

Investigation of EDM Process parameters for Hybrid Metal Matrix Composites

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Abstract. The goal of present research work is to investigate the Electrical discharge Machining process parameters namely current, pulse on time and combined equal weight percentage of silicon carbide and graphite on material removal rate, tool wear rate and surface roughness of hybrid metal matrix composites. Experimental trails are done by Taguchi's L27 orthogonal array. Signal to noise ratio is used to determine optimal setting of process parameters. Analysis of Variance is utilized to discover the most influential machining process parameters on output responses. This examination have shown results of ideal machining condition which can be utilized to boost material removal rate as well as to limit tool wear rate and surface roughness. Finally results are validated by confirmation Tests.

Keywords: Hybrid Metal Matrix Composites, stir casting process, EDM, Taguchi, Signal to noise ratio, Analysis of Variance

1. Introduction

Hybrid composites materials are new innovation in the field of metal matrix composites. This material is fabricated by combining more than two materials. These newly designed materials have acquired greater mechanical as well as tribological properties which gratifies the requisite of swiftly emergent industries. Conventional machining processes have limitation to machine these newly fabricated materials. Non-conventional machining processes have played crucial role to machine these outlandish materials. Electrical discharge machining process is widely used as non-conventional machining process.

Ahamed et al. [1] discovered the influence of machining parameters on output responses. They have found the removal of particles of silicon carbide and glass required the extended spark period. George et al. [2] investigated the parametric combination for boost the material removal rate and limit the electrode wear. Gopalkannan et al. [3] examined the influence of process parameters and their interaction on material removal rate, electrode wear ratio and surface roughness. Hourmand et al. [4] used response surface methodology to analyse EDM of Al-Mg2-Si composite. They have discovered



that voltage, current and pulse on time has a significant effect on the profile and microstructure of machined surface. Hu et al. [5] compared many surface properties machined by Powder mixed EDM with conventional EDM. Authors have observed the roughness, hardness and corrosion resistance have significantly improved by PMEDM process. Karthikeyan et al. [6] found rise in the percent volume of SiC gives negative impact on MRR while it gives the positive impact on TWR and surface roughness. Kumar et al. [7] showed the better experimental results of powder mixed EDM as compared to conventional EDM. Lin et al. [8] used orthogonal array with grey relational analysis based to optimize the electrical discharge machining process with multiple performance characteristics. Liu et al. [9] developed a high abrasive EDM process which assisted to enhance the efficiency and surface quality as compared to the conventional EDM process. Mohan et al. [10] analyzed the effect of SiC and rotation of electrode on EDM of Al-SiC composite and also obtained the good output results compared to stationary electrode.

Pecas et al. [11] employed powder mixed dielectric and obtained the high quality surfaces compared to regular EDM Process. Prakash et al. [12] used L27 orthogonal array to conduct the experiments and ANOVA to determine the significance of process parameters on the output response. Puhan et al. [13] investigated the influence of process parameters on multiple performance characteristics in EDM of Aluminium Composites. Rajkumar et al. [14] proved the microwave heat treatment an operative method compared to conventional heat treatment. Radhika et al. [15] optimized multiple performance characteristics in electric discharge machining of Aluminium matrix composites using Taguchi DOE methodology. Roy et al. [16] observed the peak current, pulse on time and concentration was contributed significantly in MRR, TWR and Ra model. They have used multi objective optimization using desirability function approach with MINITAB to produce high MRR, low TWR and low Ra values. P. Singh et al. [17] revealed the MRR found to be higher for larger current and pulse on time setting at the expenses of taper city, radial over cut and surface finish.

S. Singh [18] found improved output responses by grey relational technique. S. Singh et al. [19] discovered the conceptual signal to noise ratio and Analysis of Variance approaches for optimization of process parameters. S. Sing and M. F. Yeh [20] used grey relational approach to evaluate the effectiveness of optimizing multiple performance characteristics of abrasive powder mixed EDM of 6061 Al/Al₂O₃/20P Aluminium metal composites. They have shown that the MRR, TWR and SR in the APM-EDM process can be improved through this proposed approach. Kumar et al. [21] determined optimal combination of process parameters and enhanced output response by setting the value of optimal input parameters. Talla et al. [22] employed powder mixed EDM process and obtained significant improvement in output responses compared to conventional EDM process. The aim of present study is to investigate Electrical Discharge Machining (EDM) process parameter on machining characteristics of Aluminium hybrid composites.

2. Experimental Procedure

2.1 Fabrication of Hybrid Composites by liquid stir casting technique

In this work, Aluminium alloy AC2B is chosen as the matrix material while combined equal weight percentage of Silicon carbide and Graphite(5-15wt%) are selected as reinforcement materials. The preheated reinforcement materials are added into molten state of metal matrix material. It is mixed thoroughly by the mechanical stirrer.

2.2 Machining parameters and their level

Three parameters namely combined equal weight percentage of silicon carbide and graphite, current and pulse on time with three levels in each are chosen.

2.3 Output Responses

The effectiveness of Electrical Discharge Machining process is evaluated by material removal rate, tool wear rate and surface roughness noted. Material removal rate is assessed by the ratio of mass difference of material prior and after machining to machining time. Tool wear rate is also noted by weight difference method similar to material removal rate. Surface roughness for all the experiments are measured by Surface Tester.

2.4 Experimental set up

The experimental trails are carried out by Electric Discharge Machining process. The Model used for this experiment was ELECTRONICA- ELECTRAPULS PS 50ZNC. Copper is a common base material because it is highly conductive and strong. Its abundant availability was the reason behind its use. In this work, the tool material is employed in a round section with the size Ø8mm in diameter by 140mm in length.

2.5 Design of Experiments

The Experiment trails are directed by Taguchi technique by utilizing the machining set up. The control parameters in particular, combined equal weight percentage of Silicon carbide and Graphite, current and pulse on time is varied to lead 27 distinct tests. The mass of the work piece and tool are taken into account for calculating the MRR and TWR. The each experiment is conducted twice for better results and average values of output responses are considered for further analysis.

3. Experimental Results and Discussion

The examinations of the trial work are completed by utilizing MINITAB 17 (Trail Version), which is particularly used for DOE application. The trial observations data are converted into Signal to Noise proportion for measuring the quality attributes.

3.1 Signal to Noise Ratio for MRR, TWR and SR

Signal to noise ratio is applied to determine the optimal setting of process parameters. The maximum material removal rate values are obtained at higher S/N ratio. The minimum tool wear rate and surface roughness values are obtained at lower S/N ratio. The values of mean S/N proportion for material removal rate, tool wear rate and surface roughness are appeared in Table 1

Table 1. Signal to Noise ratio for MRR, TWR and SR

Expt. No.	Combined equal weight percentage of SiC and Gr (wt%)	Current (Amp)	Pulse on Time (μ s)	S/N for MRR	S/N for TWR	S/N for SR
				(gm/min)	(gm/min)	(μ m)
1	5	4	200	-8.24578	28.1787	-11.7766
2	5	4	400	-7.19037	30.1728	-12.7698
3	5	4	500	-6.8207	31.3727	-13.2363
4	5	8	200	-6.44786	27.7443	-13.0062
5	5	8	400	-5.64659	29.6297	-13.8745
6	5	8	500	-5.304	30.752	-14.2698
7	5	12	200	-4.97442	26.9357	-14.083
8	5	12	400	-4.27918	28.8739	-14.696
9	5	12	500	-3.98566	29.897	-15.2084
10	10	4	200	-8.75414	27.535	-12.2979
11	10	4	400	-7.63904	29.3704	-13.122
12	10	4	500	-7.25021	30.4576	-13.5156
13	10	8	200	-6.78269	27.1309	-13.3116
14	10	8	400	-5.91699	28.8739	-14.1684
15	10	8	500	-5.61337	29.897	-14.5182
16	10	12	200	-5.25615	26.3752	-14.4362
17	10	12	400	-4.52427	28.1787	-15.1327
18	10	12	500	-4.20839	29.1186	-15.4464
19	15	4	200	-8.11215	28.636	-11.4109
20	15	4	400	-6.99385	30.752	-12.4856
21	15	4	500	-6.59508	32.0412	-12.9281
22	15	8	200	-6.24942	28.1787	-12.7498
23	15	8	400	-5.40051	30.1728	-13.7862
24	15	8	500	-5.02074	31.3727	-14.083
25	15	12	200	-4.53891	27.3306	-13.9446
26	15	12	400	-3.80881	29.3704	-14.5671
27	15	12	500	-3.50447	30.4576	-15.0717

3.2 Analysis of Variance for MRR, TWR and Surface Roughness

Analysis of variance is implemented to find out most significant factor of process parameters in output responses. From Table 2, the F value result shows that the significant factors for material removal is the control factors in order Current, Pulse On time and combined equal weight percentage of Silicon carbide and Graphite. Furthermore, the current is the most significant factor since it contributes a greater percentage (83.5%) than all other control factors. The conclusions in S/N table and ANOVA are consistent with the multiple performance characteristic.

Table 2. Analysis of Variance for Material Removal Rate of Al hybrid metal matrix composites

Source	DF	Adj SS	Adj MS	% Contribution	F-Value
Wt %	2	0.00646	0.00323	3.5	107.22
Ip	2	0.154417	0.077208	83.5	2562.86
Ton	2	0.023484	0.011742	12.7	389.76
Error	20	0.000603	0.00003	0.3	
Total	26	0.184963		100	

Based on Table 3, it is observed that the pulse on time is the most significant factor for tool wear rate since it contributes a greater percentage (74.34%) than all other control factors.

Table 3. Analysis of Variance for Tool Wear Rate of Al hybrid metal matrix composites

Source	DF	Adj SS	Adj MS	% Contribution	F
Wt%	2	0.00011	5.70E-05	11.89	855
Ip	2	0.00013	6.50E-05	13.63	980
Ton	2	0.00071	0.00036	74.34	5345
Error	20	1.30E-06	1.00E-07	0.135 6	
Total	26	0.00096		100	

According to Table 4, it can be seen that the current is the most significant factor for surface roughness since it contributes a greater percentage (70.22%) than all other control factors.

Table 4. Analysis of Variance for Surface Roughness of Al hybrid metal matrix composites

Source	DF	Adj SS	Adj MS	% Contribution	F-Value
Wt%	2	0.41407	0.20704	4.68	149.51
Ip	2	6.21905	3.10953	70.22	2245.45
Ton	2	2.19623	1.09811	24.8	792.97
Error	20	0.0277	0.00138	0.3	
Total	26	8.85705		100	

Conclusions

Based on investigation of experimental results, it was notified that Material Removal Rate and Surface Roughness were greatly influenced by current whereas Tool Wear Rate was strongly affected by Pulse on Time. According to statistical data of Analysis of variance, the current was contributed higher percentage (83.5%) for Material Removal Rate and (70.22%) for surface roughness of hybrid Composites compared to other two machining parameters considered in the present study whereas for tool wear rate, the pulse on time was contributed strongly (74.34%) compared to rest of the process parameters of present study. Moreover, the derived optimal setting of Electrical discharge machining process parameters can be used to produce higher material removal rate as well as lower tool wear rate and surface roughness.

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