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Evaluation of Metal Removal Rate of 356 Reinforced SiC/Gr Hybrid Composite by Novel Encapsulate Technique During CNC Turning

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Abstract

The research is to track and analyze changes in the material removal rate (MRR) for the A356 when utilizing high speed steel coated inserts, as well as to compare the results to those obtained using non composite material and composite material. In this study, the A356 was used, which has a length of 20 mm and a diameter of 25 mm. There are two groups in this study: experimental (A356 samples turned with composite material) and control (A356 samples turned with non-composite material). For a total of 40 responses, the sample size is computed to be 20 per group. The metal matrix composite is added with a weight fraction of silicon carbide (SiC) of 5% and graphite (Gr) of 5% in the novel encapsulated base metal A356 are casted in the stir casting machine. are compared with both composite cased material and non-composite cast material. The work focuses mostly on the analysis of hardness mechanical properties. Only a few surface flaws with fine grain size were observed in stir casting process at a furnace temperature of about 600 °C to 750 °C (600, 644, 675, 700), and the enhanced hardness is higher than A356 aluminum about 100 percent as cast base metal accordingly. The goal of comparing the hybrid metal matrix with the as cast metal hardness data was to see how they compared. The usefulness of the unique encapsulation approach to manufacture composite matrix materials with superior qualities than current ones for automotive piston material applications is demonstrated by our findings.

Keywords

Stir casting, Encapsulate feeder technique, Composite material, Silicon carbide, Graphite

Introduction

High-speed machining is becoming the most sophisticated technique in the metal industry. When compared to traditional machining, high-speed turning can increase production by 5 to 10 times. As a result, high-speed machining techniques have caught the industry's interest since they can reduce machining time and cost while increasing production [1]. High-speed turning is determined by the rate of cutting and its relationship to the material to be cut. Aside from the enhanced productivity that high-speed machining provides, the concept of high-speed machining can also improve surface quality [2]. Most engineering and industrial applications necessitate lightweight, high-strength materials that are both corrosion and wear resistant during operation [3]. Wear, density, hardness, ductility, light weight, melting point, cost, and other mechanical and thermal properties of the material are considered while adding reinforcing improvements for engineering applications [4].

In comparison to other metals and materials, stainless steel, mild steel, and aluminum have good and better qualities [5]. Aluminum A356 composite al-

loy with SiC and Gr as a reinforcement are used in many applications for various industries due to the light weight and superior mechanical and tribological properties (Table 1). By addition of reinforcement material at a weight fraction ratio of 5% of SiC, 5% of Gr and 90% of A356 base metal. And moreover the tensile strength and the hardness of the material is increased and the test result should analytically [6]. By the use of the CNC machine the turning operation is done with a 1 mm depth by a CNC insert tool. The given feed rate of 1400 the operation is done the MRR of both material with metal matrix composite (Table 2) and without the metal matrix composite (Table 3). The results are taken into the SPSS software then comparing the results and determining if the process of the research is satisfied or not. They concluded that the depth of the cut, cutting speed, cutting fluid combination ratios, and feed rate in that order were the most significant contribution to the study [7]. By using Taguchi approach and grey relational analysis, explained the high speed turning operation of aluminum alloy A356 with spindle speed (m/min), feed rate (mm/min), and depth of cut (mm)for MRR. Feed rate is the most significant factor in MRR. The work on the investigation of the novel feeding technique in squeeze casting composite is considered one of the best literatures. Our team has extensive knowledge and research experience that has translate into high quality publications [8-16].

From the literature review, it is observed that the combination of SiC, Gr, and A356 and novel encapsulate method was not found. Hence the effect of the novel encapsulate feeder technique on the composite was studied in this research. The objective of this research is to improve the hardness of the composite by adding novel encapsulation.

Table 1: Chemical composite.

Grade	Chemical composition (%)						
	Al	Si	Mg	Fe	Cu	Mn	Zn
A356	92.05%	7%	0.35%	0.20%	0.20%	0.10%	0.10%

Table 2: MRR values for A356/SiC 5% wt.; Gr 5% wt. (with composite).

Samples	Cutting speed (m/min)	Feed (mm/rev)	MRR composite material
1	750	0.1	2.897
2	750	0.15	2.998
3	750	0.10	3.423
4	750	0.15	2.908
5	750	0.1	3.352
6	1100	0.1	3.472
7	1100	0.15	3.492
8	1100	0.10	2.937
9	1100	0.15	3.308
10	1100	0.05	3.449
11	1400	0.10	3.229
12	1400	0.15	2.809
13	1400	0.2	3.772
14	1400	0.25	2.707
15	1400	0.3	3.123
16	1600	0.1	3.263
17	1600	0.15	3.227
18	1600	0.2	2.899
19	1600	0.25	2.990
20	1600	0.3	3.526

Materials and Method

The study setting of this research was carried out at the Institute of Mechanical Engineering, Saveetha industries, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai, India. Since this research is on casting material, ethical approval is not mandatory. Ethical approval is only needed when research is being carried out on human samples or research related to humans or animals. Gr power of 80% was used to determine the total number of sample sizes. Control and experimental groups were the two groups. The aluminum alloy A356 was split in two, with a diameter of 25 mm and a length of 20 mm. The separated samples were transformed using a CNC turning machine (Figure 1). Turning tools used to turn the samples include high speed steel inserts [17].

In this examination two batches (control and experimental) were taken for the review. The total number of groups should be 2, the number of instances per group should be 20, and the total number of examples should be 40. The support particles were filled and then placed into the stir casting mix projection machine in each case (Figure 2). If more than one type of support molecule was used, the particles were pushed layer by layer.

Table 3: MRR values for as cast A356 alloy (non-composite).

Samples	Cutting speed (m/min)	Feed (mm/rev)	MRR non-composite material (mm^3/min)
1	750	0.1	1.811
2	750	0.15	1.836
3	750	0.10	1.869
4	750	0.15	1.847
5	750	0.1	1.876
6	1100	0.1	1.898
7	1100	0.15	1.931
8	1100	0.10	1.974
9	1100	0.15	1.944
10	1100	0.05	1.992
11	1400	0.10	2.021
12	1400	0.15	2.058
13	1400	0.2	2.079
14	1400	0.25	2.064
15	1400	0.3	2.092
16	1600	0.1	2.148
17	1600	0.15	2.171
18	1600	0.2	2.198
19	1600	0.25	2.233
20	1600	0.3	2.267

Figure 1: Noval encapsulate technique.

Figure 2: SiC 5% wt.

Figure 3: Gr particles 5% wt.

Natrayan et al. [18] The base material A356 is stir casted by the stir casting method through the novel encapsulate technique or encapsulate feeder method as the unique novelty (Figure 3). As the samples are taken to a dimension of 20 mm

Figure 4: Stir casting machine.

Figure 5: Casting sample.

diameter of a required length of 600 mm are obtained by the following steps [19].

Mix projecting is a useful technique for fabricating aluminum matrix composites. In this interaction, there are several barriers that influence the final microstructure and mechanical properties of the composites. Micron-sized SiC particles were used as support in this study to make Al-356 5% wt. SiC and Gr 5% wt. composites at two different projecting temperatures (680 and 850 °C) and blending times (2 and 6 min) (Figure 4 and Figure 5).

CNC turning operation is done with parameters including the feed rate, cutting speed, depth of cut, and are settled as a fundamental process. The high speed steel insert is used for the turning process [20]. This process is done in both sam-

ples with matrix composite material and other samples with non-composite material.

Statistical analysis

T-test is performed on the hardness observations obtained for the samples under study using SPSS statistical tool (Figure 6). The mathematical program SPSS is used to conduct the descriptive and ANOVA and Bonferroni studies. The analysis also yields the mean data, significance, and standard deviation [21] (Table 4).

Results

The results have been verified. The material with the metal matrix composite has been shown to have a higher surface roughness value and better mechanical properties than the AS cast base material. The high temperature or thermal change that induces elongation will be too much for the non-composite material to handle.

The rigidity of the material is low, and the composite matrix material must withstand higher hardness and mechanical properties. Our foundation is committed to high-quality, evidence-based research and has achieved success in a range of fields. We hope that this review adds to this distinguished tradition.

The samples are separated into two groups because they were cast using the stir casting method (with matrix composite and other without composite). By comparing both perspectives of the material with and without the composite the results are much higher than the non-composite material.

Discussion

For 20 samples with dimensions of cylinder shaped 40 mm length and 8 mm diameter drill, the material A356 is stir cast with a weight fraction of SiC wt. 5%, Gr wt. 5%, and wt. 90% of A356 base material. The specimens are placed through a wear test using MRR analysis equipment. Because the composite material's wear resistance is higher than the wear result of the other group without the matrix composite, raising the feed rate and decreasing the cutting speed would gradually raise the material's surface roughness (Figure 7).

The A356 in the second batch is cast completely from the base metal, with a weight fraction ratio of wt. 100% A356 base metal, using the stir casting method. The data is taken from a sample with a diameter of 20 mm to 24 mm and a length of 40 mm to 50 mm that is checked for MRR using a CNC turning equipment, with the average factored in. For a total of 20 samples, measurements for the material without the addition of composite material are taken. The final grain is higher than the composite material due to the high surface roughness, giving this material greater reliability [22].

During the sample preparation, the development of air bubbles and lumps are observed as the drawbacks which in turn hinder the proper stirring of the composite, which is considered as the limitations in this work [23, 24]. This raises the need for developing new or improvising the existing technique. Thus, the future scope of this investigation is to redesign the stir blades that could overcome the hurdles and this material will be useful to aircraft applications (Table 5).

Figure 6: CNC turning machine.

Table 4: Group statistics for MRR test of A356/SiC/Gr and as cast A356.

Group statistics					
Group		N	Mean	Std. d	Std. error mean
MRR	C_group	16	2.03287500	0.117693883	0.029423471
	I_group	16	3.19618750	0.297367611	0.074341903

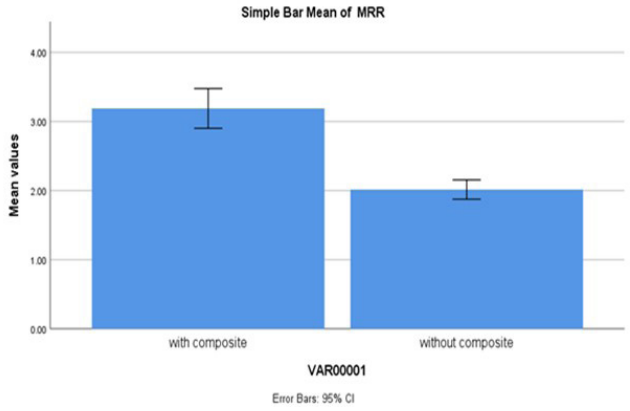

Figure 7: Compares the mean MRR of 0% reinforcement and 10% reinforcement (5% of SiC and 5% of Gr). The mean accuracy of 10% of the reinforcement is better than the 0% reinforcement and the hardness property of the 10% reinforcement is 28% better than the 0% reinforcement. Mean hardness of detection ± 1.

Conclusion

Within the limitation of study, the MRR recognition

Table 5: Sample test of MRR for A356/SiC/Gr and as cast A356 alloy.

Samples test									
t-test for equality of means									
MRR	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
								Lower	Upper
Equal variances assumed	14.260	0.001	-14.550	30	0.000	-1.163312500	0.079952856	-1.326598015	-1.000026985
Equal variances not assumed			-14.550	19.587	0.000	-1.163312500	0.079952856	-1.330317051	-0.996307949

during CNC turning of test using the high speed steel insert. The statistical analysis is done by the SPSS software. The results are compared, and the composite material results are higher than the results obtained in the non-composite material.

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None.

Conflict of Interest

None.

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