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To Determine the Effect of Machining Parameters on Surface Roughness 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 uon the 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. Surface Roughness test was performed at Institute for Auto parts and Hand Tools Technology, Ludhiyana. 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. Mitutoyo Surface Roughness Tester instrument is used for testing roughness of the specimens. 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.
The surface roughness has been measured using

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. 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.

Mr.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 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 beencarried out to understand the effect of various electrical parameters like Current, Gap voltage, Pulse ON time andPulse OFF time and non-electrical parameters like scanning speed of the tool and aspect ratio of the micro featuregenerated on Tool Wear Rate during the machining of Al1100 using Tungsten electrode.

Tijo D *et al*., (2014) Inthis work, electrode prepared with tungsten (W) and copper (Cu) powder by powder metallurgy (PM) route used astool material and pure aluminum is used as work-piece. Using reverse polarity (tool as anode and work-piece ascathode) 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.
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)

Table: 1 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 2 Observation Table for Surface Finish

Sr. No.	I(A)Peak Current	Pulse on time (ms)	Pulse off time (ms)	Surface Roughness
1	4	50	6	1.93
2	4	50	9	2.74
3	4	50	12	3.76
4	8	50	6	4.2
5	8	50	9	4.9
6	8	50	12	5.2
7	12	50	6	3
8	12	50	9	4..0
9	12	50	12	5.4
10	4	100	6	3.92
11	4	100	9	2.85
12	4	100	12	2.12
13	8	100	6	3.9
14	8	100	9	4.6
15	8	100	12	4.9
16	12	100	6	3.6
17	12	100	9	4.5
18	12	100	12	5.4
19	4	200	6	2.23
20	4	200	9	4.43
21	4	200	12	3.55
22	8	200	6	3.5
23	8	200	9	4.41
24	8	200	12	5.2
25	12	200	6	3.8
26	12	200	9	4.6
27	12	200	12	5.7

Result and discussion for surface finish

The surface finish of the machined material is showing the increasing trend as the peak current is increasing from 4 to 8 A. The behaviour is reversed as the current increased from the 8 to 12 A. The trend is observed to be the opposite in both of the plots.

The Surface finish is highly influenced by the Pulse ON time. The Surface finish is showing a increasing trend as the Pulse On Time is increased. The behaviour is opposite in both of the plots.

Also the Surface finish is largely influenced by the Pulse OFF Time. The Surface finish gets increased with the increase of Pulse OFF Time. The behaviour is predicted to be the approximate increasing.

After the observation from experimentation and from Electrical Discharge Machining, the data thus obtained is used in MINITAB software for the calculations of S/N ratio and mean.

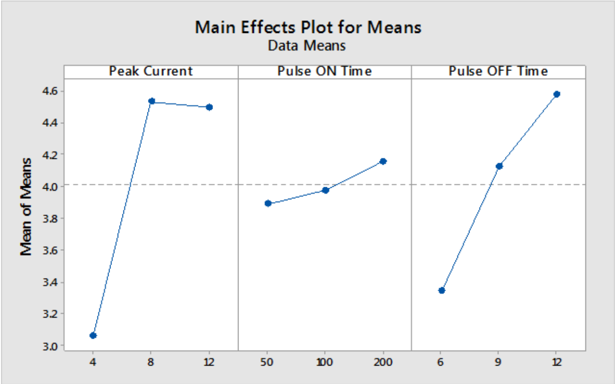

Fig. 4 Effect of Machining Parameters on Surface Roughness

Table 3 Response Table for Means

Level	Peak Current	Pulse ON Time	Pulse OFF Time
1	3.059	3.891	3.342
2	4.534	3.977	4.129
3	4.500	4.158	4.581
Delta	1.476	0.267	1.239
Rank	1	3	2

Spectroscopy

SEM (Scanning Electron Microscope) is a type of electron microscope that images the sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition and other properties such as electrical conductivity. The types of signals produced by an SEM include secondary electrons, back scattered electrons (BSE), characteristic x-rays, light (cathodoluminescence), specimen current and transmitted electrons. These types of signal all require specialized detectors that are not usually all present on a single machine. The signals result from interactions of the electron beam with atoms at or near the surface of the sample. In the most common or standard detection mode, secondary electron imaging or SEI, the SEM can produce very high-resolution images of a sample surface, revealing details about 1 to 5 nm in size. Due to the way these images are created, SEM micrographs have a very large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of a sample. Samples were tested at two levels that is 200 kV X 400 and 200 kV X 1500.

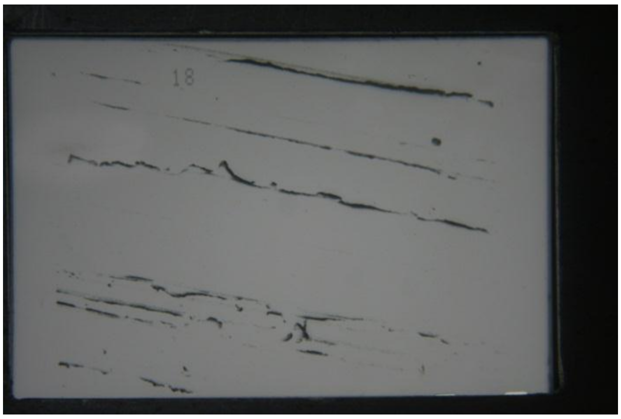

Fig: 5 EN 31 die steel at 400X resolution before Machining

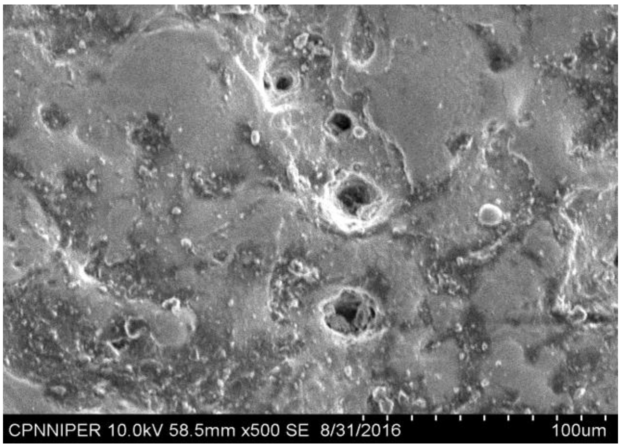

Fig. 6 EN 31 stainless steel after Machining

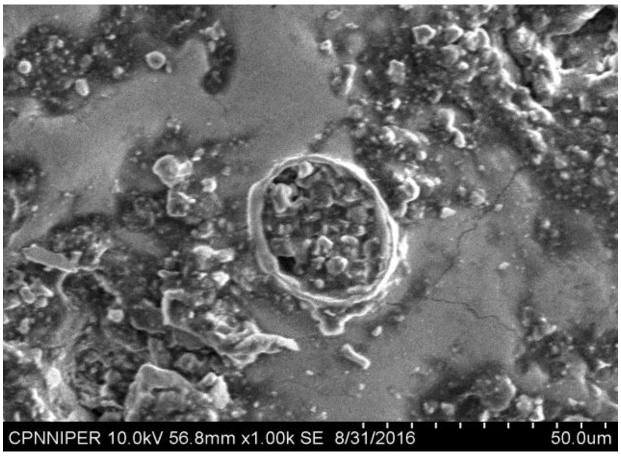

Fig.7 EN 31 stainless steel after Machining

Conclusion

For Surface Finish

- It is concluded that the Surface Finish is highly influenced by peak current than Pulse OFF time than Pulse ON Time.
- Surface Finish decreases with increase of Peak Current.
- Surface Finish decreases with increase of Pulse ON Time.
- Surface Finish decreases with increase of Pulse OFF Time.
- Surface Finish is minimum at maximum peak current.
- SEM Analysis shows that the microstructure of the material has changed due to the impact of electrical discharges. There are pits formed somewhere in the samples. Some of the irregularities are formed having no pattern.

Table 5.2 Optimal combination for Tool Wear Rate

Physical	Optimal Combination		
Requirements	Peak Current	Pulse ON Time (S)	Pulse OFF
Max. Tool Wear Rate	8	200	12
	Level-2	Level-3	Level-3

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