Parametric analysis and its effect on machinability for Incoloy 800 with copper electrode

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Abstract: In Electric Spark Machining, choice of manufacturing constraints is a necessary feature. This Electrical Spark Machining is an advanced process in all manufacturing processes. For the manufacturing of sophisticated parts, which require accurate machining that time Electric Discharge Machining used. A super alloy, heat-treated tool steel, ceramics, heat resistance steels etc. which are tough to machining. For this, we use Electric Discharge Machining which also known as Electric Spark Machining. Incoloy alloy set in the group of super stainless steels. The main element of this Incoloy alloy is nickel-chromium-iron with other extra copper, molybdenum metal. High solidity at high peak temperature and super resist of erosion is the main feature of Incoloy alloy. Vast application of Incoloy 800 is like Heat exchangers, Carburizing equipments, Heating elements and nuclear steam generator tubing. In our research, we use hollow, flat, convex and concave electrode profile for machining of Incoloy 800.MRR and TWR are the parameters we analyze after the experiment.

Keywords: Die sinking EDM, Incoloy 800, Copper tool, MMR, TWR, Tool base profile

I. INTRODUCTION

In the Electric Spark Machining (Electric Discharge Machining), choice of manufacturing constraints is a necessary feature. This electrical spark machining is an advanced process in all manufacturing processes. For the manufacturing of sophisticated parts, which require accurate machining that time Electric Discharge Machine used. A Supper alloy, warmth tool metal, warmth resistance metal etc. which are tough to machining. For this, we use the Electric spark Machining which also known as spark eroding. Incoloy alloy set in the group of super stainless steels. Main element of this incoloy alloy is nickel-chromium-iron with other extra copper, molybdenum metal. High solidity at high peak temperature and super resist of erosion is the main feature of incoloy alloy. Vast application of incoloy 800 is like heat exchangers, carburizing equipment, heating elements and nuclear steam generator tubing. In this research work, the hollow, flat, convex and concave profiles are used for machining of Incoloy800 to identify the MRR and TWR after experiment.

S. Narayanan et al. In this study, using three different electrodes copper, copper-tungsten and graphite. Investigation was performed on Inconel material with these three different electrodes. In this investigation, input parameters are peak current, pulse on time, duty factor and electrode rotational speed and output parameters are MRR, TWR and SR. After the 3.0 mm and 25 mm diameter drilling holes, process data was analyzed by regression analysis method. After the experiment, conclude that when the current is high then MRR will also high in any electrodes. Copper electrodes have effectual MRR with the increasing current after by graphite and copper tungsten electrode. The Tool wear rate is high in the copper electrode compare to the copper tungsten electrode. In the small value of current, the graphite electrode shows the lowest wear rate. It shows that because the TWR decrease when ever pulse on time increase. After the analysis of the result, we show that copper gives us the best result with the recommendation to surface roughness. [1]

M. Boccadoro et al. In this paper, the author studied EDM drilling machine potentiality for drilling holes in turbine blades. Super alloy materials are used in the turbine blades of a jet engine. In the jet engine, high temperature is created. Internal and outer cooling required drilled holes in super alloy material. For drilling holes in super alloy, Electric Discharge Machine is used. After the conclusion of this process, we find that the value of the recast layer can be lessened. From the accumulation of the process parameters, we find the erosion speed. The erosion speed is 1.6 mm/sec. Tool wear rate is down when MRR is going on 77mm^3/min. EDM drilling and shaping mixture indicates the probability to provide cooling holes with condenser while electrode is not change. It is found that laser drilling thickness is higher than shaping. The chance of producing cooling holes without changing electrodes in EDM drilling and shaping process is higher.[2]

NarcisPellicer et al. In this paper, analyze the response parameters like Material removal rate, surface roughness, depth, width and slopes by using of a copper electrode as a tool and AISI H13 as a work piece. Also, study the impact of using various types of tool electrode geometry in Die sinking EDM. After the ANOVA analysis author conclude that, when peak current grows MRR and Surface roughness also enlarge. Different profile tools like

square and rectangle give a super radial and axial wear ratio. Square and rectangle profiles are the good option for tool design and machining. Pulse of time inequality influence the Material removal rate. [3]

M. Manohar et al. In this research paper, author has studied the impact of electrode base profile and its range of impact on machining alloy. In this research also examine the various base profiles of electrode and machine surface. In this study, another selected different types of electrode profile like convex, concave and flat for the analysis. The electrode material is copper and the size is twelve metric linear unit diameters. These three different electrodes base profile radius is 6, 8 and 10 mm. flat and concave base profile electrode result are lower compare to convex base profile for MRR of drilling holes, surface finish and lesser recast layer. The lower radius of the electrode profile result is good in terms of surface finish and ductility because of its small contact size. Concave electrode profile performance is lower compare to the flat profile. When it is discussed about the tool wear rate, a flat profile tool wear rate is found the best. After the experiment, we conclude that for a low tool wear rate convex profile for machining should be used.[4]

M. Jagadeeswara Rao et al. For this project Die-sinking EDM is used for machining super alloy material and some analysis techniques were used to discover the variable which has a high influence on the output. In this study, the work piece material is Incoloy800 and the tool materials are copper, graphite and composite electrode CW75.Using L9 orthogonal array and analysis is of input parameters like current, pulse on time, pulse off time and flushing pressure over the output parameters like MRR, TWR and SR. The operation was performed in three levels with different machining process parameters. Grey relational analysis is optimizing the input data and giving a good output response. Machining was carried out by Taguchi L9 array. To attain higher material removal rate and lower tool we are rate, finding the best parameters by grey relational analysis. Results shows that current= 16, pulse on time = 150, pulse off time = 20 and flushing pressure = 3.3 are the process parameters for attaining the best output. [5]

M. Kliuv et al.In this paper, author studied about the EDM drilling machine potentiality for drilling holes in turbine blades. In the study, analysis of various data like current, discharge time and their impact on the warmth-affected sector, etc. in the process MRR going to seventy-seven mm3/min and in other hand TWR going to down. It mixture indicates the probability to provide cooling holes with condenser while electrode not change. It is found that laser drilling higher than shaping. [6]

H. C. Tsi et al. study on “Electric spark machining execution of cr/cu based composite electrodes.” In this paper, the Author study about the making tool electrode by combining the chromium and copper powders. This mixing electrode has excellent erosion-resistant quality. The surface layer of a work piece is changed quickly with using of this type of electrode. The conclusion after the experiment is material removal rate is very good while using this mixture electrode at 20 MPA work pressure. While comparing MRR between the metallic electrode and composite electrode. Composite electrodes create a good MRR.[7]

M. Ghoreishi et al. In this paper, the author studied about the functions and characteristics of this EDM technique. Big and small constancy power axles shaking of tool are compared with each other. Mixing techniques regarding material removal rate, tool wear rate, and quality of outside in spark machining. After they established that Vibro rotary grow material removal rate by up to 35%. [8]

Li Lii et al. In this research paper, using beam-based utilization fast model innovation for the investigation of EDM electrodes. In this paper study about the effect of atomic number 22 (Tic) on the copper- based work material. Economics electrode having good surface roughness compared to other electrodes. [9]

NarcissPelliccer et al. In this paper, analyze the response parameter like Rate of material removal, exterior harshness, and thickness profundity, incline using a copper electrode as a tool and AISI H13 as a work piece. Also, study about the impact of using various types of tool electrode geometry in Die sinking EDM. The author concludes that just as soon the power is growing, MRR and exterior harshness also growing. Different types of tool geometry could be an essential option for machining. [10]

SibaSankar et al. In this research, paper author is studied and analyze the surface integrity and metallurgical characteristic. After the analysis conclusion shows that ultra cold treated tool surface uncertainty is low equate to the non-tend tool. When utilizing a cryogenically treated tool, a white layer has been found in metal 825. Utilization of NTT and CTT, EDM specimens acquire higher residual stress compared to normal metal 825. [11]

Rajju B et al. In this paper, the GRA method using for the very small EDM reaming process for Inconel 600 alloys. After analyzing the process, the author concludes that voltage is an excessive feature for performance and feed rate is the lowest excessive feature. Although feed rate is used for controlling the taper angle. While using the micro EDM drilling method MRR, taper angle, Overcut, and diameter differences are upgrade through the estimate approach. [12]

Roger kern et al.The selection of electrode material is playing key character in Electric spark machining. In this Article, author checks the characteristic of graphite and metallic electrode materials. In this paper author studied about the mechanical and electrical properties, melting pint, cost, etc., and also find the electrode wear. [13]

BiingHwa Yan et al. In this paper, the author studied about the impact of the machining property with the use of titanium metals in EDM. In this experiment add on urea into liquid for use as non conducting fluid. Input parameters are high current and pulse period on the other hand Rate of material removal, EWR, and roughness as a response variable in this study. The main effect of adding urea into the liquid as a non conducting medium is Rate of material removal and rate of tool wear growing with the growing of current. Urea as a dielectric fluid also affects the surface roughness. When we using urea as dielectric fluid the harshness degrades with a growing in peak current.[14]

P. Peccas et al. In this research, silicon powder is used in spark machining as non conducting fluids. The author concludes that when this silicon powder is mixed in dielectric fluids, surface roughness is reduced. This powder's existence in electric fluid removes the nasty discharge state. [15]

II. MATERIALS AND METHODS

A. Literature Summary:

In the Electric Spark Machining, workpiece material is removed by a spark which is created by electric power. This spark arises between the workpiece and tool constantly.Composite material, superalloy are difficult to machine. Electric Discharge Machine has the capability of a machine to these complex and high strength materials. [1]

Analyze all input and output parameters and literature analysis of spark machining procedure; we remark the few following points:

I/p variables like pulse on period, pulse off period, current all are the belongings to Rate of material removal.

- We noticed that, when the current enlarge during the machining process, the Rate of material removal also enlarges. Rate of material removal also belongs to the pulse on period. When pulse on-period rise, similarly Rate of material removal also rise and it is reduced during the pulse on-period reduction.
- The consequence of various electrodes profile on exterior quality is negligible. After the studied various research paper, we come to an end that high current and pulse on-period extremely influence to Rate of material removal. Different electrode profiles and electrode material concerning to rate of material removal. In all tool materials, copper has excessive MRR compared to other materials. Copper material has various other quality which helps in electrode discharge machining. After all this research work and observation, we are curious to work in this discipline. In our future study and discover what are the consequence happen on material removal rate by an interchange of the profile of copper electrode.

B. Collection and Preparation of samples

The collection phase involved gathering the Incoloy 800 and machining of copper electrode with the hollow, flat, convex and concave profiles.

C. Experimental Analysis

To carry out the research work, the JOEMARS Make AZ 50 Die-sinking Electro Discharge Machine is used to investigate the effect of process parameters on MRR and TWR for Incoloy 800 for different combination of the copper electrode profiles.

D. Technical Specification of the Die-sinking Electro Discharge Machine

ITEM	UNIT	DIMENSIONS
Worktable size	Cm	60×30
X travel	Cm	30
Y travel	Cm	20
Z travel	Cm	20
W travel	Cm	20
Ram platen to work table	Cm	19 – 59
Maximum Load of Tool	Kg	60
Maximum Load of W/p	Kg	550
Work vessel	Cm	83 × 50 × 30
Mass of Machine	Kg	1050
Outer Size of Machine	Cm	153 × 159 × 217.5
Maximum power	A	50
Power I/P	KVA	45
Maximum Rate of Material Removal	mm^3/min	390
Tool Wear Proportion	%	0.25
Best Surface Roughness	µm Ra	0.20
Total Load	Kg	180

Outer Size	Cm	58 × 72.5 × 173
Non conducting vessel capability	L	240
Non conducting vessel pump	HP	0.5
Non conducting vessel Total Mass	Kg	Built-in
A Non conducting vessel strainer Technique		Paper strainer
Non conducting vessel outer size	Mm	Integral

Fig.1 EDM machine Set-up

Fig 2. Incoloy 800 plate

Fig 3 solid copper electrode

Fig 4 Convex shape copper electrode

Fig 5 Hollow shape copper electrode

III. RESULTS AND DISCUSSION

A. Design of Experiments

For design of experiments, the input parameter, responsible variables and constant criterions are as follows: Discharge power, Pulse on Peorid, Pulse off Period are considered as Input Parameters. Rate of Removal of Substance, Rate of Electrode Wear and Operation Time are treated as Response criterions. While Voltage, Flushing pressure, sparking gap, servo sensitivity, flushing height, working time and arc sensitivity are taken as constant criterions.

The Pulse on Period, Pulse off Period and Current are considered as process variables for three stages. The L9

B. Material Removal Rate

The Material Removal Rate is the fraction of the load variance of the earlier and later machining to the time of machining and material density.

$$TWR = \frac{Wtb - Wta}{\mathrm{D} * \mathrm{T}}$$

Where, Wtb = Before machining weight;
Wta = After machining weight;
D = Workpiece material density (gm/mm)
T = Machining time in second

C. Tool Wear Rate

The Tool wear rate is the fraction of tool weight variance of the earlier and latermachining to the time of machining and tool material density.

$$TWR = \frac{Wtb - Wta}{\mathrm{D} * \mathrm{T}}$$

Where, Wtb = Before machining weight;
Wta = After machining weight;
D = Workpiece material density (gm/mm
T = Machining time in second

D. Surface Roughness

Surface Roughness can be regarded as the quality of a surface of not being smooth and it is hence linked to human perception of the surface texture. Form a mathematical perpective it is related to the spatial variability structure of surface, and inherently it is multiscale property.

E. Taguchi Analysis

Taguchi Analysis is the method for analysis in our EDM process. Taguchi methods are statistical methods, sometimes called robust design methods, developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to engineering, biotechnology, marketing, and advertising.

F. Response Tables

After applying Taguchi analysis, the response tables are generated for the MRR, TWR and Surface Roughness for Flat Profile of Copper Electrode with Incoloy 800 for combination of Input and Output Parameters.

G. Configuration of Experiment

Configuration experiment is finding out by an accumulation of variables. In the analysis, we show that the Rate of material removal is 0.11618gm/s and the Rate of tool wear is 0.05371 gm/s. This result is not accurate because of human misconception and machine in conception. The Table contains the snapshots of the different phases of the experimental work.

Fig. 6 Spark generation during the experiment

Fig. 7 Fume generation during the experiment

Fig. 8 Incoloy800 Plate Weight During the experiment

Fig. 9 Copper Tool Weight During the experiment

Fig. 10 Final Reading of experiment

Fig. 11 Measured Surface Roughness

IV. CONCLUSION

In this work, a Die-sinking EDM machine is used for machining of Incoloy 800. Our operations are achieved for response variables which are Rate of electrode wear and Rate of material removal accompanied by impact variables like current, pulse on period, and Pluse off period. In our work, we are using an L9 orthogonal array and precedes 9 readings for all parameters for analysis of the process. After the analysis, we are using different base profile electrodes like Flat, convex, and hollow for machining of Incoloy800. We are using a copper material electrode for machining.

At the end of the operation, it is demonstrated that Rate of material removal is high at high peak current (28 A), pulse on period (135), and pulse off period (96). When we increase the peak current, spark potency also increases. This is the logic behind the highest MRR value.

As far as the percentage of electrode wear concern, the tool wear rate is growing with the peak current. The main reason behind this is flushing pressure or flushing technique. Flushing played important role in EDM machining. Also current played an important role for Tool wear rate. When we increase the current, the rate of electrode wear also increases in our study. The average tool wear rate is low during the process because workpiece material debris effect the tool surface.

From the review of the result of the Investigation carried out for different base profile electrodes like Flat, Convex and hollow, the best parameter value by using various base Profiles Electrode for Incoloy800 material is found. The result of our investigation revels that In EDM machining always to obtain a greater MRR value so, peak current must always be kept high for a higher rate of material removal value.

material removal Rate influence by Pulse on Time with some determined span. After that pulse on time does not influence MRR as much as it current influenced MRR.

During the process, it is observed that flush pressure and flushing technique plays an important role for Response parameters like Material removal rate and TWR.

Also, conclusion of our main investigation shows that for convex shape tool is more desirable compared to a Hollow and Flat profile electrode.

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Declarations

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2. The authors affirm that no conflicts of interest exist.

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