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Research Article

To Determine the Effect of Machining Parameters on Material Removal Rate of EN 31 Stainless steel using EDM

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Abstract

The objective of the work carried out is to study the effect of EDM upon the responses, such as Material Removal Rate, Tool Wear Rate and Surface Roughness. The experiments were conducted by using the Electric Discharge Machine, model ELEKTRA (EMS 5535) is located at CITCO-IDFC TESTING LABORATORY, CHANDIGARH, INDIA. The polarity of the electrode was set as positive while that of work piece was negative. The dielectric fluid used was EDM oil (Sp. Gravity – 0.763). The machine also has the capability to vary peak current, pulse on time, pulse off time etc. Considering the capability of machine and the output required for the experimentation, peak current, pulse on time and pulse off time were decided to be taken as the variable and all the other factors have to be kept fixed. To obtain the desired results with minimum possible number of experiments, Taguchi method has been employed. Using Taguchi L27 Orthogonal Array has been selected and the experiments have been designed. After performing the experiments, results of the experimentation have been analyzed and graphs for effect of various input variables upon output characteristics and for Signal-to-noise ratio have been studied and discussed using ANOVA (Analysis of Variance). Also the optimum combination of input variables has been determined which will give the best results for output parameters using Signal-to-noise ratios.

Keywords: *Taguchi Design, Orthogonal Array, EN-31 Stainless Steel, Peak Current, Pulse ON Time, Pulse OFF Time and Scanning Electron Microscopy.*

Introduction

Electric discharge machining is a non-conventional machining process and has found its wide application in making moulds, dies and in aerospace products and in surgical equipments. 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. The electrode is moved toward the work piece until the gap is small enough so that the impressed voltage is great enough to ionize the dielectric. The material is removed with the erosive effect of the electrical discharges from tool and work piece. EDM does not make direct contact between the electrode and the work piece. In this work, a study focused on the electric discharge machining of the EN-31alloy steel, whose field of applications is in constant growth. Consequently, an analysis on the influence of current and pulse on, pulse off, over surface roughness, material removal rate, tool wear ratio will performed

Literature Review

Vijaykumar S. Jatti *et al.*, (2016) uses Taguchi's method to optimize the electrical discharge machining process variables for achieving minimum tool wear rate. NiTi alloy, NiCu alloy and BeCu alloy were consider as the work piece materials and electrolytic copper was considered as tool electrode. Electrical parameters considered for the study includes gap current, gap voltage, pulse on time and pulse off time along with work piece electrical conductivity. Experiments were carried out as per the Taguchi's L18 orthogonal array. Based on the statistical analysis it was found that work electrical conductivity, gap current, and pulse on time were the most significant process parameters that affects tool wear rate. The obtained optimal parameter setting provides minimum tool wear rate.

Kurri Rohan Ramesh *et al.*, (2015) The paper represent the work done for making mathematical models for analysis of the effects of machining parameters on the performance characteristics in EDM process of Alloy steel (EN-31). The mathematical models are developed using the response surface methodology (RSM) to explain the influences of machining parameters on the performance characteristics in the EDM process.

Avdesh Chandra Dixit *et al.*, (2015) This study investigates the influence of EDM parameters on MRR, EWR while machining of AISI D3material. The

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parameters considered are pulse-on time (Ton), pulse off time (Toff) peak current (Ip) and fluid pressure. The experiments were performed on the die-sinking EDM machine fitted with a copper electrode. Electrode wear rate is mainly influenced by peak current (Ip) and pulse on time (Ton), fluid pressure has no effect on electrode wear rate.

Harshit Dave *et al*., (2014) An experimental investigation has been carried out to understand the effect of various electrical parameters like Current, Gap voltage, Pulse ON time and Pulse OFF time and non-electrical parameters like scanning speed of the tool and aspect ratio of the micro feature generated on Tool Wear Rate during the machining of Al1100 using Tungsten electrode.

Tijo D *et al*., (2014) In this work, electrode prepared with tungsten (W) and copper (Cu) powder by powder metallurgy (PM) route used as tool material and pure aluminum is used as work-piece. Using reverse polarity (tool as anode and work-piece as cathode) in electro discharge machine a hard composite layer of WC-Cu has been deposited on the Aluminum work piece surface. The effect of compaction pressure during tool preparation by PM method and peak current (Ip) and pulse on time (Ton) during EDC process on Deposition Rate (DR) and Tool Wear Rate (TWR) have been studied. A Taguchi L18 experimental design method has been used to study the effect of various process parameters on EDC process.

Design of Experiments Analysis

Genichi Taguchi developed some statistical tools to measure the qualities of manufactures goods know as Taguchi methods. This design provides a potential and efficient method for designing different products that can operate consistently over a wide range of conditions.

Minitab provides both static and dynamic response experiments. The design of experiments is used to find the best combination of input variables in an orthogonal array. In this experiment the input parameters considered are current, Ton and voltage. Since three factors are chosen the design becomes a 3 level 3 factorial Taguchi design. L27 orthogonal array was chosen for the experiment to be conducted. Consider a system which has 3 parameters and each of them has 3 values. To test all the possible combinations of these parameters (i.e. exhausting testing) we will need a set of 3ˆ 3=27 test cases. Using orthogonal array testing, we can maximize the test coverage and here we assume that the pair, that maximizes interaction between the parameters, will have more defects and that the technique work.

Material Used

EN 31 Stainless steel is one of the most widely used material in all industrial application and accounts for approximately half of the world‘s stainless steel production and consumption. Because of its aesthetic view in architecture, superior physical and chemical, weld ability, it has become the most preferred material over others. Many conventional and non- conventional methods for machining EN 31 Stainless steel are available**.**

Table: 1 Composition of EN 31 Stainless Steel

Elements	Composition
C %	0.923
Mn%	0.5734
P%	0.0459
S%	0.04555
Si%	0.2048
Cu%	0.0655
Ni%	0.0765
Cr%	1.157
V%	1.0054
Mo%	0.0388

EN-31 work piece were prepared in the form of cylindrical shape having diameter 35 mm and length 18 mm.

Fig: 1 Material used

Tool Design

The tool material used in EDM can be of a variety of material like copper , brass, aluminium alloys , silver alloys etc. the material used in this experiment is copper. The tool electrode is made in the shape of cylinder having a diameter of 10 mm.

Fig. 2 Tool Electrode

Machine used

Fig. 3 ELEKTRA (EMS 5535)

Mechanism and evaluation of MRR

MRR is the rate at which the material is removed from the work piece. Electric sparks are produced between the tool and the work piece during the machining process. Each spark produces a tiny crater and thus erosion of material is caused.

The MRR is defined as the ratio of the difference in weight of the work piece before and after machining to the density of the material and the machining and the machining time.

$$MRR = \frac{W_i - W_f}{t}$$

where,

W_i= initial weight before machining
W_f= final weight after machining
T= machining time = 45 min

Table: 2 Parameters Value during Experimentation

Experimental Variables	Level		
Parameters	Level 1	Level 2	Level 3
Peak Current (Amp.) A	4	8	12
Pulse on time (P on) B	50	100	200
Pulse off time (P off) C	6	9	12

Results and Analysis

Table 3 Observation Table for Material Removal Rate

Sr. No.	I(A)Peak Current	Pulse on time (ms)	Pulse off time (ms)	Machining Rate			MRR
				W_1	W_2 (g)	W_1-W_2(g)	
1	4	50	6	116.32	116.2	0.12	0.0026
2	4	50	9	116.2	116	0.2	0.0044
3	4	50	12	116	115.76	0.24	0.0053
4	8	50	6	117.75	115.57	2.18	0.048
5	8	50	9	115.57	113.23	2.34	0.052
6	8	50	12	113.23	110.5	2.73	0.06
7	12	50	6	113.13	109.03	4.1	0.091
8	12	50	9	109.03	104.57	4.46	0.099
9	12	50	12	104.57	99.45	5.12	0.113
10	4	100	6	98.34	98.22	0.12	0.002
11	4	100	9	98.22	98.1	0.12	0.002
12	4	100	12	98.1	97.92	0.18	0.004
13	8	100	6	128.06	125.38	2.68	0.059
14	8	100	9	125.38	122.81	2.57	0.057
15	8	100	12	122.81	120.02	2.79	0.062
16	12	100	6	113.79	108.78	5.01	0.111
17	12	100	9	108.78	103.43	5.35	0.118
18	12	100	12	103.43	98.43	5	0.111
19	4	200	6	106.38	106.28	0.1	0.002
20	4	200	9	106.28	106.18	0.1	0.002
21	4	200	12	106.18	105.99	0.19	0.004
22	8	200	6	108.75	105.73	0.02	0.0004
23	8	200	9	105.75	102.62	3.13	0.069
24	8	200	12	102.62	99.75	2.87	0.063
25	12	200	6	129.79	123.33	6.46	0.143
26	12	200	9	123.53	118.44	5.09	0.113
27	12	200	12	118.44	112.97	5.47	121

Result and discussion for material removal rate

The material removal rate increases with increase in the value of Peak current. The rate of material removal increases as the peak current increases from 4 to 8 A. The value of increase in material removal diminishes slightly as the peak current increases from 8 to 12 A.

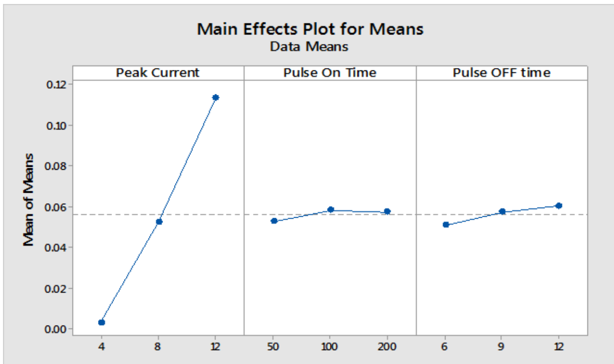

Fig.4 Effects of Machining Parameters on MRR

The material removal rate follows approximately the linear relationship with increase in peak current. The trend is observed to be some for both of SN ratio and mean plot.

The material removal rate shows a decreasing behaviour as the Pulse-ON time is increased. The impact is less as the Pulse-ON time increase from 50 to 100 S. The impact of material removal rate increase as the Pulse ON Time increases from 100 to 200 S. The trend is observed to be similar for both of the plots.

Also the material removal rate has increasing impact with the Pulse OFF Time. The material removal rate increases with increase in the Pulse OFF Time. The material removal rate is highly influenced by the Pulse Off Time.

Table 4 Response Table for Material Removal Rate

Level	Peak Current	Pulse ON Time	Pulse OFF Time
1	0.003148	0.052814	0.051004
2	0.052271	0.058444	0.057378
3	0.113333	0.057493	0.060370
Delta	0.110186	0.005630	0.009366
Rank	1	3	2

Conclusion

For material Removal Rate

- It is concluded that the material removal rate is highly influenced by peak current than Pulse OFF time than Pulse On Time.
- Material Removal rate increases with increase of Peak Current.
- Material Removal Rate increases with increase of Pulse ON Time.
- Material Removal Rate increases with increase of Pulse OFF Time.

Table 5 Optimal combination for Material Removal Rate

Physical	Optimal Combination		
Requirements	Peak Current (A)	Pulse ON Time (S)	Pulse OFF Time (S)
Material Removal Rate	12	100	12
	Level-3	Level-2	Level-3

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