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Comparing CNC Vertical Milling Performance of Novel AA6061/MgO Nanocomposite with Monolithic AA6061 alloy for Improving Surface Roughness

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Abstract

The primary goal of this study is to evaluate the surface roughness (SR) of holes drilled in recycled AA6061 Alloy with recycled AA6061 alloy reinforced with novel magnesium oxide ceramic strengthening particulates. Magnesium oxide ceramic particles of particle size < 50 nm were used as reinforcement particles, and recycled AA6061 alloys were used as matrix materials. To obtain uniform distribution of reinforcement in matrix materials, a stir cast method was used at a melting temperature of 720 °C and stirring speed of 500 rpm. Two groups of recycled AA6061 alloy and composite were manufactured. To analyze the SR a drill was made on synthesized hybrid composites with a drill diameter of 8 mm at a spindle speed of 1000 rpm. The SR of the novel SiO_2 reinforced recycled AA6061 alloy was analyzed and compared with recycled AA6061/MgO alloy composites. Observation shows that a significance value of $p = 0.000$ (2-tailed) was obtained and found it was less than ($p < 0.05$) exemplifying that there are variances among the two clusters is statistically significant. Within the limits of the current investigation, it was found that when the proportion of nano reinforcement surface areas between the intermixtures was increased the SR of nano magnesium oxide reinforced recycled AA6061 alloy composites was also significantly improved from 28% to 22.36%

Keywords

Metal matrix composites, Recycled AA6061 alloy, Novel magnesium oxide, Stir casting, CNC drilling, Surface roughness

Introduction

Metal matrix composites are used in automotive, aerospace, and marine applications because to its low density, high strength-to-weight ratio, and increased stiffness [1]. However, the distribution of ceramic particles has a big influence on how these characteristics are shaped. A particle damage process occurs when micro-sized ceramic reinforcement is added to metal matrix composites, resulting in a loss of physical properties [2]. Incorporating nanoceramic strengthening particles into the matrix alloy helps overcome this problem. The incorporation of nano-ceramic particles in the matrix alloy increases mechanical characteristics when compared to micron-sized composites [3]. Minimal wetness between the base material and ceramic reinforcing particulates, on the other hand, is a significant challenge in nanocomposites production. A limited number of micro ceramics strengthening particles and a process parameter capable of reducing these effects were used to resolve this issue [4]. Experts say nano metal matrix composites can be employed in vehicles, aircraft, and consumer items due to their low density and great performance [5].

Several research investigations on Al6061 alloys made with reinforcement have been conducted in the previous five years. There were around 932 journals in Google Scholar and approximately 398 journals in Science Direct. This research focuses on identifying the most important characteristics for hybrid aluminium metal matrix composites with low porosity and high ultimate tensile strength (UTS). The literature survey and experimental studies revealed both important and non-significant factors [6].The aluminium 6061 alloys are combined with silicon di oxide reinforced material in this article. The reinforced material was mixed using the stir casting technique. Silicon dioxide in varying ratios was combined with alloy material. Stir casting was utilized to manufacture composites with varied SiC and Al_2O_3 content (3, 6, and 9 wt.%) and (2, 4, and 6 wt.%). Microstructural examination of the Al matrix revealed a non-homogeneous dispersion of reinforcing particles [7]. Optimizing stir casting conditions to enhance Al 7075 reinforced with TiO_2 microparticles is the research's goal. The response surface method's fundamental composite design technique optimized stirring temperature, speed, and time. The material's ultimate tensile, hardness, impact, elastic modulus, and compressive strengths were assessed [8].

Only a few studies have been found that use the bottom pouring stir casting procedure to create novel magnesium oxide reinforced recycled AA6061 alloys and its SR was analyzed. Novel magnesium oxide has yet to be created for use in recycled AA6061 alloys, according to a literature study, and its physical characteristics have yet to be described. As a result of this knowledge gap, researchers have attempted to synthesize similar composites and analyze their SR for application regions. The area of expertise in the present investigation is the synthesis of nanocomposites. Hence the present study aims to develop novel magnesium oxide reinforced aluminium composites and its physical properties was analyzed.

Materials and Methods

Recycled AA6061 alloy composites were made using a sufficient aluminium alloy matrix and magnesium oxide particles with particle size smaller than 50 nm as reinforcement [9]. Table 1 shows recycled AA6061 alloy's chemical composition. Stir casting with bottom pouring produced aluminium composites. Add alloy components to a 450 °C resistance heating reservoir. The alloy was heated to 750 °F at 400 rotations per minute to ensure good melting. An external sprue injected 2 wt.% nano-ceramic Magnesium oxide reinforcement into the molten metal, the data showed. To ensure a homogeneous reinforcement dispersion in the matrix alloy, the stirring speed was increased to 500 rpm and kept at 10 min. The mould cavity was filled with molten slurry heated to 800 °C to improve viscosity. Heating the die to 250 °C reduced molten material porosity. When stirred at 550 rpm, the molten slurry was fed into the die and cooled at room temperature [10-12]. Figure 1 shows a VMC (YCM-EV1020A) drilling holes with the following parameters. Analysis was done with statistical tool software. Novel magnesium oxide particles reinforced recycled AA6061 alloy composites and SR were independent factors in the multiple comparison table and G graph. The recycled AA6061 alloy nanocomposite's SR (Mean value, standard deviation) was 168.5, 0.234, and 0.0518, respectively, in a descriptive tabular column.

Table 1: Chemical composition of recycled AA6061 alloys.

Concentration of wt%								
Cr	**Cu**	**Fe**	**Mg**	**Mn**	**Si**	**Ti**	**Zn**	**Al**
0.28	2	0.50	2.6	0.30	0.40	0.20	5.8	Balance

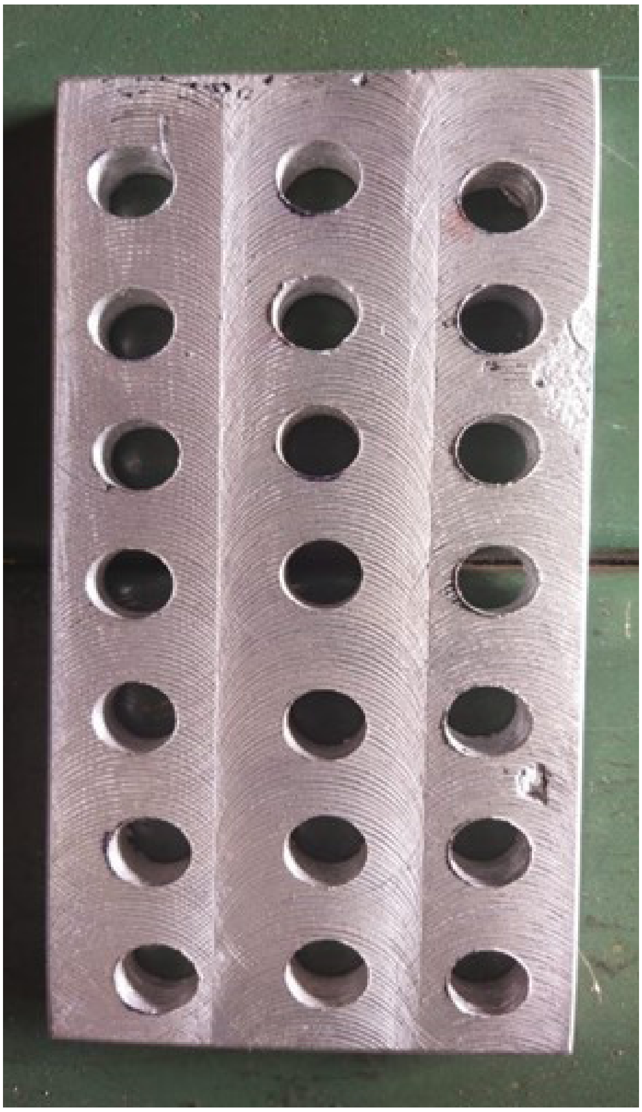

Figure 1: SR of the composite's samples of recycled AA6061 alloy and 2 wt.% of magnesium oxide ceramic particulates.

Results and Discussion

In the current investigation, a process known as stir casting was utilized to produce 2 wt.% magnesium oxide reinforcing particles. As can be observed in figure 2, the SR of the synthesised aluminium alloy composites is significantly better than that of the as-cast recycled AA6061 alloy. There are no leftover holes in the matrix alloy because the strengthening particles of magnesium oxide are equally distributed across the entirety of the matrix alloy. The SR of the machined parts is affected by several elements, one of which is cutting speed. High cutting speeds can provide rougher surfaces, whilst low cutting speeds can produce ineffective material removal rates.

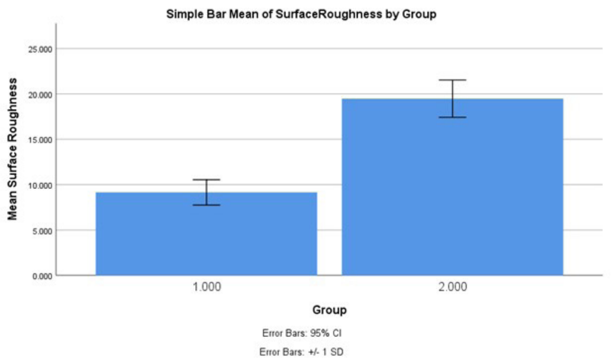

Figure 2: The bar graph shows the comparison between the SR of recycled AA6061 alloy and 2 wt.% of magnesium oxide-reinforced aluminium nanocomposites. The error bars ± 1 SD were attained. Y axis represented mean SR, and X axis denoted the number of groups.

Consequently, to machine the AA6061/MgO nanocomposite and monolithic AA6061 alloy to the appropriate surface smoothness, the best cutting speed must be identified. The feed rate is yet another critical factor that has a significant impact on SR. Low feed rates can lead to slower rates of material removal, whereas high feed rates might result in poor surface finishes because of tool chatter. To obtain the desired surface finish, the best feed rate must be chosen [13-16]. The quantity of material removed by the cutting tool in just one pass is referred to as the depth of cut. Due to greater cutting forces and vibrations, a deep cut can provide a rougher surface, whereas a shallow cut can extend the machining process [17]. Hence, the best depth of cut must be chosen depending on the characteristics of the material and the desired surface finish. SR and tool life can be dramatically impacted by coolant flow rate [18]. Inadequate coolant flow can lead to heat accumulation and thermal deformation of the machined item, whereas excessive coolant flow can lead to erosion and tool wear. Thus, the best coolant flow rate must be identified to obtain the necessary surface finish and tool life (Table 2 to table 5) [19-21].

Table 2: Comparison of SR of recycled AA6061 alloy and 2 wt.% of magnesium oxide reinforced aluminium nanocomposites.

Exp. no	Recycled AA6061 alloy	Recycled AA6061 alloy + 2 wt.% of magnesium oxide
1	9.085	16.06
2	9.012	20.299
3	10.987	16.543
4	8.432	20.824
5	8.087	17.035
6	9.923	21.435
7	9.789	17.923
8	9.234	17.178
9	9.012	17.456
10	8.912	17.967
11	8.709	20.097
12	8.589	18.379
13	12.456	18.83
14	8.248	21.023
15	8.134	20.129
16	10.043	22.398
17	11.97	20.267
18	7.893	22.358
19	7.356	22.58
20	7.178	20.673

Table 3: Average surfaceness strength of cast recycled AA6061 alloy and 2 wt.% of magnesium oxide reinforced aluminium nanocomposites.

S.no	Types of material	Average
1	Recycled AA6061 alloy	9.15245
2	Recycled AA6061 alloy + 2 wt.% of magnesium oxide	19.4727

Table 4: Group statistics for SR.

	Group statistics				
	Group	N	Mean	Std. deviation	Std. error mean
SR	1.00	20	9.152	1.392	0.311
	2.00	20	19.472	2.051	0.458

Conclusion

Magnesium oxide reinforced recycled AA6061 alloys composites were generated by employing the stir cast processing method. The SR of these composites was analysed and compared to that of as-cast recycled AA6061 alloys. When compared to cast aluminium alloy, the SR of composites made from magnesium oxide reinforced recycled AA6061 alloy rose by a substantial amount, going from 28% to 22.36% The resulting nanocomposites have a more uniform distribution of ceramic strengthening particles, decreased porosity, and increased grain refinement, therefore they may primarily be employed for functional purposes.

Acknowledgements

None.

Table 5: Independent sample test for SR represents the significance values p = 0.013.

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
SR	Equal variances assumed	6.873	0.0013	-18.61	38	0	-10.32	0.554	-11.442	-9.197
	Equal variances not assumed	-	-	-18.61	33.4	0	-10.32	0.554	-11.447	-9.192

Conflict of Interest

None.

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