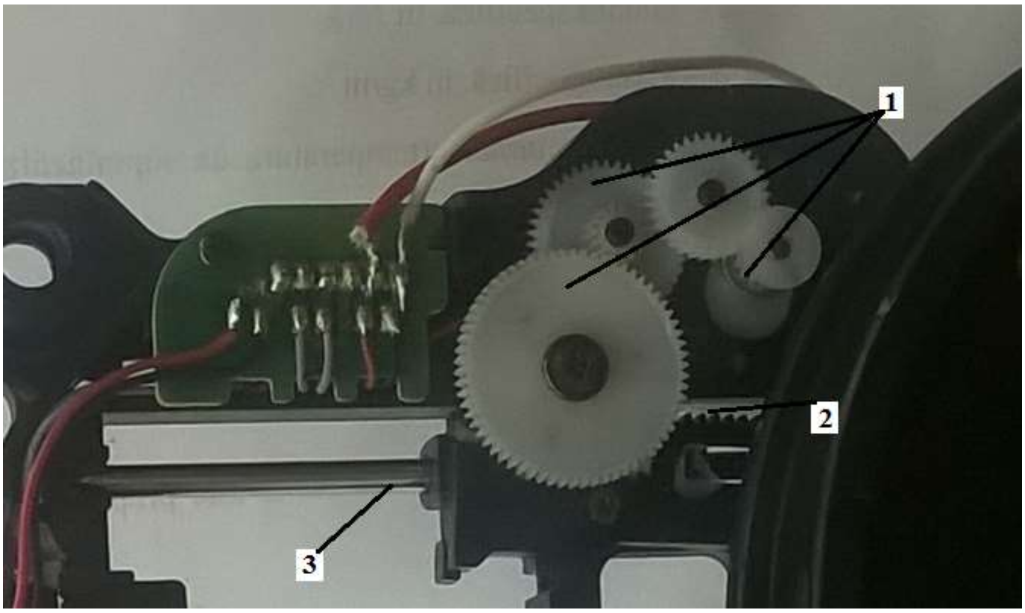

Figure 2. General overview of the mechanism for transformation of the rotational motion in rectilinear motion: 1 –circular toothed surfaces; 2 – rectilinear toothed surface; 3 –axis of orientation.

As an element that perceives the light flux from the luminous beam, created by an electro-luminous diode, we will use a photo-resistor (1) the location of which is represented in figure 3.

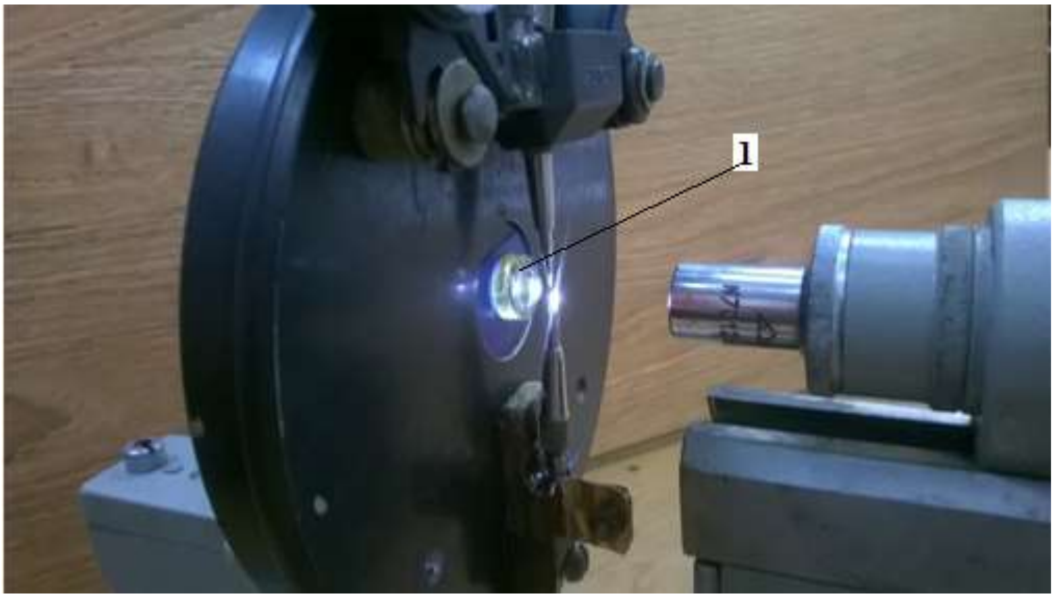

Figure 3. Location of photo resistor.

The photo resistor has the function of measuring the intensity of light flux between the electrodes. It has been thought that mainly this light flux will be at the basis of controlling the size of the gap between the electrodes.

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4. The electrical part of the device

In order to adjust the gap size between the electrodes, the mechanical part of the device has been developed, but this mechanism must be completed by the electrical part of the device which is aimed at receiving, processing and endowment of the mechanical part with the electrical signal necessary for automatic correction of this distance.

In this respect, several electrical schemes have been developed which have been checked during the working process and are represented in figures 4 and 5.

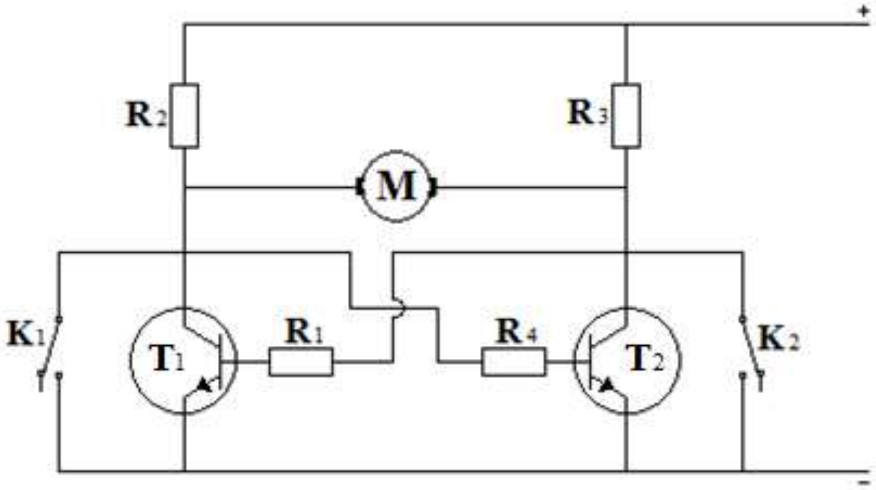

Figure 4. Electrical scheme with 2 transistors.

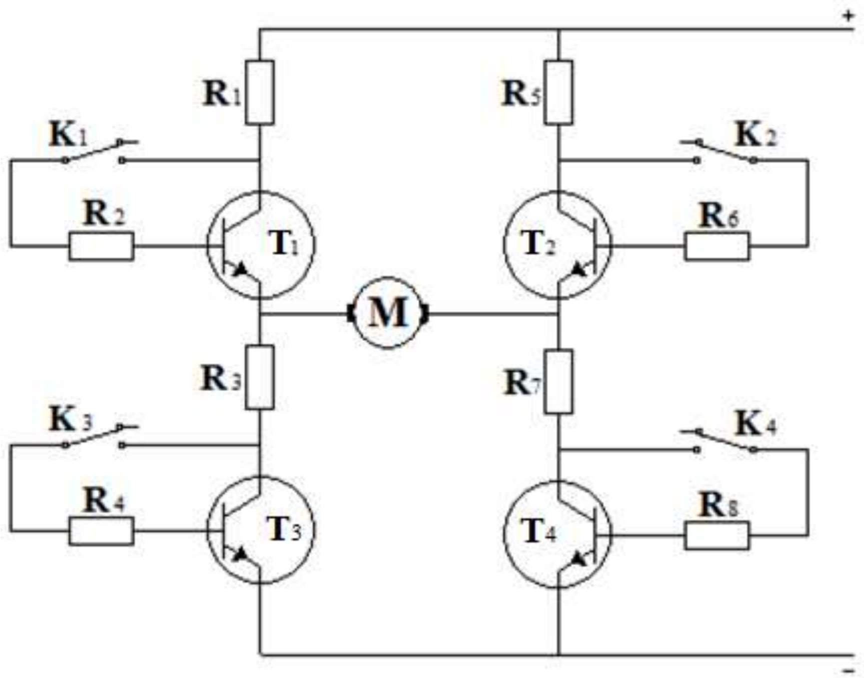

Figure 5. Electrical scheme with 4 transistors.

The functionality of the electric schemes represented in figures 4 and 5 being researched another electrical scheme has been developed that performs better during the working process. The final scheme is represented in figure 6.

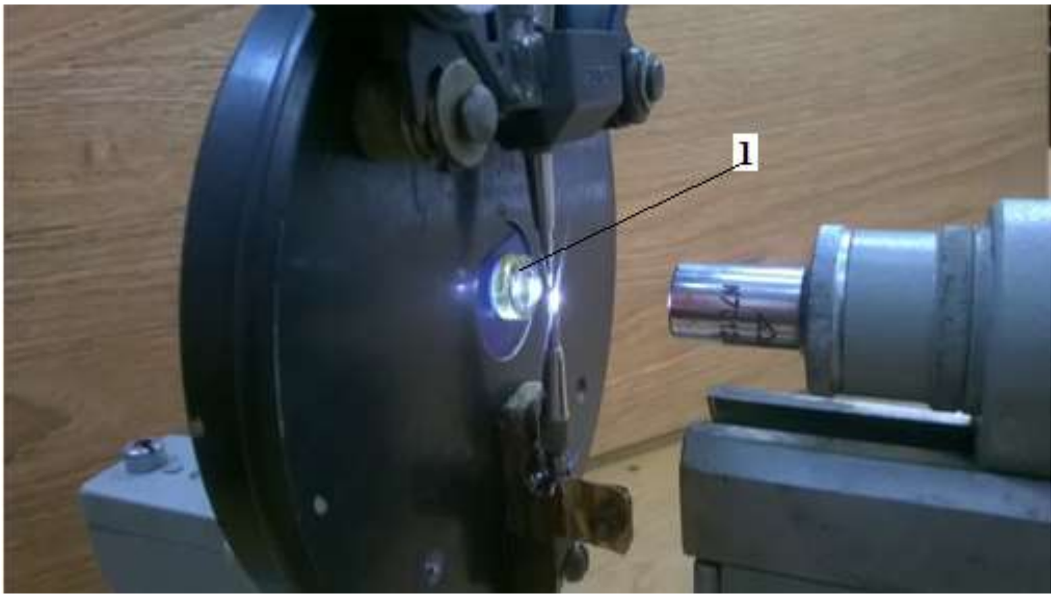

Figure 6. Optimal electrical scheme.

It should be noted that the developed device can be upgraded and adapted to different material processing installations through the pulse electric discharge method, in that way obtaining the automatic adjustment of the gap size between the tool-electrodes. As a result, one of the problems encountered during the elaboration of installation automation as a whole is solved.

5. Conclusions

The automatic routing of the gap size between the electrodes is carried out in order to regulate some elements of the energetic regimes in the course of processing by means of the electrical impulse discharge method;
- the elaboration of the automatic routing device of the size of the gap between the electrodes leads directly to obtaining the value of the stable electrical energy discharged in the gap;
- the elaborated device allows to avoid the uncontrolled attrition of the tool-electrodes, to improve the process, to automatically determine the size of the gap, resulting in a homogeneous processing, without defects, leading to increased processing accuracy.

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