ELECTRICAL DISCHARGE MACHINING - A HIGH FUTURE NONCONVENTIONAL PROCESSING PROCESS

Aurel Mihail ȚÎȚU[1,2], Constantin OPREAN[3,4], Costel CEOCEA[5,6], Alina Bianca POP[7]

Rezumat. *Eroziunea electrică se numără printre cele mai răspândite procedee de prelucrare a materialelor metalice. Acest procedeu se caracterizează prin lipsa presiunii mecanice asupra obiectului care asigură localizarea macroscopică a agentului eroziv. Această lucrare științifică evidențiază un studiu bazat pe prelucrarea experimentală a datelor precum și modelarea celor mai importanți parametri tehnologici la prelucrarea dimensională prin eroziune electrică cu și fără activare magnetică. În acest context este abordată modelarea și optimizarea parametrilor procesului ceea ce poate conduce la creșterea calității suprafeței prelucrate, la o creștere a productivității prelucrării și la o reducere a uzurii volumice a obiectului de transfer utilizat.*

Abstract. *Electrical discharge machining is one of the most common processes for processing metallic materials. This process is characterized by the lack of mechanical pressure on the object that ensures the macroscopic location of the erosive agent. This scientific paper highlights a study based on experimental data processing as well as modeling the most important technological parameters for dimensional processing by electrical discharge machining with and without magnetic activation. In this context, the modeling and optimization of process parameters is approached, which can lead to the quality increasing of the processed surface, to an increase of the processing productivity and to a reduction of the volume wear of the transfer object used.*

Keywords: *Electrical Discharge Machining, Magnetic Field, Experimental Modeling, Factorial Experiment, Quality*

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1. Introduction

A systemic approach is usually a general way of thinking that applies to all sciences, but at the same time has a particularly effective effect on the technological sciences. The essential nature of the systems approach lies in the fact that, on the one hand,

[1]Professor, Lucian Blaga University of Sibiu, 10, Victoriei Street, Sibiu, România (mihail.titu@ulbsibiu.ro).
[2]The Academy of Romanian Scientists, 54, Splaiul Independenței, Sector 5, Bucharest, Romania.
[3]Professor, Lucian Blaga University of Sibiu, 10, Victoriei Street, Sibiu, România, (constantin.oprean@ulbsibiu.ro).
[4]The Academy of Romanian Scientists, 54, Splaiul Independenței, Sector 5, Bucharest, Romania.
[5]A/Professor, Vasile Alecsandri University of Bacău, 157 Mărăști Street, Bacău, România, (costelceocea@gmail.com).
[6]The Academy of Romanian Scientists, 54, Splaiul Independenței, Sector 5, Bucharest, Romania.
[7]As/Professor, Technical University of Cluj-Napoca, North University Center of Baia Mare, 62A, Victor Babeș Street, Baia Mare, Romania, (bianca.bontiu@gmail.com).

it favors the whole over the components and, on the other, pays particular attention to the study of possible changing relationships between the components of the system. While the term system can currently refer to a single technological entity, the technological process is generally considered as a whole. In this way, all technological methods are subject to the technological process and meet certain general requirements without interfering with the operation of other methods. This approach considers electrical discharge machining dimensional management technology to be progressive, resulting in the identification of ensuring its systemic character. The concept of a technological system comes from the concept of a more general system, defined as a structured group of interconnected means of production, the functions of which are subordinate to the main goal and the components of which must be adapted to the necessary general conditions [1, 2].

The integration of electrical discharge machining in technological lines or flexible production systems has been achieved. However, this has led to the development of new concepts of usage methods; the ability to automatically adapt to certain tasks under development is essential [3].

This trend, already underway in the treatment of electrical discharge machining, refers to the consolidation of all the advancements made in many areas of human knowledge that contribute to the treatment [4].

The main limitation of the method concerns the low productivity of the processing and made it impossible to compare it with most traditional treatment methods [5].

This adaptation of course entails the presence of the treatment computer, which is all the more necessary for electrical discharge machining, as this method "stands out" in the wide random values of the setting parameters. These facts lead to an improvement in the self-adaptive operation of systems for electrical discharge control techniques and to a greater use of systems that require virtually no operator intervention, even if the operations to be performed are very different from the design of the technology system, planning of the production preparation (electrode tools, storage housings for electrode tools, tools for securing the machined object, etc.) for interphase control and final machining [6]. When electrical discharge machining was introduced in the industry, it had a number of advantages that led to its continued development; However, certain limitations have led to "technological isolation" [7]. Since the development of these microsystems is inevitable in the future, the methods used to produce micromechanical systems (e.g. microsensors, hydraulic microsystems, microswitches, optical micro markers, capillary microsystems, etc.) should be followed by the development of appropriate software microsystems. This problem must be solved in at least three ways: generating signals specific to mechanical systems; manufacturing tools that process certain micro-brands (micro-molding, micro-injection, etc.) produce brands specific to micro-electronic systems (silicon, germanium, etc.). Once the process treatment system has been further developed with an emphasis on increasing the amount of material removed, the difference between the productivity of electrical discharge machining and other conventional methods becomes smaller and smaller.

It goes without saying that these subsystems, which are suitable for EDM process systems, also need to be developed after the development of certain components. Therefore, new alternatives to automatic advanced servos and new information about the actual conditions of the erosion field will be used. The mechanical blocking of the control of technological systems during EDM machining is also undergoing changes and improvements. The intended directions are determined by the directions which should increase the rigidity of mechanical blocks to improve machining accuracy and reduce their own weight, as well as the use of new materials which can meet the requirements and reduce costs. More attention is paid to the dishes, because the area for securing the items to be treated is easily accessible. As the degree of automation of EDM machining technological systems increases, increasing attention is naturally paid to automating the technological step of gripping the object being processed. This includes, on the one hand, the possibility of automatic cleaning of the table (automatic opening of the bath, automatic return of the bath, etc.) and, on the other hand, the use of additional fixing systems adapted to the conditions of automating [8, 9].

2. Electrical discharge machining - a method of the future

The application of EDM micromachining, even during the time of experimentation, opens up new perspectives for the development of this exciting and promising field of mechatronic systems. If we look only at the EDM technology system, we can identify several directions that need to be followed in order for this method to receive the status it deserves due to the favorable opportunities it offers. Here's an overview of these rules:

- The automatic adaptation of the erosion field (automatic transfer) systems increasingly relies on “intelligent” automation systems capable of adapting in real time to the deliberate or forced changes necessary for the proper functioning of the technological system. The high requirements in terms of machining precision and dimensions (micro or macro machining) require that these systems be delivered with a higher precision that can meet these different assumptions. Self-adaptation to real conditions cannot completely solve the problem of the freedom to manipulate the actions of the operator without the constant development of control systems in the technological process. In the case of EDM machining, this requirement is critical, since this machining process is characterized by a large number of arbitrary parameters, but they usually do not have a complex shape for machining. When developing continuous adaptive control systems, we must also develop systems that link the former to centralized control systems [10];

- Development of pulse generators with a focus on specific functions adapted to specific applications. This development method is suitable for systems with precise allocation methods, batch or mass production, and the reason is that the cost of the system should be reduced. In addition, the level of automation is expected to increase significantly, since human intervention is only qualitative, adaptive and focused only on eliminating exceptions or arbitrary deviations from programs. At the same time, it is necessary to maximize the technological potential of EDM control systems to meet many technological processing requirements. This question creates a bias as it widens the range of system inputs that have a direct impact on processing properties. Among others, we can emphasize the need to use the frequency of pulsed electric discharges to improve the quality of machined surfaces, or to emphasize multi-channel machining, which offers better machining conditions, which leads to a increased productivity and productivity, machining precision, etc. • The need for automation is also becoming more and more important. The user should be exempted not only from physical activity, which depends on physiological factors, but also from psychological activity which leads to degradation, which is unthinkable when it comes to cost-effective and time-consuming procedures such as EDM [11].

The dimensional constraints of this control method will continue to decrease as technological components of the system are provided that can resolve these issues. One of the main limitations of EDM is related to the complexity of manufacturing electrode tools. This limitation determines, on the one hand, the identification and development of possibilities to determine whether the production systems of electrode tools are included in production lines or in flexible automatic lines with EDM. This electrode tool operation requires technological systems that support one or more EDM processes and are capable of automatically producing the required electrodes in real time. On the other hand, there is already a clear tendency to simplify the structural and dimensional form of electrode tools through the use of additional controlled movements appropriate to the object being processed.

If electrical discharge machining is interpolated, the treated objects must be mounted on desks to electrical discharge machine and used in a global treatment system, which requires greater flexibility in these systems [12].

Recent research has shown the possibility of treating certain small cavities with tungsten cylindrical electrode devices, the movement of which can be controlled so that they can scan the entire surface that forms the cavity to be treated. Currently, these experiments have yielded promising results, even if they are only used on microprocessors. The area that stimulates the development of the above microprocessors belongs to mechatronic microsystems; this field is constantly evolving. The demand for cost-effective, safe and quality-compliant operations, as well as operations that exceed certain limits, has led to the replacement of certain methods (electron beam, chemical erosion, microgravity, etc.) by the method of electrical discharge machining adapted to micromachining.

Dielectric fluids and their recirculation systems will also be constantly improved due to technological needs or requirements associated with maximizing or minimizing certain technological properties [13]. Synthetic dielectric fluids have already proven to be better than natural fluids in terms of the technological results obtained. This allows the controlled handling of liquids to be identified so that one or more process properties can be distinguished. Some properties can even be changed automatically, so in the same process and process, the dielectric fluid can help improve productivity at one stage of the process and improve machining accuracy at another stage. Dielectric fluid recirculation systems undergo a repair process that would be expected from the same technological development requirements that would apply to an entire electric discharge system. By using a dielectric fluid recirculation system to maximize certain properties, the working area - the erosion space - is supplied with fluid with some contamination and optimum temperature [14, 15].

Electric discharge machining is a method of sizing metallic materials, in which excess material is removed based on the erosive effect of electric discharges in the pulses repetitively generated between the processed object and the electrode, called the sender object [16].

In the framework of today's scientific and technological revolution, in which Hungary is directly involved, special attention is paid to increasing, diversifying and improving the quality of material production.

The special tasks that are posed to our industry at this stage can only be solved comprehensively and effectively with a scientific approach and optimal control of technological processes.

Using science as a productive force, people's work is increasingly moving towards reasoning and decision-making, with actions being progressively carried out by machines and automated equipment [3].

To justify and make decisions about how to manage the process, science provides the necessary tools - physical and mathematical - in the form of models that allow you to respond to possible changes in working conditions.

Since the study of physical models has some significant drawbacks, such as the duration of research with high demands on intellectual work and the inability to exclude economic factors, the current trend in the control of technological processes is the wider use of mathematical models [5].

They reproduce the studied process using certain functional conditions and allow to find the optimal operating conditions in a much shorter time and with a material cost much lower than that of the physical models [7].

Experience has always served as a means of knowing the surrounding reality, a criterion for testing hypotheses and theories [6].

It was long believed that the choice and implementation of an experimental strategy was determined by the experience and intuition of the researcher, while mathematics was only used to process the results [9].

The experiment is programmed according to a specific pre-prepared plan, is optimal for the factor change algorithm, and is complex.

In this latest version, we are generally dealing with factorial experiments, where all the independent variables that significantly affect the studied system change simultaneously at some level.

The main goal of any experiment is to mathematically form the influence of influencing factors on the target function of the system (object, phenomenon and process):

$$y = f(x1\ , x2\ , ...\ , xk) \tag{1}$$

The empirical design usually takes the form of a mathematical model first, which is considered to be the best approximation of the actual model, and then the development of research follows the provision of the data necessary to determine the coefficients (continuity) of the adopted form. of the model [9]. The goal of the transformation: to study and analyze the system under study using a model to obtain more complete data and the new associated laws. Emphasis on the mechanisms of action of factors on the system studied; confirmation of the hypothesis on internal interactions in the system; calculation and design of a system for predicting the state and behavior of the system; system optimization according to various criteria; system administration in space and time [8].

3. Experimental research

A faculty experiment was designed and implemented based on the independent variables and objective functions in Table 1. The following variables were considered:

- t_p - pause time [ms];
- t_i - impulse time [ms];

- I - intensity of the magnetic field [A];
- H - intensity of the magnetic field (which activated the process) [A.spire].

The objective functions analyzed were as follows:

- Q_p [mm^3/min] - processing productivity;
- Q_e [mm^3/min] - volumetric wear;
- g [%] - relative wear;

Ra [mm] - average arithmetic departure of the rigor profile.

Table 1) "Factor programs" – Central composed factor experiment

Process and function independent variables are objective physical values								
No.	*t_p [ms]*	*t_i [ms]*	*I [A]*	*H [A×spire]*	*Q_p [mm^3/min]*	*Q_e [mm^3/min]*	*g [%]*	*Ra [mm]*
1.	12	24.0	4	3200	3.2281	0.3342	10.35	4.0
2.	48	24.0	4	3200	4.1666	0.6166	14.80	5.2
3.	12	95.0	4	3200	7.7223	0.3193	4.13	5.2
…								
25.	30	59.5	6	9600	30.4586	0.8735	2.87	3.8
26.	30	59.5	6	9600	31.8905	0.9143	2.87	3.7

Plan and space graphs were created for all objective functions. Then we present some pictures that are more representative.

The changes in processing performance are varied; depends on the type of cleaning used, the type of material transferred and the experimental program used (depending on the work plan used). It can be seen that (Fig. 1) the processing performance at maximum magnetic field strength H = 8500 AS with a pause time tps.m = 24.

For all of the above objective functions, flat and spatial plots are constructed. We then present some more representative images.

The changes in processing performance are varied; depends on the type of cleaning used, the type of material transferred and the experimental program used (depending on the work plan used). The change in performance naturally depends on the strength of the electric current and the pulse duration values (Fig. 1). The evolution of processing performance using the first experimental software package (Table 1) is shown in Figure 1. The evolution of the volume of use differs from the performance of the process, we can see that the response curve for this function of the object is different distributed in space.

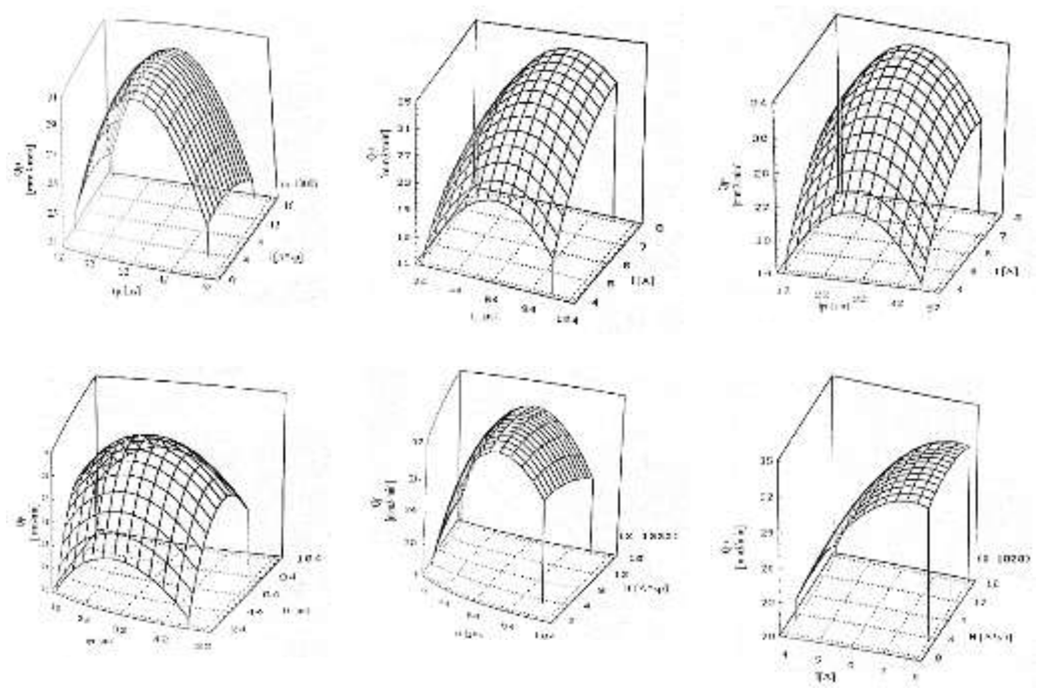

Fig. 1. Results of the central composed factor experiment

The minimum utilization of the transmission object is approx. 4000 AS for certain technological situations and approx. 14000 AS for other technological situations, with the very important emphasis that the values may vary depending on the variables analyzed. Relative wear, as is known, expresses a percentage and represents a very important object function to characterize the process. Relatively minimal wear can be achieved with an H [AS] magnetic field strength of approx. 4000 AS for certain technological situations, approx. 8000 AS of other technological nature and approx. 12000 AS for specific cases, emphasizing that the values may vary depending on the variables analyzed. The average arithmetic deviation from the string profile varies parabolic, the minimum is usually the magnetic field intensity of 14000 AS around H [AS], which is a relatively high value, but can vary downward depending on the accepted session regime.

Conclusions

EDM is a technological method that requires development in many areas due to its ability to solve important hardware problems. It should develop microprocessors and nanotechnologies and encourage the development of macro-technology.

Technological possibilities, flexibility and adaptability of the method are the properties which make it possible to evaluate this method of treatment.

The future of EDM is influenced not only by the enormous potential of this machining, but also by the attention it continues to receive both from those directly interested in industrial applications and from researchers in the field. known or equivalent.

It can be assumed that the development of EDM machining is due to the development of computer-controlled systems, the development of power and control electronics, as well as the development and production of new materials with excellent thermophysical properties. usable in production. the use of new electrode devices to improve processing accuracy (as well as other technological functions), new automatic transfer systems that can perform real-time operations and provide high system stability, block improvements mechanical or dielectric, fluids and recirculation systems, etc.

Another factor that will lead to improvements in EDM sizing systems is the availability of new materials that have special properties and require alternative machining methods. It should be noted that successful attempts have been made for spark erosion of non-conductive materials.

The answer to the question about the future of the EDM method is not difficult to formulate.

The continuous development of technicians and associated technologies directly responsible for the results of the method allows EDM to play a leading role in the application of machining methods using unconventional technologies and is one of the leaders in this field in the global industry.

With the increasingly rapid development of micro and nanotechnology, EDM places new demands on the machining method with new problems that can be relatively easily solved with this machining method.

EDM will be the method that other machining methods talk about.

In view of what has been described so far with regard to the increase in the productivity of processing, certain opinions can be cited which are supported by the very favorable results obtained.

Taking into account the connection of the object to be treated, it can be said that the material is removed from the surface by ion bombardment.

At shorter pulse times, the ion content in the ionized plasma channel is relatively low.

The decrease in the productivity of the H [AS] magnetic field intensity above certain values is due to the compression of the eroded particles in the working area.

From the analysis of the spatial graph, it can be said that the selection of the pulse times with s gives the best conditions for ms, namely 420 ms, 95 m for the 24th treatment, when the dimensional treatment is performed by magnetic activation with electrical discharge machining.

It can be assumed that the electrical load on the active space is affected by the magnetic field and reaches the opposite surface faster and accelerates the material samples.

If we refer to the specific situation of treatment with OL37 transfer objects, the increase in motivating productivity can also be placed on the streamer.

The composition of the magnetic fields shows that positive flow generators and different discharge tires are generated, so that the electric discharge can easily be initiated pulsating by magnetic activation during dimensional processing.

In the case where pulses are used with high intensity, the current density exceeds acceptable limits when the transmission object is from OL37.

Even when processed with a transfer object made of OL37, the instability of the process was significant, so we could say that it is almost impossible to process.

The use of the magnetic field composition has not only removed material from the surface of the treated object, but also greatly increased productivity.

We have also found it important to study the effect of an external magnetic field on the machining of dimensions by EDM, a magnetic activation which determines the evolution of the amount of wear.

The need for these studies was due to the fact that changes in volumetric wear largely determine the accuracy of the treatment and verify the effect of a magnetic field on the electronic and ionic components of the current discharge.

The treatment on ELER 01 indicated that the size processing with electrical discharge machining and magnetic activation reduces the amount of wear compared to the classic treatment.

This decrease is due to the angle between the lines of the electric field and the magnetic fields in the erosion field.

Considering the different directions of the two lines of force, the change in trajectory of electrically charged particles during a short pulse duration will be less, and more particles will reach the surface of the emitting object, which can be explained as follows: the formation of negative streamers.

The longer the pulse time, the more the orbit of the electrically charged particles changes, the more likely it is that a certain number of electrons will leave the intermediate space.

The relative wear of the emitting object generally characterizes the phenomenon of material removal from the surface of interacting elements during sizing, by EDM, magnetic activation, by reducing the quantity of material tested on the surface of the object of the object transferred for the sample. unit of volume at the surface of the object being processed.

Since the amount of patterned material on the workpiece or transfer object is implicitly changed using certain external magnetic fields, changes in relative wear also occur.

The use of a transmission object made of OL37 (in some cases) showed that the relative wear clearly depends on the value of the magnetic field used.

On the basis of the studies and studies carried out, it can be concluded that the main technical and economic shortcomings of the most commonly used abnormal dimension machining method, namely dimensional machining by spark erosion, have been eliminated.

The current scientific article opens up new perspectives for dimensional machining by spark erosion.

Theoretical and experimental studies in this article, prepared by the author, provide commercial companies, research institutes and universities with original, ongoing and up-to-date research that enables the technology of activation of the cell to be implemented. dimensional machining by EDM, the implementation ultimately leads to a reduction in processing costs.

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