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Optimization of machining parameters of Electric Discharge Machining for 202 stainless steel

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ABSTRACT: *Electric discharge machining is used for machining of hard materials like steel. In this paper, the effect of electrical discharge machining (EDM) parameters such as pulse-on time (T_{ON}), pulse-off time (T_{OFF}), and current (I) on material removal rate (MRR) in 202 stainless steel was studied. The experiments are carried out as per design of experiments approach using L_{27} orthogonal array. The results were analyzed using analysis of variance and response graphs. From this study, it is found that different combinations of EDM process parameters are required to achieve higher MRR and greater surface finish. Signal to noise ratio (S/N) and analysis of variance (ANOVA) is used to analyze the effect of the parameters on MRR and also to identify the optimum cutting parameters. The contribution of each cutting parameter towards the MRR is also identified.*

Keyword: *Material Removal Rate, Taguchi method, 202 stainless steel.*

I. INTRODUCTION

Electrical discharge machine (EDM) technology is increasingly being used in tool, die and mould making industries, for machining of heat treated tool steels and advanced materials (super alloys, ceramics, and metal matrix composites) requiring high precision, complex shapes and high surface finish. Traditional machining technique is often based on the material removal using tool material harder than the work material and is unable to machine them economically. An electrical discharge machining (EDM) is based on the eroding effect of an electric spark on both the electrodes used. Electrical discharge machining (EDM) actually is a process of utilizing the removal phenomenon of electrical-discharge in dielectric. Therefore, the electrode plays an important role, which affects the material removal rate and the tool wear rate. In non-traditional processing electrical discharge machining (EDM) has tremendous potential on account of the versatility of its application and it is except to be successfully and commercial utilized in modern industries (Habib,2009). In the EDM process to obtain the maximum material removal with minimum tool wear, the work material and tool must be set at positive and negative electrode (Che Haron et al.,2008). Electric discharge machining one of the most popular non-traditional material removals process and has become basic machining method for the manufacturing industries of aerospace, automotive, nuclear and medical . The source of energy used is amplified light, ionized material and high voltage. Examples are laser beam machining, ion beam machining, and plasma arc machining and electric discharge machining (Kiyak et al, 2007).

II. EXPERIMENTATION

Electric discharge machining of 202 stainless steel using different parameters:

The objective of the study is to evaluate the main effects of current, pulse on time, and pulse off time on the material removal rate (MRR) of the Following set of electrical of EDM process are expected to affect the resultant machining objective functions are given in the Table 2.1.

Table 2.1: Electrical and non-electrical parameters of EDM process

S No.	Electrical Parameters	Non-electrical Parameters
1	Peak current	Type of dielectric medium
2	Pulse-on time	Flushing Pressure
3	Pulse-off time	Volume fraction

After pilot experimentation the number of factors and the number of levels have been selected for the electrical parameters. The lists of factors studied with their levels are given in the Table 2.2 range of parameters available and used for experimentation.

Table 2.2: Range of parameters available and used for experimentation

SNo.	Machining parameter	Range	Used For Level 1	Used For Level 2	Used For Level 3
1	Current	0-30 A	3	9	15
2	Pulse-on time	0.5-2000µs	500	700	900
3	Pulse-off time	0.5-2000µs	500	700	900

The number of factors and their interactions and level for factors determine the total degree of freedom required for the entire experimentation.

Table 2.3: Orthogonal arrays experiments

S.No.	CURRENT	T-ON	T-OFF
1	3	500	500
2	3	500	700
3	3	500	900
4	3	700	500
5	3	700	700
6	3	700	900
7	3	900	500
8	3	900	700
9	3	900	900
10	9	500	500
11	9	500	700
12	9	500	900
13	9	700	500
14	9	700	700
15	9	700	900
16	9	900	500
17	9	900	700
18	9	900	900
19	15	500	500
20	15	500	700
21	15	500	900
22	15	700	500
23	15	700	700
24	15	700	900
25	15	900	500
26	15	900	700
27	15	900	900

ANOVA helps us to compare variability within experimental data. ANOVA table is made with help of MINITAB 15 software. When performance varies one determines the average loss by statistically averaging the quadratic loss.

III. RESULT AND DISCUSSION

The effect of parameters i.e. pulse on time, pulse off time and current some of their interactions were evaluated using ANOVA. A confidence interval of 95% has been used for the analysis. 27 experiments were completed so as to measure Signal to Noise ratio (S/N ratio) calculated by the formula $(S/N)_{HB} = -10\ log(MSD_{HB})$. The variation data for each factor and their interactions were F-tested to find significance of each calculated by the formula $F = \frac{MS\ for\ the\ term}{MS\ for\ the\ error\ term}$. The principle of the F-test is that the larger the F value for a particular parameter, the greater the effect on the performance characteristic due to the change in that process parameter. In this work, 202 stainless steel samples were machined with non-conventional method (EDM) by varying the EDM parameters, after that the experimental outcomes are optimized using ANOVA. The following conclusions were found from the optimized results after ANOVA. These significant values are shown in table. 3.1. In order to obtain the effect for machining parameters for each level, the S/N ratio value of each fixed parameter and level in each machining performance is summed up.

Table 3.1 Experimental result with S/N ratio for material removal rate

Exp.No.	CURRENT	T-ON	T-OFF	Material Removal Rate (gms/min)	S/N Ratio
1	3	500	500	16.000	24.0824
2	3	500	700	16.000	24.0824
3	3	500	900	12.000	21.5836
4	3	700	500	12.000	21.5836
5	3	700	700	8.000	18.0618
6	3	700	900	14.000	22.9226
7	3	900	500	6.000	15.5630
8	3	900	700	10.000	20.0000
9	3	900	900	10.000	20.0000
10	9	500	500	63.333	36.0326
11	9	500	700	73.333	37.3060
12	9	500	900	83.333	38.4164
13	9	700	500	66.667	36.4782
14	9	700	700	53.333	34.5400
15	9	700	900	80.000	38.0618
16	9	900	500	30.000	29.5424
17	9	900	700	13.333	22.4988
18	9	900	900	30.000	29.5424
19	15	500	500	75.000	37.5012
20	15	500	700	115.000	41.2140

21	15	500	900	80.000	38.0618
22	15	700	500	100.000	40.0000
23	15	700	700	75.000	37.5012
24	15	700	900	125.000	41.9382
25	15	900	500	95.000	39.5545
26	15	900	700	105.000	40.4238
27	15	900	900	110.000	40.8279

From the calculation of main effects for each level of the factors, the main effects values are presented in table 3.2. The main effect values and interactions are plotted in figures for current, pulse on time and pulse off time respectively. The main effect plot shows the influence of each level of factors on the machining performance for Higher is better.

Table 3.2: Response Table for Signal to Noise Ratios

Level	CURRENT	T-ON	T-OFF
1	20.88	33.14	31.15
2	33.60	32.34	30.63
3	39.67	28.66	32.37
Delta	18.79	4.48	1.75
Rank	1	2	3

Table 3.3: Analysis of Variance for SN ratios

Source	Sum of Squares	DF	Mean Square	% of contribution
Current	153.158	2	76.5789	0.501
Pulse-on time	11.284	2	5.6420	0.010
Pulse-off time	1.437	2	0.7186	0.489
Residual error	19.358	20	0.9679	
Total	185.237	26		

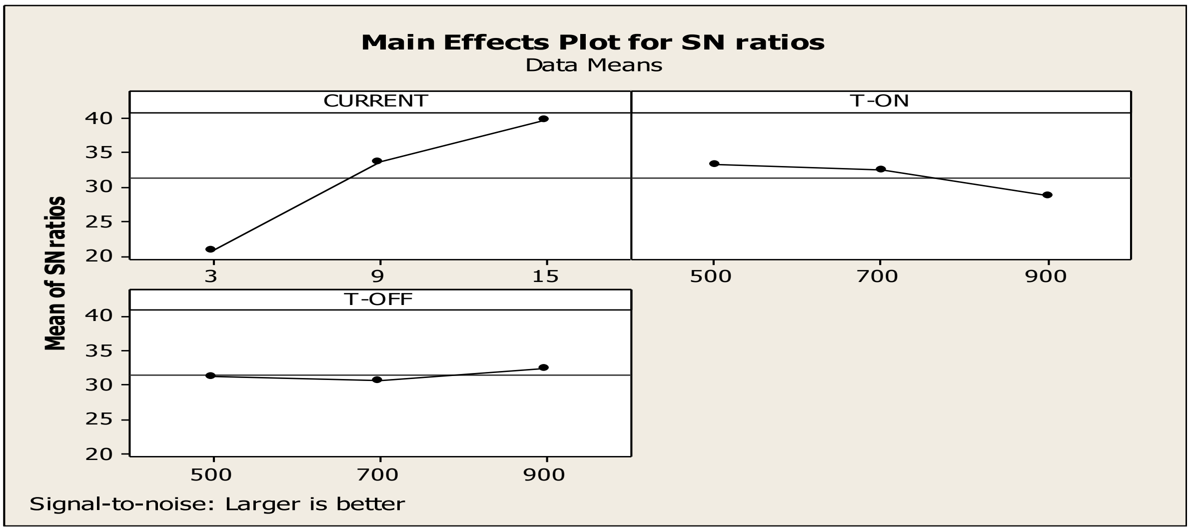

Figure 3.1: Figure Response graph for S/N ratio.

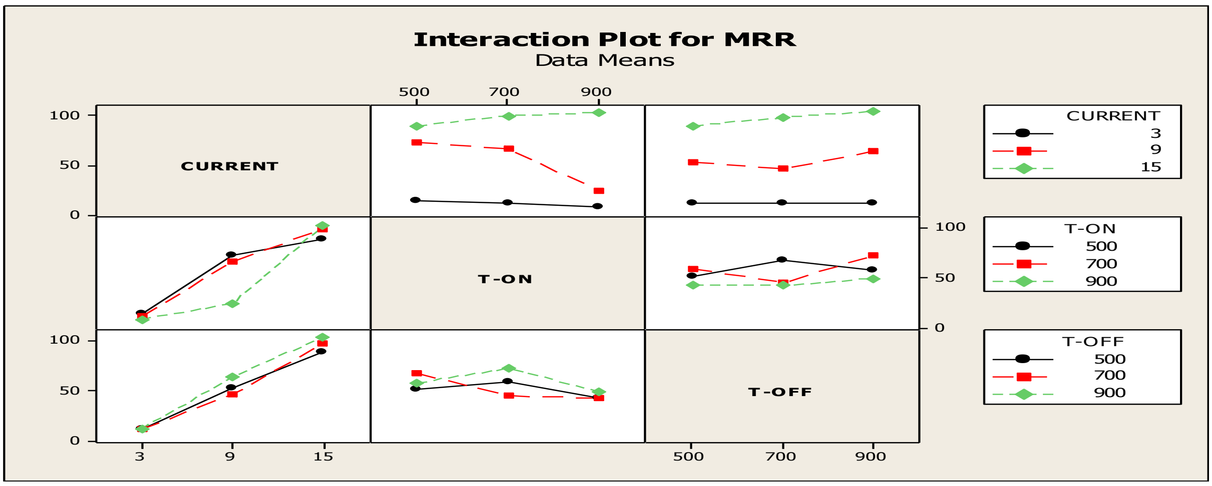

Figure 3.2: Interaction plot for S/N ratio

IV. CONCLUSION

The relative importance of the cutting parameters with respect to the pulse on time, pulse off time and current on MRR. From the analysis of the figures 3.1 & 2 and table 3.2 the optimal value for MRR is current 15A, pulse on time 500µs and pulse off time 900 µs. The according to percentage contribution data current and pulse off time are the affecting parameters.

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