Optimization of EDM process parameters for machining SS310

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Abstract - *The Electrical discharge machining is a widely used Precision manufacturing process. The EDM process involves a controlled erosion of electrically conductive materials by initiation of repetitive spark discharge between electrode tool and work piece, separated by a small gap of called as spark gap. In the current work, optimization of various process parameters to increase Material removal rate and to decrease tool wear rate is done using Taguchi's method. Coppers is used as tool materials and SS310 is used as work piece material. The process parameters selected are discharge current and spark gap. The output characteristics measured are Material Removal rate and tool wear rate. A full factorial design of experiment is used to find the influence of process parameters on Metal Removal Rate and tool wear rate. The main effects and interaction effects are plotted. From the experiments it was found that discharge current is the most influencing factors on MRR and TWR using copper as the electrode.*

***Key Words*: EDM: Electron Discharge Machining; MRR: Material Removal Rate; SS: Stainless steel; TWR: Tool Wear Rate**

1. INTRODUCTION

Electrical discharge machining (EDM) has long been the answer for high accuracy, demanding machining applications where conventional metal removal is difficult or impossible. Known by many other names, including spark machining, arc machining and (inaccurately) burning, the EDM process is conceptually very simple: an electrical current pass between an electrode and a work piece which are separated by a dielectric liquid. The dielectric fluid acts as an electrical insulator unless enough voltage is applied to bring it to its ionization point, when it becomes an electrical conductor. The resulting spark discharge erodes the work piece to form a desired final shape.

EDM has the ability to machine complex shapes in very hard metals. The most common use of EDM is in machining dies, tools and moulds made of hardened steel, tungsten carbide, high-speed steel and other work piece materials that are difficult to machine by "traditional" methods. Because of technical advances in electrode wear, accuracies and speed, EDM has replaced many of the traditional processes. Another factor contributing to the growing use of EDM is the expansion of the work envelope, particularly when it comes to heights and tapers.

1.1 EDM MACHINE

The machining is carried out on ElectronicaC-425 EDM machine. The machines setup and its specifications are given below.

Fig -1: ElectronicaC-425 EDM machine

Table -1: Specifications of the EDM machine

Work tank	600x400x280mm
Work table size	400x250mm
Table traverse	250x170mm Max
Max work piece weight	100kg
height	160m
Z axis traverse	150mm
Least counter of vernier	0.005mm
Shut height	260mm
Throat	320mm
No. of power settings	99x9
Power supply	3 phase,415v AC. 50Hz
Machine dimensions	1130x1040x1800mm
No of T slots	3
Max working current	22Amps

2. METHODOLOGY

In the present work, optimization of the input parameters for various output parameters are done using Design of Experiments. Two input parameters at three levels are considered for the experiment. The input process parameters and their levels are shown in the table below.

Table -2: Selected Input parameters with levels

Control parameters	Level1	Level 2	Level 3
Discharge current (Amp)	4	8	12
Spark gap (mm)	0.05	0.1	0.15

The experiments are conducted using full factorial design by selecting L9 orthogonal array. The experiments are designed using Taguchi's method. The experiments were conducted on die sink electric discharge machine as shown in Fig.1 which consist a work table, a servo control system and a dielectric supply system. The machine has current settings up to 22A. The experiments are conducted on AISI 310 material with dimensions are 100 mm x 25 mm x 5 mm. Work piece material properties are: Hardness (HRC)= 43-45, density (g/cm^3)= 8.16, Ultimate tensile strength (Kg/mm2) =85, Elongation % =3. The tool material used is copper with density 8.96 gm/cm3 and thermal conductivity of 386 w/mk and the machining is done with straight polarity. Spo oil is used as the dielectric fluid and the experiments were performed for a particular set of input parameters. The number of experiments and input levels are decided based on the design of experiments and the input parameters and their levels. The MRR and TWR are calculated using digital balance of accuracy 1mg and the machining time is using digital watch of accuracy 1 microsecond. The weight of the workpiece and tool before machining is recorded using the digital balance. The total machining time is also recorded using a digital watch. The input parameters and their levels are shown in Table-3.

Table -3: Process parameters selected for experimentation

Experiment No.	Discharge current (Amp)	Spark gap (mm)
1	4	0.05
2	4	0.10
3	4	0.15
4	8	0.05
5	8	0.10
6	8	0.15
7	12	0.05
8	12	0.10
9	12	0.15

The machining samples after the experimentation are marked for various process parameters. The samples after the machining process are shown in the fig.2

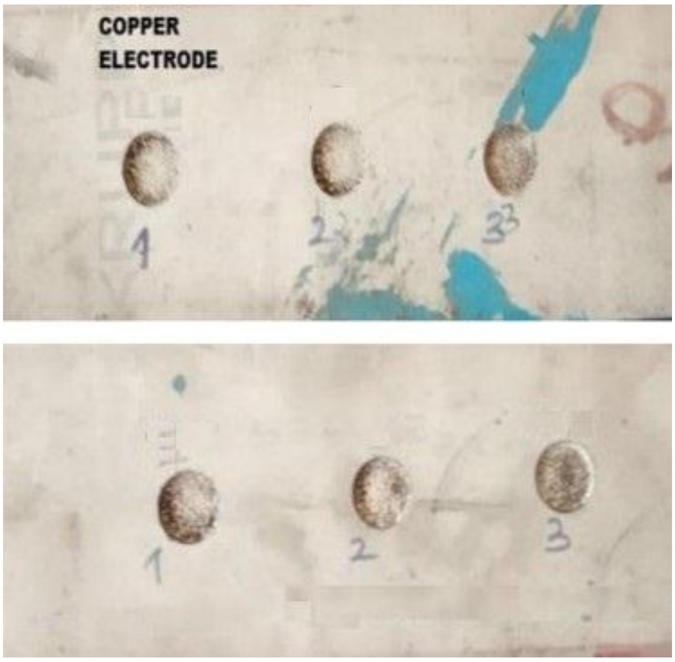

Fig -2: Samples after the experimentation

3. RESULTS AND DISCUSIONS

The output values are calculated by measuring the weight of the workpiece and tool after the machining process. The difference in the weight of the samples is used to calculate MRR and TWR. The calculated output parameters are shown in the table-4 below.

Table -4: output responses recorded after experimentation

Experiment No.	Discharge current (Amp)	Spark gap (mm)	MRR mm^3/min	TWR mm^3/min
1	4	0.05	9.677	4.650
2	4	0.10	10.193	5.580
3	4	0.15	12.534	5.391
4	8	0.05	4.313	2.391
5	8	0.10	5.298	3.597
6	8	0.15	7.373	3.256
7	12	0.05	3.124	1.584
8	12	0.10	1.801	1.291
9	12	0.15	1.481	0.859

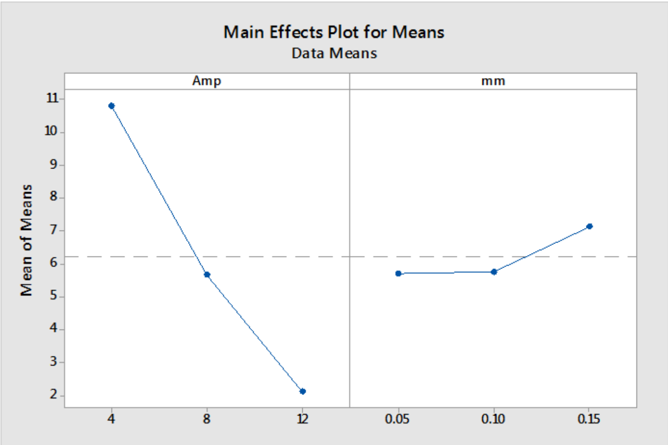

Fig -3: Main effect for means (MRR)

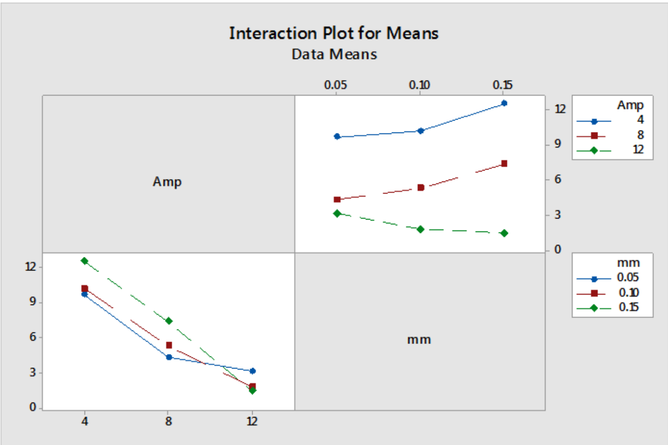

Fig -4: Interaction plot for means (MRR)

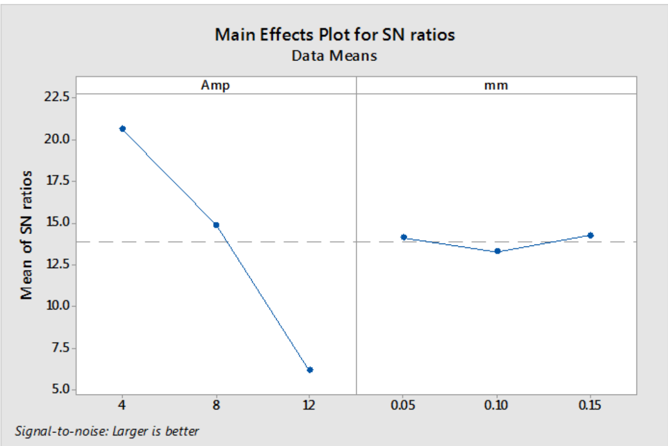

Fig -5: main effect plot for S/N ratio (MRR)

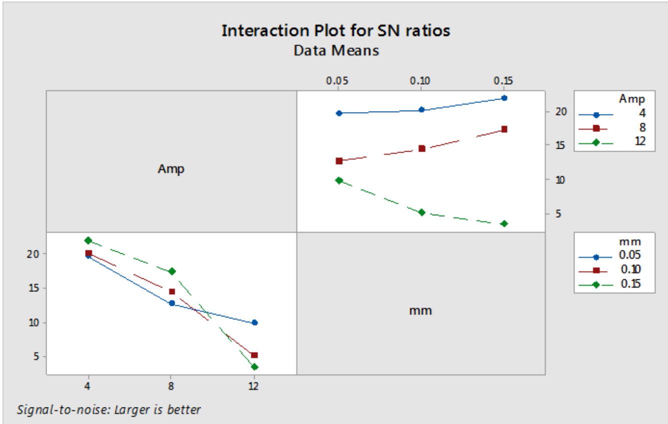

Fig -6: Interaction effect plot for S/N ratio (MRR)

Table-5: Response Table of Means for MRR

Level	Amp	mm
1	10.801	5.705
2	5.661	5.764
3	2.135	7.129
Delta	8.666	1.425
Rank	1	2

Table-6: Response Table for Signal to Noise Ratios Larger is better for MRR

Level	Amp	mm
1	20.614	14.102
2	14.844	13.253
3	6.139	14.242
Delta	14.476	0.989
Rank	1	2

Table-7: ANOVA results for MRR

Source	DF	SS	MS	F	P
Amp	2	113.9518	56.9759	30.983	0.001
mm	6	11.0335	1.8389		
Total	8	124.9854			

Table-8: Variance Components

Source	Var Comp.	% of Total	StDev
Amp	18.379	90.90	4.287
mm	1.839	9.10	1.356
Total	20.218		4.496

Table-9: Expected Mean Squares

1	Amp	1.00(2) + 3.00(1)
2	mm	1.00(2)

The following figures show the main effect and interaction effect plots for Tool wear rate

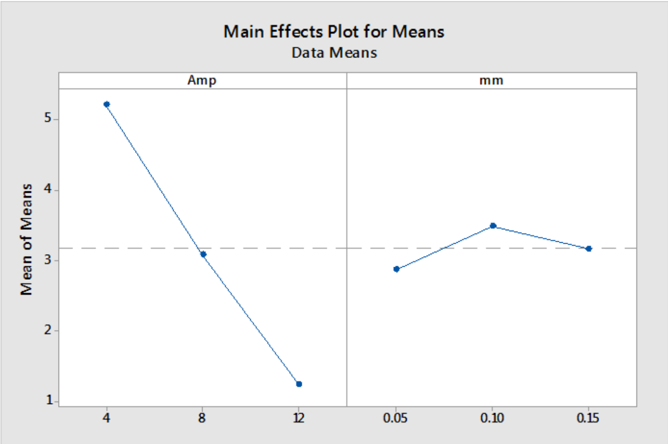

Fig -7: Main effect for means (TWR)

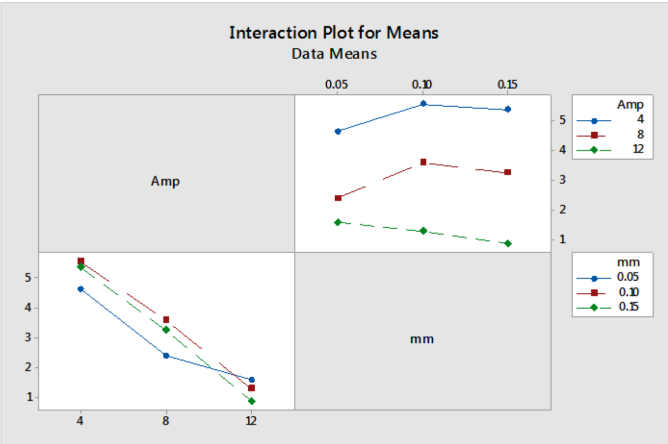

Fig -8: Interaction plot for means (TWR)

Fig -9: Main effect plot for S/N ratio (TWR)

Fig -10: Interaction effect plot for S/N ratio (TWR)

Table-10: Response Table of Means for TWR

Level	Amp	mm
1	5.207	2.875
2	3.081	3.489
3	1.245	3.169
Delta	3.962	0.614
Rank	1	2

Table-11: Response Table for Signal to Noise Ratios Smaller is better for TWR

Level	Amp	mm
1	-14.305	-8.305
2	-9.648	-9.423
3	-1.631	-7.856
Delta	12.674	1.568
Rank	1	2

Table-12: ANOVA results for MRR

Source	DF	SS	MS	F	P
Amp	2	23.5919	11.7959	46.494	0.000
mm	6	1.5222	0.2537		
Total	8	25.1141			

Table-13: Variance Components

Source	Var Comp.	% of Total	StDev
Amp	3.847	93.81	1.961
mm	0.254	6.19	0.504
Total	4.101		2.025

Table-14: Expected Mean Squares

1	Amp	1.00(2) + 3.00(1)
2	mm	1.00(2)

4. CONCLUSION

From the experimental results, the main effect plots and interaction plots are generated for Material removal rate and Tool wear rate. The S/N ratio is also calculated by considering maximum is better for Material removal rate and minimum is better for Tool wear rate. From Table-6 it can be concluded that discharge current is the most influential factor for Material removal rate and hence more discharge current is recommended. From Table-11, it can be concluded that discharge current is most influential parameter for Tool wear rate. The experimental investigations can be carried out with more number of input process parameters.

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