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ELECTRICAL DISCHARGE MACHINING PROCESS PARAMETERS

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ABSTRACT: *Electrical discharge machining (EDM) is a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes. The non-contact machining technique has been continuously evolving from a mere tool and die making process to a micro-scale application machining alternative attracting a significant amount of research interests. In recent years, EDM researchers have explored a number of ways to improve the sparking efficiency including some unique experimental concepts that depart from the EDM traditional sparking phenomenon. Despite a range of different approaches, this new research shares the same objectives of achieving more efficient metal removal coupled with a reduction in tool wear and improved surface quality. This paper reviews the research work carried out from the inception to the development of die-sinking EDM within the past decade. It reports on the EDM research relating to improving performance measures, optimising the process variables, monitoring and control the sparking process, simplifying the electrode design and manufacture. A range of EDM applications are highlighted together with the development of hybrid machining processes. The final part of the paper discusses these developments and outlines the trends for future EDM research.*

INTRODUCTION

It is an advanced machining process primarily used for hard and difficult metals which are difficult to machine with the traditional techniques. Only electrically conducting materials are machined by this process. The EDM process is best suited for making intricate cavities and contours which would be difficult to produce with normal machines like grinders, end mills or other cutting tools. Metals such as hardened tool-steels, carbides, titanium, Inconel and kovar are easily machined through EDM. EDM is a thermal process which makes use of spark discharges to erode the material from work piece surface. The cavity formed in EDM is a replica of the tool shape used as the erosions occur in the confined area. Since spark discharges occur in EDM , it is also called as “spark maching”.

The material removal takes place in EDM through a rapid series of electrical discharges. This discharges pass between the erode and the work piece being machined. The fine chips of material removed from the work piece gets flushed away by the continuous flowing di-electric fluid. EDM can be used to machine only electrically conductive materials. Otherwise it cannot be used.One of the electrodes is called as tool and other is called as workpiece. Here the tool is connected with the negative terminal of the power supply and the workpiece is connected with the positive terminal.

WORKING PRINCIPLE

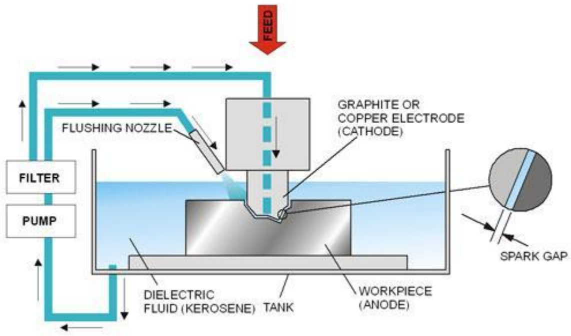
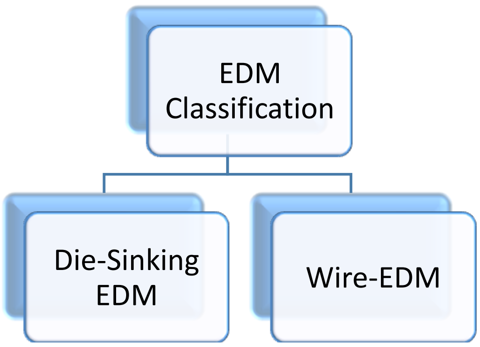


Figure: EDM Setup

In Electrical discharge machining; a potential difference is applied across the tool and w/p in pulse form. The tool and workpiece must be electrically conductive and a small gap is maintained in between them. The tool and workpiece is immersed in a dielectric medium (kerosene or deionized water). As the potential difference is applied, electrons from the tool start to move towards the workpiece. Here the tool is negative and w/p is positive. The electrons moving from the tool to the w/p collide with the molecules of dielectric medium. Due to the collision of electrons with the molecule, it gets converted into ions. This increases the concentration of electrons and ions in the gap between the tool and w/p. The electron moves towards the w/p and ions towards the tool.

An electric current is set up in between the tool and w/p and called as plasma. As the electrons and ions strikes the w/p and tool, its kinetic energy changes to heat energy. The temperature of the heat produced is about 10000 degree Celsius. This heat vaporizes and melts the material from the workpiece. As voltage is break down, the current stops to flow between the tool and w/p. And the molten material in the w/p is flushed by circulating dielectric medium leaving behind a crater.

CLASSIFICATION OF EDM



Die-sinking EDM (Ankur et al., 2017) is also known as volume EDM or the cavity type EDM (Mohan et al., 2004). In which both the tool material and the work separated by a small gap and kept immersed in the dielectric fluid which helps the spark to concentrate at a particular point. Both the work-piece and tool material are connected to the power supply in the Die-sinking EDM (Goyal et al., 2016). A large number of spark generated at the particular locations, generally thousands spark per second with the actual duty cycles which are controlled by the input parameters.The “pulse-on-time” and “Pulse-off-time” are known as the controlling cycles (Muthuramalingam and Mohan, 2013).
The pulse-on-time determines the length or the duration of spark during the machining.It is found in the studies that the higher values of pulse-on-time decrease the surface quality of the material (Krishna et al., 2008, Rao et al., 2010).

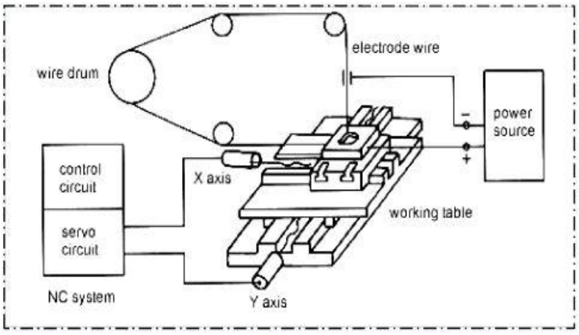


Figure :Wire-EDM

Pulse-off-time is generally the period time when a spark is replaced by another spark. High values of pulse-off –time allows the dielectric fluid to out and cleans the machining debris and avoiding the short circuits during the machining process.

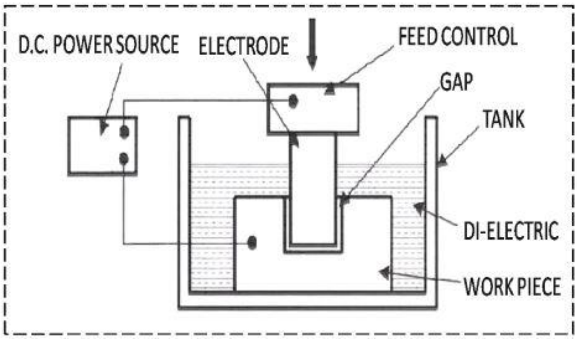


Figure : Die-Sinking EDM

A lot of research has been done on development and its application areas (Vates 2014, Chiang and Chang, 2006). The working principle of WEDM (Umesh et al., 2017) is same as the working principle of Die-sinking EDM (Aspinwall et al., 2008). WEDM is also known as Wire-cutting EDM or Wire EDM. It is the special form of Electro discharge machining which uses a continuously moving wire electrode (Yuan et al. 2008).In the WEDM process, a thin wire is fed up through the work submerged in the dielectric tank (Kozak et al. 2004).

Ionized water is generally used as the dielectric fluid in the WEDM (Chaw et al., 2004).WEDM has a wide range of application in the manufacturing of dies and 3D shapes which are difficult to manufacture by other machining operations (Liao and Yu, 2004). The main operation of the dielectric fluid is to flush out the machining debris from the cutting zone. Flushing of the dielectric fluid is the main factor which affects the feed rate or WEDM process.

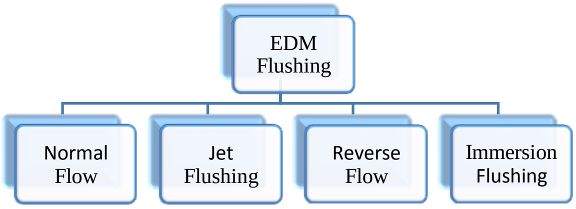
DIELECTRIC FLUID AND ITS FLUSHING METHODS:

Dielectric fluid acts as an insulating medium. The main aim of the dielectric fluid is to maintain the constant resistance across the gap between the tool with some other additives (Prihandana et al., 2009). The dielectric fluid is flushed out through the spark gap to remove the machining debris from the surface of work-piece. Flushing of machining debris from the gap is very important to avoid the short circuits (Luo,1997).

The cutting is irregular and machining conditions would be poor if the flushing process is applied incorrectly and also leads to decrease in the tool life and increase in production time (Jain, 2009).

Flushing operation plays an important role in stable machining and achieving higher surface finish rates.

There are four main dielectric flushing methods:



Normal flushing method is generally used flushing method in the EDM processes. The dielectric fluid is introduced under a certain amount of pressure and forced to flow between the gap of tool material and work-piece (Masuzawa and Heuvelman, 1983). Sometimes it produces a tapered opening in the work piece so sometimes it is undesirable. In the reverse flow flushing method, there is not taper opening in the work-piece a vacuum is used instead of pressure.

Desired EDM machining conditions can be achieved by the jet flushing method. Sometimes it takes longer machining times than the Normal flow and Reverse flow flushing methods. Pumping and sucking action is used to remove the debris from the machining surface. Immersion flushing is valuable for the deep cavities and blind holes (Schumacher, 1990).

LITREATURE REVIEW

EDM is one of the most popular and widely used among all non-traditional machining processes. A lot of research has been done on the EDM modeling, optimization of its process parameters and its applications. There are still many research gaps in the EDM applications and optimization of process parameters on ceramic materials. Asal et al., 2013 conducted an experiment to optimize the process parameters of EDM by the use of ANOVA. The pulse on time, current and spark gap were the main input parameters. The brass and copper took as electrode material with the DEF-92 as the dielectric fluid. The DOE is constructed through the Minitab software he concluded that surface roughness increases with increase in the discharge current.

Goyal et al., 2016 investigated the effect of input parameters such as Discharge current, voltage and pulse-on-time to optimize the responses such Tool wear rate, Material removal rate and surface quality with the copper as the tool material. It was concluded in the research that MRR and TWR increase with the increase in the values of discharge current and voltage and surface quality start decreasing with the increase in the values of pulse-on-time and discharge current.

The optimal values of surface quality are found at a lower value of pulse-on-time and discharge current.(Chandramouli et al.,2014) Conducted an experiment to investigating EDM process parameters by the use of Taguchi method. The effect of various input parameters on the output parameters is investigated by the Taguchi method. Discharge current, pulse-on-time and pulse-of-time were taken as input parameters to optimize the surface roughness, tool wear rate and material removal rate. It was concluded that in the research that material removal rate increases with the increase in the pulse on time and discharge current but it affects the surface quality of the material.

Raghuraman et al., 2013 performed an experiment on the Mild Steel IS-2026 to optimize the output parameters MRR, TWR and surface roughness with the input parameters pulse-on-time, pulse-off-time and discharge current with the copper as tool material. It was found in the result that lower tool wear rate found at lower values of current and pulse on time and surface quality starts decreasing with increase in the discharge current and pulse-on-time. It was also found that the GRA is the best optimizing technique to optimize the process parameters.

Ghewade et al., 2011 studied the effect of EDM on the various parameters like gap voltage, pulse on time, Peak current and duty cycle on the Inconel-718 work piece. Taguchi method is used to analyze the effect of input parameters on the output parameters. It was concluded that peak current and gap voltage are the main parameters which affects the MRR and Electrode wear rate is mainly influenced by the pulse on-time and duty cycle.

EFFECT OF ELECTRICAL AND NONELECTRICAL PARAMETERS:

Both Electrical and non-electrical parameters of EDM influence the performance of EDM. Electrical parameters majorly affect the performance of EDM than the non-electrical parameters.

Effect of electrical parameters

It is difficult to explain the effect of all electrical parameters on the performance due to the stochastic thermal nature of the electro-discharge machining. This section of the paper describes the research in the area of monitoring, control, and optimization of various electrical parameters which affect the performance of the EDM.

Effect of peak current

To investigate the effect of peak current in EDM on MRR and surface roughness pulse on time varied and other parameters like pulse off time, voltage and wire feed rate kept constant. The material removal rate is low at low values of current and it is nearly constant as the values of current are low (Chen et al., 2013,Patel et al.,2011, Kumar et al., 2008). The material removal rate of material starts increasing the value of current increasing (Mandal and Saha, 2007, Rahman et al., 2011).

Effect of pulse-on-time

To observe the effect of pulse-on-time on the EDM performance peak current is varied while the other parameters like pulse-off-time, voltage and wire feed rate kept constant. It is observed that the MRR is increasing with the pulse-on-time at all the values of current and surface quality of material starts decreasing when there is an increase in the value of pulse-on-time (Khan et al.,2011, Habib, 2009, Pradhan and Biswas, 2008). Optimum values of surface roughness can be found at the lower value of pulse-on-time and current (Jiang et al.,2012).

Effect of pulse-off-time

It is found that MRR starts decreasing when there is an increase in the values of pulse-off-time. Long pulse-off-time makes a cooling effect on both the electrode and the work-piece material hence results in decreasing the cutting speed and EDM performance degradation (Lin et al., 2012, Goyal et al., 2016, Weng and Her, 2002).

Surface roughness improves with the higher values of pulse-off-time. It was also found in some studies that first the surface roughness decreasing with the pulse-off-time then starts increasing when there is an increase in the values of pulse-off-time (Bhattacharyya et al., 2007, Marafona and Wykes, 2000, Lee et al., 1990).

Effect of servo voltage

The effect of servo voltage on the performance of EDM is observed by varying the pulse duration and kept constant all other parameters. MRR starts increasing with increase in the servo voltage initially.

But then starts decreasing with increase in the servo voltage (Sanchez et al., 2001, Jain et al., 2007, Reddy and Rao, 2005). On other hand surface quality of material also starts decreasing with increase in the voltage (Sarkar et al., 2006).

Effect of non-electrical parameters

Beside the electrical parameters, non-electrical parameters also influence the performance of EDM. The flushing of dielectric fluid, rotational movement of work-piece and electrode plays an important role in achieving the desired performance measure in the EDM.

Effect of dielectric flushing

Dielectric flushing affects the performance measures of EDM. During the roughing operations, flushing of dielectric fluid affects the tool wear rate and electrode wear rate while during the finishing operations it affects the surface roughness (Wong et al., 1995, Kagaya et al., 1986). In addition,different properties of dielectric fluids also play a vital role in the performance of EDM.

It was found in the studies the kerosene oil with additives provides the excellent EDM performance and high MRR and low electrode wear rate can be achieved without formation of any metal carbide on the surface of work-piece (Benedict, 1987).

The flushing methods can classify into: Normal flow flushing (Wong et al., 1995), Jet flow flushing (Masuzawa et al., 1992), Immersion flow flushing (Makenzi and Ikua, 2014, Backman, 1990) and reverse flow flushing (Wong et al., 1995).Some researchers applied the magnetic field to move the debris from the gap and some applied the forced vibrations to move the machining debris from the gap between tool material and work-piece (Bruijn et al., 1978).

Effect of rotational movement of tool material

Besides the dielectric flushing effect on the performance of EDM, the rotational movement of tool material also affects the performance measures of EDM. Better surface quality and material removal rate be achieved by the applying the rotational movement of tool material over the work-piece by improving the circulation of dielectric fluid in the spark gap (Enache et al., 1990, Murti and Philip, 1986).

Effect of rotational movement of work-piece material

Rotational movement of work-piece material in EDM improves the performance measures of EDM in terms of surface quality and material removal rate (Kunieda and Masuzawa, 1998, Mohri et al., 1989). The rotation of work-piece improves the dielectric flushing over the work-piece which results in the better surface quality and low electrode wear rate and High material removal rates (Soni and Chakraverti,1994, Enache, 1993). Still, these non-electrical parameters need further study.

CONCLUSION

The introduction of EDM to the metal cutting has been a viable machining option of producing highly complex parts, independent of the mechanical properties of workpiece material. This is by virtue of the capability of EDM to economically machine parts, which are difficult to be carried out by conventional material removal processes. With continuous improvement in the metal removal efficiency and the incorporation of numerical control, the viability of the EDM process in terms of the type of applications can be considerably extended. The basis of controlling the EDM process mostly relies on empirical methods largely due to the stochastic nature of the sparking phenomenon involving both electrical and non-electrical process parameters. The complicated interrelationship between the different optimised process parameters is therefore a major factor contributing to the overall machining efficiency. However, several means of improving the machining performance commonly measured in terms of MRR, TWR and SR have been made with an overwhelming research interest being paid to the metallurgical properties of EDM part. Thus, the EDM process needs to be constantly revitalised to remain competitive in providing an essential and valuable role in the tool room manufacturing of part with difficult-to-machine materials.

REFERENCES:

[1] Manufacturing Science by Amitabha ans Asok Kumar Mallik ISBn 81-85095-85-X Reprint 2009, pp 383-385

[2] N.C. Jain, R.M.Belokar and Dr. K.K. Chakaraborti, A study and effect of insulated copper electrodes on SAE 7075 aluminium alloys in EDM, Emerging trends in manufacturing (Proceedings of XVI national convention of production engineers), January 2002, pp 468

[3] K. P. Rajurkar and S.R. Nooka,"Surface Finish of ElectroDischarge Machined Componenets", University of Nebraska, Lincoln, NE 68588-U.S.A, ICAMT-94, August 1994 pp-133143.

[4] S. Kalpajian, S.R. Schmid, Material removal processes: abrasive, chemical, electrical and high-energy beam, in: Manufacturing Processes for Engineering Materials, Prentice Hall, New Jersey, 2003, p. 541.

[5] S. Webzell, That first step into EDM, in: Machinery, 159, (4040) Findlay Publications Ltd, Kent, UK, November 2001, p. 41.

[6] Anonymous, History and development, in: The Techniques and Practice of Spark Erosion Machining, Sparcatron Limited, Gloucester, UK, 1965, p. 6.

[7] A.L. Livshits, Introduction, in: Electro-erosion Machining of Metals, Department of Scientific & Industrial Research, Butterworth & Co., London, 1960, p. x.

[8] E.C. Jameson, Description and development of electrical discharge machining (EDM), in: Electrical Discharge Machining, Society of Manufacturing Engineers, Dearbern, Michigan, 2001, p. 12.

[9] L. Houman, Total EDM, in: E.C. Jameson (Ed.), Electrical Discharge Machining: Tooling, Methods and Applications, Society of Manufacturing Engineers, Dearbern, Michigan, 1983, pp. 5– 19.

[10] P.F.Thomson, Surface damage in electrodischarge machining.