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Parametric Investigation and Improvement of Electrical Discharge Machining Process

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Abstract: Efficiency and quality are two significant viewpoints have become extraordinary worries in the present aggressive worldwide market. Each generation/fabricating unit, for the most part, centers around these zones in connection to the procedure just as the item is created. The electrical discharge machining (EDM) process, even now it is an accomplished procedure, wherein still, the chose parameters are frequently a long way from the most extreme, and simultaneously choosing enhancement parameters is expensive and tedious. Material Removal Rate (MRR) during the procedure has been considered as a profitability gauge with the intent to expand it. To limit surface roughness is been taken as the most significant yield parameter. These two alternate extremes in nature prerequisites have been selected to choose an ideal procedure condition (ideal parameter setting). The objective is acquired by Regression Analysis, Analysis of Variance, and Adaptive Multi-objective genetic algorithm. The model is demonstrated to be powerful; MRR and Surface Roughness improved utilizing streamlined machining parameters for aluminum Al6061.
Keywords: EDM, Composite, Genetic Algorithm, Regression, Optimization

I. INTRODUCTION

It is a non-customary electro-warm machining procedure, in which electrical vitality is utilized to create electrical flash and material expulsion happens because of warm vitality delivered by the sparkle [2]. EDM is fundamentally used to machine high quality temperature safe composites and materials hard to-machine [3]. EDM can be utilized to machine unpredictable geometries in little bunch or even on work shop premise.

II. LITERATURE REVIEW

Investigated Work material is to be electrically conductive to be machined by EDM. Utilized scientific demonstrating of white layer profundity to correspond the prevailing info parameters of the WEDM procedure, including a harsh cut pursued by a trim cut all the while, regular kick the bucket steel (M2 – solidified and toughened) was machined utilizing metal wire as cathode [1]. Researched the relationship of procedure parameters in EDM of CK-45 steel with novel device anode material, for example, Al-Cu-Si-TiC composite item utilizing powder metallurgy system [2]. displayed the use of reaction surface approach (RSM) for researching the impact of hardware shapes, for example, triangular, square, rectangular and round with size factor thought alongside different procedure parameters like release ebb and flow, beat on schedule, beat off time and instrument zone. The examination uncovered that the best apparatus shape for higher MRR and lower TWR is roundabout, trailed by triangular, rectangular and square cross-segments. set up observational relations with respect to machining

parameters and the reactions in investigating the machinability of the tempered steel AISI 304 utilizing copper terminals. The machining factors utilized were voltage, rotational speed of cathode and feed rate over the reactions MRR, EWR and SR [4]. Contemplated the impacts of EDM on Al6061-30%Al2 O3. Metal network composites. They chose top current; beat on schedule and heartbeat off time as machining parameter and material evacuation rate and apparatus wear rate as reactions [5]. Explored the impact of procedure parameters and their communications viz., voltage, beat on schedule, current and heartbeat off time on the material evacuation rate (MRR) in hardened steel (304) as work piece [7]. Sign to commotion proportion (S/N) and investigation of change (ANOVA) was utilized to break down the impact of the parameters on MRR and Taguchi technique used to locate the ideal cutting parameters [8]. contemplated the impact of working parameters like heartbeat on-schedule and heartbeat off-time for reactions, for example, Metal expulsion rate (MRR) and Tool Wear Ratio (TWR) on the EDM utilizing steel as workpice and cryogenic and noncryogenic anode of copper material [9], contemplated the impact of procedure parameters, for example, release current, beat on-schedule and heartbeat off-time for process execution criteria, for example, MRR, Tool Wear Ratio (TWR), Relative Wear Ratio (RWR) and surface harshness [10].

Figure1:- EDM Machine

III. EXPERIMENTAL STUDY

The raw material for this experiment is Al6061 composite plate of 80*50*5 mm^3 dimensions. The experimentations be there performed by operating on Electric Discharge Machine classified as (die-sinking type) ELECTRONICA -ELECTRAPLUS PS 50ZNC whose polarization on the electrode be located as negative whereas that of work piece be located as positive. In this experiment copper electrode of 10×100 mm2 used. Copper tool used having 5,6 and 7 mm solid diameter and 100 mm length. And the die-sinking type PS50 ZNC EDM machine is used. Marketable grade EDM oil (specific gravity= 0.763, freezing point= 94˚C) was used as dielectric liquid to perform the experiment. Side flushing with nozzle was recycled to flush away the eroded materials from the sparking zone. In this experiment duty cycle is kept constant 5. For a three-level factor are attempted with an overall number of 27 trials completed on die sinking EDM. The calculation of material removal rate has been done by using electronic sense of balance weight machine as displayed in Fig. For each weight measurement first soak the work piece from paper or cloth to prevent from extra weight measurement. This machine having capability measure weight up to 300 g and accurateness is 0.001 g.



Fig 2:- Al6061 before machining Fig 3:- Al6061 After machining Fig 4:- copper electrode

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Table 1: Machining process parameter and their level

Machining parameter	Symbol	Unit	Levels		
			Level 1	Level 2	Level 3
Peak current	Ip	A	4	7	10
Pulse on time	T_{on}	µs	100	150	200
Duty factor	Df	-	0.4	0.5	0.6

IV. TAGUCHI DESIGN EXPERIMENTS

STATISTICA 9.0 offers many possible ways in which an experiment can be carried out. A number of ordinary orthogonal arrays have been created to ease of experimental design. For each of these arrays can be used to design experiments to suit numerous experimental situations. A number of orthogonal arrays, such as L4, L8, L9, L12, L16, L18, L27 and so on, created for two or three level factors. STATISTICA 9.0 estimates response tables and creates main effects and S/N ratios plans intended for:

1) S/N ratios [Signal-to-noise ratios] vs. control factors.

2) Means vs. control factors.

A taguchi design or an orthogonal array method is designing the experimental procedure using different types of design like, two, three, four, five, and mixed level. In this study, a three-factor mixed level setup is chosen with an overall nine numbers of trials to be conducted and hence the OA L-27 be there selected. As a few more factors are to be added for further study with the same type of material, it was decided to utilize the L-27 setup, which in turn would reduce the number of experiments at the later stage. In addition, the comparison of the results would be simpler. The levels of experiment parameters and peak current (I), Pulse on time (T_{on}), duty factor (Df).

Table 2:- Experimental result of MRR and Surface roughness

Exp No	Input parameters			Output parameters			
	Peak current (I)	Pulse on time (T_{on})	Duty factor (Df)	MRR (mg/min) 13.35	SR (µm)	S/N Ratio of MRR(L_b)	S/N Ratio of SR (S_b)
1	4	100	0.4	19.83	6.55	13.35	16.32
2	4	150	0.5	27.91	7.86	19.83	17.90
3	4	200	0.6	13.98	7 .40	27.91	17.38
4	7	100	0.4	20.91	7.60	13.98	17.62
5	7	150	0.5	36.48	7.8	20.91	17.84
6	7	200	0.6	15.14	7.42	36.48	17.40
7	10	100	0.4	25.85	7.89	15.14	17.94
8	10	150	0.5	8.178	7.41	25.85	17.39
9	10	200	0.6	7.74	6.40	8.178	16.12
10	4	100	0.5	10.6	6.9	7.74	16.78
11	4	150	0.6	23.098	6.2	10.6	15.85
12	4	200	0.4	8.64	6.7	23.098	16.52
13	7	100	0.5	12.07	6.8	8.64	16.65
14	7	150	0.6	18.061	7.92	12.07	17.97
15	7	200	0.4	12.29	7.86	18.061	17.91
16	10	100	0.5	20	8.36	12.29	18.72
17	10	150	0.6	20.72	7.8	20	17.84
18	10	200	0.4	7.74	11.02	20.72	20.84
19	4	100	0.6	9.68	8.8	7.74	18.99
20	4	150	0.4	16.83	10.98	9.68	20.81
21	4	200	0.5	10.033	10.58	16.83	20.48
22	7	100	0.6	10.903	13.53	10.033	22.63
23	7	150	0.4	15.65	10.77	10.903	20.64
24	7	200	0.5	7.931	10.70	15.65	20.58
25	10	100	0.6	13.23	13.03	7.931	22.30
26	10	150	0.4	16.026	14.72	13.23	23.36
27	10	200	0.5	0.158	14.20	16.026	23.045

V. OPTIMIZATION OF EXPERIMENTAL RESULT OF EDM PROCESS PARAMETER BY ANOVA

In EDM experiments are conducted using Taguchi, orthogonal array, ANOVA. The effects of individual EDM process parameters on the selected quality characteristics– MRR and SR are calculated separately below. The average value and S/N ratio of the response characteristics for each variable from different level are calculated from experimental.

A. Effect on MRR

To describe the effect of various input parameters (peak current, pulse on time, duty factor) on MRR the experiments were conducted using L-27 orthogonal array

Table 3:- ANOVA table of MRR (S/N data)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
I	2	310.96	155.481	3.42	0.053
Ton	2	5.92	2.961	0.07	0.937
Df	2	58.73	29.365	0.65	0.534
Error	20	908.43	45.421		
Lack-of-Fit	2	57.45	28.727	0.61	0.555
Pure Error	18	850.97	47.276		
Total	26	1284.04			

It can be observed from the table that peak current affect the MRR maximum 24% followed by duty factor4.5 %. Pulse on time has minimum affect only 0.46% and graph is shown below.

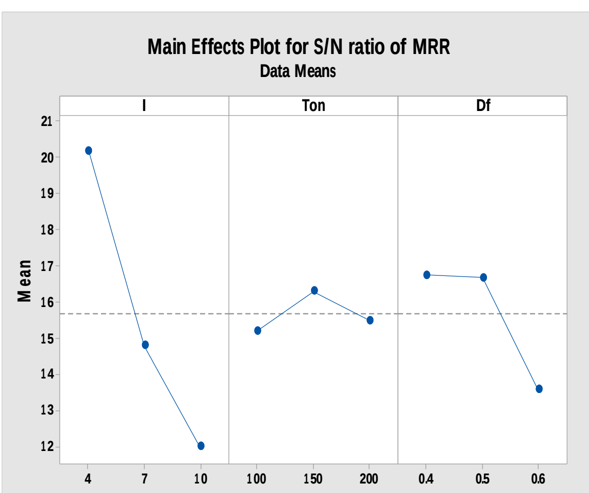

Figure 5: Effect of process parameters on MRR(S/N data)

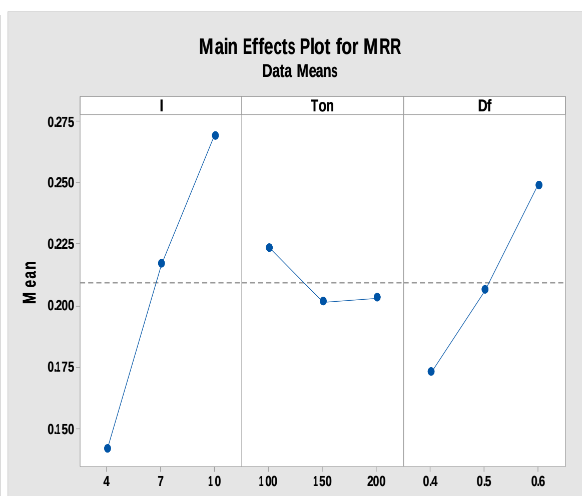

Figure 6: Effect of process parameters on MRR

B. Effect on Surface Roughness

To describe the effect of various input parameters (peak current, pulse on time, duty factor) on SR the experiments were conducted using L-27 orthogonal array. S/N ratio of optimized SR.

Table 4 ANOVA table of SR (S/N data)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
I	2	93.071	46.5353	49.42	0.000
Ton	2	15.171	7.5855	8.06	0.003
Df	2	4.445	2.2225	2.36	0.120
Error	20	18.832	0.9416		
Lack-of-Fit	2	4.173	2.0864	2.56	0.105
Pure Error	18	14.659	0.8144		
Total	26	131.519			

It can be observed from the table that peak current affect the SR maximum 70.76% followed by Pulse on time 11.54 %. Duty factor has minimum affect only 3.38% and graph is shown below.

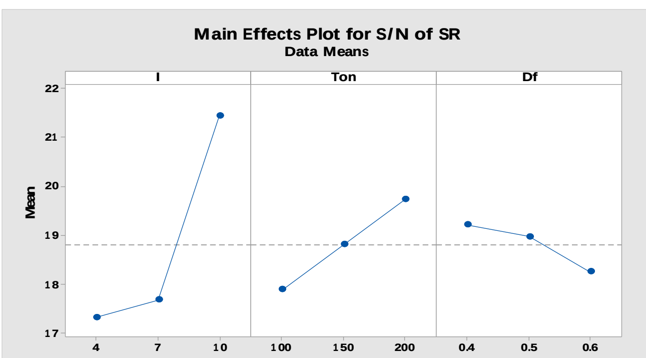

Figure 7: Effect of process parameters on SR(S/N data)

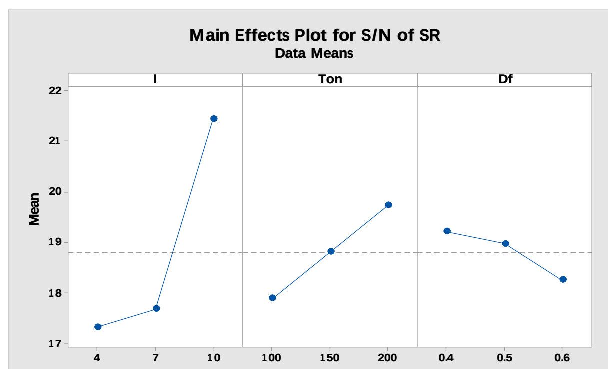

Figure 8: Effect of process parameters on SR

C. Optimization of EDM Parameters by Genetic Algorithm

In this research work the result obtained is used for modelling by using Regression. This Regression is relating the process parameters to the response and generates a Mathematical equation. By this Mathematical equation all constraints can be formulated. And further Optimization can be performed by using Evolutionary algorithms. Regression means the effect analysis of variance is a tool to point out the effect of Error on Response/ output parameters, Main factor and interaction factor. In this project "MINITAB 19" software is used for regression analysis. Here P1, P2, P3, P4 and P5 are Peak Current, Pulse on Time, Safety Factor, MRR and SR respectively.

Regression Equation

P4(MRR) = 0.349 - 0.00344 P1 - 0.001711 P2 + 0.282 P3 ---(1)

Regression Equation

P5 = 7.65 + 0.349 P1 + 0.0031 P2 - 3.11 P3 -- (2)

Table 5:- optimized candidate point

Candidate Points	Candidate Point 1	Candidate Point 2	Candidate Point 3
P1 - WB_Ip	2	2	2
P2 - WB_Ton	59.3	59.5	59.6
P3 - WB_Df	0.78	0.78	0.78
P4 - WB_MRR	0.46062	0.46028	0.4601
P5 - WB_SR	6.106	6.1067	6.107

Table 6:- Comparison of Result

Optimization Method	Peak current (Ip) (amp)	Pulse on time (T_{on}) (sec)	Duty factor (Df)	MRR (mg/min)	SR (µm)
ANOVA	4	100	0.6	0.41	0.7
AMOGA	2	59.3	0.78	0.46062	6.106.

VI. CONCLUSION

In this investigational experiment on EDM to know the effect of machining outputs taken for consideration are material removal rate and surface roughness of the Al6061 work piece using the copper tool with side flushing method have been investigated. Both these outputs are important in industrial applications. The conduction of experiment depends upon various parameters settings such as peak current (I), pulse on time (Ton) and Duty factor (Df) have been selected. Based on L-27 orthogonal array by taguchi design was conducted and Minitab 18 software package was used for analysis of the experiment. The results on outputs are to some extent be authenticated. The following points conclude the experiment are:

A. From the results of MRR we conclude that the peak current is most significant or influencing factor then pulse on time and at last is voltage on the given input. MRR increased linearly with some extent of current and increases and decreases slightly with Pulse on time.

B. In case of surface roughness the voltage is the effective parameter after that current and pulse on time are less effective on machined work piece.

C. For optimizing the MRR and SR lower current and pulse on time is required whereas duty factor should be more.

D. AMOGA provides better solution for the design space created.

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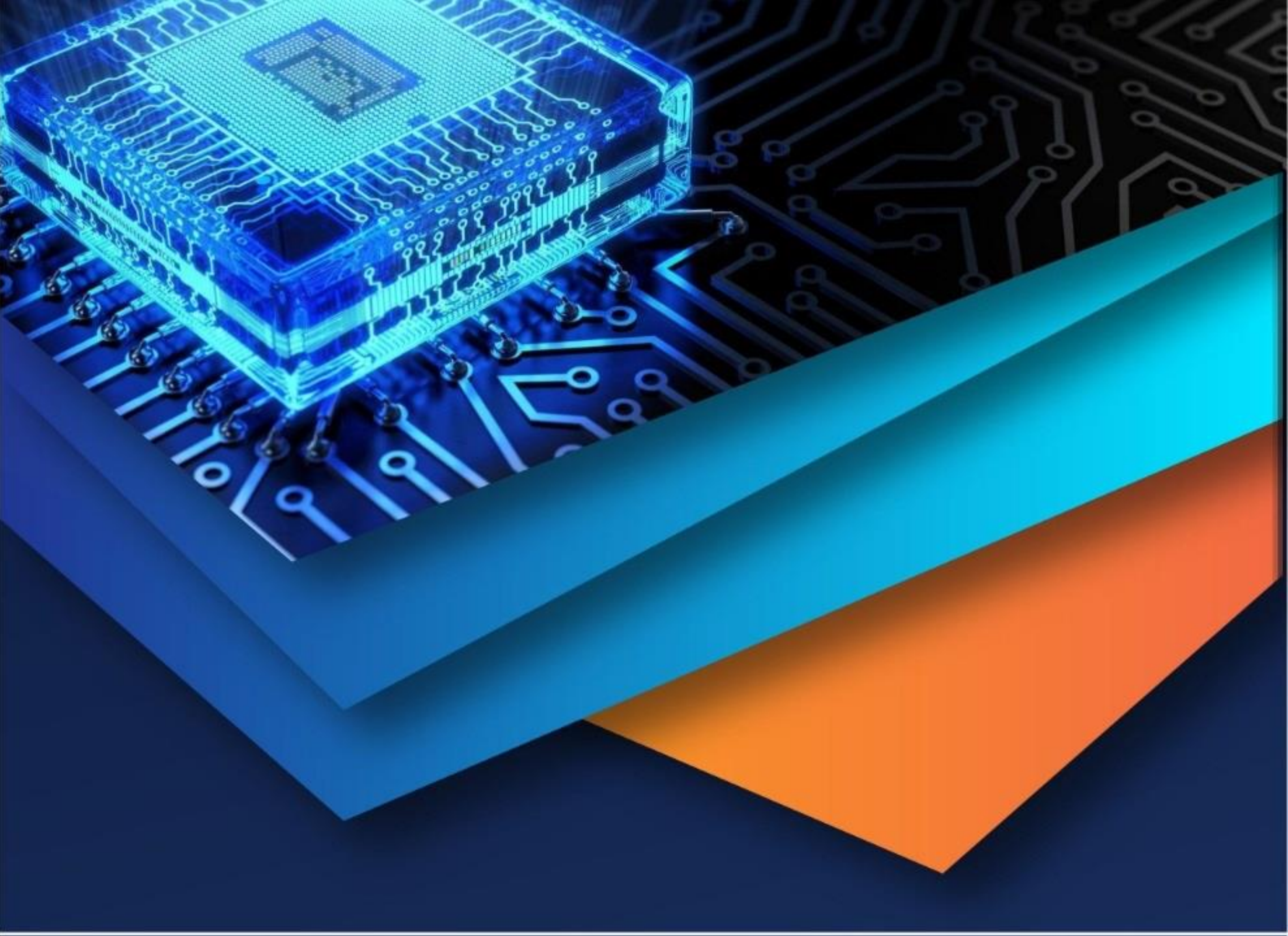

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