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OPTIMIZATION OF MACHINING PARAMETERS IN EDM OF AL 6061 15%SIC 6%MHA COMPOSITE BY TAGUCHI METHOD

Rajesh Choudhary*
Assistant Professor
Department of Mechanical Engineering
Malout Institute of Management & Information Technology
Malout, Distt. Mukatsar. 152107

ABSTRACT

In this study machining of metal matrix composite has been conducted by electric discharge machining to investigate the effect of control parameters like current, pulse on time, pulse off time and voltage on material removal rate. The attempt has been made to use the crushed ash of mustard husk and SiC as reinforcement in Al 6061 matrix to fabricate the metal matrix composite through stir casting route. Experiments were conducted on electric discharge machine having facility to adapt the changes in control parameters. The effect of various parameters like tool electrodes, gap current, pulse on time and voltage was observed on metal removal rate. L18 orthogonal array was selected to conduct the experiments. The effect of current and pulse on time is found to be more pronounced on MRR.

KEYWORDS: *Optimization; Machining; Composite; Taguchi; Characteristics; Rice Husk Ash (RHA)*

1. INTRODUCTION

The necessity for requirement of high strength, wear resistance, thermal stability and performance have shifted the trend of monolithic materials to composite materials. The metal matrix composite (MMC) are gaining popularity among advanced materials for their consistent use in components manufacturing of aircrafts and automobiles and military armaments. Efforts are being made by the researchers to improve the performance of composite materials by adding suitable reinforcements. These reinforcements are polymers, ceramics and metals. There are certain prerequisites before going to design composite materials. There should be proper physical compatibility of reinforcement with matrix. The reinforcement should not be thermally instable at high operating temperatures. The composite should provide adequate strength in longitudinal and transverse direction. The ceramic reinforcements are used to enhance the strength and wear resistance of matrix material. The trend of using the agriculture waste material as ash is gaining interest among the researchers in fabrication of composites. The use of fly ash and agricultutre waste ash as reinforcents improves the hardness, strength, density and wear resistance of composites. These reinforcements can be used with Aluminium, magnesium, titanium and copper as matrix materials. These composites are finding vast applications in component manufacturing of sports cars, gas turbine and aircrafts [1-3]. In this study aluminium alloy Al 6061 based metal matrix composite was fabricated through stir casting route with mustard husk ash and SiC as reinforcements. Later on machining performace was measured by conducting electrical discharge machining by copper and brass tool electrodes.

2. MATERIALS AND EXPERIMENTAL PROCEDURE

2.1 Stir casting of MMC

The Al based MMC was fabricated through stir casting route. The mustard husk was converted to ash by heating in muffle furnace at 600°C for one hour in order to remove all volatile components. The resulting powder was sieved and fine powder of mesh size 300 was separated and used as reinforcement in aluminum matrix composite. The fig. 1 shows the procedure adopted to fabricate the composite with stir casting route.

(A) (B)

(C) (D)

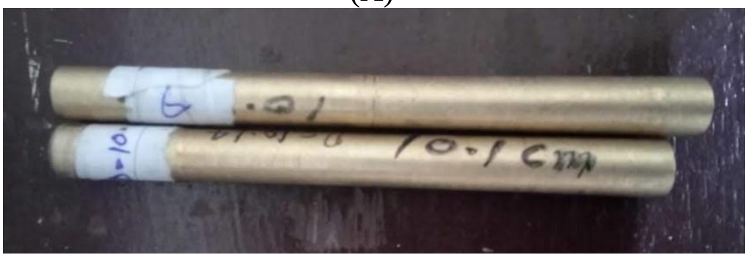
Fig. 1 Stir casting of Al 6061 15%SiC 6%MHA Composite (a) Mustard husk (b) Mustard ash (c) Silicon carbide (d) Stir casting set up

After adding the calculated quantity of reinforcements in the molten metal stiring was carried out by stirrer at 300 rpm. After the complete mixing of reinforcements in the molten metal, the liquid metal was poured in the moulds to form the composite plates. Fig. 2 shows the casting obtained after stir casting procedure.

Fig. 2 Stir cast Al 6061 15%SiC 6%MHA Composite

The copper and brass cylindrical tool electrodes were used for conducting the experiments on electric discharge machine. The diameter of tool electrode is 10 mm. Fig. 3 shows the selected copper and brass tool electrodes used for maching of MMC.

(A)



(B)

Fig.3 Copper and Brass tool electrodes

2.2 Design of experiments (DOE)

Taguchi design method is the simplest and standardized method to reduce the number of experiment caused by the variation in an experiment. A large number of experiments have to be carried out when the number of the process parameters increases. To solve this task, the Taguchi method uses a special design of orthogonal arrays to study the entire process parameters with only a small number of experiments [4-6]. As this project is related to experimentation process so a suitable design of experiments is necessary to achieve desired results in minimum no. of trials. Taguchi method is used here for design of experimentation. For conducting the experiments Taguchi list L**18** mixed orthogonal array is selected on the basis of process parameters. Therefore, an L18 (2^1*3^4) mixed orthogonal array with 5 columns and 18 rows was used two accommodate one two-level noise factor and four three-level controls factors. Three replicates of each trial experiments were performed to evaluate the MRR quality characteristics. Table 1 shows the list of input parameters and their level as per Taguchi OA L18.

Table: 1 Design of experiments L18 OA

S/No.	Tool Electrode	Current (A)	Pulse On Time (µs)	Voltage (V)	Pulse off Time (µs)
1	Cu	6	120	50	62
2	Cu	6	150	60	77
3	Cu	6	180	70	92
4	Cu	10	120	60	62
5	Cu	10	150	70	77
6	Cu	10	180	50	92
7	Cu	14	120	50	77
8	Cu	14	150	60	92
9	Cu	14	180	70	62
10	B	6	120	70	92
11	B	6	150	50	62
12	B	6	180	60	77
13	B	10	120	70	77
14	B	10	150	50	92
15	B	10	180	60	62
16	B	14	120	60	92
17	B	14	150	70	62
18	B	14	180	50	77

2.3 Experimental set up and procedure

The experiments were conducted on Sparkonix make electric discharge machine with 50 Amp. capacity. This machine is having the provisions to adjust the various process parameters. Out of 18 experiments, nine experiments were conducted by copper and remaining nine experiments were conducted by brass electrode. Some trail experiments were conducted to finalize the levels of selected parameters. A work holding fixture was designed and fabricated to hold the non-ferrous workpiece during machining. All the experiments were conducted for 20 mins. to record the metal removal rate.

3. RESULTS AND DISCUSSIONS

The response parameter MRR values are tabulated in Table 2. From table it is clear that MRR obtained with copper tool electrode is higher as compared to brass tool electrode. The machined composite specimens are shown in Fig. 4.

Table: 2 Measured values of metal removal rate in gm/min.

S/No	Tool electrode	Pulse current (µs)	Pulse on time (µs)	Gap voltage (V)	Pulse off time (µs)	MRR (g/min)
1	Cu	6	120	50	62	0.0283
2	Cu	6	150	60	77	0.035
3	Cu	6	180	70	92	0.036
4	Cu	10	120	60	62	0.037
5	Cu	10	150	70	77	0.036
6	Cu	10	180	50	92	0.038
7	Cu	14	120	50	77	0.041
8	Cu	14	150	60	92	0.038
9	Cu	14	180	70	62	0.043
10	B	6	120	70	92	0.024
11	B	6	150	50	62	0.035
12	B	6	180	60	77	0.036
13	B	10	120	70	77	0.038
14	B	10	150	50	92	0.036
15	B	10	180	60	62	0.037
16	B	14	120	60	92	0.037
17	B	14	150	70	62	0.038
18	B	14	180	50	77	0.039

3.1 ANALYSIS OF MRR

Table. 9 shows the response table for means of MRR (larger the better). Based on the analysis of the mean ratio, the optimal machining conditions for MRR is obtained with copper tool (Level 1), current 14A (level 3), On time 200µs (level3), Pulse off time 77 µs (Level 2) and Voltage 60V (level 2). Thus the optimum level for each process parameter is A1, B3, C3, D2 & E2.

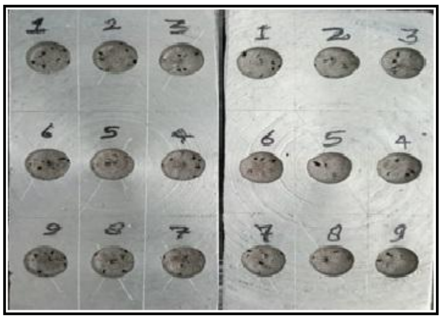


Fig. 4 Machined Samples of Al 6061 15%SiC 6%MHA composite work piece

Table 3 Response table for Mean ratios for MRR

Level	Tool electrode	Current	Pulse On time	Pulse Off time	Voltage
1	0.03692	0.03238	0.03422	0.03638	0.03622
2	0.03556	0.03700	0.03633	0.03750	0.03667
3		0.03933	0.03817	0.03483	0.03583
Delta	0.00137	0.00695	0.00395	0.00267	0.00083
Rank	4	1	2	3	5

Response table for means is shown in Table 3. The most influential parameter among all parameters is current followed by pulse on time. Analysis of variance is also performed to see the leve of contribution of each parameter during the machining process. The main purpose of ANOVA is to identify the effect of individual factor. A larger F- value indicates that the process parameter significantly affect the process response. ANOVA analysis signifies that the current parameter is the most significant parameter among all parameters. Fig. 5 Shows the main effects plot of response MRR at different level of parameters. In this figure, the curve which has larger inclination from the mean line have greater impact on MRR than the curve that is horizontal to the mean line. Fig. 5 shows the positive trend of MRR with increase in current and pulse on time whereas it decreases after achieving level 2 for pulse on time and voltage. The copper tool shows higher metal removal rate as compared to brass tool electrode [7].

Table: 4 Analysis of variance (ANOVA) for means ratios for MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Tool electrode	1	0.000008	0.000008	0.000008	0.70	0.434
Current	2	0.000150	0.000150	0.000075	6.26	0.034
Pulse On time	2	0.000047	0.000047	0.000023	1.96	0.222
Pulse Off time	2	0.000022	0.000022	0.000011	0.90	0.456
Voltage	2	0.000002	0.000002	0.000001	0.09	0.918
Tool electrode*Current	2	0.000005	0.000005	0.000003	0.22	0.806
Residual Error	6	0.000072	0.000072	0.000012		
Total	17	0.000306				

Fig. 6 shows the 3D plot for MRR varing with current and pulse on time. The graph shows the positive trend of response with current and pulse on time. Fig. 7 shows the interaction plot for the mean ratio of the MRR with regard to tool electrode and pulse current. It Amp.can be clearly seen that the 3 lines are not parallel to each other and there is strong interaction between brass tool electrode and current at 10 and 14.

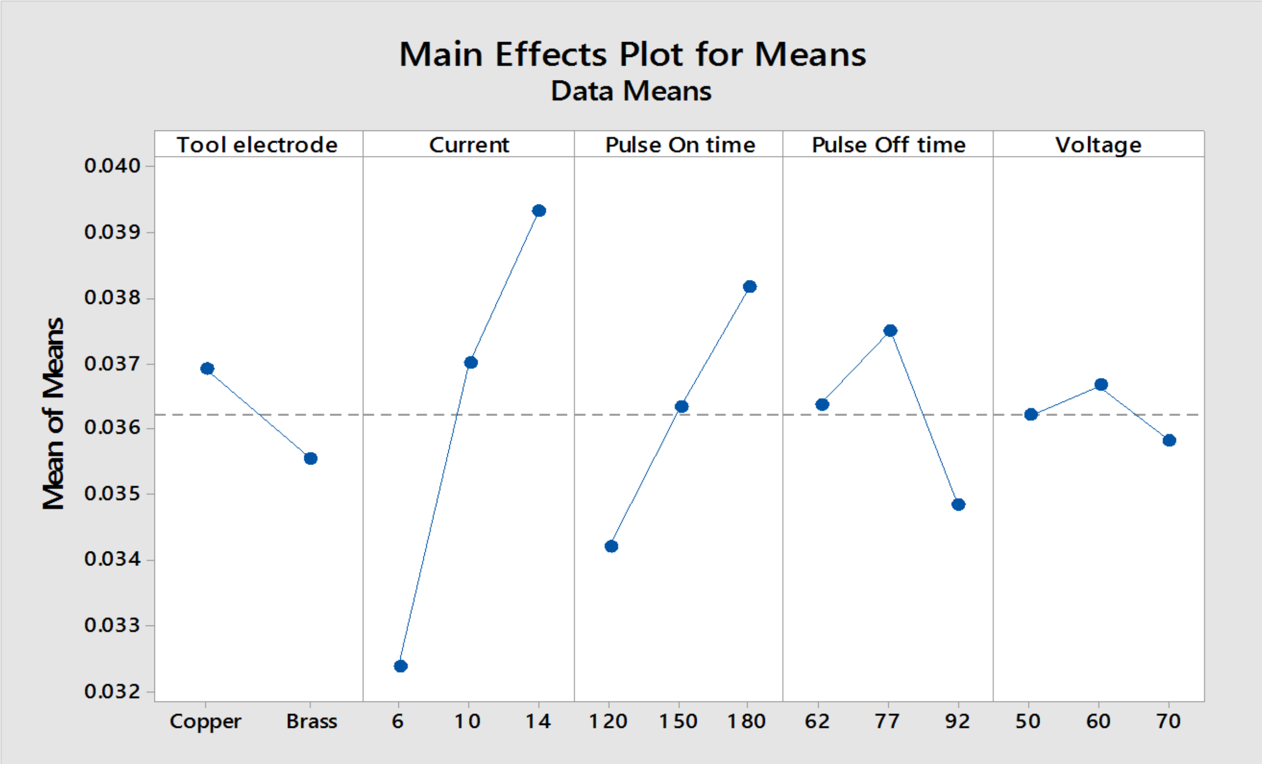


Fig: 5 Main Effect Plot of Means for MRR

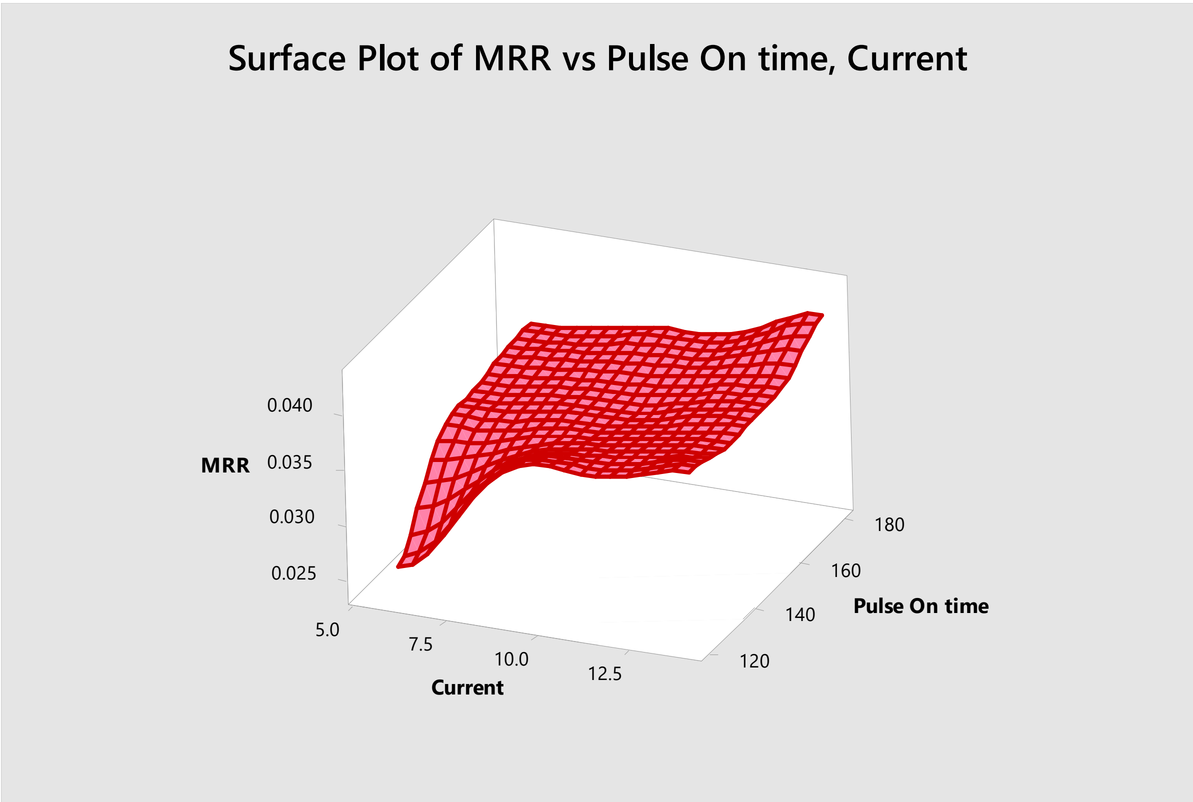


Fig. 6 3D Surface plot for MRR varing with current and pulse on time

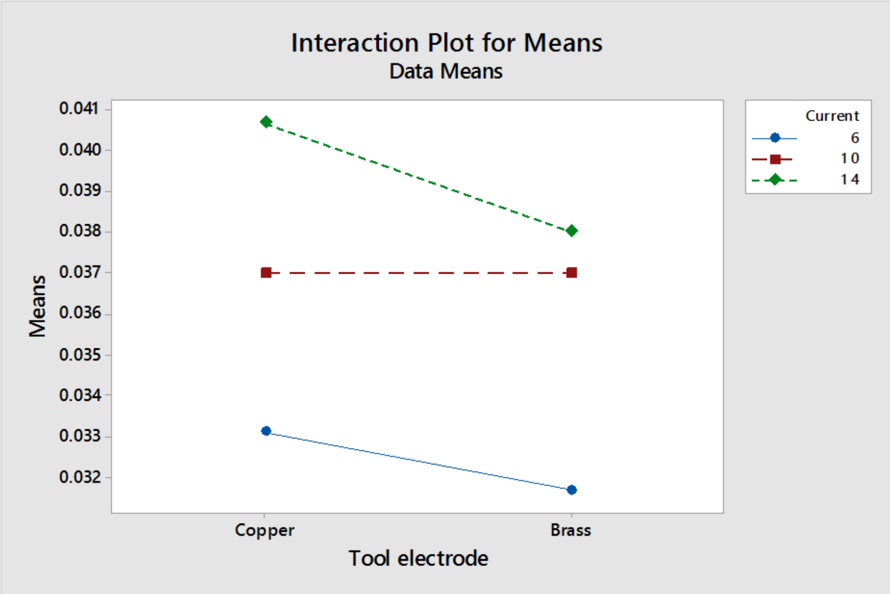


Fig. 7 Interaction plot for the means of response MRR

4. CONCLUSIONS

The effects of Tool electrode, pulsed current, applied voltage, pulse on time & pulse off time is experimentally investigated during electric discharge machining of Al based hybrid composite. Based on experimental observations following conclusions are drawn:

1. Material removal rate was found to be higher in case of copper tool electrode as compare to brass tool electrode for MMC. This is due to higher electrical conductivity of copper which aids machining stability during EDM process.
2. Material removal rate of composite workpiece increases with increase in gap current and pulse on time.
3. Strong interaction between brass tool electrode and current is observed at 10 Amp and 14 Amp current for MRR. Interaction between copper tool and current is observed at 10Amp.
4. Current is the most significant parameter among selected parameters.
5. Maximum MRR (0.041 gm/min.) is observed at 14 Amp, 120µs On time, 50 V and 77 pulse off time.
6. Copper tool provide better machining stability as compared to brass tool electrode.

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