Parameter Optimization of Electric Discharge Machining

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***Abstract* -** The aim of this project is to optimize the various parameters in the electric discharge machining. Electrical discharge machining (EDM) is one of the earliest non-traditional machining processes. EDM process is based on thermoelectric energy between the work piece and an electrode. A pulse discharge occurs in a small gap between the work piece and the electrode and removes the unwanted material from the parent metal through melting and vaporising. The electrode and the work piece must have electrical conductivity in order to generate the spark. There are various types of products which can be produced using EDM such as dies and moulds. Parts of aerospace, automotive industry and surgical components can be finished by EDM. This paper reviews the research trends in EDM on ultrasonic vibration, dry EDM machining, EDM with powder additives, and EDM in water. Electro discharge machining (EDM) process is a non-conventional and non-contact machining operation which is used in industry for high precision products. EDM is known for machining hard and brittle conductive materials since it can melt any electrically conductive material regardless of its hardness. The workpiece machined by EDM depends on thermal conductivity, electrical resistivity, and melting points of the materials. The tool and the workpiece are adequately both immersed in a dielectric medium, such as, kerosene, deionised water or any other suitable fluid. This paper provides an important review on different types of EDM operations. A brief discussion is also done on the machining responses and mathematical modelling.

Keywords - Electric Discharge Machining, Metal Removal Rate, Voltage, Current, etc.

1. AIM OF THE PROJECT

The aim of this project is to study the working principle of the electric discharge machining, various parameters and concepts involved in a non-traditional machining process.

2. PROBLEM STATEMENT

In the present time the various operations means metal removal process can be done by the electric discharge machining. It is one of the methods for removing the material from the metal surface. The different types of operations are done by using this process. Such as drilling, grooving, profile making, surface cutting etc. It is very convenient process and mostly used in today's time, but it causes a problem to users sometime. The material which is removed is not get removed properly so, It not get good surface finish to in operation. Other things are also get affected by which the parameters which are applied during this process time. The cause and problems are different for different materials. It get vary with respect to material and material properties. To optimize the machining operations the parameters are optimization is carried out. The parameters are taken into considerations as per the material type and material properties. According to the optimized parameters the process is carried out. The parameters are basically changed to make the process efficient.

3. INTRODUCTION

Electrical discharge machining (EDM) is a non-traditional concept of machining which has been widely used to produce dies and moulds.[1] It is one of the most extensively used non-conventional material removal processes.[2] where the process is based on removing material from a part by means of a series of repeated electrical discharges between tool called the electrode and the work piece in the presence of a dielectric fluid.[3] It is an electro-thermal machining process where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark. Electrical discharge machining mainly consists of two major components that are machine tool and a power supply. The machine tool holds a shaped electrode, which advances into the workpiece and produces a shaped cavity. The electrical spark is produced from a power supply. It produces a high frequency series of electrical discharges between the electrode and the workpiece, which remove metal from the workpiece by thermal erosion or vaporization is showing the electric setup of the electric discharge machining process. The tool is made cathode and work piece is anode and a potential difference is applied between the tool and work piece which finally leads to generation of spark. An important characteristic of EDM is that both the tool and work piece must be electrically conductive and completely immersed in a dielectric medium supplied continuously by the pump. Generally kerosene or deionised water is used as the dielectric medium. A proper gap must be maintained between the tool and the workpiece with the help of servo mechanism. Depending upon the applied potential difference and the gap between the tool and workpiece, an electric field would be established. As the electric field is established between the tool and the job, the free electrons on the tool are subjected to electrostatic forces. As a result of which electrons are plucked out from the tool and then accelerated towards the job through the dielectric medium. As they gain velocity and energy, and start moving towards the job, there would be collisions between the electrons and dielectric molecules. Such collision may result in ionization of the dielectric molecules.[3]

Thus, as the electrons get accelerated, more positive ions and electrons would get generated due to collisions. This cyclic process would increase the concentration of electrons and ions in the dielectric medium between the tool and the job at the spark gap creating a channel known as "plasma". The electrical resistance of such plasma channel would be very less. Thus all of a sudden, a large number of electrons will flow from the tool to the job and ions from the job to the tool. This is called avalanche motion of electrons. Such movement of electrons and ions can be visually seen as a spark. Thus the electrical energy is dissipated as the thermal energy of the spark. The high speed electrons then impinge on the job and ions on the tool. The kinetic energy of the electrons and ions on impact with the surface of the job and tool respectively would be converted into thermal energy or heat flux. Such intense localized heat flux leads to extreme instantaneous confined rise in temperature which would be in excess of 10,000oC. Such localised extreme rise in temperature leads to material removal. The molten metal is not removed completely but only partially. . An important advantage is that in EDM process there is no direct contact between the electrode and the work piece where it can eliminate mechanical stresses, chatter and vibration problems during machining. This promotes Electric discharge machining (EDM) to machine difficult-to-machine materials and high strength temperature resistant alloys too. It is mainly used by toolmakers for complex injection moulds, punch dies and cavities made from hard to machine.[2]

3.1. Working Principle of EDM

The working principle of EDM process is based on the thermoelectric energy. This energy is created between a workpiece and an electrode submerged in a dielectric fluid with the passage of electric current. The workpiece and the electrode are separated by a specific small gap called spark gap. Pulsed arc discharges occur in this gap filled with an insulating medium, preferably a dielectric liquid like hydrocarbon oil or de-ionized water. Schumacher described the technique of material erosion employed in EDM as still arguable. This is because ignition of electrical discharges in a dirty, liquid filled gap, when applying EDM, is mostly interpreted as ion action identical as found by physical research of discharges in air or in vacuum as well as with investigations on the breakthrough strength of insulating hydrocarbon liquids.[1]

The working principle of EDM is shown in the figure below. This technique has been developed in the late 1940s. The electrode moves toward the workpiece reducing the spark gap so that the applied voltage is high enough to ionize the dielectric fluid. Short duration discharges are generated in a liquid dielectric gap, which separates electrode and workpiece. The material is removed from tool and workpiece with the erosive effect of the electrical discharges. The dielectric fluid serves the purpose to concentrate the discharge energy into a channel of very small cross sectional areas. It also cools the two electrodes, and flushes away the products of machining from the gap. The electrical resistance of the dielectric influences the discharge energy and the time of spark initiation. Low resistance results in early discharge. If resistance is large, the capacitor will attain a higher charge value before initiation of discharge.

A servo system is employed which compares the gap voltage with a reference value and to ensure that the electrode moves at a proper rate to maintain the right spark gap, and also to retract the electrode if short-circuiting occurs. When the measured average gap voltage is higher than that of the servo reference voltage, preset by the operator, the feed speed increases. On the contrary, the feed speed decreases or the electrode is retracted when the average gap voltage is lower than the reference voltage, which is the case for smaller gap widths resulting in a smaller ignition delay. [1]

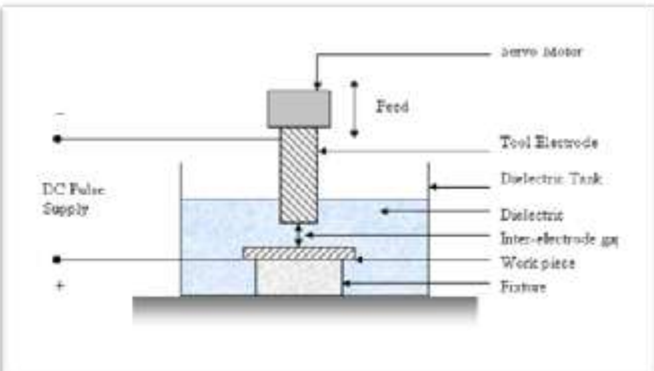

Fig 1. Working Principle of EDM

4. LITURATURE SURVEY

EDM now become a flexible technology in terms of workpiece hardness, machining rate, complexity of part geometry and surface finish. EDM process is based on thermoelectrical energy between the workpiece and an electrode.[1] EDM is a non-traditional concept of machining which has been widely used to produce mould and dies in industries. It is really a very vast field and comprises of various areas of research. The different issues that can be considered for research in EDM can be Materials, Optimization of process parameters, variants of EDM, Automation, Green manufacturing and electrode manufacturing.[2] It is a non-conventional and non-contact machining operation which is used in industry for high precision products. EDM is known for machining hard and brittle conductive materials since it can melt any electrically conductive material regardless of its hardness. The workpiece machined by EDM depends on thermal conductivity, electrical resistivity, and melting points of the materials. The tool and the workpiece are adequately both immersed in a dielectric medium, such as, kerosene, deionised water or any other suitable fluid. The dimensions are affects on the process and dimensions of the final product. Dimensional accuracy is important in fabricating miniaturized product in order to reduce the material waste and machining cost as well as to achieve a better quality product after and on performing the process.[5]

5. EXPERIMNTAL DETAILS

5.1. Workpiece

A cubical piece of (20mm x 20mm x 15mm) AISI 304 stainless steel has been used as a workpiece material for the current experiment. Workpiece is carefully kept and handle to avoid it from rusting. Percentage chemical composition of workpiece is minimum of 18% chromium and 8% nickel, combined with a maximum of 0.08% carbon and remaining is Fe.

5.2. Tool

A copper piece of rectangle cross section (25mm x 25m) taken as a tool. The tool is tightened in the shank which is clamped in EDM tool holder.

5.3. Calculation of MRR

MRR is a rate at which the metal is removed from the workpiece. Its unit is mm^3/s. The material is removed from the workpiece because of series of spark between the two electrode.[6]

MRR= (Wi - Wf) / t x d

Where, Wi = Initial weight of the material

Wf = Final weight of the material

t = Machining time

d = density

The metal removal rate is called as the rate of material removed per second or the ratio of change in volume of workpiece during machining divided by duration of machining. [6]

5.4. Calculation of spark energy

Evaluation of spark energy is important due to melting and evaporation of workpiece material and outcome of machining on surface roughness, microstructure, microhardness, heat affected zone. Following equation is used for calculating the spark energy.[6]

Spark Energy = Id x Vg x Ton

Where Id = Current Input

Vg = Voltage applied

Ton = Pulse on Time

5.5. Condition of EDM Process

Table 1 shows the details of experimental conditions used in the present study.

Table 1. Experimental Conditions

Sr.No	Parameters	Details
1	T on (micro sec)	10, 30, 100, 200
2	Discharge Current (amp)	4, 6, 8, 12
3	Voltage (volts)	5, 10, 15, 20
4	Dielectric	EDM oil servo 40
5	Machining Time (minute)	10
6	Polarity	Straight

6. RESULT AND DISCUSSION

In the present work, effect of different EDM parameter on MRR has been discussed. Three different parameters, namely Pulse on time, Input current, Voltage has been used at four different levels to study the effect in variation of parameters on material removal rate. In this study we only discussed about the metal removal rate parameter. Below table shows the actual loss of weight takes place during the machining. and rate of material loss is calculated.

6.1 Reduction in weight of material at various parameters

By keeping current and voltage constant following readings are taken. Initial weight of component is 27.0738 grams.

Table 2. Reduction in weight of component in grams

Parameter		Initial Weight (gm)	Final Weight (gm)	Weight Loss (gm)
Current = 4 amp &Voltage = 5 volts	Ton			
	10	27.0738	26.9947	0.0791
	30	26.9947	26.8840	0.1107
	100	26.8840	26.6109	0.2731
	200	26.6109	26.0795	0.1358

By keeping Pulse on time and voltage constant following readings are taken. Initial weight of new component is 29.0937 grams.

Table 3. Reduction in weight of component in grams

Parameter		Initial Weight (gm)	Final Weight (gm)	Weight Loss (gm)
Pulse on time = 10 micro sec & Voltage = 5 volts	Current			
	4	29.0937	29.0258	0.0679
	6	29.0258	28.9195	01063
	8	28.9195	28.0335	0.886
	12	28.0335	28.0240	0.0095

By keeping pulse on time and current constant following readings are taken. Initial weight of new component is 26.0530

Table 4. Reduction in weight of component in grams

Parameter		Initial Weight (gm)	Final Weight (gm)	Weight Loss (gm)
Pulse on time = 10 micro sec & Current = 4 amp	Voltage			
	5	26.0530	25.9554	0.0976
	10	25.9554	25.8225	0.1329
	15	25.8225	25.6054	0.2171
	20	25.6054	25.1344	0.4710

6.2. Effect of parameters on metal removal rate

Effects of parameters on various parameters on metal removal rate as shown in fig.

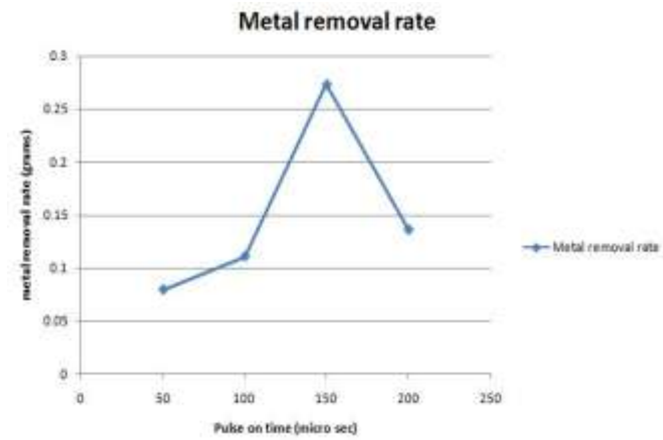

Fig 1. Variation of MRR with Pulse on time

A non linear relationship between pulse on time and MRR has been observed as shown in fig.1. MRR increases as the value of Ton increases upto 100 to 150 micro second. with further increase in the pulse on time from the 150 to 200 micro second the metal removal rate decreases slightly. this may attributed to reason that with high pulse on time. i.e. beyond 150 more materials gets melted also tool wear rate is more.[6]

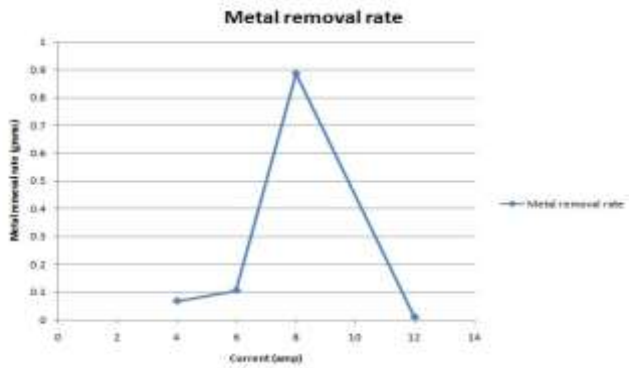

Fig 2. Variation of MRR with Current

A non linear relationship between current and metal removal rate has been observed in fig.2. It is normally observed that MRR was mostly affected by current. in a range of 4 to 8 amp the metal removal rate is increases. Beyond the 8 amp the MRR gets decreases slightly. Decrease in MRR is be due to the contamination of plasma column in gap. This contamination is caused by debris from electrodes.[6]

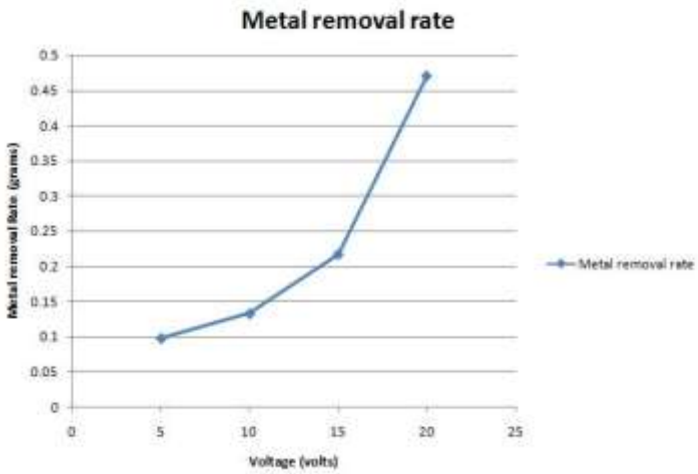

Fig 3. Variation of MRR with Voltage

A non linear relationship between voltage and metal removal rate shown in fig 3. there is increase in the metal removal rate as the value of the voltage increases. But due to increase in the voltage causes increase in the tool wear rate and poor surface finish.[6]

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