Optimization of Materials on EDM Machine – A Review

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Abstract — With the increase in industrialisation and globalization, the demand of highly finished products are increased. As the source and final assembly of products are different, it is necessary to optimize the materials in order so that only the required materials should be used to overcome the cost and to improve the performance. EDM (Die Sinking) machine is one of the most important machines which provides highly surface finished products. There are various parameters responsible to get desired MRR, TWR, Coolant, Current, Voltage, etc. Keeping the affecting parameters constant, and selection of best materials amongst the various materials which would give required highest surface finish on those parameters .

Index Terms— EDM, Parameters, Materials, Optimization, Analysis, Process, Experiments.

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1 INTRODUCTION

EDM is one of the non-conventional manufacturing process, in which the material is removed by erosive action of electric spark occurring between a tool electrode and workpiece based on the fact that no tool force is generated during machining. Both workpiece and tool electrode are drenched in a solution called dielectric medium.The mechanical characteristics of workpiece and electrode are not a concern because the electrical energy is converted into thermal energy causing melting of the material. Hard materials and more complex shapes which cannot be processed by other conventional methods can be easily processed by EDM Process. It is widely used in mold and die making. The material removal rate of this machining is low but provides the highly surface finished materials with improved mechanical properties due to thermal effect.

2 DIE SINKING EDM

In this process potential difference between the tool and work piece is used for machining process. Both the tool and the work piece are electrically conductive and submerged into the die electric fluid. It is necessary to maintain the gap between the tool and work piece. Electric field will be generated between the tool and work piece due to supplied potential difference and the gap between the tool and workpiece. Electrons will be emitted from the tool when the bonding energy of the electron is less. Emission of such electrons from the tool is known as Cold emission. This electrons are then accelerated towards the work piece with the help of die electric fluid. Die electric fluid also controls the heat produced produced due to spark.

3 TYPES OF FLUSHING

It is basic requirement of dielectric fluid that it should maintain its dielectric strength (insulating properties) during its whole operation. At the start of EDM, there is no problem. But after discharge the debris or fragments are produced in the gap reduce the dielectric strength, which cause unwanted discharges. This unwanted discharge is harmful and can damage to both tool and work piece. Hence it is necessary to remove such unwanted debris from the gap. For this purpose different types of flushing methods are use. .

The two parameters which affects the TWR and MRR are:
(i) Type of dielectric and (ii) The method of its flushing.

In EDM, flushing can be achieved by following methods:

3.1 Suction flushing

In this method of flushing, dielectric fluid may be sucked by either the work piece or the electrode. This technique is used to overcome any tapering effect because of sparking between machining debris and the side walls of the electrodes. Suction flushing through the tool is more effective than through the work piece.

3.2 Injection flushing

In this method, dielectric is fed through either the work piece or the tool which are pre-drilled to supply the flow. With the help of this technique, tapering of components increases due to the lateral discharge action occurring as a result of particles or debris being flushed up the sides of electrodes.

3.3 Side flushing

Whenever it is difficult to drill a flushing holes on a work piece or tool as discussed in injection molding then Side flushing technique is employed. When there is a requirement of flushing of entire working area, Special precautions is need to be taken for the pumping of die electric.

3.4 Flushing by dielectric pumping

If we want to do deep hole drilling this method can be efficiently employed. Flushing is obtained by using the electrode pulsation movement. When the electrode is raised, clean dielectric is sucked into mix with contaminated fluid, and as the electrode is lowered the particles are flushed out.

4 TOOL MATERIALS

Tool material should be such that it would not undergo much tool wear when it is impinged by positive ions. Thus the localized temperature rise has to be less by tailoring or properly choosing its properties or even when temperature increases, there would be less melting. Further, the tool should be easily workable as intricate shaped geometric features are machined in EDM.

Thus the basic characteristics of electrode materials are:

(1) High thermal conductivity
(2) High electrical conductivity
(3) High melting point
(4) Higher density
(5) Easy manufacturability
(6) Cost is less

The different electrode materials which are used comonlly in the industry are:

(1) Graphite
(2) Copper
(3) Brass

5 DIELECTRIC FLUID

Al Geometrically Complex and intricate component or hard material component which are precise and difficult to machine like ceramics super alloys, carbides, heat treated tool steels etc. EDM method is using for different tool material. Tool steel consist of carbon and alloy steel which are mostly used for making tool. Suitability of this tool is because of their distinctive hardness, resistance to abrasion, resistance to deformation at elevated temperature. Tool steel is basically used for heat treated state. Tool steel is made to a number of grades for different application. The higher carbon grades are used for metal cutting tool, stamping dies, etc. [1]

6 LITERATURE SURVEY

In this chapter few search are done on selected research paper related to EDM with effect of metal MRR,TWR, OC, surface roughness (SR) workpiece material, we are broadly classified all the paper into five different category, i.e. paper related to material related workpiece or tool, tubular electrode, tool design, some paper related to Effect of multiple discharge.

Sushil Kumar Chaudhary and **Dr. R.S. Jadoun** [2] has made a research review on the current advancement of EDM machine. They stated that Electrical discharge machining (EDM) is a process for shaping hard metals and forming deep complex shaped holes by arc erosion in all kinds of electro conductive materials. The erosion of Materials occurs due to pulse of Current. Researchers have explored a number of ways to improve EDM Process parameters such as Electrical parameters, Non-Electrical Parameters, tool Electrode based parameters & Powder based parameters. This Paper gives research work done on to the development of die-sinking EDM, Water in EDM, dry EDM, and Powder mixed electric Discharge Machining. In this review paper, Researcher works on enhancement of Material removal rate (MRR), reduction of tool wear rate (TWR), improve Surface Quality (SQ) by experimental investigation is expressed. Various approaches like Vibration, rotary and Vibro-rotary mechanism based on EDM, water based EDM has been employed for increase of EDM efficiency, Dry EDM use of gas instead of oil electrolyte, PM-dielectric Electric Discharge Machining .

Sandeep Kumar [3] has published research paper status of recent development in EDM machine. He stated that it is based on the thermoelectric power between the work piece and tool. The process includes controlled erosion of electrically conductive work piece by introduce of the rapid and repetitive spark discharge between the tool and work piece by the use of dielectric medium. He also give the various application in EDM machine in automobile, nuclear, surgical industry and thin and fragile parts. He concluded that EDM can be used as viable machining operations for producing complex parts, EDM is independent of the mechanical properties of the workpiece and in order to remain competitive as a micro-manufacturing technology, EDM process should use computer numerically controlled.

C. Bhaskar Reddy et al [4] has made research on the growth of EDM machine and its various application. Experiments with wire EDM on reciprocating dry sliding pin on plate revealed that the **Zro2-WC** composite exhibits better tribological characteristics over **Zro2-TiCN and Zro2-TiN**. The recent observation is being the application of the Wire-EDM in Granite Mining, operations to avoid the heavy manual involvement. The technique starting from a simple means of making tools and dies has reached the stage as the best alternative of producing micro scale parts. He concluded that EDM are flexible enough to meet the requirements in the global meatal cutting industries. Thus, the ultimate goal of Wire EDM process is to achieve an accurate and efficient machining operation combined with quality with at most best machining performance by the various factors affecting the process and identifying the optimal machining condition from number of combinations.

Manpreet Singh et al [5] conducted research on recent development in wire EDM machine. They stated that EDM is used to manufacture geometrically intricate shapes with great accuracy and good surface finish that are difficult to machine with the help of conventional machining processes. They also considered the various affecting parameters on EDM machine.

They concluded that wires with greater tensile strength can be made but they face adverse effects in terms of increase in resistance to breakage. Some work is also done on cryogenics treatment on various pieces of materials. Thus, WEDM can serve the purpose of high speed machining with good quality products in short time period and at reduced costs.

D.T. Pham et al [6] published research papers on Micro-EDM and its development. As MRR is in micro and due to the high precision and good surface quality that it can give, EDM is potentially an important process for the fabrication of micro-tools, micro-components and parts with micro-features. Researches are conducted of micro EDM on wire, drilling, milling and die-sinking. The focuses are laid on the planning of the EDM process and the electrode wear problem. Special influences are made to achieve high accuracy, including positioning approaches during EDM and electrode grinding. They concluded that while assigning process tolerances for micro-EDM all aspects of the process, such as type of electrode grinding, type of positioning and duration of the operation, should be considered, overall machining efficiency based on empirical methods and in order to remain competitive as a micro-manufacturing technology, micro-EDM processes should use reliable algorithms and strategies with repeatable results.

Edrees Abd Ali Khudhair and **Mustafa Mohsin Khuder** [9] has published research paper on effect of current on EDM machine. They stated that electric spark is used in this thesis to generate high electrical discharge at high currents. Electric current was passed (DC pulse type) from the power supply to the capacitor then to the electrode and work piece, the electric discharge machining process are created bubbles within the small gap between the work piece and electrode. Electric current was passed (DC pulse type) from the power supply to the capacitor then to the electrode and work piece, the electric discharge machining process are created bubbles within the small gap between the work piece and electrode. They concluded that MRR in this method are about (0.74581 - 1.53663 mm3/min), wear of electrode between (0.006567 - 0.131354) and the material removal and electrode wear increases in current.

Khushmeet Kumar and **Sushma Singh** [7] has conducted experimental study of Al-Sic (30%) composite on EDM machine. Engineering Composite Materials are gradually becoming very important material for their scope due to their high fatigue strength, thermal shock resistance, high strength to weight ratio etc. Hence, it is essential for searching an advanced machining method by which machining of composite can be performed with ease and accuracy. For effective machining of AL6061/Sic (30%) composite, an electrochemical discharge machining (EDM) has been developed. The developed EDM has been utilized to machine holes on AL6061/Sic (30%). Material removal rate and tool wear rate were obtained experimentally for Brass and Copper tool. Materials with different tool diameter and different levels of current. They concluded that Based on the experimental results it may be concluded that MRR and TWR are directly proportional to the current. They saw that MRR for 8mm tool diameter at 5 amp current is 2.22mg/min for brass tool where as it is 2.38 mg/min for copper tool which is 0.16mg/min (7.21%) more than that of brass tool. Also the corresponding tool wear rate (TWR) was observed as 1.43mg/min for brass tool and for copper tool it is 1.57mg/min which indicates the TWR of copper tool is more by 9.79% as that of brass tool.

Kuldeep Ojha et al [8] has published review papers MRR improvement in sinking Electrical Discharge machine. They published that Material removal rate (MRR) is an important performance measure in EDM process. Despite a range of different approaches, all the research work in this area shares the same objectives of achieving more efficient material removal coupled with a reduction in tool wear and improved surface quality. Apart from all these, various parameters, dielectric and ultrasonic performance are also considered. They concluded that found that the basis of controlling and improving MRR mostly relies on empirical methods. This is largely due to stochastic nature of the sparking phenomenon involving both electrical and non-electrical process parameters along with their complicated interrelationship. Being an important performance measure, the MRR has been getting overwhelming research potential since the invention of EDM process, and requires more Study /experimentation/modeling in future.

7 PROBLEM FORMULATION

Electric Discharge Machining (EDM) is a Traditional Machining technique of metal removal process consisting of erosion of material from the work piece due to series of discrete sparks between work piece and electrode separated by a thin film of dielectric fluid medium. In the Electro-discharge machining (EDM) process electric current is to be converted into heat. The surface of the electrode material is heated in the area of the discharge channel at a very high intensity. After that current is interrupted, due to which the discharge channel collapses immediately, as a result of that the molten metal on the surface of the work piece and the electrode both evaporates at a very high intensity and send liquid material into the dielectric.

The process removes metal via electrical and thermal energy, having no mechanical contact with the workpiece. Its unique feature of using thermal energy is to machine electrically conductive parts regardless of their hardness; its distinctive advantage is in the manufacture of mold, die, automotive, aerospace and other applications. The system moves in different axes and movement is control manually by computer system. Most of the analysis can be done by MINITAB software.

With the increase in industrialization and globalization, there is a great need and demand in the manufacturing process. The customers demand are increasing rapidly, as a result the need of advanced manufacturing process arise. Most of the industries spread worldwide, due to this advancement competition are increasing at a great scale. Thus, the need of highly efficient products, high surface finish, improved mechanical properties, reliability, life, durability various strength.

Performance of water based dielectric is yet to be investigated

for machining materials like composites and carbides. Copper electrode has frequently been used as electrode material in ultrasonic vibration assisted EDM. Other electrode materials need to be investigated thoroughly. Some portion of the material is conductive and some portion is non-conductive. But EDM requires conductive workpiece. So the composite properties of the workpiece may also lead to some observations. Researcher works on enhancement of material removal rate (MRR), reduction of tool wear rate (TWR), improve Surface Quality (SQ) by experimental investigation.

(1) Studying the effect of cutting other materials like Al and steel.
(2) Using other dielectric solution such as oil.
(3) Using other tool electrode materials such as steel and carbon.
(4) Studying the surface roughness in the current of EDM.

It is not possible to achieve high surface finish by other machines, as result lots of research are presently being carried out. There are very less materials on which the researches are done like aluminum and some composite, so we decided to compare and optimize the following material.

(1) Brass
(2) Copper
(3) Aluminum composites
(4) Brass composites.

8 EXPERIMENTAL PROCEDURE

Electrical discharge machine is the one of the non-conventional machining process, which convert electrical energy into heat energy. It is based on thermos electrical power between workpiece and the tool. In the EDM machine workpiece is sinked in the die-electrical medium. The process is done by high current density between tool and workpiece. As a result, due to large potential difference spark is produced between the electrode and the workpiece. Thus, highly finished surfaces are formed with the help of spark. There is no physical contact between the tool and the workpiece.

Various research paper are published on the EDM machine. Different researchers have published their own views regarding EDM machine. Most of the researchers have focused to obtain highly finished surfaces in least time with high quality. They also tried to optimize various effecting parameter on EDM machine like MMR, Electric current voltage, Die-electric medium, Electrode material, discharge duration, Workpiece material, Cutting speed, FEED, Depth of cut, Surface roughness of material, tool wear rate, peak current, pulse duration, polarity, change in weight Size and shape of the workpiece.Most of the researchers have made focused by considering parameters of the same material. Very few researches had been carried out on the optimization of materials like aluminum, copper and their very few composites.

9 CONCLUSIONS

From literature review we conclude that the most of work done on single composites materials not much work done on parameters, working fluid, tools etc.

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