

Effect of Weight Percentage and Cutting Parameter on Surface Finish of SiC Reinforced Aluminium Composite

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Abstract: In the present work, aluminium alloy of series 1100 is selected as a matrix material and SiC of 45 microns as reinforcement. The composites are synthesized by 2 stage stir casting route, by varying a weight % of reinforcement from 6 % and 10%. The surface roughness of prepared composite were examined after plain turning operation. The machining parameters like speed, feed, DOC, SiC Wt. % are varied at 3 different levels. In order to minimize the time, cost and material a taguchi L9 orthogonal array was used for experiment. From the studies it was observed that the roughness value will increase with the increasing in reinforcement percentage.

Key words: AL-1100, SiC, Stir Casting, Surface roughness, Lathe tool dynamometer and DOE.

1. Introduction:

The applications of metal matrix composites (MMCs) are being increasing day to day in both the aerospace and automobile industries, because of their improved properties compared to monolithic metals. Today, among various metal matrix composites (MMCs) synthesized, aluminium metal matrix composites in general and discontinuously reinforced aluminium metal matrix composites, such as Al-SiC in particular, are emerged as the forerunner for a variety of general and special applications. Studies on machinability of light alloy composites reinforced with Al/ SiC fibers/particles [8-12] indicate poor machinability due to abrasive wear of tools. Moreover, quality of the machined surface also deteriorates with tool wear [1]. The developed aluminium metal matrix composites is considered to be a promising material for the high temperature applications. Because composite materials are important engineering materials due to their excellent mechanical properties such as higher strength to weight ratio, improved hardness, good wear resistance, low density, good thermal conductivity and low coefficient of thermal expansion. It is particularly due to increase in performance and weight saving for more reduction of fuel consumption [2]. When loads are applied externally to the composites, metal matrix transmits loads to reinforcements and then loads are carried by dispersed reinforcements bonded with the matrix. Strong interface bond between reinforcements and matrix is required to obtain high strength of composites. Interface bond is formed by reaction or mutual dissolution during casting. Therefore, good wetting of the reinforcements is necessary during casting [3]. The aim of this study is to observe the effect of SiC reinforcements in Al matrix composites on microstructural aspects, hardness and machinability test.



2. Experimental procedure:

2.1. Material

Al was used as matrix material and SiC particles were added as reinforcements to prepare composites in this study. The chemical composition of Al used as matrix material is given in table 1. To increase the wettability of SiC particles in the molten Al, 1 wt. % of magnesium (Mg) was added to molten aluminium during casting.

Table1. Chemical Composition of Al 1100

Material	Weight %
Fe	0.95% Max
Si	0.95% Max
Zn	0.1% Max
Cu	0.05-0.2%
Mg	0.05% Max
Al	99.0-99.95%

2.2 Preparation of Composites

SiC reinforced MMCs were prepared by stir casting process. The Al 1100 plates, were cut into small pieces by using a hand press, placed in a graphite crucible and heated upto 750°C above its melting point (660°C). Degassing tablet was used to remove entrapped gases. Mg ingot was added in the melt to increase the wettability of SiC particles in the molten Al. Silicon carbide particles were preheated at 800°C for about two hours. Heat treated SiC particles were added in molten metal through funnel at 700°C. After SiC addition, the liquid metal-reinforcements mixture was stirred for 5 minutes. Finally composites were poured in preheated metal mould. The melt was allowed to solidify in the mould. It was then cut according to ASTM G-65 Standards.

3. Testing

The hardness measurement was carried out on the base metal and composition samples using Rockwell hardness tester. For 20 second dwell time was taken 1/16th inch steel ball indenter and 100kgf. For measured the hardness at 5 different locations and average result was tabulated. Computerized BANKA lathe machine was identified to carry out the machinability test. Lathe tool dynamometer is attached to the tool post in order to find out the cutting forces acting on the tool while machining. The machining parameters like speed, feed, depth of cut and SiC wt % are varied in 3 levels as shown in table 2.

Table 2. Parameters used in machinability test

Parameter	Levels		
SiC wt %	0%	6%	10%
Speed	175	263	395
Feed	0.067	0.111	0.167
DOC	0.2	0.4	0.6

Surface roughness (Ra) of the machined surface of a specimen was measured (Mitutoyo SJ201) portable surface roughness device according ISO 4287 standards.

4. Design of experiments

The Taguchi strategy was in apply to machinability levels like feed rates, cutting speed and depth of cut were examined to decide the impact of machining parameters at first glance harshness and the cutting power. The full factorial test cutting parameters with four levels and three variables include 64 test results.

This expands the quantity of trial runs correspondingly it requires investment and requires a high cost. In this manner, taguchi proposed an exceptional configuration of orthogonal exhibit to examine the full parameter with a little number of trials keeping in mind the end goal to diminish the trial process. This technique make less quantity of investigations by utilizing orthogonal array and minimizes the impacts of elements that can't be controlled. Moreover, it gives a basic, effective and orderly way to deal with indicating the ideal cutting parameters in the assembling process.

The taguchi's quality loss function approach was performed to compute the deviation between the trial values and the ideal cutting qualities. This capacity are further recovered into a signal to-noise (S/N) proportion and the cutting parameters are assessed in light of the S/N. The S/N proportion signs can be isolated into three gatherings: the smaller the-better, the bigger the-better, and the nominal the-best. This study intended to improve the surface roughness (Ra) and cutting force (F). Henceforth, a smaller the-better has been debated to register the S/N proportion. Where Ra is the obtained value of surface harshness and cutting force for the test in that examination, and n is the quantity of tests in the trials, a high flag to S/N ratio. Table 3 indicates L9 standard orthogonal array.

Table 3. L9 Orthogonal Array

SL.NO	Cutting speed(rpm)	Feed rate (mm/sec)	Depth of cut(mm)	SiC Wt. %
1	175	0.067	0.2	0%
2	175	0.111	0.4	6%
3	175	0.167	0.6	10%
4	263	0.067	0.4	10%
5	263	0.111	0.6	0%
6	263	0.167	0.2	6%
7	395	0.067	0.6	6%
8	395	0.111	0.2	10%
9	395	0.167	0.4	0%

5 Result and Discussion

Uniform dissemination of SiC particles are seen from the got small scale diagrams as appeared in figure 1. It is additionally watched that silicon carbide particles have great wettability with the option of magnesium ingot. Agglomeration of support particles were likewise found in specific regions.

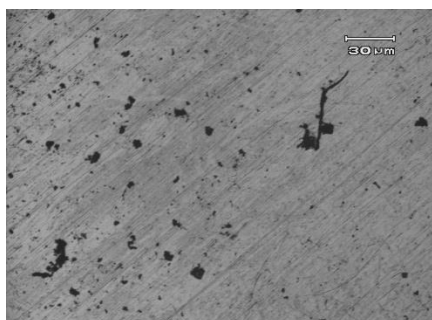


Figure 1(a) Microstructure of Al-6% SiC

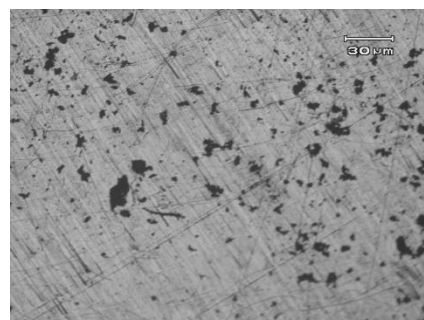


Figure 1(b) Microstructure of Al-10% SiC

5.1 Hardness Graph

Table 4. Hardness value

Material	Load in kg	Indentation	Scale	Indentation Time	Rock well number					Average value
					1	2	3	4	5	
Base metal	100	1/16 ¹¹ ball	B	20 sec	44	45	42	39	41	42
Al+6%SiC	100	1/16 ¹¹ ball	B	20sec	48	42	53	49	74	53
Al+10%SiC	100	1/16 ¹¹ ball	B	20sec	53	53	52	53	61	55

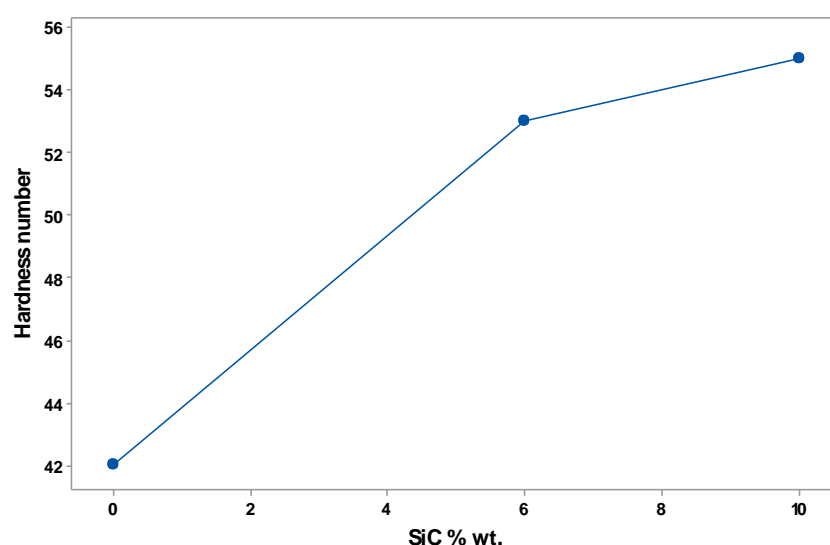


Figure 2. Scatterplot of hardness v/s SiC Wt %

From figure2 to conclude that with percentage of SiC particles added to the base alloy Al-1100 the hardness will also increase when compared to base alloy.

5.2 Residual Plot

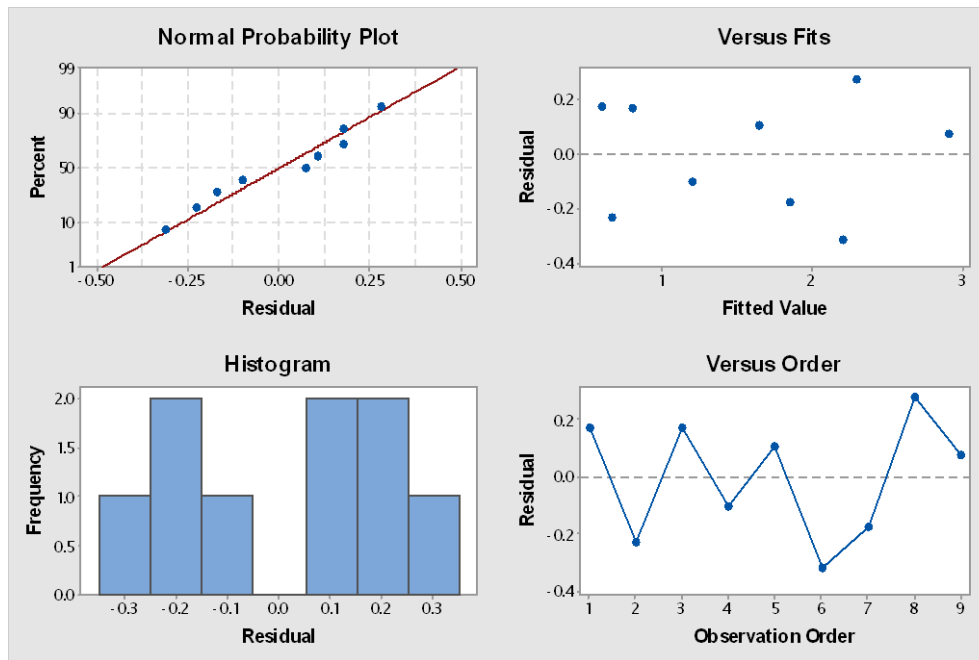


Figure 3. Residual Plots

Table 5. Analysis variance

Level	SiC Wt %	DOC	Feed	Speed
1	3.2885	-4.6935	-4.4878	-1.6898
2	-3.7393	-0.9016	-0.9938	-1.9096
3	-7.3964	-2.2521	-2.3656	-4.2478
Delta	10.6849	3.7919	3.4939	2.5580
Rank	1	2	3	4

1. In above plot, straight line dividing points into two equal of hence our experimental data meeting the normality assumptions (model adequacy).
2. The above graph shows our experimental data roughly obeys the constant variance assumption.
3. The observation order v/s residual plot shows that experiments are done randomly.

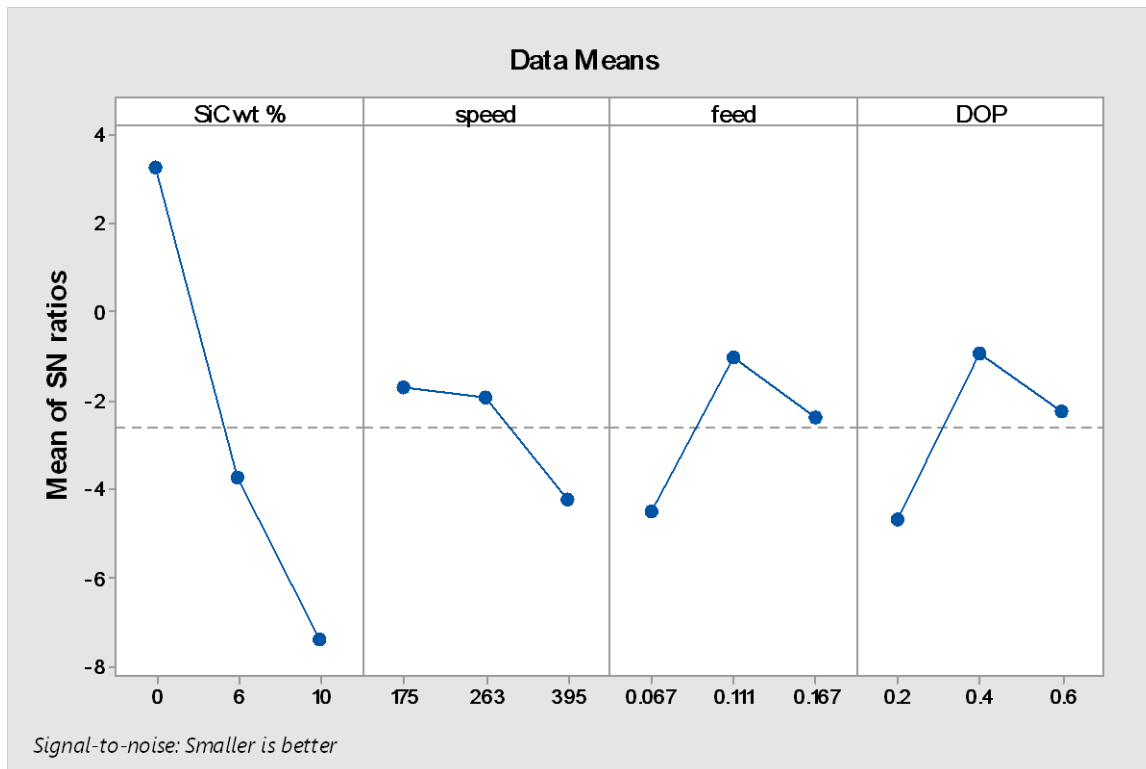


Figure 4. Main Effects plot v/s S/N ratio

Based on main effect plots for S/N ratio, To identified optimum variance of the each variables i.e. for material at 10% maintain speed 175rpm, feed maintain at 0.167 or 0.111mm/rev and for depth of cut 0.4mm.

Table 6. Analysis Variance value table

Source	D F	Adj MS	F-Value	P-Value
SiC Wt. %	1	4.2200	48.67	0.002
Speed	1	0.5830	6.72	0.060
Feed	1	0.2411	2.78	0.171
DOP	1	0.2646	3.05	0.156
Error	4	0.3468		
Total	8	5.6555		

We have checked the basic assumptions of DOE. We applied taguchi methods to find the optimum levels of the parameters. To the run the model at 95% confidence interval, 5% significance level. The P value of SiC Wt % is .002 is less than 0.05, so it is significant, and for speed is 0.06 which is nearly equal to 0.05 so it is also significant. The P value of feed and DOP are 0.171 and 0.156 respectively, which are more than 0.05, so these are not significant level.

6 Conclusion

The test study on the machining parameters, for example, cutting force and surface roughness of the as cast composites at various weight part of fortifications accompanying focuses:

- a) The surface roughness of Al-1100 increases as Wt. % of SiC increases.
- b) Clustering and non- homogenous dispersion of SiC particles were found in the microstructure of Al matrix.
- c) It is observed that increase in the reinforcement content increases the hardness of aluminium metal matrix composites.

7 Reference

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