Effect of EDM process parameters on Metal Removal Rate and Surface Roughness of Aluminum Matrix Composite

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Abstract: Composite area unit gaining more and additional attention in structural, thermal, tribological and environmental applications these days, as a result of they need high strength to weight quantitative relation than typical alloy. during this work, Silicon carbide of a 100-mesh size has been used as reinforcement and its weight proportion is varied by 5 % in Aluminum 7075 matrix. Aluminum Matrix Composites (AMCs) have been fabricated using electromagnetic stir (EMS) casting methodology. The impact of Electro Discharge Machining (EDM) method parameter on Metal Removal Rate (MRR) and Surface Roughness (SR) are investigated. it's noticed that current was the foremost influencing issue on MRR and SR for 5 weight % SiC reinforced AMCs. Regression models for MRR and SR were developed for 5% wt. SiC reinforced AMCs. AMCs can widely use in Piston, brake drum, brake disc, poppet valve guide.

IndexTerms **- Aluminum Matrix Composites, Electromagnetic stir casting, Electro Discharge Machining.**

I. Introduction

A composite is a structural material that comprises of two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure. Composites are classified according to their matrix material like, polymer, metal and ceramic. Metal Matrix Composites (MMCs) consist of at least two components, metal as a matrix and the ceramic as a reinforcement. By combining matrix as in metal form and reinforcement in ceramic form, prevalent properties are obtained [1, 2].

The various processing techniques are developed to produce AMCs, which should be categorized by solid, liquid and vapor state of materials. In liquid metallurgy route, stir casting is lot of wide spread methodology. The liquid metallurgy techniques include liquid metal matrix with the reinforcement to produce AMCs. This process produces nearly net shape component as compared with diffusion bonding, so less machining required. This process requires approximate 5 to 6 mins for produce AMCs and they are most commonly used [1]. In mechanical stir casting, the stirrer is employed to rotate molten metal in crucible. But, in mechanical stirring the stirrer gets erode frequently during stirring process and eroded particles are mixed with composite [3]. Therefore, the standard of composite is deteriorated. Moreover, in some cases the reinforcing particles are broken, which also deteriorate the composite quality. These problems can be overcome by using a novel technique of Electromagnetic stirring (EMS) process. In this process, electromagnetic field is created by supplying AC power [4]. This field is used to rotate the molten aluminum and hence, effective and reliable stirring is achieved [5]. Electromagnetic stirring can draw reinforcement into melt, so distribution is achieved [3, 6, 7].

A359 alloy reinforced with 2%, 4%, 6% and 8 wt.% of Al2O3 of average 30µm size produced using EMS process. The tensile strength of A359/Al2O3/8 wt.% which is about 45% higher than that of non-reinforced A359 and maximum hardness value obtained at 8 wt. %, which is about 58% higher than the A359 matrix [6]. SS304 has Better corrosion resistance than Type 302,Also perceives High ductility, excellent drawing, forming, and spinning properties. Essentially non-magnetic, becomes slightly magnetic when cold worked. S. P. Dwivedi et al. have investigated mechanical properties of AMCs, which have fabricated via EMS method. They reported that significant improvement in tensile strength, hardness and toughness by addition of SiC particle in A356 [8]. In present work, EDM process parameters like, Current, Pulse on time (T on) and Pulse off time (T off) have been selected for investigation onMRR and SR.

II. Experimental Methodology

Al 7075 aluminum alloy selected as the matrix material, because of it has better mechanical strength and has good fatigue strength. Figure 1 and 2 shows the aluminum 7075 as a rod form with its PMI report. Silicon carbide (SiC) of 100 mesh size (149 micron) has been selected as the reinforcement; because of it is hard, wear-resistant, low cost and easily available.

Figure 1: Aluminum 7075

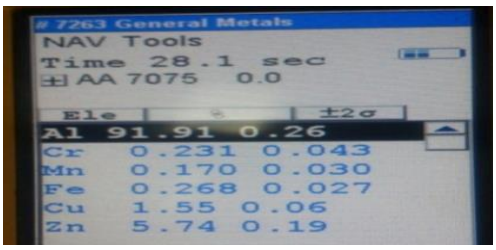


Figure 2: PMI Report of AA 7075

The AMCs have been fabricated through EMS process and set up is shown in fig.3. Aluminum is melted in muffle furnace at a 775 0C. After melting of aluminum, it is placed 3 Phase 15 HP Induction motor stator for stirring. Current is adjusted through 3

Phase variac for stirring, mean time SiC particles are added in molted aluminum. Electromagnetic stirring is rigorously carried out by keeping 15 to 22 amperes for 5 minutes. Then molted AMCs has been removed from crucible and solidified in die. After solidification of AMCs samples, they have been removed from die and study their microstructures.

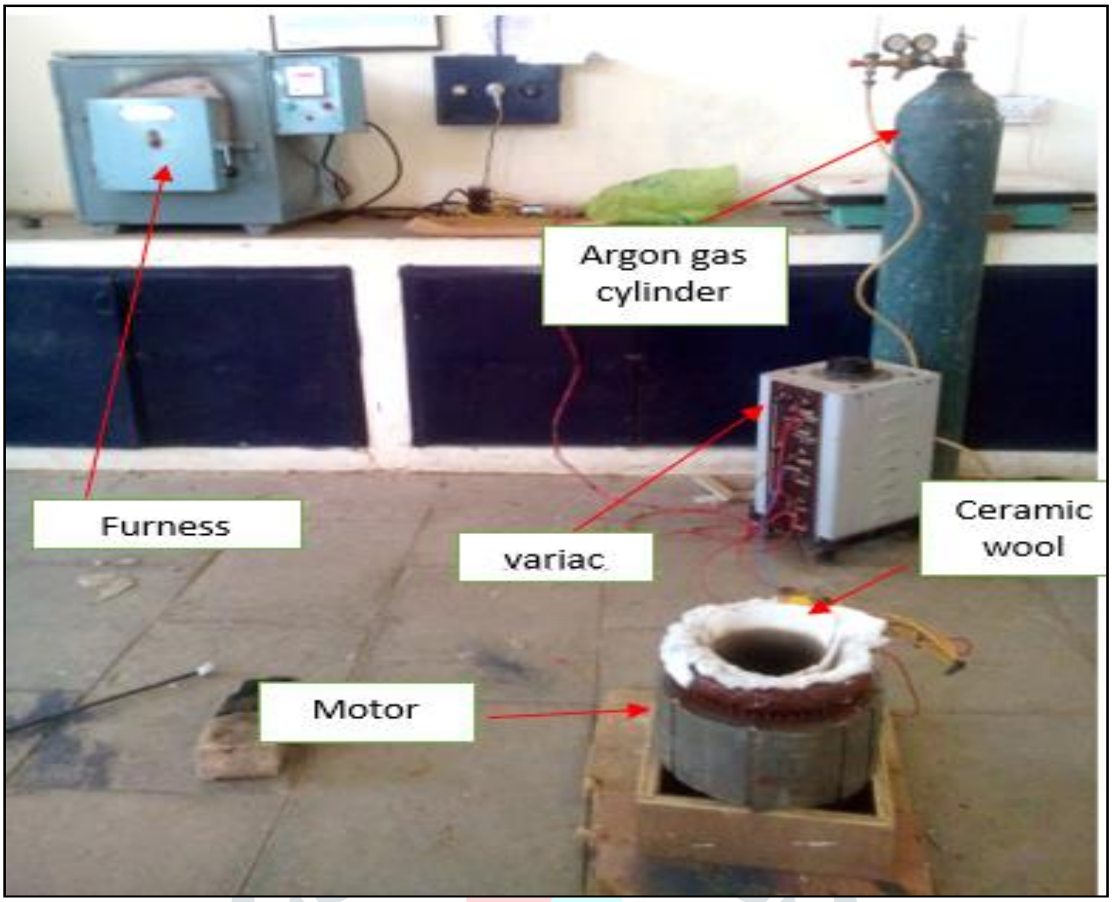


Figure 3: EMS setup

Following are the process parameter select to investigate the effect on MRR and surface roughness. Selection of parameters is done in such a manner that arching is avoided and the MRR should quantify.Full factorial method has been used for EDM experimentation. Here 3 parameters and 3 levels selected, so total 27 experiments have been carried out.

Table 1: EDM process parameters

Parameter	Low Level	Intermediate level	High level
Current (Amp)	8	10	12
T on (µs)	100	150	200
T off (µs)	50	100	150

III. Result and Discussion

Figure shows that microstructure of 5 weight % SiC reinforced in aluminium 7075 matrix. From the above figure, it is observed that the SiC particle distributed in aluminium matrix. The value of MRR and SR observed for different value of Current (A), T on (µs) and T off (µs) are shown in table 2.

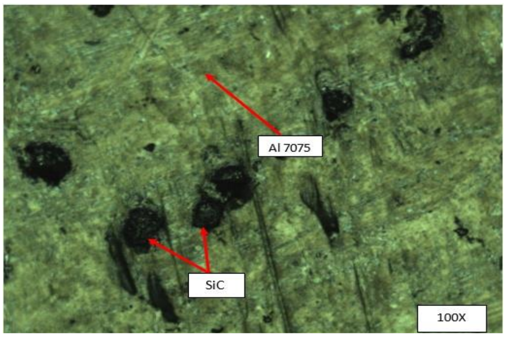
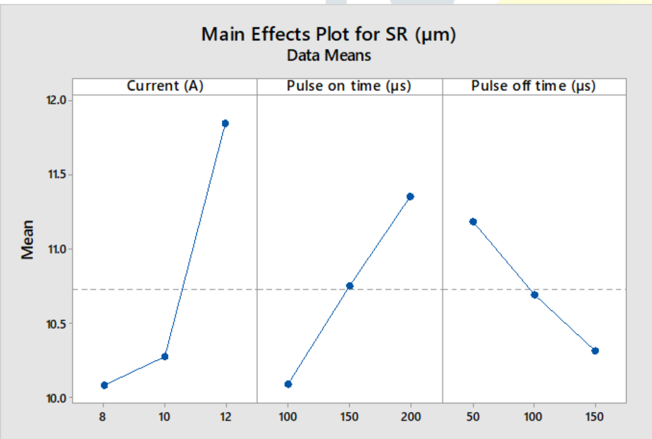


Figure 4: SiC reinforced AMC

Table 2: MRR and SR of 5% wt. SiC reinforced AMCs

Experiment No.	Input Parameters			Output Parameters	
	Current (A)	T on (μs)	T off (μs)	MRR (gm/min)	SR in Ra (μm)
1	8	100	50	0.156	9.71
2	8	100	100	0.228	8.72
3	8	100	150	0.185	8.62
4	8	150	50	0.253	10.31
5	8	150	100	0.208	10.27
6	8	150	150	0.258	10.21
7	8	200	50	0.292	11.21
8	8	200	100	0.254	11.06
9	8	200	150	0.256	10.65
10	10	100	50	0.256	10.84
11	10	100	100	0.315	9.77
12	10	100	150	0.238	8.78
13	10	150	50	0.280	10.77
14	10	150	100	0.238	10.13
15	10	150	150	0.262	9.79
16	10	200	50	0.356	11.61
17	10	200	100	0.338	10.89
18	10	200	150	0.315	9.91
19	12	100	50	0.375	11.66
20	12	100	100	0.458	11.51
*21	12	100	150	0.320	11.22
22	12	150	50	0.426	12.06
23	12	150	100	0.458	11.78
24	12	150	150	0.375	11.47
25	12	200	50	0.452	12.52
26	12	200	100	0.478	12.14
27	12	200	150	0.386	12.21

Main effect plots for MRR and SR are shown in figure 5 and 6 respectively. It is observed that MRR is increased with current and pulse on time. In case of pulse of time, initially MRR increased then decreased. SR is increased with current and pulse on time, while decreased with pulse of time.



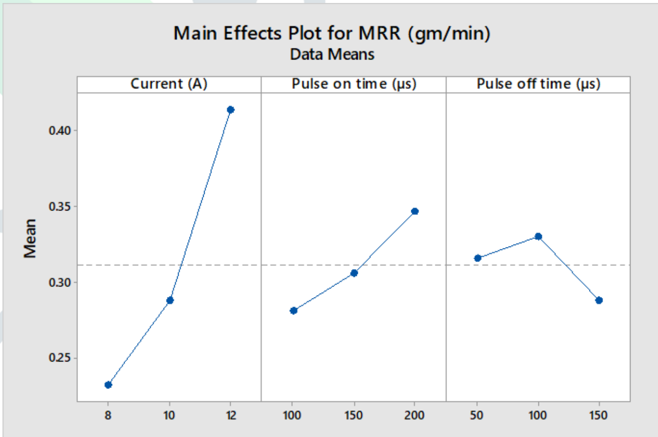


Fig 5: Effect of EDM process parameters on MRR of AMCs

Fig 6: Effect of EDM process parameters on SR of AMCs

Table 3: ANOVA for MRR

Source	D F	Seq S S	Adj S S	Adj M S	F	P	% Contribution
Current (A)	2	0.156223	0.156223	0.078111	66.46	0	83.55
T on (μs)	2	0.020108	0.020108	0.010054	8.55	0.002	10.75
T off (μs)	2	0.008298	0.008298	0.004149	3.53	0.049	4.44
Error	20	0.023508	0.023508	0.001175			
Total	26	0.208136					
S = 0.0342838			R-Sq = 88.71%		R-S q(adj) = 85.32%		

Table 4: ANOVA for SR

Source	D F	Seq S S	Adj S S	Adj M S	F	P	% Contribution
Current (A)	2	16.7109	16.7109	8.3555	52.53	0	60.46
T on (µs)	2	7.1877	7.1877	3.5938	22.59	0	26.00
T off (µs)	2	3.4249	3.4249	1.7125	10.77	0.001	12.39
Error	20	3.1815	3.1815	0.1591			
Total	26	30.5051					
S = 0.398843			R-Sq = 89.57%		R-Sq(adj) =86.44%		

For the above-mentioned tables, adjusted sum of squares for a term is the increase in the regression sum of squares compared to a model with only the other terms. It quantifies the amount of variation in the response data that is explained by each term in the model. Adjusted mean squares measure how much variation a term or a model explains, assuming that all other terms are in the model, regardless of the order they were entered. Unlike the adjusted sums of squares, the adjusted mean squares consider the degrees of freedom. The adjusted mean square of the error (also called MSE or s2) is the variance around the fitted values. F-value & p-value, which is used is to make decision about the statistical significance of the terms and model. The p-value is a probability that measures the evidence against the null hypothesis. Lower probabilities provide stronger evidence against the null hypothesis.A sufficiently large F-value indicates that the term or model is significant.

ANOVA Tables shows that, percentage contribution of current, T on and T off on MRR were varied as, 83.55, 10.75 and 4.44 for 5 weight % SiC reinforced AMCs respectively. The percentage contribution of current, T on and T off on SR were varied as, 60.46, 26.00 and 12.39 for 5 weight % SiC reinforced AMCs respectively. Current was the most influencing factor on MRR and SR for 5 weight % SiC reinforced AMCs.

In this current study, MRR and SR were taken as a response (output) parameters, while current, T on and T off were taken as independent (input) variables. Regression models (equations) for MRR and SR of 5% wt. SiC reinforced AMCs were developed, which are shown below:

MRR = - 0.214741 + 0.0455 Current (A) + 0.000662222 Ton (µs) - 0.000278889 T off (µs)

SR = 5.31741 + 0.439167 Current (A) + 0.0126333 Ton (µs) - 0.0087 T off (µs)

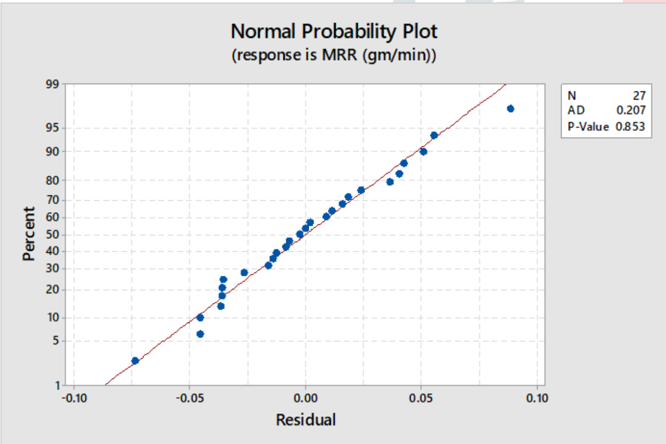


Figure 7: Normal probability plots of residuals for MRR

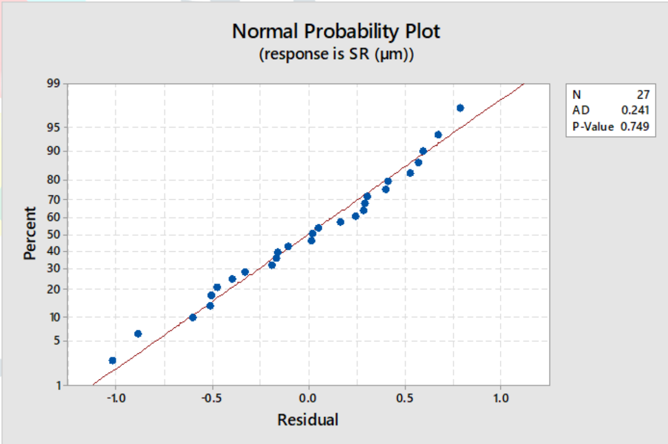


Figure 8: Normal probability plots of residuals for SR

Adequacy of above regression models were confirmed with normal probability plot of residuals. The normal probability plots for wear loss and COF are presented in Figs. 7 and 8 respectively. Figs. 7 and 8 shows, most of the points are near to straight line. So, the developed MRR and SR models are adequate.

IV. Conclusion

- Electromagnetic stirring is successfully used to fabricate AMCs with 5% wt. SiC reinforced AMCs.
- MRR is increased with increase current and pulse on time. In case of pulse of time, initially MRR increased then decreased.
- Surface roughness increases with increase current and pulse on time and decreases with increase pulse off time.
- It is also concluded that current was the most influencing factor on MRR and SR for 5 weight % SiC reinforced AMCs.

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