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Comparative Analysis of Machining Parameters In Milling Process of MMC and HMMC(Al+10%Sicp+5%Gr)

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***Abstract*—This paper deals with the comparative analysis on the use of graphite (Gr) reinforcement in aluminium matrix composites has been reported to be beneficial in reducing wear due to its solid lubricant property, but it results in reduction of mechanical strength. Addition of silicon carbide (SiC), on the other hand, improves both strength and wear resistance of composites, but high amount of SiC makes machining difficult and composites become brittle. Thus, SiC can be advantageously used as a second reinforcement to overcome the problem of strength reduction of Gr reinforced composites, resulting in what is known as hybrid composites. Aluminium matrix composites reinforced with equal weight fraction of SiC and Gr particulates up to 10% are studied with regard to hardness improvement and modified dry sliding wear behaviour. Studies based on design of experiments techniques indicate that there is an increasing trend of wear in Al–SiC–Gr hybrid composites beyond % reinforcement of 7.5%. Hybrid composites exhibit better wear characteristics compared to Gr reinforced composites. Interaction between load and sliding distance is noticed in both the composites and this may be attributed to the presence of Gr particulates.**

Keywords—mmc; surface roughness; tool flank wear; taguchi; S/N; WC; PMMC; milling

1.INTRODUCTION

Aluminium matrix composites (AMCs) are replacing the conventional aluminium alloys due to improved strength to weight ratio, which is one of the most desirable characteristic in automotive engine pistons, brake pads, turbine blades, etc. to mention a few among the most common applications of AMCs. AMCs reinforced with soft reinforcement particles of Gr have been reported to be possessing better wear characteristics owing to the reduced wear because of formation of a thin layer of Gr particles, which prevents metal to metal contact of the sliding surfaces. A linear relation be-tween the wear volume and load is the observation of Liu et al. for laser processed Al–Gr composites with 1.55 wt.%Gr. The wear has been significantly influenced by the formation of a thin lubricating film of Gr particulates and removal of worn material was noticed consequent to the failure of this film [1]. Lin et al. have investigated Al–Gr composite with 0–6 wt.%Gr and the results indicate reduced wear rate with increase in particulate content. Decrease of wear has been attributed to prevention of direct contact of sliding surfaces and reduced ploughing effect of Al chips due to the quick formation of lubricating film of graphite particulates [2]. The investigation on machining of Al–Gr composites by Krishnamurthy et al. has indicated considerable reduction of cutting forces and this has been attributed to the possible reduction of friction due to solid lubrication of Gr particulates [3].

Thus, the addition of Gr facilitates easy machining and results in reduced wear of Al–Gr composites compared to Al alloy. But high amount of Gr may result in increase of wear due to decrease in fracture toughness with increase in % reinforcement of Gr particulates as noticed by Ted Guo et al. [4]. Hassan et al. have reported decrease in hardness with increase in % reinforcement of Gr due to increased porosity [5]. The implication of these observations is that the % reinforcement of Gr in Al–Gr composites is bounded by certain limit beyond which it is not beneficial to add Gr as reinforcement. This should not discourage to make use of the beneficial influence of addition of Gr in Al–Gr composites. Hard ceramic particulates of SiC when added as a second reinforcement is a panacea towards the difficulties encountered with high % reinforcement of Gr in Al–Gr composites. Al–Gr composites containing SiC are re-ferred as Al–SiC–Gr hybrid composites. The salient observations of some of the studies on Al–SiC–Gr hybrid composites are high-lighted in the following few lines.
Riahi et al. have focused upon the influence of tribolayer containing primarily Gr on wear of Al–10SiC–4Gr hybrid composites [6].The investigations of Basavarajappa et al. on Al–15SiC–3Grcomposites have indicated that the degree of subsurface deformation and thereby the wear rate in graphite composites is less than that of graphite free composites [7]. Rohatgi et al. have reported that the reduction in friction coefficient of Al–10SiC–6Gr is due to the combination of increase in bulk mechanical properties as a result of addition of SiC and formation of graphite film [8]. Ted Guo et al. have observed that wear of Al–10SiC–2–8Gr increases up to 5%Gr because of reduced fracture toughness and then de-creases due to formation of thick solid lubricant film which over-rides the effect of fracture toughness [4]. Thus, aluminium matrix hybrid composites

posses better tribological properties over composites with single reinforcement as envisaged by these investigations.

The reported studies have indicated that efforts are scarce on parametric studies on the tribologicalbehaviour of aluminium ma-trix hybrid composites. Consequently, the present investigation fo-cuses on the study of the influence of % reinforcement of SiC particulates, load, sliding speed and sliding distance on the tribologicalbehaviour of Al–SiC–Gr hybrid composites.

II.Experimental procedures and measurements

A.Materials

Al–SiC–Gr and Al–Gr composites required for the investigation are fabricated by stir casting [9]. LM25 is used as the matrix alloy and details of its composition is given in Table 1. Table 2 provides the details of SiC and Gr particulates which are used as reinforcements. Table 3 gives the details of hybrid composites. Al–SiC–Gr hybrid composites with combined weight % reinforcement of 2.5%, 5%, 7.5% and 10% are used. In each of these composite as seen in Table 3, % reinforcement of each of SiC and Gr is equal. Similar details of Al–Gr composites are given in Table 4.

B.Experiments

The al cast composites are of 10 mm diameter, 50 mm length from which wear test specimens of length 35 mm and 8 mm diameter are machined. The end of the specimens are polished with abra-sive paper of grade 600 and followed by grade 1000. Dry sliding tests are carried out as per ASTM G99-95a test standards on pin-on-disc equipment the disc of which is of EN31 steel with surface roughness, R_a 0.1. The pins are cleaned with acetone and weighed before and after testing to an accuracy of 0.0001 g to determine the amount of wear. The sliding end of the pin and the disc surfaces are cleaned with acetone before testing. The hardness of the composites is evaluated using Brinell's Hard-ness Tester.

The experiments were performed on a vertical milling machine. The machining tests (face milling of the composites were performed) in a computer numerical controlled vertical machining center (VMC ARIX 100) capable of a working speed of 5000 rpm. The view of the experimental set-up for milling operation is shown in Figure 1.

The surface roughness was measured using a surface analyzer of Surfcoder 3500 made by Kosaka and represented as the roughness average (Ra, µm). The results of the roughness average values shown in Table I.

Table 1

Chemical composition of the matrix alloy LM25.

Element	Si	Mg	Fe	Cu	Cr	Zn	Ni	Mn
Content, %	7.1	0.3	0.3	<0.012	0.004	0.002	0.01	0.28

TABLE I. MACHINING PARAMETERS AND THEIR LEVELS

Level	**Machining parameters**		
	Speed (rpm)	***Feed rate (mm/min)***	***Depth of Cut (mm/min)***
Level 1	1000	10	0.5
Level 2	1500	15	1.0
Level 3	2000	20	1.5

Table 2

Details of reinforcements.

Reinforcement	Hardness, GPa	Grain size, lm	Density, g/cm^3
SiC	24.5–29	10–20	3.22
Gr	0.25	70–80	2.09–2.23

Figure 1 Experimental set up

Table 3
Details of Al–SiC–Gr hybrid composites.

	Al–SiC–Gr hybrid composites				
Combined % reinforcement	0.00	2.50	5.00	7.50	10.0
SiC	0.00	1.25	2.50	3.75	05.0
Gr	0.00	1.25	2.50	3.75	05.0
Hardness, BHN	67	72	70	68	66

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Table 4

Details of Al–Gr composites.

Al–Gr composites					
% Reinforcement of Gr	0.00	2.50	5.00	7.50	10.0
Hardness, BHN	67	62	55	53	52

III.Taguchi's Parameter Design

Taguchi methods are statistical methods developed by Genichi Taguchi to improve the quality of manufactured goods, and more recently also applied to, engineering, biotechnology, marketing and advertising by minimizing the effect of the cause of variation without eliminating the cause. This method involves reducing the variation in a process through robust design of experiments. In this study, Taguchi method, a powerful tool for parameter design of performance characteristics, was used to determine optimal machining parameters for minimum surface roughness of End milling process.

This method uses a special design of orthogonal arrays to study the entire parameter space with minimum number of experiments only. In this study, three machining parameters were used as control factors and each parameter was designed to have three levels shown in Table I. According to the Taguchi quality design concept, a *L27* orthogonal array was chosen for the experiments (Table II).

The experimental observation are presented and further transferred into signal to noise ratio (S/N ratio) as shown in Table III. S/N is defined as the ratio of mean of the signal to the standard deviation of the noise. S/N ratio takes in to account the amount of variability in the response data and closeness of the average response to the target. The S/N ratio depends on the type of quality characteristics; lower the better have selected for minimization problem of surface roughness values.

The signal-to-noise (S/N) can be calculated as,

S/N ratio for Surface finish= $-10 \log_{10} (y^2)$ (1)

The S/N ratio values of surface roughness value is calculated using the equation (1)

Table 5. Hybrid MMC Speed Vs Cutting force

SPEED	FEED	DOC	FX	FY	FZ
1000	10	0.5	28.51	14.67	111.4
1500	10	0.5	37.36	9.079	104.6
2000	10	0.5	6.459	12.28	45.37

S. no	Speed (rpm)	Feed (mm/ min)	Doc (mm)	Ra	S/N(Ra)	Fz	S/N(Fz)
1	1000	10	0.5	0.88	1.1103	111.4	-40.9377
2	1000	10	1	0.27	11.3727	136.6	-42.709
3	1000	10	1.5	1.4	-2.9226	113.4	-41.0923
4	1000	15	0.5	2.32	-7.3098	36	-31.1261
5	1000	15	1	2.05	-6.2351	43.28	-32.7257
6	1000	15	1.5	1.72	-4.7106	37.55	-31.4922
7	1000	20	0.5	0.87	1.2096	103	-40.2567
8	1000	20	1	0.77	2.2702	93.6	-39.4255
9	1000	20	1.5	0.48	6.3752	82.21	-38.2985
10	1500	10	0.5	0.75	2.4988	104.6	-40.3906
11	1500	10	1	0.41	7.7443	93.27	-39.3948
12	1500	10	1.5	0.43	7.3306	93.17	-39.3855
13	1500	15	0.5	0.62	4.1522	92.23	-39.2974
14	1500	15	1	0.35	9.1186	65.29	-36.2969
15	1500	15	1.5	0.506	5.917	39.93	-32.026
16	1500	20	0.5	0.44	7.1309	43.18	-32.7057
17	1500	20	1	0.226	12.9178	53.69	-34.5979
18	1500	20	1.5	0.567	4.9283	54.12	-34.6672
19	2000	10	0.5	2.473	-7.8645	45.37	-33.1354
20	2000	10	1	0.53	5.5145	21.07	-26.4733

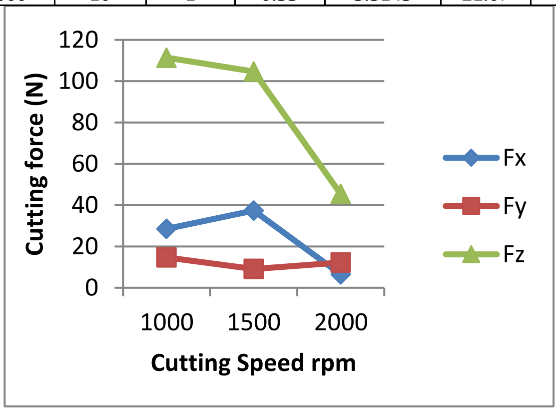

TABLE II.EXPERIMENTAL RESULTS OF END MILLING PROCESS

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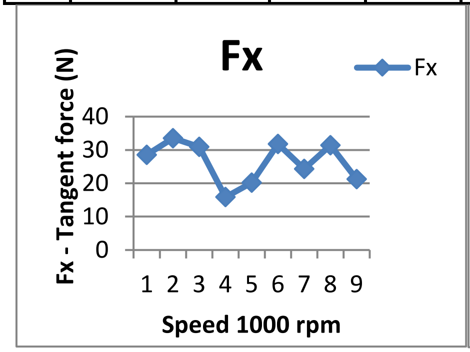
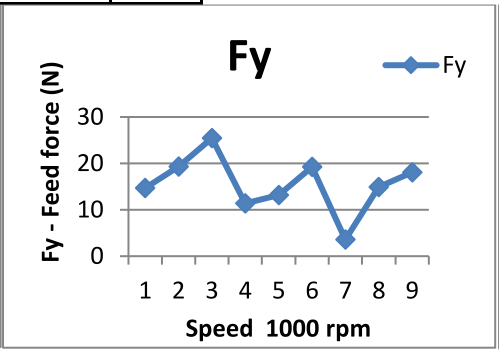
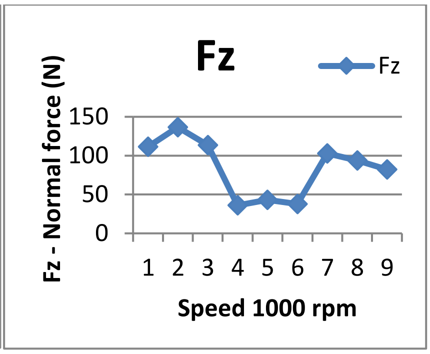
Table 6.Hybrid MMC speed Vs Force

Sl. No	Speed (rpm)	Feed mm/ min	Doc (mm)	Fx (N)	Fy (N)	Fz (N)
1	1000	10	0.5	28.51	-14.67	111.4
2	1000	10	1	33.53	-19.32	136.6
3	1000	10	1.5	30.97	-25.45	113.4
4	1000	15	0.5	15.85	-11.35	36
5	1000	15	1	20.21	-13.19	43.28
6	1000	15	1.5	31.78	-19.28	37.55
7	1000	20	0.5	24.35	-3.577	103







IV. ANALYSIS OF RESULTS

ANOVA results of Al–SiC–Gr hybrid composites are given in Ta-ble7.FactorsA(% reinforcement),B(sliding speed),C(load) are significant as their P-value is less than 0.05.. The% contribution of the significant factors is calculated by dividing the sum of squares of a factor by the total sum of squares. The values of % contribution of the significant factors are indicated in Ta-ble8.The contribution of the sliding distance is highest followedby sliding speed, load and% reinforcement.

TABLE 7.RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS OF THRUST FORCE (SMALLER IS BETTER)

Level	A	B	C
1	-38.16	-38.41	-36.70
2	-35.93	-34.81	-35.96
3	-35.99	-36.87	-37.43
Delta	2.23	3.60	1.47
Rank	2	1	3

a)MMC

Level	A	B	C
1	-37.56	-37.72	-38.03
2	-36.53	-35.65	-36.61
3	-36.89	-37.61	-36.35
Delta	1.03	2.07	1.68
Rank	3	1	2

b)HMMC

TABLE 8.ANALYSIS OF VARIANCE FOR S/N RATIO OF SURFACE ROUGHNESS a)MMC b)HMMC

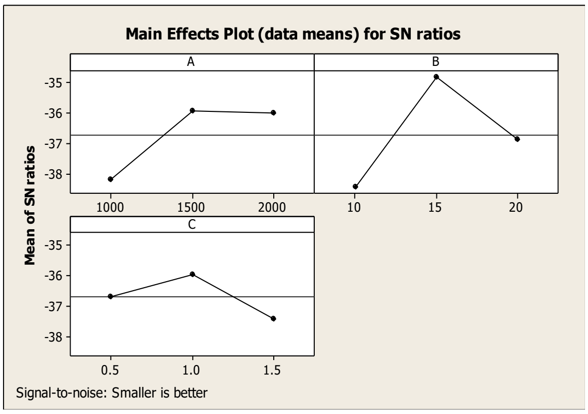
Source	DF	Sum of square	Mean square	F	P	
A	2	29.078	14.539	1.95	0.205	
B	2	58.854	29.427	3.94	0.064	
C	2	9.731	4.866	0.65	0.547	
A*B	4	106.052	26.513	3.55	0.060	SIGNIFICANT
A*C	4	42.272	10.568	1.42	0.312	
B*C	4	74.808	18.702	2.50	0.125	
Error	8	59.730	7.466			
Total	26	380.524				

a)MMC

Source	DF	Sum of square	Mean square	F	P	
A	2	4.946	2.473	0.41	0.675	
B	2	24.373	12.187	2.04	0.193	
C	2	14.780	7.390	1.24	0.341	
A*B	4	299.314	74.828	12.51	0.002	SIGNIFICANT
A*C	4	24.235	6.059	1.01	0.455	
B*C	4	26.346	6.587	1.10	0.419	
Error	8	47.851	5.981			
Total	26	441.845				

b) HMMC

Table 9.MAIN EFFECTS PLOT FOR S/N RATIO OF THRUST FORCE a)MMC b)HMMC



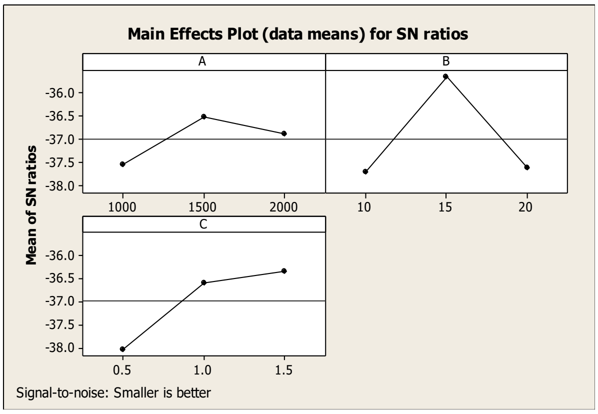
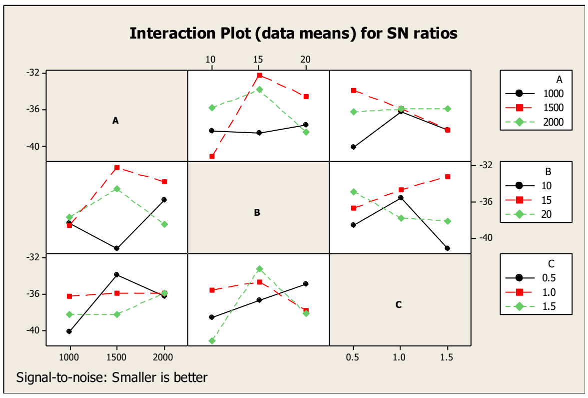


Table 10.INTERACTION PLOT FOR S/N RATIO OF THRUST FORCEa)MMC b)HMMC



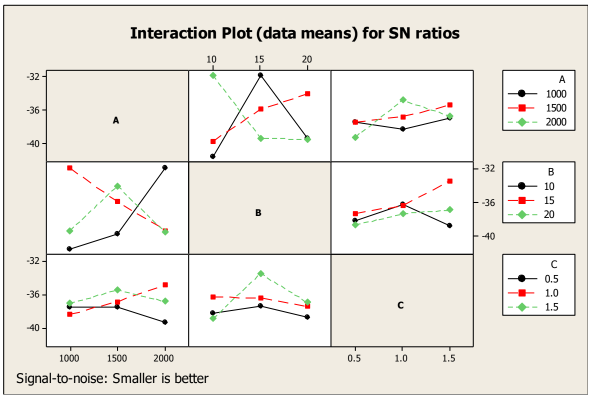
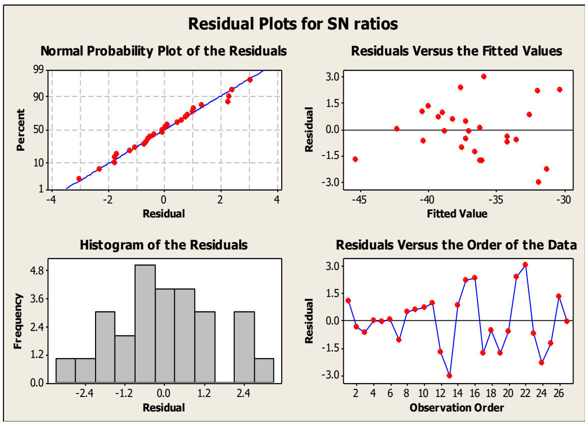
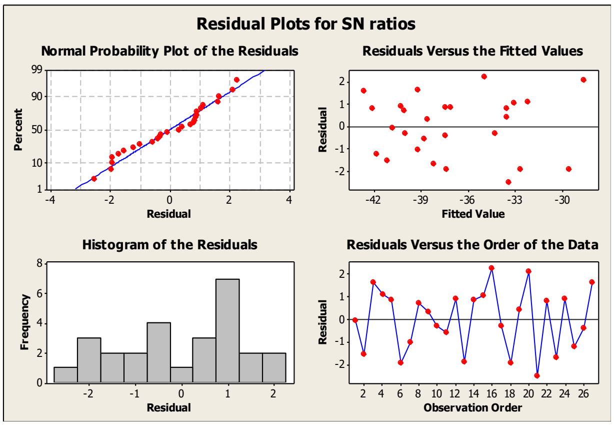


Table 11.RESIDUAL PLOTS FOR S/N RATIO OF THRUST FORCEa)MMC b)HMMC





V.RESULTS AND DISCUSSION

Experimental observations are analyzed for identifying the optimum level of parameters. Fig. 3 shows graphically the effect of 3 control factors on surface roughness on AMC. The analysis of experimental data was carried out using Minitab 15 software. Analysis of the result leads to the conclusion that factors for AMC at level B1 A2 C3 gives the minimum surface roughness for AMC. The influence of control parameter on the output has been evaluated using S/N ratios response analysis. The control factor with the greatest influence of was determined by difference between max and min values means of S/N ratios. Ranking of predominant parameter influencing the surface roughness using in the S/N ratio obtained for different parameter levels are listed in the following table. From these tables that affect the response feed rate is the dominant factor which influences the response of surface roughness. Increasing feed rate results is better Surface finish

VI. CONCLUSION

This paper has presented an investigation on the optimization and the effect of machining parameters on the surface roughness in End Milling operations. An optimum parameter combination for minimum SR was obtained by using the signal-to-noise (S/N) ratio. It can be observed from these tables that feed rate was the most dominant parameter influencing the surface roughness in Aluminum Matrix Composites. The fine surface roughness values obtained is 0.596μm using the optimal combination levels of machining parameter are speed 1500 rpm, feed rate 10 mm/min and Depth of cut 1.5mm/min.

VII. REFERENCES

[1] S. Durante, G. Rutelli and F. Rabezzena: *Surf. Coat. Technol.*, 1997, **94–95**(1–3), 632.
[2] B. Mohan, A. Rajadurai and K.G. Satyanarayana: *J.Mater. Process. Technol.*, 2004, **153– 154**, 978.
[3] K. Marsden: *J. Met.*, 1985, **37**(6), 59.
[4] Y.Z. Zhan and G.D. Zhang: *Mater. Des.*, 2006, **27**,79.
[5] M. Gallab and M. Sklad: *J. Mater. Process.Technol.*,1998, **83**, 277.
[6] E.O. Ezugwu, J. Bonney and Y. Yamane: *Int. J.Mater. Process.Technol*., 2003, **134**, 233.