ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

Investigation of Surface Roughness on M300 Steel Machined By EDM

Deepu P.Nair, Dr. Binu C.Yeldose, Dr. Cibu K. Varghese

***Abstract*— Maraging steel (M 300) exhibits high level of strength and hardness and possesses an extreme resistance to crack propagation, even in the most extreme environments. Optimization of present work is essential for effective machining. The present work is aimed at characterizing the electric discharge machining of maraging steel. Taguchi's L9 orthogonal array was chosen to conduct the experiments by varying EDM parameters like voltage, current and pulse on time. The surface roughness is taken as the output response. Signal to noise ratio and ANOVA is used to analyze the effect of parameters on surface roughness and also to identify the optimum machining parameters.**

***Index Terms*—Maraging steel, Orthogonal array, Electric discharge machining, Surface roughness.**

I. INTRODUCTION

Electric Discharge Machining (EDM) is a controlled material removal technique where by high frequency electric spark are used to erode the work piece which takes a shape corresponding to that of tool electrode [1]. The cutting tool is made from electrically conductive material such as copper or graphite. The electrode made to the shape of cavity required, and the work pieces required are both submerged in a dielectric fluid which is a nonconductor of electricity. A servomechanism maintains a gap between the electrode and the work, preventing them from coming into contact with each other. The ignition of the discharge is initiated by a high voltage, overcoming the dielectric breakdown strength of the small gap. A channel of plasma is formed between the electrodes and develops further with discharge duration. As the metal removal per discharge is very small, discharges should occur at high frequencies (103-106 Hz). For every pulse, discharge occurs at a single location where the electrode materials are evaporated and/or ejected in the molten phase. As a result, a small crater is generated both on the tool electrode and work piece surfaces. Removed materials are cooled and re-solidified in the dielectric liquid forming several hundreds of spherical debris particles, which are then flushed away from the gap by the dielectric flow.

II. LITERATURE SURVEY

Electrical discharge machining (EDM) is an important manufacturing process for machining hard metals and alloys [1]. This process is widely used for producing dies, molds, finishing parts for aerospace, automotive, and surgical components. The process is capable of getting required dimensional accuracy and surface finish by controlling the process parameters [2]. Rebolo [3] investigated the effect of EDM parameters on material removal rate and surface quality. From the experiments it has been concluded that for positive polarity the edm samples presents a normal behavior with increasing mrr when machining energy is increased. S.H Lee [4] had studied the operating parameter on tungsten carbide and effectiveness of edm process is evaluated in terms of surface quality and mrr. He found out that mrr increases with increase in open voltage but TWR and surface roughness increases with increase in open circuit voltage. I. Puertas[5] had analyzed the influence of current intensity, pulse time and duty cycle over output responses such as S.R and MRR. In the case of Ra parameter the most influencing factor was current followed by pulse on time. In order to obtain surface finish low values to be used for current intensity and pulse on time. M. Kiyak [6] had studied the influence of EDM parameters on surface roughness for machining AISI P20 tool steel. Parameters such as current, pulse time and pulse off time are selected. It has been observed that the surface roughness increases with increase in current and pulse on time. C. J Luis [7] has conducted the study to analyze the influence of pulse time, duty cycle, voltage and flushing pressure over silicon carbide work piece. It has been seems that current and voltage has significant influence on MRR. Rao [1] conducted the 27 experiments by varying EDM parameters such as current, pulse on time and duty factor. The output responses such as S.R, MRR and hardness are assessed. Rao observed that the MRR and S.R increases with increase in current and duty factor. But when pulse on time increases MRR and surface roughness decreases. Hardness value increases as the current value increases from 5A to 10 A and then decreases as current increases from 10A to 15A. Rajmohan [8] conducted the study on the 304 stainless steel and investigated the influence of pulse on time, pulse off time, voltage and current affecting MRR. The current and pulse off time are the significant factor affecting MRR in edm. The present work is concentrated on M300 which is extremely used in aerospace, gyroscope etc.

III. EXPERIMENTAL DETAILS

In order to maximize the desirable performance measures the investigation was done in following sequences

A. Selection of work piece material and electrode material

The work piece material used for the study is M300 steel and tool material is copper tungsten. The copper tungsten was selected because it is subjected to low wear compared to copper.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

B. Identifying the EDM process parameters and fixing the levels

On the basis of the literature survey [4, 8] and previous work experience, it was concluded that the voltage, current, pulse on time has significant effect on surface roughness. The working range of process parameters selected is shown in Table I.

Table I. Experiment parameters and levels

Parameter	**Unit**	**Levels and Values 1**	**2**	**3**	**Response**
Voltage	V	80	120	160	Surface roughness
Current	A	0.5	1	1.5	
Pulse on time	μS	0.8	1.6	3.2	

C. Selection of Orthogonal array

The selection of OA is based upon the number of factors and levels corresponding to each of the factors. The degree of freedom for each of the factor is 2 and therefore the total dof obtained is 6 (i.e., 3x2=6).The selected OA degree of freedom must be greater than the total dof of all the factors. The dof for OA is 8(i.e., number of experiments-1). Hence L9 is considered for the study. The selected OA is presented on the following Table II.

Table II. Experiment layout using L9

Run	Parameters: Voltage	Current	Pulse on time
1	80	0.5	0.8
2	80	1	1.6
3	80	1.5	3.2
4	120	0.5	1.6
5	120	1	3.2
6	120	1.5	0.8
7	160	0.5	3.2
8	160	1	0.8
9	160	1.5	1.6

D. Conduct the experiments as per the selected OA

The cylindrical work piece of maraging steel M300 material of 25 mm diameter and thickness of 1.8mm are selected for the experiments. The electrode used for the experiment is the copper tungsten of 10 mm in diameter which is shown in Figure 1.The Agie Charmilles edm machine of Roboform 200 is used for the study of edm parameters affecting the surface roughness. The work piece is mounted on the fixture which has the same dimension of the samples. EDM-30 is used as die-electric fluid.

Fig.1: Work piece and Electrode

E. Record the performance measures

The machining performance was evaluated surface roughness. The surface roughness is referred as roughness or smoothness of a given surface. In this study, it was measured in terms of roughness average (Ra), which is an arithmetic average of peaks and valleys of a work piece surface measured from the centerline of evaluation length. It was measured by TALYSURF CLI 2000 surface roughness tester. The machining performance measures SR were evaluated for all the conditions and presented in Table III.

Table III. Performance measure of EDM

Run	Parameters: Voltage	Current	Pulse on time	S.R (Ra)
1	80	0.5	0.8	0.147
2	80	1	1.6	0.193
3	80	1.5	3.2	0.210
4	120	0.5	1.6	0.106
5	120	1	3.2	0.220
6	120	1.5	0.8	1.400
7	160	0.5	3.2	0.135
8	160	1	0.8	1.73
9	160	1.5	1.6	0.156

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

In this experiment the desired characteristic for the surface roughness is lower the better.

F. Find the optimum condition for the Surface roughness

Taguchi method of design of experiment is to reduce the number of experiment, yet cover the entire parameter space with the help of special design of orthogonal array. The results of such experiments are then transformed into signal to noise ratio (S/N) ratio to measure the deviation of the performance characteristics from the desired values. The performance characteristic for the surface roughness is chosen as the smaller the best.

$$S/N = -10\log\left[\frac{1}{n}\sum_{i=1}^{n}\left(y_i^{\,2}\right)\right]$$

Where n is the number of measurements in a trial and yi is the measured value in the trial.

IV. RESULTS AND DISCUSSIONS

After the experimental procedure, response factors surface roughness of machined surface was calculated from the observed data. Then a statistical analysis was performed using MINITAB 16 software and the signal to noise ratio values of surface roughness are tabulated in Table IV. The S/N ratio could be the effective representation to find the significant parameter by evaluating the minimum variance. By applying the above equation, the S/N ratio values of machining performance for each experiment of L9 OA can be calculated for the SR values.

Table IV. S/N ratio for surface roughness

Run	Parameters			S.R	S/N ratio for Surface roughness (db)
	V	I	µs	(Ra)	
1	80	0.5	0.8	0.147	16.6537
2	80	1	1.6	0.193	14.2889
3	80	1.5	3.2	0.210	13.5556
4	120	0.5	1.6	0.106	19.4449
5	120	1	3.2	0.187	13.15`5
6	120	1.5	0.8	1.400	-2.9226
7	160	0.5	3.2	0.135	17.3420
8	160	1	0.8	1.73	-4.7609
9	160	1.5	1.6	0.156	16.1375

The selected three parameters have a different influence on the machining performances. The significant parameters are found to by the analysis of variance (ANOVA) and the optimal machining parameters are obtained using main effect plots. From the calculation of main effects for each level of factors, the main effect values are presentation in Table V.

Table V. Response table for signal to noise ratios

Level	A	B	C
1	14.833	17.814	2.990
2	9.891	7.560	16.624
3	9.573	8.924	14.683
Optimum	1	1	2
Delta	5.260	10.254	13.634
Rank	3	2	1

The main effect values are plotted in Figure. 2 for the voltage, current and pulse on time respectively. The main effects plot shows the influence of each level having major contribution are selected from the plot and are the optimized levels for the particular factor.

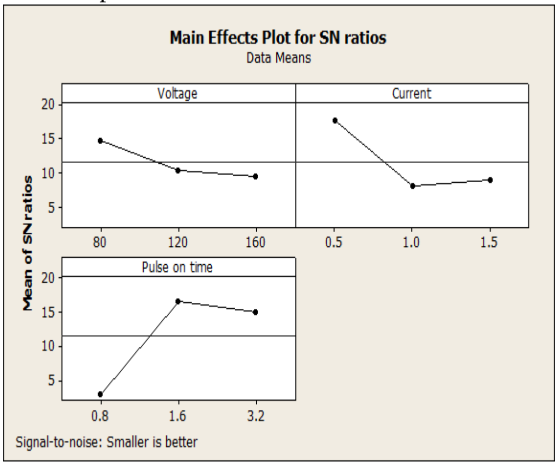

Fig.1: SN ratio plot for surface roughness

The ANOVA is a statistically based, objective decision making tool for detecting any difference in the average performance of groups of items tested. ANOVA helps in formally testing the significance of all main factors and their interactions by comparing the mean square against an estimate of experiment at specific confidence levels. The P value reports the significance level percentage (%) is defined as the significance rate of process parameters on the output responses. It can be observed from Table VI.that voltage, current and pulse on time affects surface roughness by 7.52, 27.50 and 52.58 respectively.

Table VI. ANOVA result for surface roughness

Source	DOF	Sum of square	Mean sum of squares	F ratio	% of contribt-i on
Voltage	2	52.19	26.09	0.77	8.2
Current	2	186.03	93.01	2.74	29.41
Pulse On time	2	326.37	163.18	4.81	51.54

Error	2	67.85	33.92		10.7
Total	8	632.43			

The optimal level of the machining parameters is the level with the lowest S/N ratio value. Based on the analysis of S/N ratio, the optimal machining performance for the surface roughness is obtained at a voltage of 80V (level 1), current of 0.5A (level 1) and pulse on time of 1.6µs (level 2).

V. CONCLUSION

In this study the influence of the process parameters and optimization of M300 steel in the die sinking EDM was studied by using Taguchi L9 orthogonal array method. From the results, it was found that voltage, current and pulse on time has been found to play significant role in EDM operations. Also it was found that the for the lower surface roughness the optimum levels for voltage, current and pulse on time is A1-B1-C2.The level of importance of the machining parameters and their individual contributions on the surface roughness is determined by using analysis of variance (ANOVA). The parameter current was fond to be the most effective on the surface roughness followed by the voltage and pulse on time.

REFERENCES

[1] G. Krishna Mohana Rao,"Influence of the machining parameters on electric discharging machining of maraging steels," Proceeding of the world congress of engineering, vol.II, pp.978-988, July 2008.

[2] A. M. Nikalje, "Influence of parameters and optimization of EDM performance measures on MDN 300 steel using Taguchi method," International journal of manufacturing technology, vol.69, pp. 41-49,April 2013.

[3] J. C. Rebolo,"An experimental study on electro discharge machining and polishing of high strength copper-berlliyum alloys, "Journals of material processing technology,vol.103, pp. 389-397,Dec 2000.

[4] S. H. Lee," Study of the effect of machining parameters on the machining characteristics in electrical discharge machining of tungsten carbide," Journal of material processing technology,vol.115, pp. 344-358,Sep 2001.

[5] I. Peuratos,"Analysis of the influence of EDM parameters on the surface quality, MRR and EW of WC-Co," Journals of material processing technology,vol.153,pp.1026-1032,2004.

[6] M. Kiyak, "Examination of machining parameter on surface roughness in EDM of tool steel," Journals of material processing technology, vol.191, pp.141-144, 2007.

[7] C. J Luis," Material removal rate and electrode wear study on the EDM of silicon carbide," Journals of material processing technology,vol.164,pp.889-896,2005.

[8] Rajmohan T." Optimization of machining parameters in EDM of 304 stainless steel," International conference on modeling, Procedia engineering, vol.38, pp.1030-1036, 2012.

AUTHOR'S PROFILE

Deepu P. Nair: P.G Scholar, Production and Industrial Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

Dr. Binu C. Yeldose: Professor, Production and Industrial Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

Dr. Cibu K. Varghese: Associate Professor, Production and Industrial Engineering, Mar Athanasius College of Engineering, Kothamangalam, Kerala, India