Optimization and Analysis of Process Parameters for the machining of INCOLOY 800HT on EDM using electrode of different material: A Review

Gaurav kumar
Department of Production Engineering
Govt. College of Engineering, Amravati 444604
Maharashtra,India
gauravgagan.rnsg@gmail.com

Asst. Prof. M. J. Deshmukh
Department of Mechanical Engineering
Govt. College of Engineering, Amravati 444604
Maharashtra,India
mjdeshmukh@hotmail.com

Abstract - Electrical discharge machining (EDM) is the non-traditional machining processes work on the basis of thermo electric energy between the work piece and the electrode. In this process, the material removal electro thermally by series of successive discrete discharges between electrode and the work piece. The performance of EDM process using different electrode material. In a few years, EDM researchers have explored number of ways to improve sparking efficiency including unique experimental concepts of EDM traditional sparking phenomenon. Despite a range of different approaches, this new research shares the objectives of achieving more efficient metal removal coupled with a reduction in tool wear and improved surface quality. In this Material Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR) is measured for detailed analysis by use of different electrode materials Brass, Copper and graphite and work piece material as INCOLOY800HT have employed for the experiments. The dielectric fluid used as Kerosene diluted with water. Objective of the experiment is show the best material in terms of higher MRR, lower TWR, and excellent surface finish.

Keywords:-*TWR,MR,SR.*

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I. INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining process, in which electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark. EDM is mainly used to machine difficult to- machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries on job-shop basis. Work material to be machined by EDM has to be electrically conductive. EDM Machining process is a non traditional method to produce any types of cavity in the any type of material. Using the different tool material, the performance of EDM can be improved. The experimental Set up of EDM (Fig.1).

Fig. 1 Experimental setup of EDM

II. EDM PROCESS PARAMETERS

In EDM a potential difference is applied between the tool and work piece. As shown in Fig. 2 (EDM process) both the tool and the work material are conductors of electricity. The tool and the work material are immersed in dielectric medium. Generally kerosene or deionized used dielectric medium.

A gap maintained between the tool and the work piece. Depending upon the applied potential difference and the gap between the tool and work piece, an electric field established. the tool is connected to the negative (Cathode) terminal of the generator and the work piece is connected to positive (Anode) terminal. The electric field is established between the tool and the job, the free electrons on the tool are produce electrostatic forces. he work function or the bonding energy of the electrons is less, electrons would be emitted from the tool (assuming it to be connected to the Negative terminal). that emission of electrons are called cold emission. The “cold emitted”

electrons are 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 dielectric molecule depending upon the work function or ionization dielectric molecule and the energy of the electron. the electrons get accelerated, more positive ions and electrons would get generated due to collisions. This cyclic process would increase concentration of electrons and ions in the dielectric medium between the tool and the job at the spark gap. The concentration would be so high that the matter existing in that channel could be as "plasma". The electrical resistance of such plasma channel would be very less. 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. Material removal occurs due to instant vaporization of the material as well as due to melting.

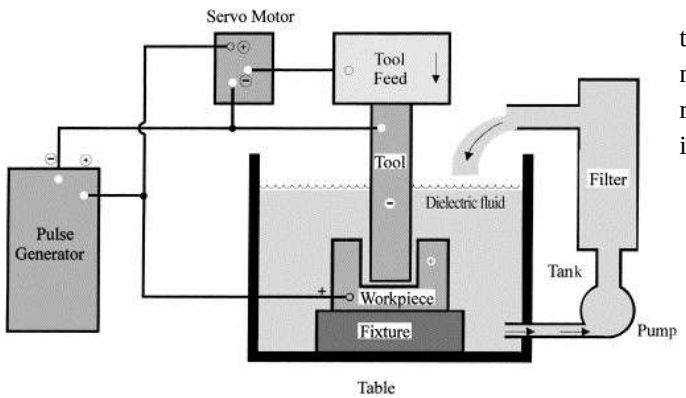

Fig. 2 EDM process

A. Electrode Material

1. Copper Electrode:

Copper is generally used as an electrode material. It extruded or drawn and then machined to required size and shape, low wear under both Roughing and Finishing operations and has the capacity to remove large amount of material

2. Brass Electrode:

This is alloy of copper and zinc, Brass does not resist wear as well as copper or tungsten, but is much easier to machine and can be die-cast.

3. Graphite:

This is used as electrode material in EDM mostly.

B. Work piece Material

INCOLOY 800HT alloy

It used for its strength at high temperatures and its ability to resist carburization, oxidation, and other types of high-temperature corrosion.

The process parameters they influence the experiment of optimizing machining of the INCOLOY800HT alloy are shown below.

i) Discharge current -it represents mean value of the discharge current intensity.
ii) Pulse-on time - It is duration of time (µs) current is allowed to flow per cycle.
iii) Pulse-off time - It is duration of time (µs) between the two successive sparks (pulse-on time).
iv) Duty cycle - It is percentage of pulse-on time relative to the total cycle time.
v) Dielectric pressure - This is flushing pressure of dielectric jet which removes the chip produced during the EDM process away from the gap zone.
vi) Polarity - The machine run normal polarity or reverse polarity

III. MACHINING CHARACTERISTICS

The effectiveness of EDM process is evaluated by terms of the machining characteristics. The EDM efficiency are measure in terms of the machining characteristics by surface roughness, material removal rate and tool wear rate. The most important machining characteristics considered are:

i) Surface Roughness (R_a): Surface finish is the essential requirement to determining surface quality of a product. The average surface roughness is the integral absolute value represent by below

$$R_a = \frac{1}{L}\int_0^L |Y(x)dx|$$

Where 'L' is the length taken for observation and 'Y' is the ordinate of the profile curve.

ii) Material removal rate (MRR): Material removal rate should be high as possible to give least machine cycle time leading to increased productivity. Material removal is the difference of weight of work-piece before machining and after machining. It is calculated by the formul as given below.

$$MRR = \frac{W_i - W_f}{\rho_w \; t} \quad \text{mm}^3/\text{min}$$

Where, W_i is the initial weight of work-piece in g; W_f is the final weight of work-piece after machining in g; t is the machining time in minutes and ρ_w is the density of work piece material.

iii) Tool Wear Rate (TWR): The Tool wear rate is the difference of electrode weight before and after machining and is expressed as:

$$TWR = \frac{E_i - E_f}{\rho_e \ t} \quad \text{mm}^3/\text{min}$$

Where,

E_i is the initial weight of electrode in gm;

E_f is the final weight of electrode after machining in gm;

t is the machining time in minutes and ρ_e is the density of electrode material.

IV. LITERATURE REVIEW

V. Muthukumar [1] presented a Mathematical Modelling for Radial Overcut on Electrical Discharge Machining of Incoloy800 by Response Surface Methodology. The experiments planned as per central composite design (CCD) method. After conducting 30 experiments, a mathematical model was developed to correlate the influences of these machining parameters and ROC. From the obtained results, It was found current and voltage have significant effect on the radial overcut. The predicted results based on developed models are found to be in good agreement with the predicted values match the experimental results reasonably well with the coefficient of determination 0.9699 for ROC.

V.B. Chaudhari [2] investigated the effects of electrical process parameters performances of die sinking electrical discharge machining with two types of dielectric medium i) Oxygen and Air (Dry EDM), ii) Kerosene on Incoloy800, the effect of input parameter on responses have been optimized using Taguchi L9 orthogonal Array and it is resulted that MRR is more for EDM using kerosene as dielectric as compare to dry EDM. It is observed from ANOVA that peak current and pulse on time are most significant parameters for MRR and TWR

Muthu Kumar.V [3] demonstrated optimization of WEDM process parameters of Incoloy800 super alloy with multiple performance characteristics and concluded that the Grey-Taguchi Method it is most ideal and suitable for the parametric optimization of the Wire-Cut EDM process, when using the multiple performance characteristics such as MRR, SR and kerf width.

Om Prakash Sahani [4] Presented a detailed experimental investigation of mild steel using copper as an electrode the machining characteristics such as material removal rate was considered and parameters like current, voltage and pulse on time were varied. It concluded that the MRR increases nonlinearly with the increases in Voltage then MRR increases with increase in pulse on time up to a certain limit then decreases. Increase Current provides an initial increase but further increase in current results in decrease in MRR.

Ashok Kumar [5] investigated the feasibility of machining the En-19 tool steel by using U-shaped copper electrode performed on electrical discharge machine. The Diameter of U-shaped electrode, Current and Pulse on time are taken as process input parameters and material removal rate, tool wear rate, Overcut on surface of work piece are taken as output parameters. A set of eighteen experiments(Taguchi design) were performed and relationships were developed between input and output parameters. The result indicates that the current increases the MRR is also increases and the pulse on time is increasing the TWR is also increasing. Finally, Overcut is directly proportional to the diameter of the electrode. It is also depend on current and pulse on time. As the current increases the overcut is also increasing.

M-G. Her [6] explained the micro-hole machining of a copper plate using the electro-discharge machining (EDM) process. Tungsten carbide was selected as the electrode and compared with a copper-electrode. A centerless grinding process was employed to grind the electrode down to the desired diameter. Results have shown that electrode wear and hole enlargement are both smaller when positive polarity machining is selected; whereas electrode wear is larger and machining speed is higher when negative polarity machining is selected. High quality micro-hole machining in copper can be achieved by the proposed method.

V. RESEARCH GAP, PROBLEM AND CHALLENGE

Super alloys are machined on the EDM. INCOLOY800HT alloy in which optimization experiment can be performed in order to know which electrode will be suitable for its machining on the EDM. No optimization work are done taking in consideration electrodes of different materials and INCOLOY800HT alloy.

The objective of the article has been report the work carried by various researchers in field of EDM electrode. In the literature has been observed from the existing published work.

1. Mostly work on EDM relates to optimization of other super alloy such as Inconel, Nimonic alloy. There is not much published work on EDM of INCOLOY800HT.
2. In addition works include work piece material such as hardened steel and it's machining on the EDM using copper as electrode Use of work piece material as INCOLOY800HT alloy and process optimization on EDM using electrodes of different materials is not carried out

VI. CONCLUSIONS

This paper presents a review of research work in the area of determination and optimization of the process parameters for EDM. A number of researcher works on the basis of various

optimization techniques were including RSM, Taguchi method. A review of research work for various optimization techniques indicates successful industrial applications of Taguchi method, RSM. These are popular optimization techniques to make experimental design uncontrollable factors such as environmental parameters predict responses and optimize the EDM process for accuracy level. Research work has been carried out in order for better way the machining of the Incoloy alloys still there are shortcomings in the machining processes used for machining of the Incoloy alloy. Electrodes used in the EDM process are the one which play a key role in machining of super alloys. Using different electrodes it is tried to conclude the best electrode for machining of INCOLOY800HT alloy.

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