

Electrical Discharge Machining Process an Overview

¹Jayanth Soragaon, ²Ananth Prabhu M, ³Ankush Balehola, ⁴Dr B P Mahesh

^{1,2,3}Student, Department of Mechanical Engineering, JSS Academy of Technical Education, Bangalore-560060, India

⁴Professor, Department of Mechanical Engineering, JSS Academy of Technical Education, Bangalore-560060, India

Abstract - Electrical Discharge Machining (EDM) is a Non conventional machining method which has many years of history. EDM was developed as an accurate machining method for hard materials in the starting. Many researches and new methods have been discovered in electrical discharge phenomena in recent years. Smooth and very fine finish machining, modification of mould die on its surface, machining of materials which are insulated are keyed among the methods in the EDM field. These methods are related with control in the characteristics of surface of the material and with control in motion of the electrode. EDM also referred as spark machining or spark erosion machining is a directed metal removal process based on the principle effects of erosion of electrical discharges taking place between two electrically conducting materials dipped or immersed in a dielectric fluid medium. EDM process is used by various industries for machining all types of electrically conductive materials such as metallic alloys, some of the ceramics and metals. In this paper, we introduce EDM principle and operation, discuss recent trends and applications, advantages and disadvantages of EDM.

Keywords: Nonconventional Machining, Electrical Discharge Machining.

I. Introduction

Electrical discharge machining (EDM) is a modern or unconventional machining process which is used to produce moulds and die. It is also used for finishing parts for automobile and aerospace industry and surgical components for medical applications. EDM process was developed in 1940 where the process is related to removal of metal from a workpiece by means of continuous electrical discharges between tool (electrode) and the work piece in the medium of dielectric fluid. Though it has a wide machining range it is difficult to machine materials like ultra- hard ceramics, reaction bonded silicon carbide and titanium. Low metal removal rate and poor surface quality are the major disadvantages of EDM.

The unconventional machining methods are now substituting the traditional machining methods rapidly for various applications due to their noteworthy advantages which

are proving themselves to a great extent to the present industrial needs. Increase in the requirements for industrial products and recently discovered materials are getting developed which are very rigid and have high strength in nature are difficult to cut by traditional machining methods. Machining of such materials by the unconventional machining processes has added sufficiently great lifeline to the broadening of industrial scenario and given new aspect to the quality and quantity of the produced components. Very large numbers of respective process capabilities are involved by this machining process and selection of the right parameter is very important for these modern machining processes which may affect the process of carrying out an operation. Due to a large number of process parameters, the purpose of selecting these parameters within the range is not served. An intense situation is occurred in case if numbers of goals or objectives are more in the process. Problems on such circumstances can be solved easily by considering the optimization techniques which are used to optimize certain parameters involved in these processes. The EDM process uses spark-erosion in order to machine rigid and high strength materials which are difficult to machine and then successfully obtain the required shapes and sizes with improving productivity of machining and better accuracy.

II. Principle of EDM

EDM process works on the principle that a spark is generated between the work piece and the tool and the metal is removed by spark erosion. This spark erosion is similar to that of electric spark which creates a small hole by melting the surface of the metal through which it contacts. This spark generated increases the temperature and produces heat. Due to this the metal is removed by evaporation and erosion. In this electrical discharge machining process both the work piece and the tool must be made by a conductive material.

III. Equipment used in EDM

EDM contains of following equipment:

3.1 Power Generators

In EDM process, electrical energy in the short duration impulses are to be supplied at the machining gap between the

tool and the work piece. Direct current pulse power generators are used to achieve the purpose. The following are the different types of EDM generators:

1. Resistance-Capacitance type generators
2. Rotary impulse type generators
3. Static pulse generator

3.2 Dielectric fluid and Flushing methods

The chips that are sticking to the surface are driven away with the help of dielectric fluid. This fluid is in general a flushing system where the chips are flushed away. Dielectric fluid promotes spark between the work piece and tool thus increasing its metal removal rate. The dielectric fluid performs the following functions:

- Dielectric acts as conductor of spark focusing the heat energy to a very narrow region on the work surface.
- Act as flushing medium to carry away the tiny particles of metal removal.
- Act as a cooling medium to dampen down the spark and cool the tool electrode during machining.

The dielectric fluid for EDM should have the following requirements:

- Should possess sufficiently high dielectric strength to remain electrically non-conductive until the required breakdown voltage is reached.
- De-ionize rapidly after the spark discharge has taken place.
- Be chemically neutral so as not to attack the tool, work piece, or other machine equipment's.
- Possess high flash point to avoid any fire hazards.
- Possess high viscosity for easy circulation and wetting capacity.

3.3 Flushing

Flushing is the process of circulating the dielectric fluid between the tool electrode and the work piece in a proper way so as to maintain a clean environment for efficient machining of the work piece. Few methods of flushing are described below:

3.3.1 Injection or Pressure flushing

The dielectric fluid is injected continuously into the gap between the tool and the work piece called as spark gap either through the hole drilled in the work piece or tool.

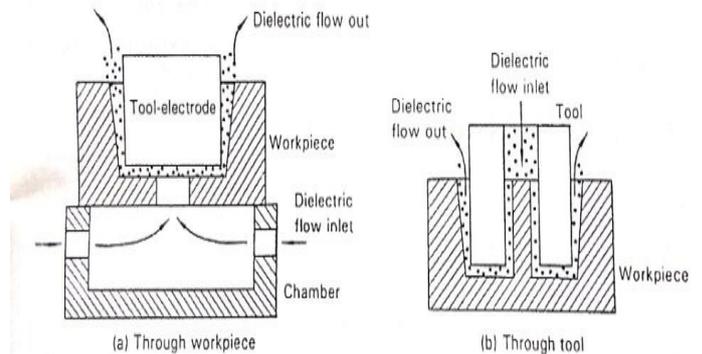


Figure 1: Injection flushing

3.3.2 Suction flushing

To overcome the tapering effects on components resulting from injection flushing, suction flushing is employed. The dielectric fluid is sucked either through the pre-drilled tool or work piece.

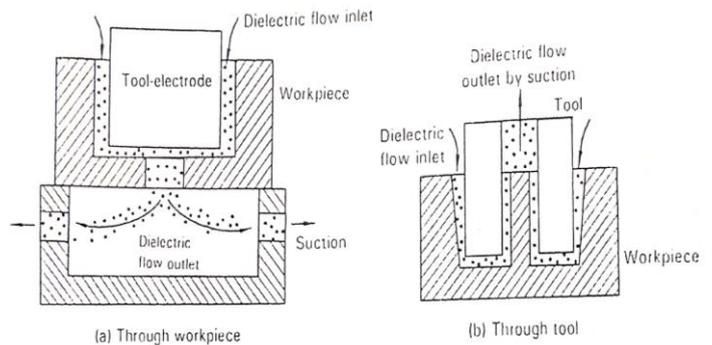


Figure 2: Suction flushing

3.3.3 Side flushing

Side flushing method is used when it is impossible to drill holes on the tool or the work piece. This method makes use of nozzles which are carefully adjusted to force the fluid evenly around the periphery of the tool electrode.

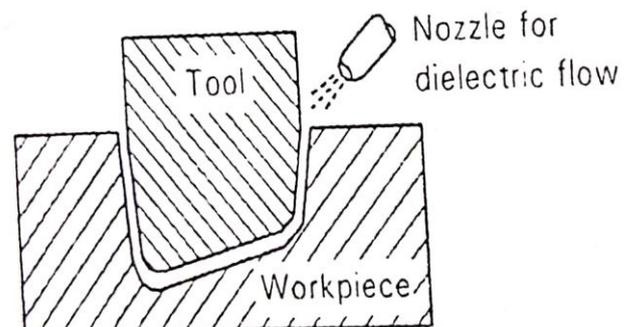


Figure 3: Side Flushing

3.4 Tool electrode

In EDM process, the shape of the tool is made similar to that desired in the workpiece. In this process, erosion of tool takes place due to spark hence selection of tool depend on its wear ratio, cost of material and ease to tool fabrication. Commonly used electrodes are copper and brass. Graphite and copper graphite are by far the most versatile electrode materials. Easy machining can be obtained by these electrodes and are available in different grades for application to all work piece materials.

3.5 Servo feed Mechanism

EDM machines are equipped with servo controlled mechanism that automatically moves the tool at a proper rate thereby maintaining a stable gap between the work piece and tool. This is one of the important parameter in EDM process. Servo mechanisms may be either of the form, solenoid operated, electric motor-driven or operated hydraulically or a combination of these.

3.6 Pumps and Filters

Circulation of dielectric fluid at a suitable pressure into the spark gaps is done using pumps, while filters serve their usual purpose of filtering the wear debris and other impurities present on the work surface thereby circulating pure dielectric fluid to the tool and the work piece gap.

IV. EDM operation

The work piece which is electrically conductive is positioned in the EDM machine. This work piece is connected to one pole of a pulsed power supply (positive terminal). An electrode which is electrically conductive, shaped to match the dimensions of the desired hole or cavity, is connected to the remaining pole of power supply (negative terminal).

The work piece and electrode are then positioned in such a way that a small gap is maintained between the two. To provide an accurate amount of electrical resistance in the gap, an insulating (dielectric) fluid is supplied between the work piece and electrode. The servo-system mechanism is used which is commanded by signals from the gap voltage sensor system in the power supply and this controls the feed of the electrode or work piece to accurately match the rate of material removal. Air gap will be in the range of 0.005-0.05 mm.

Now the current is passed to the electrode, due to this high frequency current a spark is produced in gap between the work piece and the electrode. The frequency of spark at the rate of 10000 sparks per second can be achieved. Due to high

temperature induced between the work piece and electrode, the surface of the material melts and metal removal occurs. This is also called spark erosion.

When the material melts it produces chips. These chips will stick on to the surface of the material which forms a bridge and a short circuit is caused. To prevent this insulated (dielectric) fluid is supplied continuously between the gap. This helps in carrying away the chips and acts as a coolant.

An accuracy of about 0.005mm can be achieved in EDM process.

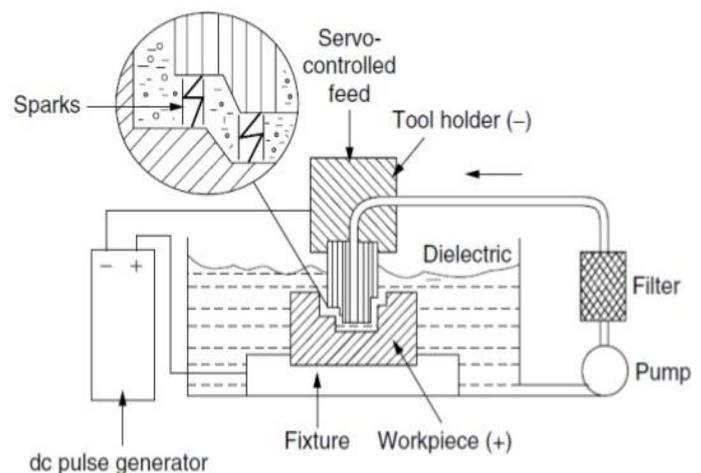


Figure 4: Schematic representation of EDM

V. Mechanism of Metal Removal in EDM process

Initially, the gap between the tool and the work piece, which consists of the dielectric fluid, is not conductive. But, under the pulsed application of DC, the dielectric fluid in the gap is ionized, causing the spark to discharge or jump between the tool and the work piece as shown in fig 1.

The spark impinges on the elevated surface of the work piece at a very high temperature of around 100000 C causing a small portion of the work piece to melt and vaporize.

The magnetic field and electric field forces are generated due to spark which produces a tensile force resulting in tearing of particles of molten and softened metal from the work surface thereby causing metal removal to take place. The continuously flowing fluid flushes away the excess material removed from machining gap.

VI. Process parameters in Electrical Discharge Machining

The important parameters that determine the accuracy and surface finish in EDM include:

- Influence of spark frequency
- Influence of current
- Spark gap

6.1 Influence of spark frequency

The effect of decreasing the current and increasing its frequency result in improved surface finish in view of the small crater size as shown in fig 1. This is because; the energy available for metal removal during a given period is shared by a large number of sparks. The corresponding crater size is reduced.

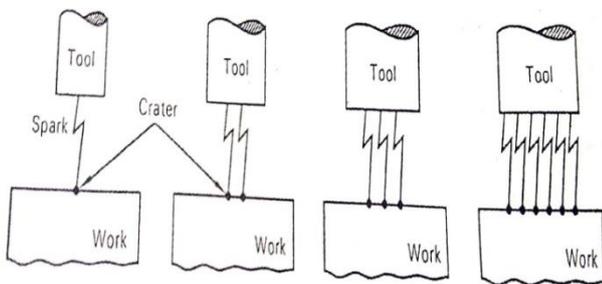


Figure 5: Influence of spark frequency on EDM process

6.2 Influence of current

The amount of material removed and the surface finish obtained depends on the current in the spark which has been discharged. Fig 1.2 shows the influence of current on metal removal. It is clear from the figure that as the current increases, each individual spark removes a large crater of material (bulk metal removal) from the work piece. Since the depth of the crater defines the surface finish, a large crater results in poor surface finish. In view of the surface finish and metal removal rates, the amperage settings need to be done accordingly.

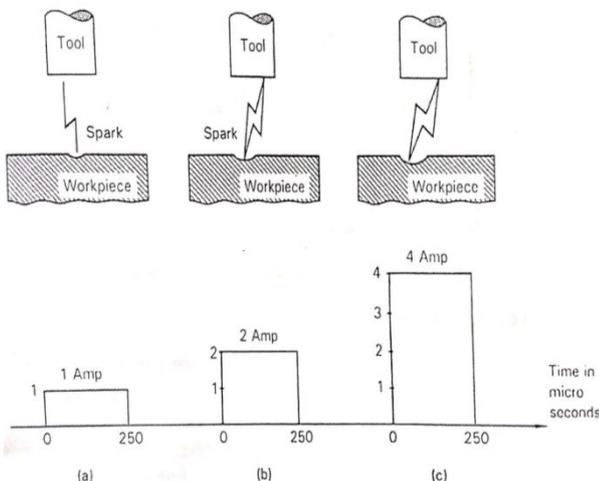


Figure 6: Influence of current on EDM process

6.3 Spark gap

Typical spark gap between the tool and the work piece ranges from 0.01-0.05mm. The smaller the gap, the closer the accuracy with a good surface finishes. However, efficient flushing becomes difficult to achieve with small gaps.

VII. Heat affected zones in EDM

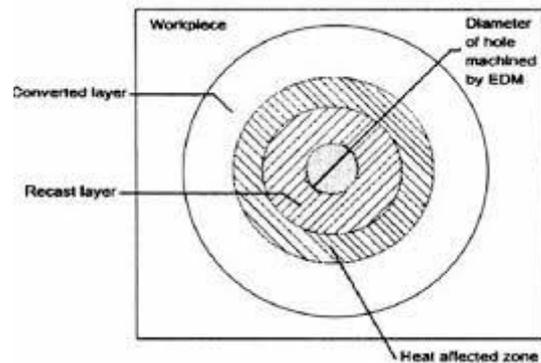


Figure 7: Heat affected Zone

There are three different layers or zones: Recast layer, converted layer and heat affected zone as shown in the fig above.

Zone 1: Re-solidification of the molten material occurs if it is not flushed quickly and this will harden easily and adhere to the work surface due to cooling effect of the insulated fluid. This layer is called the recast layer which is about 2-40 μm . This layer contains micro-cracks on the surface of the work piece. Such surface layers should be removed before using these products.

Zone 2: Heat affected zone is formed due to high heat produced during machining and during the cycles of quenching. Thickness of this layer is 25 μm . The reasons for this layer to form are the heating and cooling cycle. Some of the effects related to this layer are weakness of the grain boundary, cracks on the grain boundary and residual stresses.

Zone 3: Converted layer is found below the heat affected zone, where a change in grain structure is apparent from the original structure. Below this converted layer lies an unaffected base layer which remains as it is i.e. in the same condition prior to the EDM process.

VIII. Development in EDM

Lot of improvements, research and developments are made in the field of EDM from past few years but still there are gaps in its research process. Lot of improvements and developments have been done in the materials and modeling

techniques in the past. Lot of researches is being made in the field of ceramics and composites. These researches are creating new and interesting research scopes in the process of EDM.

IX. Applications of EDM

- EDM process is highly economical for machining very hard materials as the hardness of the work piece material is independent of tool wear
- Useful in manufacturing of tool
- Used for making broach, straight hole making or curved axes, and for making complicated cavities which cannot be produced by traditional machining process.
- EDM is used widely for die making.

X. Advantages and Drawbacks of EDM

Advantages of EDM process include:

- EDM maintains dimensional accuracy with high degree so it is recommended for die making and tool making.
- Complicated geometrical shapes can be produced which are very difficult to produce by other machining processes.
- The main advantage is that the tool never applies direct pressure on the work piece. Hence, weak metal can be processed without any risk of distortion.
- A smart surface end may be obtained; a really smart surface is also obtained by redundant finishing ways.
- Fine holes can be drilled easily and can be machined accurately.
- High material removal rate can be achieved as compared to other un-conventional machining process.

XI. Disadvantages of EDM

- EDM process is not applicable for very large sized work pieces as size is overly controlled by the size of the setup.
- Metal removal in EDM process occurs slowly.
- There is a chance of distortion of the work piece due to very high temperature generated at the machining zone.
- Sharp corners cannot be produced by the EDM process.
- Materials which are electrically non-conducting cannot be processed by the EDM.

XII. Conclusion

Electron discharge machining is one of the widely used non-conventional machining processes that are capable of manufacturing the complicated shapes. The only limitation within the EDM is that the work piece ought to be semiconducting in nature. With the time there's heap of enhancements within the EDM and its aided processes in addition as development and improvement techniques that created some new analysis and increased scopes within the EDM. Some of these analysis and studies found that parameters which are non-electrical conjointly play a very important role within the performance of the EDM.

Developments in modeling techniques have created many opportunities and increased scopes within the EDM and improve the performance of EDM method. It is found that there are unit ample developments and enhancements within the improvement techniques however the target is similar to the improvement techniques to enhance the EDM performance, to induce the specified output from the input and to develop some new hybrid and more efficient techniques in order to machine new materials underneath the higher operating conditions. Through the recent developments and improvement techniques utilized in the EDM processes minimize the tool wear rate, maximize the metal removal rate and improve the surface quality.

REFERENCES

- [1] Norlina Mohd Abbas, Darius G. Solomon, Md. Fuad Bahari, "A review on current research trends in electrical discharge machining (EDM)", *International Journal of Machine Tools & Manufacture*, 47 (2007) 1214–1228.
- [2] Manish Gangil, M. K. Pradhan, Rajesh Purohit, "Review on modelling and optimization of electrical discharge machining process using modern Techniques", *Materials Today: Proceedings* 4 (2017) 2048–2057.
- [3] Ho, K. H., & Newman, S. T. (2003). State of the art electrical discharge machining (EDM). *International Journal of Machine Tools and Manufacture*, 43(13), 1287-1300.
- [4] S. Chakraborty, V. Dey, S.K. Ghosh, "A review on the use of dielectric fluids and their effects in electrical discharge machining characteristics", *Precision Engineering* xxx (2014) xxx–xxx, <http://dx.doi.org/10.1016/j.precisioneng.2014.11.003>
- [5] H.S. Shan, P.C. Pandey "Modern Machining Process" *Tata McGraw-Hill Education Pvt. Ltd.* First edition (1980).

Citation of this Article:

Jayanth Soragaon, Ananth Prabhu M, Ankush Balehola, Dr B P Mahesh, "Electrical Discharge Machining Process an Overview" Published in *International Research Journal of Innovations in Engineering and Technology (IRJIET)*, Volume 3, Issue 11, pp 52-57, November 2019.
