STM JOURNALS

International Journal of
Electro-Mechanics and
Material Behavior

Volume 1, Issue 2, 2023
July—December
DOI (Journal): 10.37591/IJEMB

https://journals.stmjournals.com/ijemb

Review IJEMB

Electrical Discharge Machining for Precision Metal Working Industries

T.R. Vijayaram[1,*]

Abstract

EDM is called as Electrical Discharge Machining. Otherwise called as Spark Erosion Machining, Electro-Erosion Machining, Spark Machining, and Electro Discharge Machining. It is an unconventional machining process to machine hard metals and alloys. EDM has been a significant machining technique. The electrode, work piece materials, dielectric, and the range of pulse rate, current, and voltage make up the basic EDM process. The dielectric serves the following purposes: it transports removal particles, raises the energy density in the plasma channel, restores the dielectric strength, and cools the electrode. To remove the worn particles from the area between the electrode and the work piece, dielectric fluid is pushed through the arc gap. Mineral oil, kerosene, paraffin, distilled water, and deionized water are the most widely used dielectric fluids. Recent trends involve the use of clear and low viscosity fluids to make cleaning easier. This review paper discusses the operation, machining parameters and applications in metal working industries.

Keywords: Electrical discharge machining, dielectric medium, distilled water, electric power supply, dielectric fluids

INTRODUCTION

Electrical Discharge Machining is known as EDM. Also known as electro-erosion machining, spark machining, electro discharge machining, and spark erosion machining. It is an unorthodox method of machining alloys and hard metals. The idea is based on how spark discharges erode metals. An arc is created when two current-conducting wires come into contact with one another. A tiny crater has been left where the metal has worn away at the point where the two wires come into contact. One of the most significant and often utilized production technologies in metallurgical and manufacturing engineering today is the EDM process. It is a process of metal removal based on the principle of metals by an interrupted electric spark discharge between the electrode tool (cathode) and the work piece (anode) [1]. The electrodes used are graphite, and copper normally. Fundamentally, the electric erosion effect is understood by the breakdown of electrode material accompanying any form of electric discharge. Usually, a gas, liquid, or occasionally solids are used for the discharge. Light hydrocarbon oils, paraffin, and kerosene are the frequently used dielectric fluids. Ionizing the dielectric fluid and dividing its molecules into ions and electrons is a prerequisite for creating a discharge. A schematic sketch of EDM is shown below in Figure 1.

***Author for Correspondence**
T.R. Vijayaram
E-mail: vijayaram.mech@bharathuniv.ac.in

Professor, Department of Mechanical Engineering, School of Mechanical Engineering, BIST, BIHER, Selaiyur, Chennai, Tamil Nadu, India

Received Date: January 25, 2024
Accepted Date: February 20, 2024
Published Date: February 29, 2024

Citation: T.R. Vijayaram. Electrical Discharge Machining for Precision Metal Working Industries. International Journal of Electro-Mechanics and Material Behavior. 2023; 1(2): 7–11p.

EDM PROCESS DESCRIPTION

The main components in EDM are the electric power supply, the dielectric medium, the work piece, the tool, and a servo control unit. A DC electric power supply is electrically connected to both the tool and the work piece.

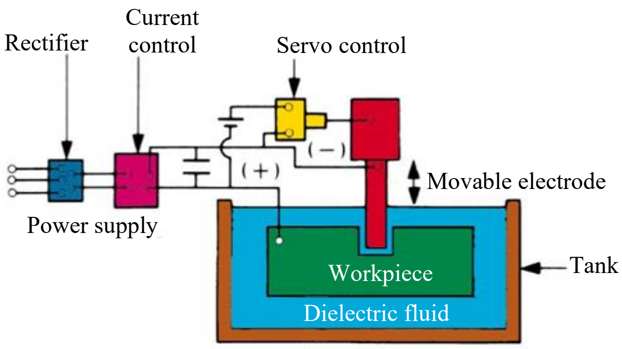

Figure 1. Electrical discharge machining.

The power density in the channel's discharge is close to 500 MW per square centimeter, while the current density is on the order of 10,000 A/square centimeter. The tool serves as the cathode and the work piece serves as the anode when it is connected to the positive terminal of the electric source. The work piece and the tool are separated by a space known as the SPARK GAP, which is maintained in the range of 0.005 to 0.05 mm. Appropriate dielectric slurry, which is non-conductive, is forced through this gap at a pressure of no more than 2 kgf/square centimeter [2]. When a suitable voltage in the range of 50 to 450 V is applied, the dielectric breaks down and electrons are emitted from the cathode and the gap is ionized. When more electrons collect in the gap, the resistance drops causing electric spark to jump between the work piece surface and the tool. Every electric discharge or spark produces a concentrated stream of electrons that accelerates and moves at a very high speed from the cathode to the anode. This ultimately causes compression shock waves on the electrode surface and the work piece surface, especially in the high spots that are closest to the tool [3]. A localized temperature rise is caused by the compression shock waves that are produced. The entire process takes place in a few microseconds. The spot where the electrons strike has a temperature of about 10,000 degrees Celsius. This temperature is sufficient to melt a part of the metals. The forces of electric and magnetic fields caused by the spark produce a tensile force and tear off particles of molten and softened metal from this spot in the work piece. Thus, the metal is removed in this way from the work piece. Typically, the amount of material removed per spark discharge falls between 1/10000 and 1/1000000 cubic millimeters. In typical production, EDM could easily achieve a tolerance value of + or - 0.05 mm. For steel, 0.40 microns is the best surface finish that can be obtained economically.

Electrical Discharge Wire Cutting

Wire EDM is one kind of EDM. An alternative name for wire EDM is electrical discharge wire cutting. In this procedure, the work piece is cut by a wire that moves slowly and follows a predetermined path. This method is used to cut plates up to 300 mm thick and to form hard metal into punches, tools, and dies [4]. It can also be used to cut complex parts for the electronics sector. A schematic sketch of wire cut EDM is shown below in Figure 2.

The wire is usually made up of brass, copper, tungsten, and molybdenum and wire diameter is nearly equal to 0.30 mm for roughing cuts and 0.20 mm for finishing cuts. The wire should have high electrical conductivity and tensile strength and it is used only once, as it is relatively inexpensive compared to the type of operation it performs. It travels at a constant velocity in the range of 0.15 to 9 m / minute, and a constant gap (kerf) is maintained during the cut [5].

MODERN EDM MACHINES

In addition to having multiheads to cut two parts at once, computer controls to control the wire's cutting path and angle with respect to the work piece plane, controls to prevent wire breakage, automatic self-threading features in the event of wire breakage, and preprogrammed machining strategies to optimize the operation, modern EDM machines can produce three-dimensional shapes [6]. Several components, including tools with intricate profiles, are made using electrical discharge machining. The EDM provides economic advantage for making stamping tools, wire drawing and extrusion dies, header dies, forging dies, and intricate mould cavities. It has been extremely used for machining of exotic materials used in aerospace industries, refractory metals, hard carbides, and hard enable steels [7].

PROCESS PARAMETERS IN EDM

Electrode wear rate and material removal rate are the responses, while pulse current, gap voltage, and pulse-on-time are the parameters taken into account in EDM. In wire EDM cutting, six process parameters are taken into account: wire feed, wire tension, gap set voltage, peak current, and pulse on/off time. The two most crucial parameters for EDM are MRR (material removal rate) and Ra (roughness parameter, or average roughness). Many industries and researchers have long sought to maximize MRR and minimize Ra [8]. The EDM process's process parameters are explained in Figure 3.

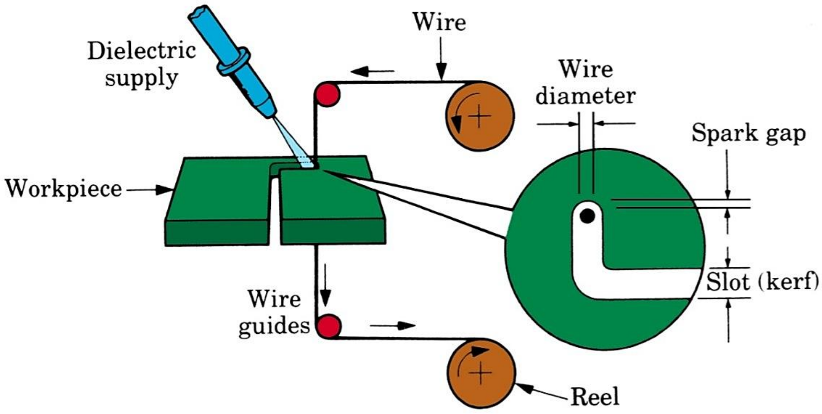

Figure 2. Wire Cut EDM.

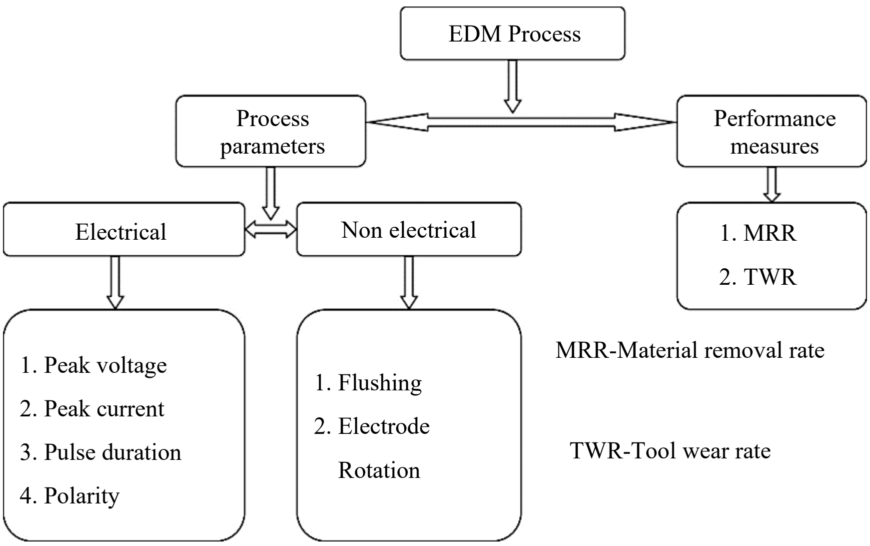

Figure 3. Process parameters in EDM.

The EDM process removes material by thermal energy. The temperature at the spark zone is actually high enough to vaporize the material. Thermal energy is provided by electricity flowing between the tool and workpiece in the form of a spark. Amperes are used to denote the amount of electricity used in the machining process. Increasing the amperes also increases the amount of material removed. The specimen's material removal is computed using the mass loss percentage over the course of the machining process [9]. The MRR is calculated using this observation and a measurement at each suggested interval during the EDM experiments. Because both the tool and the specimen serve as electrodes in EDM, the tool wear process is fundamentally similar to the material removal technique. Tool wear or electrode wear results from electron or positive ion bombardment. The electron barrage at the positive electrode produces the EW. The EW is generated at the negative electrode by the bombardment of positive ions. Heat is produced when positive or negative ions collide with the electrode surface. The heat vaporizes the electrode material and a small amount of electrode material is removed with each spark. This removal of material is known as electrode wear.

APPLICATIONS, ADVANTAGES AND DISADVANTAGES OF EDM

Typical EDM Applications include Fine cutting with thread shaped electrode, Drilling of micro-holes, Thread cutting, Helical profile milling, Rotary forming, Curved hole drilling, Delicate work piece like copper parts for fitting into the vacuum tubes can be produced by EDM, The process can be applied to all electrically conducting metals and alloys irrespective of their melting points, hardness, toughness, or brittleness. Other applications include deep, small-diameter holes using tungsten wire as the electrode, narrow slots in parts, cooling holes in super alloy turbine blades, and various intricate shapes. Parts should be designed so that the required electrodes can be shaped properly and economically. Avoiding deep slots and small openings is advised. The surface finish specified should not be too fine for economic production. The majority of the material removal should be completed by conventional methods in order to attain a high production rate (roughing cut). The work piece can replicate any complex shape that can be created with the tool. It is possible to fabricate the tool using split sectioned shapes, weld, braze, or apply conductive epoxy adhesives that set quickly to create extremely complex shapes. The machining process takes less time than traditional methods. When working with extremely hardened work pieces, EDM can be used economically. As a result, the work piece's distortion from the heat treatment procedure can be removed. No mechanical stress is present in the process. It is because the physical contact between the tool and the work piece is eliminated. It is therefore possible to machine delicate and thin work areas without distortion. The cratering type of surface finish naturally makes room for lubricants, which prolongs the die life. It is possible to create hard, corrosion-resistant surfaces, which are essentially necessary for die making [10].

Applications of EDM Machining

- It is used to make holes with sizes that are less than 0.1 mm.
- It is utilized in die sinking or die manufacturing, fixtures, and gauging.
- It is used to make holes in air brakes or pneumatic brakes.
- It is used in press tools and extrusion dies.
- It is utilized in die molds for plastics.
- It is applied in die-casting dies and mold inserts.
- EDM machining is utilized in the repair of worn dies for hot and cold forging and re-machining.
- It is used to make forging dies like connecting rod forging dies
- EDM machining is used in Sintering dies.
- It is used in calibrating tools.
- It is utilized in the shaping of carbide tools and templates.
- It is used in the following applications: Aerospace; Medical; Electronics; Semiconductor.
- It is used in the manufacture of hard Electrodes.
- It is used in the manufacture of micro-tooling for Micro-EDM, Micro-USM and such other applications for micromachining.

Advantages of EDM Machining

- It can be used even in the heat-treated condition, and for any hard material.
- Complicated shapes made on the tool are able to be reproduced.
- A high accuracy can be achieved; about 0.005 mm.
- Economically, a good surface finish can be achieved; up to 0.2 microns.
- Machining time is not more than the conventional machining process.

- Mechanical stresses are not developed in this process (the tool and work do not have contact).
- The tool life is longer due to proper lubrication and cooling.
- Hard surfaces that are also resistant to erosion can be developed easily on the dies.
- It can be applied to any material that is electrically conductive.

Disadvantages of EDM Machining
- Excessive wear of the tool
- Reproduction of the sharp corner is not possible
- Change in metallurgical properties of materials due to the development of high heat.
- The material to be machined must be an electrical conductor
- Requirement for redressing of a tool for deep holes
- Over-cut is formed
- Expert machinists are hard to find

CONCLUSION

The EDM process is applied in this paper. Erosion was used in the Electrical Discharge Machining (EDM) process to remove material. Exploration was conducted both locally and globally to increase the potential of EDM. A series of persistent electrical discharges form between the tool and the work piece in dielectric fluid and remove the unwanted material. It's a different kind of machining. As stronger, more resilient materials are used in manufacturing and as ultra-precision machining becomes more necessary.

REFERENCES

1. M. Kunieda, B. Lauwers, K.P. rajurkar, B.M. Schumacher, 2005, Advancing EDM through Fundamental Insight into the Process, CIRP Annals - Manufacturing Technology, vol. 54 (2), pg. 64-87.
2. Norliana Mohd. Abbas, Darius G. Solomon, Md. Fuad Bahari, 2006, EDM: Global Techniques and Local Scenario, 1st International Conference & 7th AUN/SEED-Net Fieldwise Seminar on Manufacturing and Material Processing (ICMM2006), Kuala Lumpur, 14-15 March 2006, pg 71-76.
3. W. Rehbein, H.P. Schulze, K. Mecke, G. Wollenberg, M. Storr, 2004, Influence of Selected Groups of Additives on Breakdown in EDM Sinking, Journal of Materials Processing Technology, vol. 149, pp. 58-64.
4. Serope Kalpakjian, Steven Schmid, 2006, Manufacturing Engineering and Technology, Fifth Edition, Prentice Hall, Singapore.
5. Federation of Malaysian Manufacturer [www.fmm.org.my/retrieved on 25 January 2010].
6. Li Li, Y.S. Wong, J.Y.H. Fuh, L. Lu, 2001, EDM Performance of TiC Copper-based Sintered Electrodes, Materials and Design, vol. 22, pp. 669-678.
7. Shankar Singh, S. Maheshwari, P.C. Pandey, 2004, Some Investigations into the Electric Discharge Machining of Hardened Tool Steel using Different Electrode Materials, Journal of Materials Processing Technology, vol. 149, pp. 272-277.
8. H.C Tsai et al., EDM performance of Cr/Cu-based composite electrodes, Int. J. Mach. Tools Manuf. (2003)
9. König W, Dauw DF, Levy G, Panten U. EDM-future steps towards the machining of ceramics. CIRP Annals. 1988 Jan 1;37(2):623-31.
10. Altpeter F, Perez R. Relevant topics in wire electrical discharge machining control. Journal of Materials Processing Technology. 2004 Jun 10;149(1-3):147-51.

