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Effect of machining parameters on MRR and TWR in EDM of AISI P-20 tool steel using L_{18} orthogonal Array

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Abstract — *Electrical discharge machining (EDM) is a non-traditional manufacturing technique that has been widely used in the production of precision engineering components throughout the world in recent years. The most important performance measure in EDM is the MRR and TWR. In this study, the experimental studies were conducted under varying pulse on time, current and electrode diameter. The numbers of experiments were conducted by L_{18} orthogonal array of Taguchi's methodology. Signal-to-noise (S/N) ratio was employed to determine the most influencing levels of parameters that affect the MRR and TWR in the EDM of AISI P20 tool steel. To validate the study, confirmation experiment has been carried out at optimum set of parameters and predicted results have been found to be in good agreement with experimental findings. ANOVA find the influence of parameters in the experiments.*

Keywords*- EDM, Taguchi method, MRR, TWR, ANOVA*

I. INTRODUCTION

Electric Discharge Machining (EDM) technology has Unconventional Machining technique and become an important manufacturing process. In today technology there is a heavy demand of the advanced and difficult to machine materials, such as high strength thermal resistant alloys or even some ceramics materials any hardened steels. EDM is a thermoelectric process that erosion of material from the work-piece due to series of discrete sparks between work piece and electrode separated by a thin film of dielectric fluid medium **[1]**. Electric Discharge Machining (EDM) is an essential operation in several manufacturing in several industries, which gives importance to variety, precision and accuracy. Several researchers have attempted to improve the performance characteristics namely the material removal rate, surface roughness, delimitation factor, residual stress. But the full potential utilization of this process is not completely solved because of its complex and stochastic nature and more number of variables involved in this operation.

Khan [2] investigated electrode wear and material removal rate during EDM of aluminium and mild steel using copper and brass electrodes and concluded that electrode wear is more during machining along their cross section than along its length. Copper electrode wear less as compare to brass electrode because the thermal conductivity of copper is higher than brass. Electrode wear is more during machining of mild steel than aluminium. EW is increases with increases of current and Gap voltage and MRR is sharply increases with increases of current. **Malhotra and Rani [3]** investigated the control parameters for surface roughness inside flushing from a die sink EDM and concluded that experimental investigation on the effect of current, pulse on time, spark Gap, voltage, duty cycle and flushing pressure on surface roughness wear rate when using EDM on EN-31 Die Steel using copper as electrode, and find current and pulse on time have maximum influence on surface roughness. **Cydus [4]** developed a model electrode wear (EW) and recast layer (WLT) through response surface methodology in a die sinking EDM process. For this purpose a central composite rotatable design (CCRD) involving three variables with five levels employed to establish a mathematical model between input parameters and responses (EW & WLT) and conclude that Pulse current was found the most important factor effecting the both EW and WLT, while pulse off-time has no significant effect on both responses. **Bhattacharya et al [5]** performed an experiment to see the Performance of ZrB2–Cu composite as an EDM electrode as the low wear resistance of electrodes like Cu, Cu alloys and graphite is a major problem for electrical discharge machining (EDM) operation. In this research they made an attempt to develop a metal matrix composite (ZrB2–Cu) to get an optimum combination of wear resistance, electrical and thermal conductivity. For different process parameters of EDM during machining of mild steel. The ZrB2–40 wt% Cu composite showed more metal removal rate (MRR) with less tool wear rate (TWR) than commonly used Cu tool. But the diametric overcut and average surface roughness are found to be lessening case of Cu tool than composite tool. **Bao et al. [6]** Material removal and surface damage of Ti3SiC2 ceramic during electrical discharge machining (EDM) were investigated. As increasing in the discharge current, working voltage, but increased declaratively with pulse duration. Micro cracks in the surface and loose grains in the subsurface resulted from thermal shock were confirmed, and the surface damage in Ti3SiC2 ceramic led to a degradation of both strength and reliability.. **Kiyak et al. [7]**the experimental study of the EDM of 40CrMnNiMo864 tool steel (AISI P20) tool steel they Examine machining parameters on surface roughness in EDM of tool steel **George et al [8]** optimize the machining parameters in the EDM machining of C–C composite using Taguchi method. The process variables affects electrode wear rate and MRR, according to their relative significance, are *V*g, *I*p and Ton, respectively.

In the past, manufacturers have tried to enumerate the control parameters to improve machining quality. Literature review indicates that a number of input parameters affect the quality of machined component in die sink EDM. In this study, the effect of machining parameters and their levels of significance on the material removal rate and electrode wear were statistically evaluated by using analysis of variance (ANOVA). Experiments were conducted under different machining parameters namely, pulse on time, electrode diameter and discharge current. The settings of machining parameters were determined using Taguchi Method.

II. EXPERIMENTAL WORK

The experiments were performed on a ELECTRONICA- ELECTRA PLUS PS 50 ZNC EDM machine tool. The composition of AISI P-20 tool steel work material used for experimentation in this work is a given in Table 1. U shaped Copper electrode with 4 and 6 mm diameter was used in the experiments. The parameters, selected for various settings of pulse on time, electrode diameter and discharge current were used in the experiments Table 2. The photo graphic view of the machining zone has been shown in figure 1.

Table 1 Composition of AISI P-20 steel

Elements	C	Si	Mn	Cu	Cr	Mo	P	S
Weights %	0.40	0.40	1.0	0.25	1.20	0.35	0.03	0.03

2.1 Taguchi Method

Taguchi method has become a power full tool for improving productivity during research and development so that high quality products can be produced quickly and at low cost. This is in contrast to the traditional method for controlling the source of the variation (variation of environmental conditions and other noise factors) at low cost [9].

Figure 1Experimental setup

Figure 2 Machined work-piece

To evaluate the effects of machining parameters of EDM process in terms of machining Performance characteristics such as MRR and EW a Taguchi method used here to model the EDM process. In this study, Taguchi method, a powerful tool for parameter design of performance characteristics, for the purpose of designing and improving the product quality. In the Taguchi method, process parameters which influence the products are separated into two main groups: control factors and noise factors. The control factors are used to select the best conditions for stability in design or manufacturing process, whereas the noise factors denote all factors that cause variation.

According to Taguchi based technique, the characteristic that the smaller value indicates the better machining performance, such as MRR is addressed larger-the-better and EW is addressed as smaller-the-better type of problem. The S/N Ratio, i.e. η, can be calculated as shown below:

$$S/N \text{ ratio} = \eta = -10\log\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_{MRR}^{2}}\right) \quad (1)$$

$$S/N \text{ ratio} = \eta = -10\log\left(\frac{1}{n}\sum_{i=1}^{n} y_{EWR}^{2}\right) (2)$$

The process parameters chosen for experiments are: pulse on time (T_{on}), peak current (I_p) and electrode diameter (D) while the response function are MRR and EW. According to the capability of commercial EDM machine available and general recommendations of machining conditions for AISI P-20 tool steel the range and the numbers of levels of the parameters are selected as given Table 2.

Table 2 Setting of levels for process parameters

Parameters	Unit	Symbol	Level		
			I	II	III
Electrode Diameter	mm	D	4	6	-
Pulse on time	µs	T_{on}	50	500	1000
Discharge current	A	Ip	1	3	5

***Table 3* Experimental design using L_{18} orthogonal array**

Run	Dia (mm)	Ip (A)	Ton (µs)	MRR (g/min)	S/N ratio (db)	TWR (g/min)	S/N ratio (db)
1.	4	1	50	0.0360	-28.873	0.000017	95.391
2.	4	1	500	0.4360	-27.210	0.000033	89.629
3.	4	1	1000	0.3140	-10.061	0.000025	92.041
4.	4	3	50	0.7971	-1.9697	0.000018	94.894
5.	4	3	500	1.3000	2.2788	0.000025	92.041
6.	4	3	1000	1.8890	5.5246	0.000135	77.393
7.	4	5	50	1.5580	3.8513	0.000150	76.478
8.	4	5	500	1.9720	5.8981	0.000433	67.270
9.	4	5	1000	2.9730	9.4638	0.000300	70.457
10.	6	1	50	0.0700	-23.098	0.000010	100.00
11.	6	1	500	0.2200	-13.151	0.000020	93.979
12.	6	1	1000	0.8400	-1.5144	0.000005	106.020
13.	6	3	50	0.5738	-4.8247	0.000065	83.741
14.	6	3	500	1.5120	3.5910	0.000150	76.478
15.	6	3	1000	1.9000	5.5750	0.000140	77.077
16.	6	5	50	1.8776	5.4720	0.000130	77.721
17.	6	5	500	2.5290	8.0589	0.000170	75.391
18.	6	5	1000	3.6730	11.3004	0.000185	74.656

III. RESULT AND DISCUSSION

This phase of the design of experiment process is to analyze and interpret the experimental results to improve the performance characteristics of the EDM process. This approach is used in a simplified way to subjectively point out column which has large influence on the response. The some data associated with first level, second level and third level is noted that and difference of largest and smallest of the three levels represents "delta". The magnitudes of differences are compared to each other, to find out the relatively strong control factors. Table 4 and 5 show the result of this method. According this method, the priority level of significant parameters, for performance characteristic MRR and TWR are as follows: Ip, Ton and D and Ip, Ton and D respectively.

Table 4 S/N ratio response table for MRR

Level	Diameter	Current	Pulse on time
1	-2.3443	-13.9849	-8.2405
2	1.6958	1.6958	-0.0891
3	-	7.3408	3.3814
Delta	1.3897	21.3257	11.6219
Rank	3	1	2

The main effect plot for MRR and EW shown Figure 3 and Figure 4. Analysis of the result, leads the conclusion the factors at level Electrode Diameter (Level 2), Ip (Level 3) and Ton (Level 3) gives the maximum MRR. Similarly, it recommended from figure 5, use the factors at level Electrode Diameter (Level 1), Ip (Level 3) and Ton (Level 2) for minimization of Tool wear rate.

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Table 5 S/N ratio response table for EW

Level	Diameter	Current	Pulse on time
1	83.96	96.18	88.04
2	85.01	83.60	82.46
3	-	73.66	82.94
Delta	1.05	22.51	5.57
Rank	3	1	2

By statistically there is a evaluation tool these are provides a results at some confidence level as to whether results estimates are significantly different. A better feel for the relative effect of the different machining parameters on the MRR and EW was obtained by decomposition of variances, which is called analysis of variance [10]. The results of ANOVA for the machining outputs are presented in Tables 6 and Table 7. Larger F-value indicates that the variation of the process parameter makes a big change on the performance characteristics. For this experimental study confidence level equals 95% and α risk equal to 0.05 is chosen.

Table 6 Analysis of Variance for Mean data for MRR

Parameters	DF	SS	Adj SS	V	F-ratio	P
D	1	8.69	8.69	8.691	0.70	0.451
Ip	2	1465.08	1465.08	732.540	58.74	**0.001**
Ton	2	427.12	427.12	213.558	17.13	**0.011**
D × Ip	2	8.65	8.65	4.325	0.35	0.726
D × Ton	2	13.91	13.91	6.953	0.56	0.611
Ip × Ton	4	142.03	142.03	35.508	2.85	0.168
Residual Error	4	49.88	49.88	12.470		
Total	17	2115.36				

Table 7 Analysis of Variance for Mean data for EW

Parameters	DF	SS	Adj SS	V	F-ratio	P
D	1	4.98	4.98	4.981	0.41	0.559
Ip	2	1527.63	1527.63	763.817	62.24	**0.001**
Ton	2	114.52	114.52	57.259	4.67	0.090
D × Ip	2	235.15	235.15	117.577	9.58	0.030
D × Ton	2	54.47	54.47	27.237	2.22	0.225
Ip × Ton	4	128.85	128.85	32.212	2.62	0.186
Residual Error	4	49.09	49.09	12.273		
Total	17	2114.70				

For the MRR and EW the F-ratios from the tabulated value are as follows: $F_{0.05;\,4;\,17} = 2.96$. According to the above statement, parameters Ton, Ip are significant factors and D are insignificant factors and factors Ip are significant factor. Ton and D are insignificant factors remaining factors (columns) are estimates of error variance respectively.

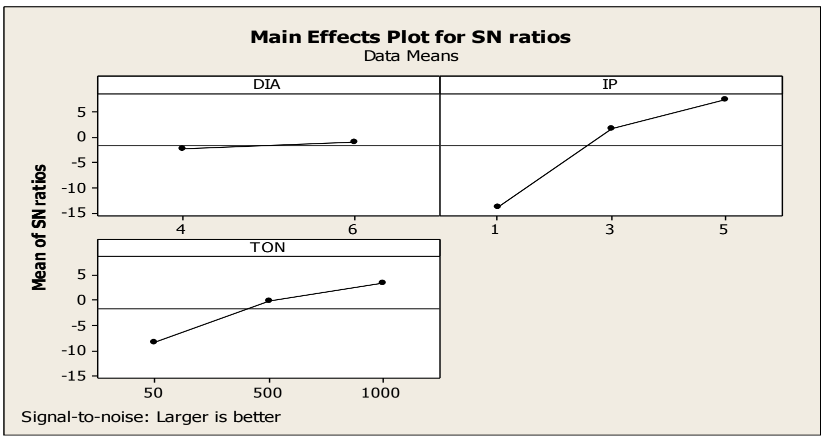

Figure 3 Main effect plot of MRR

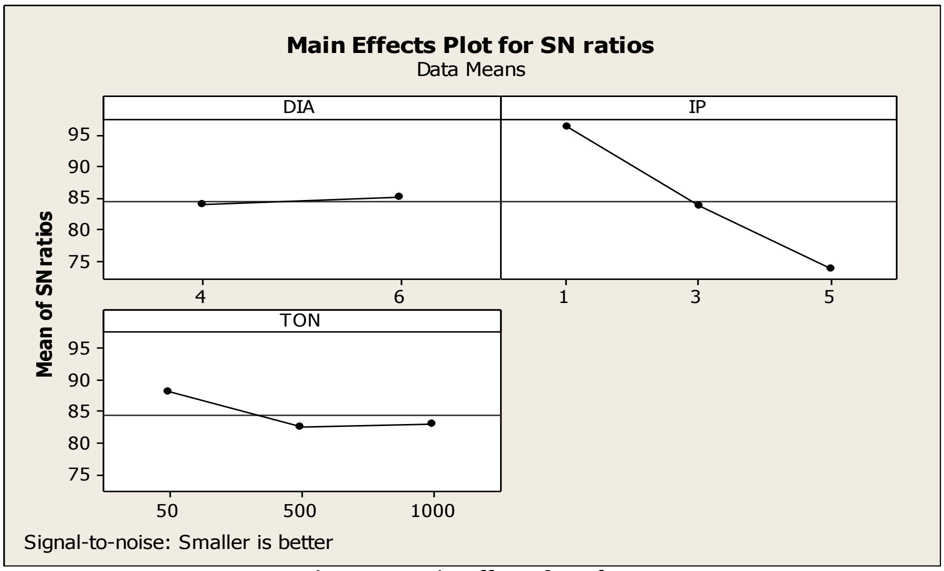

Figure 4 Main effect plot of EW

IV. CONFIRMATION EXPERIMENTS

The last stage experiments after selecting optimal parameters by the Taguchi's methodis to be predict to verifying improvement of machining performance characteristics and finding the optimal machining parameters [9]. The predicted S/N ratio using the optimal levels of the machining parameters can be calculated with the help of following prediction equation:

$$\eta_{opt} = \eta_m + \sum_{j=1}^{k} (\eta_j - \eta_m)$$

Here, η_{opt} is the predicted optimal S/N ratio, η_m is the total mean of the S/N ratios, η_j is the mean S/N ratio of at optimal levels and k is the number of main design parameters that affect the quality characteristics.

Table 6 Results of confirmation experiments for MRR and EW

Response	Parameters	D (mm)	I_p (A)	T_{on} (µs)	Predicted Value	Experimental Value
MRR	Level	2	3	3	2.808	2.86
	values	6	5	1000		
EW	Level	1	3	2	0.000421	0.000433
	values	4	5	500		

V. CONCLUSION

The effect of die sinking EDM process parameters in terms of Material removal rate and electrode wear rate of AISI P-20 tool steel using Taguchi's L_{18} orthogonal array. It is observed that the S/N Ratio with Taguchi's parameters design is a simple, systematic, reliable and more efficient tool for optimizing performance characteristics of Die sinking EDM process parameters. Based on the experimental results and analysis, the following conclusions can be drawn:

- For maximum material removal rate and minimum electrode wear optimal combination of process parameters are electrode diameter (6mm), discharge current (5A), pulse on time (1000µs) and electrode diameter (4mm), discharge current (5A), pulse on time (500µs) respectively.
- Discharge current and pulse on time were found to be the significant parameters. Increasing pulse on time and discharge current leads to high productivity of machining response as material removal rate.
- Pulse on time is significant parameter leads to low quality of the electrode wear.
- Actual gain 2.86 for MRR is very close to the predicted 2.808. It shows very good reproducibility and confirms the success of the experiments.

REFERENCES

[1] K. H. HO, S. T. Newman, "State of the art of Electrical discharge machining (EDM)", Int. J. of Machine Tools and Manufacture, vol. 43, pp. 1287-1300, 2003.

[2] A.A. Khan, "Electrode wear and material removal rate during EDM of aluminium and mild steel using copper and brass electrodes," International Journal Advance Manufacturing Technology, vol. 39, pp. 482-487, October 2008.

[3] Navdeep Malhotra, Sona Rani and Khalid sheikh, "Optimization of control parameters for surface roughness in side flushing form of die sink EDM", Journal of engineering research and studies, pp 228-233, 2011.

[4] Ulyas Caydas, Ahmet Hascalik, "Modeling and analysis of electrode wear and white layer thickness in die-sinking EDM process through response surface methodology" Int. J. Adv. Manuf. Technol, vol. 38, pp. 1148-1156, 2008.

[5] A.K. Khanra, B.R. Sarkar, B. Bhattacharya, L.C. Pathak and M.M. Godkhindi, "Performance of ZrB2–Cu composite as an EDM electrode," Journal of Materials Processing Technology, vol. 183, pp. 122-126, 2007.

[6] C.F. Hu, Y.C. Zhou and Y.W. Bao, " Material removal and surface damage in EDM of Ti3SiC2 ceramic", Ceramics International, Vol. 34, pp. 537-541, 2008.

[7] M. Kiyak, O. Cakir, "Examination of machining parameters on surface roughness in EDM of tool steel," Journal of Materials Processing Technology, vol. 191, pp. 141–144, 2007.

[8] P.M. George, B. K. Raghunath, L.M. Manocha and Ashish M. Warrier, "EDM machining of carbon-carbon composite a Taguchi approach," Journal of material processing technology, vol. 145, pp. 66-71, 2004.

[9] Ranjit K. Roy, Design of experiments using the Taguchi approach: 16 steps to product and process improvement, John Wiley & Sons, Inc. New York, 2001.

[10] D. C. Montgomery, Design and analysis of experiments, Wiley, New York, 2001.

