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Parametric Analysis during Electric Discharge Machining of Aluminium MMC using Taguchi's Methodology

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Abstract: The advancement in the material processing has leads to the development of composite materials which possess the better mechanical properties than conventional materials. In the present paper, machining of developed aluminum metal matrix composite was performed using electric discharge machining process. the experimentation was planned as per Taguchi's methodology using L_9 orthogonal array. Voltage, current, and pulse on time were used as input process parameters whereas surface roughness was used as response parameters for the process. The results predicted that the parametric combination A_1 B_1 C_3 i.e. Current 5, Pulse On at 3µs and Pulse Off at 3µs produces better surface in comparison with other parametric combinations.

Keywords: Electric Discharge Machine, Metal Matrix Composites, Taguchi Methodology

I. INTRODUCTION

Today is the era of advancement in manufacturing as well as machining technology. Researchers are working on development of new materials using various reinforcements and coatings techniques to improve their mechanical and tribological properties. [1-3]. In order to analyze their machining behavior, a number of machining processes are being widely used [4,5]. A lot new machining techniques are being developed in the field of micromachining. In the field of micromachining, electric discharge machining (EDM) process is a quite familiar name. A part of it, EDM drilling is excellent for machining deep and narrow holes regardless of material hardness and location, whereas die-sinking EDM works well to machine micro-parts and perpendicular walls of die and molds [6].Current paper investigates the carbonaceous layer and its formation during the erosion. During Electric Discharge Machining process several material loadings take place on the workpiece surface within the processing zone. To model the comprehensive material removal and its effects on the resulting material properties especially in the rim zone and on surface integrity it is necessary to describe these loadings on several length scales in detail [7]. The influence of EDM parameters on material removal rate, electrode wear, machining time and micro-hole quality when machining Ti6Al4V is studied and conclusion says that due to an inefficient removal of debris when increasing hole depth, a new strategy based on the use of helical-shaped electrodes has been proposed[8]. Dhar and Purohit [9] evaluated the effect of current (c), pulse-on time (p) and air gap voltage (v) on MRR, TWR, ROC of EDM with Al–4Cu–6Si alloy–10 wt. % SiC_P composites. The MRR was found to decrease with an increase in the percent volume of SiC, whereas the TWR and the surface roughness increase with an increase in the volume of Sic. it shown the graph between interactive effect of the percent volume of Sic and the current on MRR [10]. Taweel [11] fabricated Tool electrode material such as Al–Cu–Si–Tic composite produced using powder metallurgy (P/M) technique and using workpiece material CK45 steel. B.Mohan et.al [12] explains the evolution of effect of the EDM Current, electrode marital polarity, pulse duration and rotation of electrode on metal removal rate. TWR and SR. EDM of Al-Sic with 20-25 vol. %, the MRR increased with increased in discharge current and specific current it decreased with increase in pulse duration. The EDM process's workpiece generated by the superposition of multiple discharges, as it happens during an actual EDM operation, by diameter of the discharge channel and material removal efficiency can be estimated using inverse identification from the results of the numerical model [13].

A. Experimental Planning and Design

The experiments were performed on the specimens prepared from the fabricated composite. The fabrication of the present composite completes with the use of aluminum as matrix and alumina as reinforcement. The aluminum was heated to around 750 degree Celsius before mixing with alumina particles. The molten aluminum is mixed with the reinforcement using mechanical stir process. The final metal matrix composite was prepared using mechanical casting method. The experimentation was planned as per Taguchi's Methodology [14].The investigation on surface roughness is completed using the electric discharge machining process.

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Table 1 Process Parameters and their Levels

Process Parameter	Level 1	Level 2	Level 3
Current (Ampere)	5	7	9
Pulse On (µs)	3	5	7
Pulse Off (µs)	1	2	3

Table 2 L_9 Orthogonal Array

Experiment No.	Current	Pulse On	Pulse Off
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

II. RESULTS AND DISCUSSION

Table 1 shows different parameters and their levels whereas table 2 shows orthogonal array used for experimentation. The table 3 shows the surface roughness during machining at different levels using design of experiments. Table 4 shows the analysis of variance and Figure 1 and Figure 2 shows the plots for S/N ratio and data means.

Table 3 Response Table for Surface Roughness

Experiment No.	Current	Pulse On	Pulse Off	Surface Roughness	S/N Ratio
1	5	3	1	2.35	-7.42136
2	5	5	2	2.39	-7.56796
3	5	7	3	2.43	-7.71213
4	7	3	2	2.54	-8.09667
5	7	5	3	2.62	-8.36603
6	7	7	1	2.72	-8.69138
7	9	3	3	2.79	-8.91208
8	9	5	1	2.92	-9.30766
9	9	7	2	2.98	-9.48433

Table 4 Analysis of Variance for Surface Roughness

Source	DF	SS	MS	F-Value	P-Value	% Contribution
Current	2	0.3856	0.1928	559.77	0.002	90.96
Pulse On	2	0.0338	0.0169	49.19	0.020	7.97
Pulse Off	2	0.0037	0.0018	5.45	0.155	0.87
Error	2	0.0006	0.0003			0.14
Total	8	0.4239				

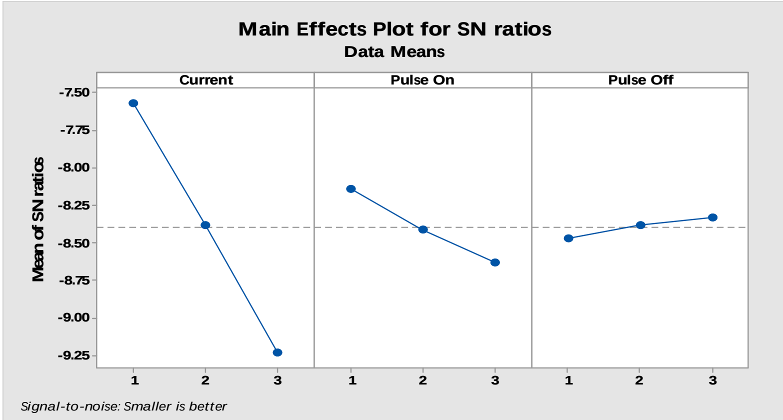

Figure 1 Signal to Noise Ratio for Surface Roughness

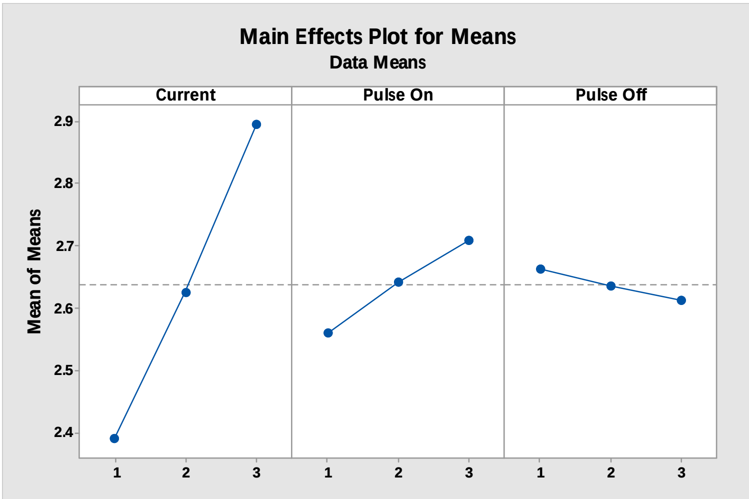

Figure 2 Data Means Plot for Surface Roughness

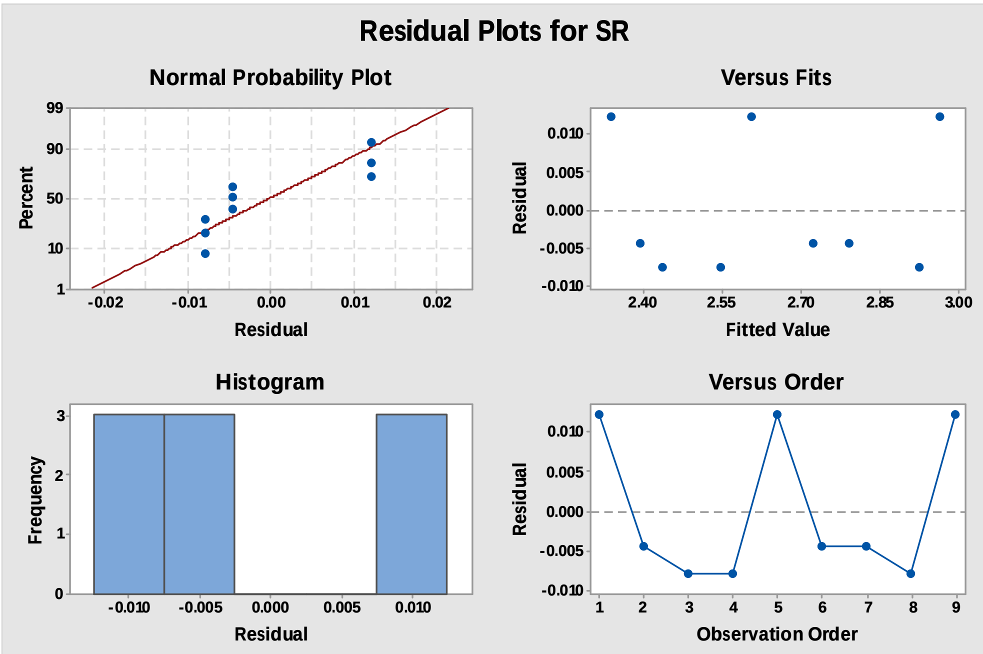

Figure 3 Residual Plots for Surface Roughness

The analysis of variance shown for surface roughness predicts that discharge current is most influential factor in experimental parameters. The discharge current has 90.96% contribution in generating quality surface whereas pulse on time has 7.97% followed by pulse off time with 0.87% contribution. The S/N ratio plot predicts the best parametric combination as A_1 B_1 C_3 i.e. Current 5, Pulse On at 3µs and Pulse Off at 3µs for best surface finish.

III. CONCLUSIONS

This study concerns the experimental investigation of Aluminum metal matrix composite. The conclusions obtained from this investigation are as follow:

A. The fabrication of Al/Alumina was successfully completed using mechanical stir casting process.
B. The composite was successfully machined using electrical discharge machining process.
C. The best parametric combination for the better surface quality was found to be A_1 B_1 C_3 i.e. Current 5, Pulse On at 3µs and Pulse Off at 3µs.

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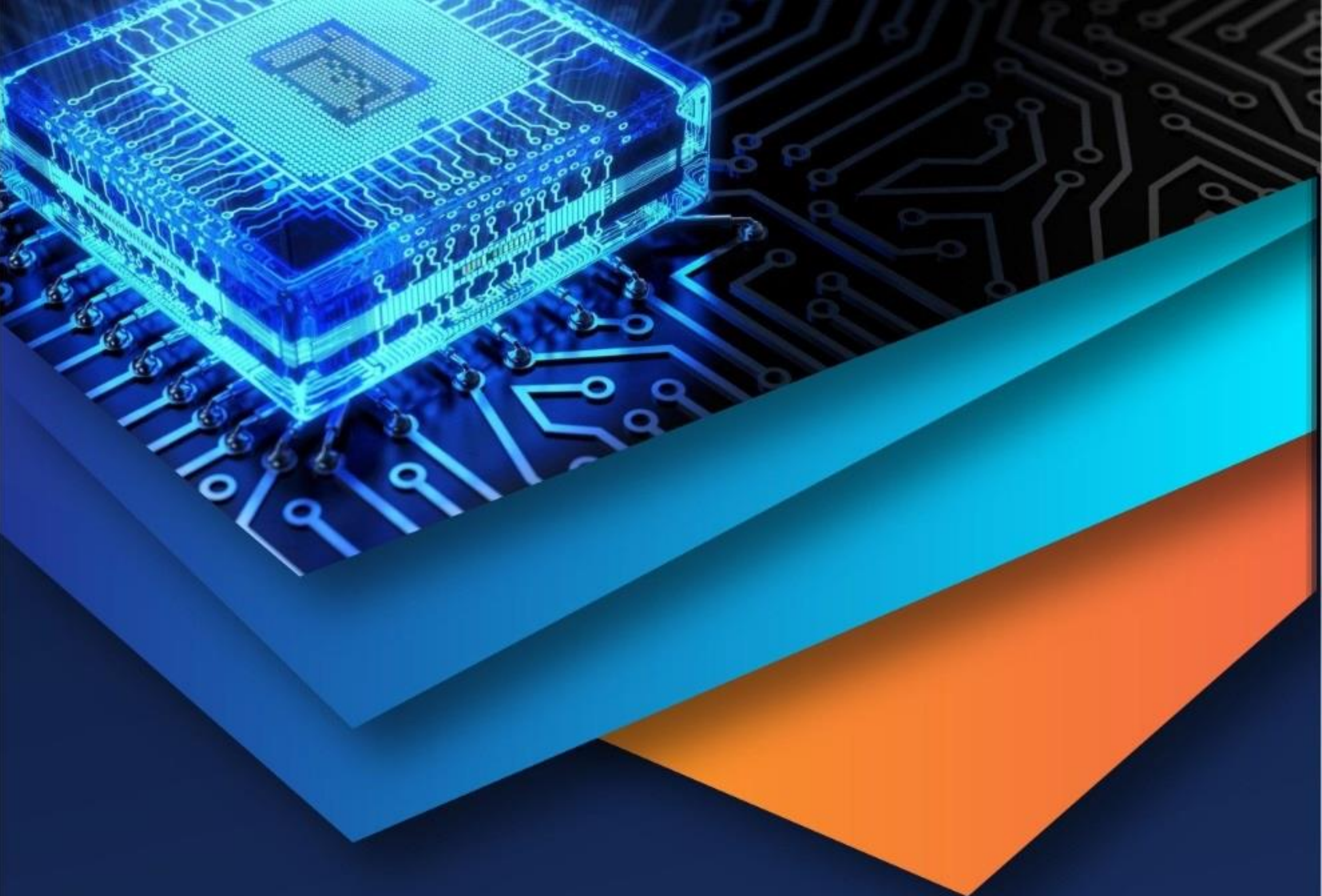

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