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Optimization of Process Parameters for Rotary EDM Using EN31 Tool Steel: Present and Future Scope

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Abstract- In the present study rotary-Electro Discharge machining of EN31 tool steel is carried out by the use of a pure copper electrode. Various response variables such as “Material Removal Rate” (MRR), “Tool Wear Rate” (TWR) and “Machining Rate”(MR) had been studied against the selected process variables. The selected process variables were Peak Current (I), Voltage (V), Duty Cycle and Electrode rotation (N). EN31 Tool Steel is hardened, high carbon steel which increases its hardness and reduces its machinability. Reduced machinability means it is not economical to use conventional methods to machine EN31 Tool Steel. So, non-conventional methods play an important role in machining of such materials.

Keywords- Electric discharge machining (EDM); Tool steel; Tool wear rate; Optimization techniques;MRR

I. INTRODUCTION

Non-traditional machining processes, such as “Electrical Discharge Machining” (EDM), “Electrochemical Machining” (ECM), “Laser Beam Machining” (LBM), “Abrasive Water Jet Machining” (AWJM), “Abrasive Flow Machining” (AFM), and hybrid machining processes provides the best alternatives and sometimes for machining the only alternatives is high-strength, corrosion resistant, and wear resistant materials. Many advanced materials such as super alloys, engineering ceramics and metal matrix composites cannot be machined by traditional methods, or at best they are machined with more tool wear and the cost achieved is high[3]. By these advanced or nontraditional manufacturing processes we can get the required quality of the surface of the machined parts. Deep internal cavities can also be produced by this method. These processes are rapidly gaining importance in producing complex parts from a variety of material such as super alloys, ceramics, plastics, fiber reinforced composites, wood and textiles in diverse applications throughout the aerospace, automotive, electronic and medical industries, i.e. essentially all competitive manufacturers of durable goods.

A. *Electrical Discharge Machining (EDM)*

Since for more than fifty years, the best machining technique in non-traditional process is EDM. In EDM, material removal takes place by high temperature generated by sparks between the workpiece and tool electrode. About 1,000 to 100,000 sparks are generated between the tool electrode and workpiece in each second. As the spark is generated in between the workpiece and the tool, the shape of the tool is impinged on the workpiece. Material such as copper, graphite, tungsten carbide etc. having high electrical conductibilty, as a result they are used as a tool electrode. Factors that should be taken into account while selecting the tool material include low tool wear ratio, good machinability, good electrical conductivity, high melting point and low electrical resistance.

While machining, the purpose of dielectric fluid are following:

1. Cooling effect for workpiece as well the tool electrode.
2. Acts as a medium to carry the eroded particles.

Essential properties of a dielectric fluid:

1. Optimum viscosity should be there in dielectric fluid.
2. Easily availability of the dielectric fluid.
3. It should be on-reactive.

In this study, experiments would be performed on EN31 tool steel to investigate its machining characteristics. The selected process parameters are peak current, voltage, duty cycle and electrode rotation. In this study, the main aim is to identify the significance of various process parameters on machining characteristics. The selected response variables which are used to represent the machining characteristics are material removal rate, tool wear ratio and machining rate.

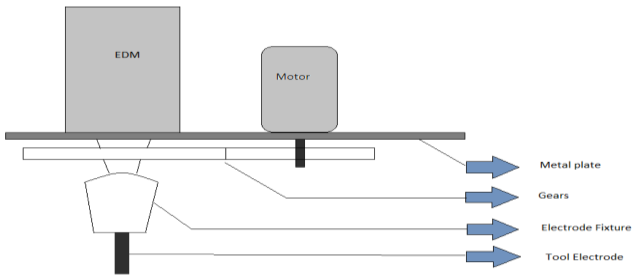

Figure 1:- Electrodischarge machine.

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B. Principle

Electrical discharge machining is a process in which the material is removed by the electric spark. The electric spark is used to cut the tool and the material is then taken out by flushing. In between tool and the workpiece there is a small gap which is known as spark gap. In this process less amount of metal is removed from the workpiece.[5]

C. *Types of EDM*

Basically, there are two different types of EDM:
1) Die-sinking
2) Wire-cut.

1. Die-sinking EDM

This process is mainly used to produce the blind cavities. Here in this process both the electrode and workpiece are submerged in an insulating liquid i.e dielectric fluid. The dielectric fluid mainly used is water. In this process, a suitable power supply is connected to the workpiece and the tool. The source of current can be automatically turned on or off. As we switch on the current, an electric tension is generated between the two metal parts.

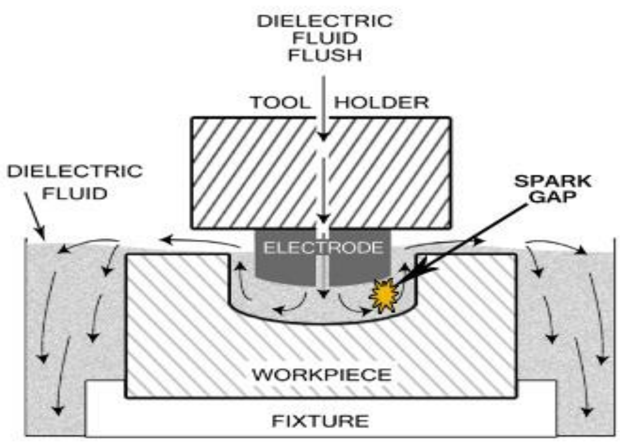

Fig 2 :- Die sinker EDM

2. Wire-cut EDM

In this process, a thin wire made up of metal is placed on to the workpiece. The workpiece and the wire i.e cutting tool both are placed into the dielectric fluid tank. Water is the mainly dielectric fluid used[2]. For making punches, slots and dies, Wire cut EDM is used. Plates less than 300 millimeters can be cut by this method only.[7]

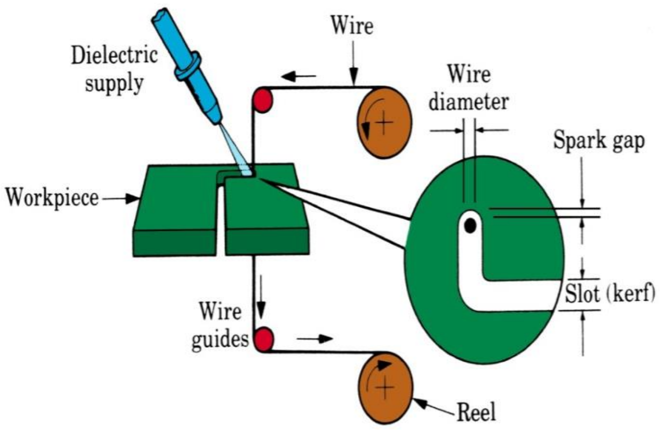

Fig 3.wire cut EDM.

II . LITERATURE REVIEW

Mohan et al. (2004) did study that SiC/6025 Al composites was used in EDM by using the brass electrode. The process variables that were used during this process are material removal rate (MRR), electrode wear rate (EWR) and surface roughness (SR) to determine the machinability. Various process variables that are used during this experiment are pulse duration, diameter of the hole and speed of rotation of the electrode. MRR, EWR and SR have positive effect upon the peak current.[5]

Kuppan et al.(2008) proposed a small deep hole drilling of Inconel 718 using EDM has been carried out. Here in this whole process the tool that is used for machining the Inconal 718 is electrolytic copper tube. To study the machining characterstics, there are some parameters that are choosed which are peak current, pulse on time and speed of the electrode. With the use of central composite design (CCD) these experiments were planned. The response variables were material removal rate (MRR) and depth averaged surface roughness (DASR). Desirability functional approach was used to optimize the maximum MRR along with the desired surface roughness value.[6]

Reddy et al.(2010) studied four factors that are duty cycle, servo control, current and voltage over the outputs on TWR,MRR, Surface roughness and hardness if AISI304 SS on die-sinker EDM. With the mixed level of design they employed DOE technique and analysed that there are a minimum number of runs. They achieved that MRR is high for fixed current, servo cycle and duty cycle.[11]

M.M. Rahman et al.(2011) investigated that as there is increase in current, the surface roughness and MRR also increases. Experiments are carried out through machining

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characteristics on austenitic stainless steel 304. As there is increase in peak current, TWR also increases.[12]

S. K. Dewangan(2010) did study that AISI D2 workpiece is used and the tool that is selected is a U-shaped copper electrode having machining parameters pulse on time, discharge current and diameter of the workpiece. L18 orthogonal array he conducted experiments. L18 orthogonal array is based on Taguchi method.[13]

S. H. Tomadi et al.(2009) to determine the error between the experimental value and predicted value confirmation test is performed. They found that for better finishing of the surface copper tungsten is used.[14] For optimization they use full factorial DOE and they found out that there is less wear of tungsten carbide as there is increase in the pulse off time and with there is increase in the current, voltage, and pulse on time, tool wear increased[15].

B. Bhattacharyya et al.(2007) investigated that the use of mathematical model for correlating the higher order for machining parameters during surface integrity of M2 is based on RSM. Here the machining parameters are peak current and pulse on time.[16]

Puertas et al.(2004) Investigated on the die-sinking EDM that for a machine the most important aspect is its machining condition. In their experiment they used 94WC-6CO material and the selected machining parameters are pulse on time and duty cycle. TWR, MRR and Surface roughness can be determined by the mathematical simulation with the DOE there is increase in roughness.[17]

Simao et al.(2003) investigated work on different workpiece on the surface of alloy on machining over EDM. In this experiments the tools are made of powder metallurgy and in the dielectric fluid the suspended powder is used.[18]

T.M.ChenthilJegan et al.(2012) determines the machining parameters for the machining of AISI 202 SS metal on EDM. The selected parameters are current, pulse on time and pulse off time.[19] Grey relational analysis technique is used for optimization of the machining variables like MRR and Surface roughness. From results we get that factor which affect MRR is discharge current[20].

T.Rajmohan et al.(2012) experimented under L9 orthogonal array design by using DOE technique and considering the effect of machining parameters on MRR for the machining of AISI 304 SS. The machining parameters used are pulse on time, current and voltage. Signal to noise ratio is used for optimization.[21]

M. Kiyak et al. (2007) did study on AISI P20 tool steel about the effect of process parameters on the surface roughness during machining. The parameters of EDM that are selected are pulse current, pulse time and pulse off time.[22] The roughness of the surface of the workpiece and tool are effected by the two main factors which are pulse on time and current[23]. Surface roughness increases if current and pulse on time both these factor increases. Lower current, lower pulse time and relatively higher pulse off time resulted in the better surface finish.

Ashok Kumar et al.(2011) experimented the machining on EDM by using the U shaped tubular tool made of copper for the machining of EN-19 tool steel. U-shaped is mainly used for internal flushing in EDM. The results are optimized by the use of Taguchi's L18 Orthogonal array. As a result they found that if the pulse on time reduces then the material removal rate increases. Also if pulse on time increases, Tool wear rate also increases.[24]

Srinivasa Rao et al.(2010) experimental that a mathematical model has been developed in order to predict the die-sinking EDM in case of AISI 304 SS workpiece. MRR,TWR and SR are the Process variables that are used in fuzzy logic model. For the investigation of the model, a regression analysis of experiments and output that is predicted were performed. To reduce the number of runs, fuzzy logic modeling was established throughout the experiments.[25]

III. CONCLUSION

Rotary Electro-discharge Machining of EN31 gives us information about various process parameters i.e Peak Current, Voltage, Duty Cycle and Electrode rotation and response variables i.e Material Removal Rate, Tool Wear Rate and Machining Rate. ANOVA will suggest the key factors for identifying our process variables for achieving different response variables. Lastly design of experiment will gives us information about correlation (regression line) which will make relationship between process variables and response variables

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