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Optimization of Process Parameters during EDM of Al/SiC Metal Matrix Composite

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Abstract: Metal matrix composites are one of the newly developed engineered materials of considerable interest. Metal matrix composite consists of at least two constituent parts, of which one constituent part being a metal and the other part may be a different metal or another material, such as ceramic or organic compound. These materials are known as the difficult-to-machine materials because of the hardness and abrasive nature of reinforcement element like silicon carbide (SiC). Hence, they imposemach inability related challenge, to conventional machining process such as turning, milling etc. Electrical discharge machining (EDM) is a non-conventional process becoming a popular choice for machining these materials. In view of this, the present work is aimed at investigating the effect of tool shape and size factor on material removal rate during electrical discharge machining of aluminiumbased metal matrix composites, in conjunction with the variation of electrical parameters namely, gap current, gap control, pulse on time, and pulse off time while keeping other electrical parameters constant. In this study, LM24/SiC metal matrix composites were fabricated using liquid metallurgical route and the prepared composites were characterized for micro structural analysis, hardness and chemical composition. Taguchi L36 (21 x 36) orthogonal array design was used to carry out the experiments. Signal to noise ratio and analysis of variance were used to determine the most significant parameters that influence the responses. Linear multiple regression model was developed to predict material removal rate. Optical microscopy test revealed fairly uniform distribution of SiC in the matrix
Keywords: Aluminiumalloy, Electric Discharge Machining, EDM, MMC, Material Removal Rate, Metal Matrix Composites, Taguchi,ANOVA.

I. INTRODUCTION

The Metal Matrix Composites (MMCs) have been successfully applied in aerospace industries since 1970s and in the middle of 1980s these materials reached the automobile industry and nowadays their uses are gaining importance. The most important advantages of metal matrix composites are increased strength, decreased weight, and higher service temperature, improved wear resistance, higher elastic modulus.

Metal matrix composite consists of at least two constituent parts, of which one constituent part being a metal and the other part may bea different metal or another material, such as ceramic or organic compound. These materials are known as the difficult-to-machine materials because of the hardness and abrasive nature of reinforcement element like silicon carbide (SiC). Hence, they impose machinability related challenge, to conventional machining process such as turning, milling etc. Electrical discharge machining (EDM) is a non-conventional process becoming a popular choice for machining these materials. In view of this, the present work is aimed at investigating the effect of tool shape and size factor on material removal rate in electrical discharge machining of aluminiumbased metal matrix composites, in conjunction with the variation of electrical parameters namely, gap current, gap control, pulse on time, and pulse off time while keeping other electrical parameters constant. The objectives are to enhance the capability of machining performance i.e. more material removal rate and better surfacefinish and to get better output product. Electro Discharge Machining (EDM) is an electro-thermal non-conventional machining process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of thespark.

II. LITERATUREREVIEW

[1]Narinder Singh and Onkar Singh Bhatia (2016) reviewed on optimizing the process parameters in die sinking EDM. The effect of discharge current and pulse duration has been taken into consideration in various research works but variation in pulse interval has not been investigated or it has been taken into consideration in conjunction with pulse duration by way of duty factor.

[2]J. Jeykrishnan (2016) has done many calculations and analysis for optimum MRR and TWR, it has been concluded that the optimum MRR value for EN24 tool steel is achieved by varying the different levels of

input parameters such as current (A), pulse on time (µs) and pulse off time (µs) by using the Minitab and also by applying the Taguchi's technique. So the conclusion of this workis that, the optimal value of MRR was determined at levels AIII, BI, and CIII (current discharge at 11A, pulse on time 5µs, and pulse off time 6µs), whereas for TWR the optimal value is contributed by the three process parameters at levels AI, BII, and CII (current discharge at 3A, pulse on time 6 µs, and pulse off time 5µs).

[3]K.S. Morankar and R.D.Shelke (2017) reviewed the Influence of Process Parameters in EDM Process where It can be seen that peak current have more significance on MRR and TWR. Feed has less significance on TWR lower gap voltage tends to give higher value of MRR. The value of Ra increases with increase of discharge current and open discharge voltage but decreases with an increase of duty factor, current and gap voltage.

[4]Niraj Kumar Ohdar and Babuli Kumar Jena (2017) studied EDM process parameters using Taguchi Method with Copper Electrode At peak current 12(A), pulse on time 15(µs), pulse off time 3(µs) and flushing pressure 0.3(kg/cm2) it is observed that the material removal rate becomes high. For TWR, the most significant factor is found to be peak current followed by pulse on time. For MRR, the most significant factor is found to be pulse on time followed by pulse off time. At peak current 14(A), pulse on time 5(µs), pulse off time 7(µs) and flushing pressure 0.3(kg/cm2) the tool wear rate reduces significantly.

[5]V.Vikram Reddy and P.Vamshi Krishna (2016) studied the effect of Process Parameters during EDM of Stainless Steel 304 using Taguchi Method investigate the influence of process parameters such as peak current (I), pulse on time (Ton) and pulse off time (Toff) on performance measures namely, material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR) during electrical discharge machining (EDM) of stainless steel 304, All the chosen responses namely MRR, TWR, and SR are increased with increase in peak current and pulse on time. However MRR and SR decrease with increase in pulse off time.

[6]Somnath M. Kale and D.S.Khedekar (2016) investigated to describe the relation of various machining parameters and their effects on output parameters while machining of Inconel 718. Current is most affecting parameters for both MRR and TWR. Material removal rate and tool wear rate increases as the current and pulse on time increases. While material removal rate and tool wearrate decreases as the voltage increases. The optimal values of process parameters which have composite desirability 0.54 are current 41.11
(A), voltage 80(V) and pulse on time 500 (µs).

[7]T.VijayaBabuand J.S Soni (2017) carried out the optimization of process parameters for surface roughness in Inconel 625. The machining parameters are pulse on time, pulse off time and peak current. After successful application of Taguchi method and ANOVA it is concluded, Surface roughness increases with increase on pulse on time and decrease with increase in pulseoff time. For surface roughness most significant factor is pulse on time followed by pulse off time. Peak current is insignificant factor for surface roughness.

[8]S. Chandramouli and K. Eswaraiah (2016) optimized EDM Process parameters in Machining of 17-4 PH Steel used Taguchi method for the optimization of the process parameters for machining of 17-4 PH steel material with copper tungsten electrode which reveals the proper selection of input parameters.

A. Material Preparation:

Al-Si-Cu reinforced silicon carbide metal matrix composite was prepared by liquid metallurgy route (stir casting method). A known quantity of Al alloy bars was cleaned to remove surface impurities and then the base metal was charged in electric resistance furnace & raised up to 760℃. The Silicon carbide (SiC) particles were also preheated to 800℃ to remove moisture. The aluminium alloy was melted & degassed by purging hexa-chloro-ethane tablets to remove the entrapped gases from molten alloy. The slag powder was sprayed to remove the slag content. The preheated silicon carbide particles by weight ratio were reinforced with the base metal. The melt was stirred with the help of stirrer. The stirring was maintained for 10 min at impeller speed of 400rpm. The melt temperature wasmaintained 720℃ during addition of silicon carbide particles. The molten alloy with reinforced particulates was poured in the preheated permanent metallic moulds. The pouring temperature was maintained at 700℃. The melt was then allowed to solidify the moulds. The composite were made with a different amount of silicon carbide (SiC) i.e. 3, 5, 7 wt%. After removing the specimens from moulds the specimens are machined to the required size for tests and to carry out machining test on die sinkEDM.

IV. RESULT ANDDISCUSSION

The Taguchi method furnishes an excellent procedure for experimental design in minimum number of runs. The different compositions of metal matrix as well as tool shapes and cross sectional areas were indicated as factor levels. This was carried out as per the Taguchi's method of orthogonal arrays. Four electrical parameters were also included into the experimental design. In this way, a total of 36 experimental runs were identified as per the L36 Taguchi orthogonal array with different combinations of factors and levels shown in table.

Table.1. Taguchi's experimental design and observed values

Too L Sha Pe	Tool Area	Wor k piec e	Curr ent amp	T_{on} µs	T_{off} µs	Gap Cont rol µm	MRR mm^3/min
C	195	3	2	5	5	1	79.300
C	280	5	4	7	7	2	37.453
C	365	7	6	9	9	3	36.232
C	195	3	2	5	7	2	79.300
C	280	5	4	7	9	3	37.400
C	365	7	6	9	5	1	36.200
C	195	3	4	9	5	2	59.524
C	280	5	6	5	7	3	37.400
C	365	7	2	7	9	1	18.116
C	195	3	6	7	5	3	79.300
C	280	5	2	9	7	1	24.345
C	365	7	4	5	9	2	36.200
C	195	5	6	5	9	2	37.400
C	280	7	2	7	5	3	36.200
C	365	3	4	9	7	1	79.300
C	195	5	6	7	5	1	37.400
C	280	7	2	9	7	2	36.200
C	365	3	4	5	9	3	79.300
S	195	5	2	9	9	3	31.835
S	280	7	4	5	5	1	36.200
S	365	3	6	7	7	2	39.600
S	195	5	4	9	9	1	37.400
S	280	7	6	5	5	2	36.200
S	365	3	2	7	7	3	39.600
S	195	7	4	5	7	3	27.899
S	280	3	6	7	9	1	79.300
S	365	5	2	9	5	2	37.400
S	195	7	4	7	7	1	28.623
S	280	3	6	9	9	2	79.300
S	365	5	2	5	5	3	37.400
S	195	7	6	9	7	3	36.200
S	280	3	2	5	9	1	39.600
S	365	5	4	7	5	2	33.333
S	195	7	2	7	9	2	36.200

A. Signal to Noise ratio and Analysis of Variance for Material RemovalRate

In order to study the significance of the process variables towards MRR, analysis of variance (ANOVA) was performed at a confidence interval of 95% i.e. a significance level of 0.05. It was found that workpiece that is wtp of SiC particulates was significant process parameters for MRR and gap current was the next in line at 85% confidence level. The response tables 3 and 4 shows the average of each response characteristic for each level of each factor. The tables include ranks based on delta statistics, which compare the relative magnitude of effects. The delta statistic is the highest minus the lowest average for each factor. Minitab assigns ranks based on delta values; rank 1 to the highest delta value, rank 2 to the second highest, and so on. The ranks indicate the relative importance of each factor to the response. The greatest effect on material removal rate and is followed by discharge current and pulse on time. As MRR is the "higher the better" type quality characteristic and from the S/N dataanalysis.

Table.2. Signal to noise ratio for mrr

Level	Tool Shape	Tool	Work piece	Discharge current	Pulse On time	Pulse Off time	Gap Contact roll
1	32.86	32.86	35.77	31.61	32.85	32.75	32.05
2	31.83	32.22	30.95	32.39	31.78	31.87	32.75
3		31.95	30.32	33.04	32.40	32.42	32.23
Delta	1.03	0.91	5.45	1.43	1.07	0.88	0.69
Rank	4	5	1	2	3	6	7

Table.3. Analysis of variance for mrr

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Tool Shape	1	494.9	494.9	494.9	3.37	0.079
Work Piece	2	7215.8	7215.8	3067.9	24.54	0.000
Current	2	243.6	243.6	121.8	0.83	0.499
Pulse on Time	2	155.4	155.4	77.7	0.53	0.596
Pulse off Time	2	111.8	111.8	55.9	0.38	0.688
Gap Control	2	36.9	36.9	18.4	0.13	0.883
Error	24	3528.2	3528.2	147.0		
Total	35	11786.4	11786.4			

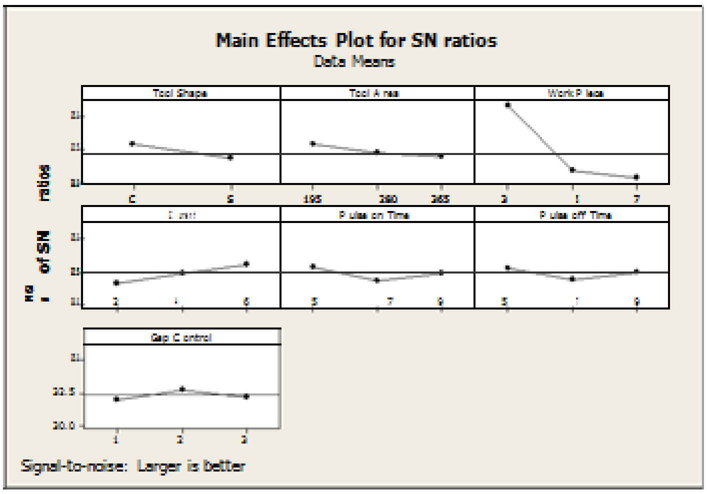

Figure. 1. Main effects plot for SN ratios for MRR

B. Regression Analysis for Material RemovalRate

Regression analysis was carried out to ensure a least squared fitting to error surface in Minitab 16 environment. Regression analysis has been performed to find out the relationship between input factors and MRR. During regression analysis it is assumed that the factors and the response are linearly related to each other. The general first order model is proposed to predict the MRR over the experimental region can be expressed as equation 1 and2.

1) Material removal rate for circular toolshape

MRR = 94.4433 - 0.0295586*tool area - 7.76155*work piece + 1.59242*discharge current–0.626314*pulse on time + 0.0047 0603 * pulse off Time - 0.617419*gap control

2) Material removal rate for square toolshape

MRR = 87.0278 - 0.0295586*tool area - 7.76155*work piece + 1.59242*discharge current – 0.626314*pulse on time + 0.00470603*pulse off time -0.617419*gap control

V. CONCLUSION

In this study LM24/ SiC metal matrix composites were fabricated and characterized for micro-structural analysis. The effect of tool shape and size on material removal rate was investigated. To carry out experimental runs Taguchi L36 orthogonal array was employed. Based on the experimental results following conclusions weredrawn:

(i).LM24/SiC composites were successfully fabricated using liquid stir casting technique. (ii).Optical microscopy test showed fairly uniform distribution of SiC in the matrix.
(iii).Based on Taguchi analysis and ANOVA the most significant parameter which influences material removal rate was workpiece composition followed by discharge current and pulse on time.

(iv). Optimal parameter setting for achieving high material removal rate are circular shape tool, 195 mm2 cross sectional area, 3 wtpctSiC, 6 Amp discharge current, 5 µs pulse on time, 5 µs pulse off time and 2 µm gapcontrol.

(v). Linear multiple regression model was developed for predicting MRR. Further, confirmation runs resulted in an average percentage of 6.15, underlining the satisfactory prediction of MRR by the developedmodel.

VI. FUTURESCOPE

(i). The effects of the input parameters during EDM of composites can be optimize for surface roughness and tool wearrate.
(ii). Metal matrix composites would be fabricated by using other manufacturing techniques such as powder metallurgy route and spray casting, and then the results can be compared with stir castingtechnique.
(iii). The study can further be extended by varying the particle size and its effect on the EDM process parameters can beexamined.
(iv). Other EDM process parameters such as type of dielectric, flushing pressure, type of flushing and powder mixed dielectric media effect on material removal rate and surface roughness can bestudied.

REFERENCES

[1]. Narinder Singh and Onkar Singh Bhatia, Optimization of Process Parameters in Die-Sinking EDM - A Review, IJSTE - International Journal of Science Technology & Engineering, 2016, 2 (11) ISSN: 2349-784.
[2]. J. Jeykrishnan, Optimization of process parameters on EN24 Tool steel using Taguchi technique in Electro-Discharge Machining (EDM), IConAMMA-2016 10.1088/1757-899X/149 /1/012022.
[3]. K.S Morankarand R.D.Shelke, Influence of Process Parameters in EDM Process- A Review, International Journal of Innovations in Engineering and Technology (IJIET) 2017, 8(1), ISSN: 2319 –1058.
[4]. Niraj Kumar Ohdar and Babuli Kumar Jena SaumyaKantaSethi, Optimization of EDM process parameters using Taguchi Method with Copper Electrode, International Research Journal of Engineering and Technology (IRJET), 2017, 4(4), ISSN: 2395- 0072.
[5]. V.Vikram Reddy and P.Vamshi Krishna, International 106 Journal of Engineering Trends and Technology (IJETT), V31(2), 114 January 2016. ISSN:2231-5381.
[6]. Somnath M. Kale and D.S.Khedekar, Optimization of Process parameters in EDM for Machining of

Inconel 718 using Response Surface Methodology, International Journal of Innovations in Engineering and Technology (IJIET), 2016, 7(3), ISSN: 2319 – 1058.

[7]. T.VijayaBabu and J.S Soni, Optimization of process parameters for surface roughness of Inconel 625 in Wire EDM by using Taguchi and ANOVA method, International Journal of Current Engineering and Technology, 2017, 7(3), P-ISSN 2347 – 5161

[8]. S. Chandramouli and K. Eswaraiah, Optimization of EDM Process parameters in Machining of 17-4 PH Steel using Taguchi Method, 5th International Conference of Materials Processing and Characterization (ICMPC 2016), 4 (2017) 2040–2047.

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