

NEWS AND PERSPECTIVES ON THE USE OF THE PROCESS OF PROCESSING BY ELECTRICAL EROSION IN MODERN ORGANIZATIONS

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ABSTRACT: When traditional machining methods reach their limit, electric discharge machining can be the answer. The EDM process allows for high accuracy and is applicable for any conductive material.

Electric discharge machining does not use any force to remove material. Instead, an electric discharge occurs between workpiece and tool. In this case, a wire is used to “cut” the material.

EDM involves the direction of high-frequency electrical spark discharges from a graphite or soft metal tool, which serves as an electrode, to disintegrate electrically conductive materials such as hardened steel or carbide.

The technology management is set by policies and practices that positively influence technologies, in order to build, maintain and increase the competitive advantage of companies based on proprietary knowledge and know-how.

Technology management is applied to the most appropriate managerial techniques to ensure that the technological factor is exploited to achieve the company's objectives

KEYWORDS: electrical erosion, process, EDM, electrode, unconventional technologies, management, machining

1. INTRODUCTION

Electrical Erosion or Electrical Discharge Machining is a nonconventional processing technology used especially for processing hard and very hard materials or those that cannot be processed by conventional methods.

Nonconventional technologies are processing processes complementary to conventional ones with an advanced degree of automation and superior technological indicators. They are used to process parts and materials with special specific properties and complex configurations.

These technologies mainly use electricity in various forms: thermal, mechanical, radiant, electrochemical or combinations. Their application is done in the form of impulses.

The erosive effect of electric discharges in a liquid medium was discovered by the English physicist Joseph Priestley in 1800.

Through the research of the Russian scientist Aleksandr Vyacheslavovich Lazarenko, the way was opened for the application and deepening of the process of dimensional processing of metallic materials. He and the Russian researcher I. Zolotih laid the foundations for research into the theory of electrical erosion.

Following these researches, this industry has developed more and more, following that in 1954, in Milan, being the first exhibition in which the first

machine tools for processing by electrical erosion appear.

In Romania, the first research on this procedure was in Timisoara at the Polytechnic Institute of Timisoara, at the Department of Electrical Engineering led by Professor Nanu Aurel.

The development of the process took place in Romania, when the prestigious universities of that period began to do detailed research on electrical erosion, and at this time it is widely used in car manufacturing lines, electric motor manufacturing lines. Currently, the largest companies using this process are: Mitubishi Electric, Sodick, GF Machining Solutions Management, Makino, Chmer EDM, ONA Electroerosion, Methods Machine Tools, Seoul Precision Machine, Exeron, Schnghai Esuntek Machinery, Excetek Technology, AA EDM, MC Machinery Systems, Beaumont Machine, Knuth Machine Tools.

2. GEOGRAPHICAL LEVEL OF EDM ON WORLD

At the geographical level, the following countries have the highest preponderance of using this process in industry:

- North America: USA, Canada And Mexico
- Europe: Germany, England, France, Italy, Russia, Turkey, Romania, etc

- Asia: China, Japan, Korea, India, Australia, Indonesia, Thailand, Philippines, Malaysia and Vietnam
- South America: Brazil, Argentina and Columbia
- Africa: Saudi Arabia, Egypt, Nigeria and South Africa

According to the website Marketwatch.com, the cars used for electrical erosion will grow by 9.6% each year until 2026, resulting in \$ 5944.5 million, and today the value is \$ 3439.1 million. Through these values we realize how consistent is the growth of the EDM market and how much this process of electrical erosion is used. [1]

In recent years, electrical erosion processing equipment has a great constructive and functional diversity, which is growing on a large scale. The most important customers are mainly active in medical, defense, aviation, automotive and industry sectors.

3. GENERAL THEORETICAL CONSIDERATION OF EDM

The EDM is a machining method in which the material is not mechanically loaded. The part to be machined is placed in the machine in a liquid dielectric. The workpiece takes on the role of an electrode and in the dielectric there is also a very precisely tensioned wire that forms the other electrode. An electric current is carried between the electrodes. The short circuit creates sparks on the surfaces of the electrodes, which are immediately dissipated as microscopic chips by the dielectric. Our Agie Charmilles CUT 200SP wire EDM machine is characterized by a backlash-free wire guide and extremely high surface accuracy on the cutting surfaces.

In the EDM process an electric spark is used to cut the workpiece, which takes the shape opposite to that of the cutting tool or electrode. The electrode and the workpiece are both submerged in a dielectric fluid, which is generally light lubricating oil. A servomechanism maintains a space of about the thickness of a human hair between the electrode and the work, preventing them from contacting each other.

EDM spark erosion is the same as having an electrical short that burns a small hole in a piece of metal it contacts. With the EDM process both the workpiece material and the electrode material must be conductors of electricity.

The EDM processing machines can be classified according to several criteria:

- Electrical Discharge Machining (EDM). The electrode is a solid metallic body, with an active

surface of the shape conjugated with the surface to be processed on the semi-finished product, or of a simple, profiled shape.[2]

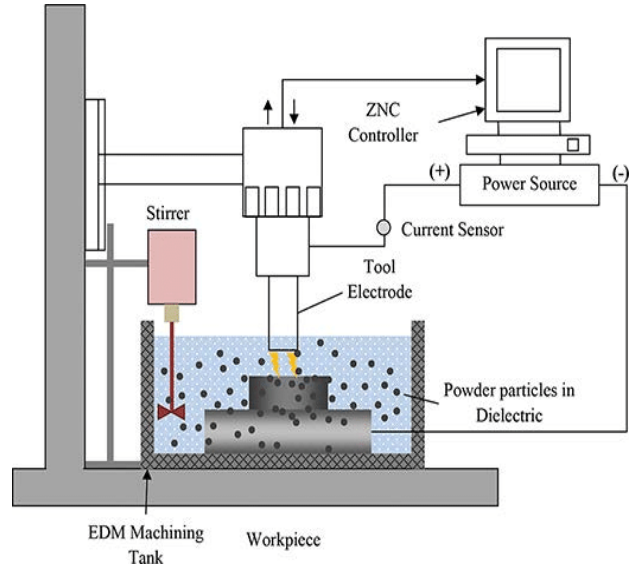


Figure 1. Electrical Discharge Machining (EDM)

- Electrical erosion with filiform electrode (W-EDM - Wire Electrical Discharge Machining). The electrode is made in the form of a metal wire with a circular section, of submillimetre dimensions (0.05 ÷ 0.35 mm).

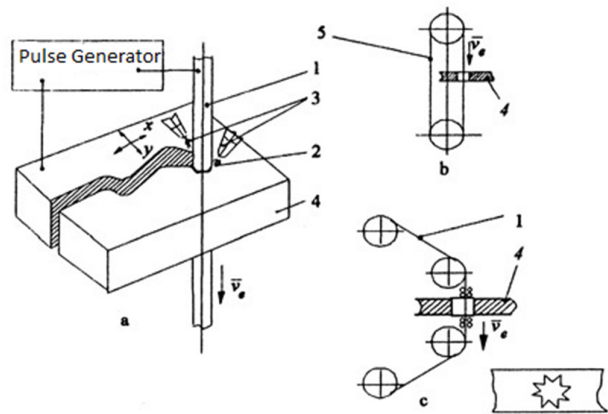


Figure 2. Schematic diagram of an EDM machine: 1-pulse generator; 2-advance regulator; 3-electrode; 4-piece to be processed; 5-dielectric tank; 6-filter; 7-pump; 8-cooler system; 9-tank for the working environment; 10-working medium (dielectric). [2]

The main difference between the electrical erosion with massive electrode and the one with filiform electrode consists in the way of generating the surfaces and the constructive form of the electrode-tool (cathode).

General theoretical considerations regarding the approached topic EDM processing is a method of dimensional processing of metallic materials, in

which the removal of excess material is done based on the erosive effects of impulse discharges, repeatedly primed between the object to be processed and an electrode called transfer object. EDM processing is applied to metal materials with high hardness, to obtain surfaces of a shape that can not be easily and accurately achieved by conventional cutting procedures. The processed metal is subject to erosion by electric discharges made between the metal and a copper cathode, in a dielectric medium (for example kerosene). During processing, the electric discharges also erode the cathode, which changes its dimensions ("wears out") over time.[5]

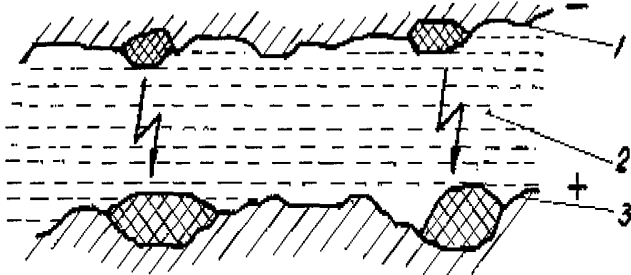


Figure 3. Principle diagram of EDM processing: 1- cathode (electrode tool); 2- dielectric medium; 3- anode (part electrode).

With a sufficient voltage and power of the source, an electric discharge occurs between the source electrode and the semi-finished part. This discharge passes successively through the following stage: luminescent discharge, spark, spark-arc and arc.

4. LOGICAL DESCRIPTION OF EDM

In order for this material discharges to take place as a result of these discharges, in addition to the processing, it is necessary to meet the following conditions:

- Direct introduction of electricity to the surface of the semi-finished part to be processed, which results that it and the electrode-tool are made of electrically conductive materials, and their connection to the power supply voltage to meet the conditions for piercing;
- Temporary impulse dosing of electricity in the interaction area electro-tool-dielectric-part-semi-finished product. The condition is necessary to realize the effect of the discharge energy on the semi-finished product and the sampling of material;
- Ensuring a polarized character of the impulse electric discharges. The thermal effect of the discharge will lead to the sampling of material both from the semi-finished part, act and from the electrode-tool, therefore the aim is for the sampling from the semi-finished part to be as large as possible. The phenomenon can be directed by connecting the workpiece and the tool electrode to the corresponding polarities and by using, in the manufacture of the tool

electrode, some materials with high erosive resistance or the formation of protective films;

- Continuous restoration of the initial state in the erosive interval, so that the discharges can be repeated practically in identical conditions. For this it is necessary the efficient evacuation of the erosion products and the restoration of the priming distance of the discharges.[6]

The machining fluid ensures the electrical insulation environment between the part and the tool and ensures the circulation of the sampled metal particles. For EDM processing to be efficient, the dielectric must:

- to possess high chemical resistance to the action of air
- not to change its viscosity during processing
- to have low thermal and electrical conductivity
- have a flash point above +40 C
- to evaporate as little as possible due to heating during processing
- to have high deionization capacity
- to have a high dielectric strength and a cooling capacity
- not to produce by decomposition harmful gases or corrosive compounds
- to have low viscosity and good watering capacity, to penetrate intersections
- be chemically stable and not produce conductive residues
- have high temperatures of inflammation
- to have an affordable price[12]

The main dielectrics used in the process of electrical erosion are: oil, transformer oil, mineral oil, deionized water, industrial water, aqueous suspensions, ethyl alcohol, methyl alcohol.

Contact electroerosion processing is based on the initiation of unstationary arc discharges by interrupting the electrical contacts traversed by the current, contacts established temporarily between the tool electrode and the object to be processed, which are in relative motion. [13]

The processing is done under the concomitant action of the non-stationary arc discharges and of the mechanical and thermal actions that appear at the contact surface.

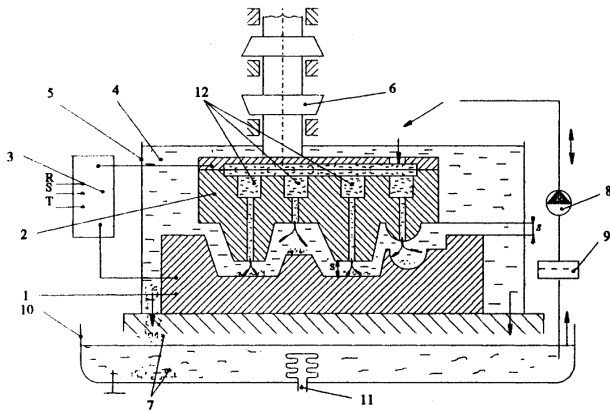


Figure 4. Schematic diagram of an EDM plant
 1.piece-rise; 2.tool electrode; 3.voltage pulse generator; 4.dielectric; 5.vat; 6.advance system; 7.microparticles; 8.pump; 9.filter; 10.reservoir; 11.cooling system; 12.tool electrolyte cooling channels

The main component parts of an EDM machine are:
 - Pulse generator that can be with accumulation (dependent) or without accumulation (independent). The dependent generator forms pulses that are based on the discharge of stored energy in an electric or magnetic field, and the independent generator is based on the interruption of the current provided by a direct current source or on the direct generation of pulses by rotating electric machines or saturated circuits. magnetic.

- The electrode-tool which consists of an active part that participates directly in the generation of the surface and which is made of a material corresponding to the requirements of the erosion process and of an auxiliary part, with which it is fixed to the head of the processing machine.[8]

The principle behind this process is the ability of controlled electric sparks to erode material. The workpiece and electrode do not touch during this process. In between is a gap that is roughly as thick as a human hair. The amount of removed material with a single spark is small, yet the discharge occurs roughly several 100,000 times a second.

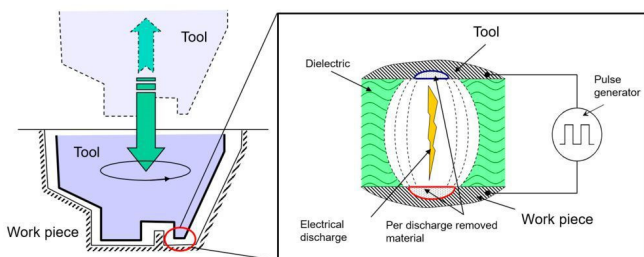


Figure 5. The electrode tool is lowered into the workpiece (left). In the small gap between tool and workpiece, a discharge occurs that removes material (right).[14]

While the electrode is moved closer to the workpiece, the electric field in the gap, also known as spark gap, increases until it reaches the breakdown volume. For this process, it is necessary that the fluid in which this discharge occurs is not conductive, or dielectric. The discharge causes strong heating of the material, melting away small amounts of material. This excess material is removed with the steady flow of the dielectric fluid. The liquid is also useful for cooling during the machining. Moreover, it is necessary for controlling the sparks.

5. MANAGEMENT OF UNCONVENTIONAL TECHNOLOGY, PARTICULARITIES OF THIS SUBJECT AIMING AT ELECTRICAL EROSION

According to George Eisler's doctoral dissertation in 2002 (3), the definition of technology management should be: "Technology management can be defined as a holistic and integrated application of engineering, science and management capabilities to the strategic manager of product and process technologies. , new and relevant, in order to form and fulfill the objectives and goals necessary for the success of the organization ". [3]

Through this successful definition of technology management, we can highlight two important aspects:

- Technology contributes to the formation and fulfilment of the business strategy of the organization
- The objective of technology management is to contribute to the success of the organization [9]

By interpreting the concept of technology management by George Eisler we bring to light three types of management that determine the relationships within an organization: [3]

- Socio-economic management is the system of organizing efficient management and optimizing the values of all resources, in order to achieve success.
- Technical-material management, is the system of organizing the supply of raw materials for the production unit, which is made to contribute to the complete, complex and timely provision of the economic unit with labor and labor; ensuring the optimal storage conditions of material resources; rational supply of jobs with the necessary material resources; rational use of material resources, so as to comply with established consumption norms and determined production stocks.
- Human management consists of all activities aimed at ensuring, developing, motivating and maintaining human resources within the organization in order to achieve with maximum efficiency its objectives and meet the needs of employees.

Also through this definition of technology management, emphasizes the need to perform this

type of management throughout the life cycle, ie from the conception of technology to its replacement, we can highlight three management concepts:

- Strategic technology management, which involves the development of technological strategies in line with business strategy
- Change and innovation management, focuses on change management through innovation, to adopt new ways to meet customer needs
- The management of the organization and operations includes each stage of the life cycle of the technologies and is supported by the evaluation and appreciation of the performances and risks at the level of the technologies and the organization. [4]

There are numerous examples of companies that have managed to implement electrical discharge machining for their benefit. In many cases an update to a newer and more modern EDM machine has done the trick. These are some case studies that tell the stories of some successful companies and their experience with electrical discharge machining

6. CONCLUSIONS

The concept of unconventional technologies refers to a group of technologies based on an energy transfer to the processing area, in other ways than those assumed by the so-called classical technologies.

In principle, unconventional technologies are used when the use of a classical technology is inefficient or really impossible.

It is not possible to speak about an absolutely clear delimitation in between the fields of nonconventional technologies, signalling differences between the opinions of the specialists involved in the research or use of different unconventional processing methods.

The technologies are fully automated, so the quality of the products is ensured from the design, the productivity is high and they are technically and economically efficient for large series productions.

These are complex installations that require special working environments (high pressures, or vacuum, or special ionization environments).

The cost of processing is higher than for processing by conventional processes and can be reduced by increasing the number of parts of the same type processed.

The use of EDM technology leads to significant annual savings for the processing of various parts (punches, molds, etc.), savings that allow the payback period of investments (cost recovery) for EDM equipment to be about 3-7 years, when they are used and exploited rationally. It is estimated that, in the case of well-organized series production, the payback period can be much shorter.[10]

Globally, in 2017, the EDM market was estimated at \$ 4.65 trillion and was expected to be worth approximately \$ 7.97 trillion in 2024, according to reports from ZION Market Research.[11]

7. REFERENCES

1. <https://www.marketwatch.com/press-release/electrical-discharge-machining-edm-market-2020-top-countries-data-with-future-scope-market-size-definition-opportunities-with-strategic-growth-and-top-key-players-analysis-and-forecasts-to-2026-2020-12-02>
2. Dumitru, Calueanu, Ioan, Surugiu, *Caracteristicile impulsurilor in prelucrarea prin electroeroziune*
3. Eisler, George, *Health Care Technology Management (HCTM): An Assessment of its Application in Canadian Teaching Hospitals*. PhD Thesis, 2002
4. Nanu, A., Nanu, Dan, *Tratat de tehnologii neconventionale, Vol. II Prelucrarea prin eroziune electrica*, Editura Universitatii "Lucian Blaga" din Sibiu 2004
5. Grigoriev, Sergey, N., Kozochkin, Mikhail, P., Porvatov, Artur, N., Volosova, Marina, A., Okunkova, Anna, A., *Electrical discharge machining of ceramic nanocomposites: sublimation phenomena and adaptive control*, October 2019
6. Jaiswal, Vishal, Kumar, *Literature Review on Electrical Discharge Machining (EDM) "International Journal for Scientific Research and Development" 6.5, 2018: 239-241, 2018, <http://www.ijrsrd.com/articles/IJSRDV6150198.pdf>*
7. <https://www.sciencedirect.com/science/article/pii/S0307904X09000791>
8. Mater, J., *Study of thermal stresses induced surface damage under growing plasma channel in electro-discharge machining*, Process. Technol., 202, 2008
9. Barry, Rogers, *The Remarkable Abilities of Wire WDM*, 2018
10. Jameson, E., C., *Electrical Discharge Machining*, 2001

11. <https://www.globenewswire.com/news-release/2018/09/12/1569727/0/en/Global-Electrical-Discharge-Machine-Market-To-Reach-Around-USD-7-97-Billion-By-2024-Zion-Market-Research.html>
12. <https://ems.utcluj.ro/electroeroziune/index.html>
13. Besliu, Vasile, Ojegov, Alexandr, *Istoria dezvoltarii prelucrarii prin eroziune electrica* [http://www.libruniv.usarb.md/xXx/reviste/tehnocop/continut/Tehnocop_1\(2\),2010/tehnocopia1\(2\), 2010-57-64.pdf](http://www.libruniv.usarb.md/xXx/reviste/tehnocop/continut/Tehnocop_1(2),2010/tehnocopia1(2), 2010-57-64.pdf)
14. <https://www.etmm-online.com/what-is-electrical-discharge-machining-and-how-does-it-work-a-689686/>