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Experimental Study on the Rate of Material Removal from Novel Hybrid Composites Made of Al7075/5%B4C + 2% Mg and Al7075 Alloy using Wire Electrical Discharge

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Abstract

This study compares the removal rates of the new boron carbide and magnesium reinforcement materials with and without the Al7075 alloy. Al7075 alloy served as the main component of the matrix, and magnesium and novel boron carbide served as reinforcement. At 720 °C and 500 rpm, the Al7075 alloy was stir cast to guarantee uniform reinforcement distribution. There were 20 samples in each group, an 80% pretest power, a 0.05% beta, and a 95% CI. In this study, material removal rate (MRR) is found through the difference between the workpiece's initial and final weights in grams. These results showed a statistically significant difference between the two groups, with a p value of 0.000 ($p < 0.05$). The casting voids caused the MRR of Al7075 to achieve its maximum for the same process parameter within the study's constraints. The casting voids caused the MRR of Al 7075 to achieve its maximum for the same process parameter within the study's constraints. It was concluded from the results that due to casting voids, the MRR of Al7075 is maximal at the same process parameter.

Keywords

Aluminum, Boron carbide, Magnesium, Hybrid composite, Casting, Sustainable production

Introduction

This study's focus is on the rate of material removal. The MRR is a measurement of the volume of material that is removed from the workpiece per unit of time while cutting hybrid composites made of Al7075/5%B4C + 2% Mg and Al7075 alloy [1-3]. The machining accuracy, surface quality, and general process efficiency may all be impacted by the MRR, making it a crucial performance metric in WEDM [4, 5]. During wire electrical discharge machining (WEDM), the MRR of the Al7075 alloy and the Al7075/5%B4C + 2% Mg hybrid composites will be compared to identify any changes in the machining capabilities of the two materials [1, 6, 7]. Al7075 is being used as sustainable manufacturing. The mechanical characteristics of the resultant composites, such as higher hardness, tensile strength, and wear resistance, are improved by the addition of boron carbide particles to the aluminum matrix. Because boron carbide particles are extremely hard, less tool wear happens during machining, boosting MRR [8].

Magnesium is a special material for experimental studies in WEDM, because of its lightweight, high thermal and electrical conductivity, and softness. Due to their superior mechanical qualities over traditional metals and alloys, the usage of composite materials is widespread many other disciplines, including domestic applications, sports, utilities, the maritime, aircraft, and car industries, as well as several other businesses [9,10]. As the special machining processor under job shop category the scheduling these kind of processes [11, 12]. The most common uses include those for vehicles, gears and shafts, and aircraft constructions [13, 14]. Al7075's growing use in sustainable production manufacturing methods highlights its value as a sensible alternative for sectors looking to reduce their negative environmental effects and advance long-term sustainability [15].

High electric energy is used in the unconventional machining technique known as high-speed EDM to effectively remove materials [16]. An experimental study on the MRR during WEDM of these materials may be beneficial for optimizing the machining of aerospace components, such as aircraft structural parts or turbine blades, as well as for producing high-strength components, such as suspension parts or engine components, in the automotive industry. WEDM might be a desirable machining technique due to the precision and accuracy needed in the manufacturing of medical equipment may be helpful for machining medical items, like implants or surgical instruments, more effectively [17].

There have been 41 and 132 citations for similar publications published in the last five years, respectively, on Google Scholar and Science Direct. Boron carbide serves as a reinforcing ingredient in the AMMCs, improving their overall performance. Boron carbide is renowned for its remarkable mechanical qualities, including high hardness, high melting point, and strong wear resistance [18, 19].

Technology can be utilized to enhance the WEDM's effectiveness while cutting various materials and optimising the machining procedure [20]. It might also clarify how the B_4C, and Mg additions affect the hybrid composite's machinability and in determining whether there are any potential benefits or drawbacks to employing the hybrid composite rather than the alloy in WEDM applications [21]. It is reported that comparatively fewer research has been published on investigate the MRR of Al7075/5%B_4C + 2% Mg Hybrid composites which compared with Al7075 alloy. This study set out to compare the MRR of hybrid composites comprised of Al7075 alloy and 5%B4C and 2% Mg. The aim of the experiment was to determine the rate of component removal from hybrid composite materials.

Materials and Methods

The main materials of interest in this work are hybrid Al7075/5%B4C + 2% Mg composite and Al7075 alloy. These materials are available as plates, rods, and other machining-friendly shapes for purchase.Al7075 is being used as Sustainable production. A WEDM machine would be required to do the testing for the machining operations. This device typically includes a wire electrode, a workpiece holding, and a controller for setting and adjusting the machining parameters. Other components, such as dielectric fluid and wire electrodes, can also be necessary, depending on the WEDM machine being utilised [22]. The basic materials employed in this investigation were magnesium, aluminum 7075, aluminum 7075, and boron carbide. When the material was procured from a vendor in Chennai, it was in the form of rods, which is what is required for our research since it needs to be flat. In this research, aluminum alloys 7075 and 7075 hybrid were examined. Al7075 alloy and hybrid metal matrix composites are created utilising the stir casting process [23-25].

In group 1, the aluminum 7075 composite of 780g was cast and formed into round shape (20 × 300) and the slot was machined in WEDM [26]. In group 2, the aluminum 7075 780g composite which has reinforcement 250 grams of boron carbide, and 50 gram of magnesium balance aluminum 7075 material was cast and formed into round shape (20 × 300mm) and the slot was machined in WEDM [27-30]. During the drilling process in a WEDM, data were collected from the Control Group Al7075 for 20 samples and the Experimental Group Al7075/5%B4C + 2% Mg for 20 samples by varying the input parameters, such as pulse on, pulse off, and wire feed rate [31].

The composites are cut using WEDM. The following is being machined The following input parameters can be used to compute the MRR in cubic centimetres per minute (cc/min) after milling: depth of cut (mm), breadth of cut (mm), and feed rate [32].

Statistical analysis

SPSS was used as the software program for the statistical analysis for this investigation. The MRR in mm^3/min is influenced by three independent variables: the wire feed rate, pulse on, and pulse off. The two composites, Al7075 and Al7075 Hybrid composites, were compared and their significance was assessed using the independent variable sample T-test [33].

Results

In this study, the MRR of Al7075/5%B4C + 2% Mg hybrid composites was examined, and it was compared to Al7075 alloy, which offers better performance than the base metal. Each group considered. Therefore, the main objective of this study is to determine the milled slot's maximum MRR. which has been measured using the proper calculation, and to record all the readings and using the SPSS software, finding increases in material removal and comparing the parent material with the hybrid metal matrix composites' standard deviations yielded a significance value of 0.000 ($p < 0.05$) [34, 35].

Values from 20 samples are displayed in table 1. The mean, standard deviation, and 95% confidence interval for the mean of the Al7075/5%B4C + 2% Mg hybrid composites and the Al7075 alloy are shown in Table 2 and table 3. Al7075 alloy has a mean MRR of 16.4192, whereas hybrid composites made of Al7075/5%B4C + 2% Mg have a mean MRR of 14.8541. Standard deviations of MRR for Al7075 alloy and hybrid composites made of Al7075/5%B4C + 2% Mg are 0.38650 and 0.25411, respectively. Al7075 alloy has a minimum standard error mean of 0.08643, and Al7075/5%B4C + 2% Mg hybrid composites have a minimum standard error mean of 0.05682.

Figure 1 to figure 3 graphs the average MRR during WEDM for Al7075/5%B4C + 2% Mg hybrid composites and Al7075 alloy. With a P value of 0.000 (p 0.05), these findings demonstrated a statistically significant difference be-

Table 1: MRR during WEDM of Al7075/5%B4C + 2% Mg hybrid composites and Al7075 alloy.

Exp no	Al7075 alloy	Al7075/5%B4C + 2% Mg hybrid composites
1	16.08	14.72
2	16.01	15.02
3	16.68	14.94
4	15.68	15.27
5	16.73	14.82
6	15.78	14.58
7	16.08	15.29
8	16.36	14.69
9	16.54	14.87
10	16.97	15.25
11	16.92	14.69
12	16.83	14.91
13	16.08	15.36
14	16.59	14.67
15	16.74	14.67
16	16.35	14.67
17	16.09	14.74
18	16.76	14.66
19	16.73	14.53
20	16.37	14.73

Table 2: Group statics of the MRR during WEDM of Al7075/5%B4C + 2% Mg hybrid composites and Al7075 alloy.

Group statistics					
Groups		N	Mean	Std. deviation	Std. error mean
MRR	EG	20	16.4192	0.38650	0.08643
	CG	20	14.8541	0.25411	0.05682

tween the two groups. 20 samples of the Al7075 alloy and Al7075/5%B4C + 2% Mg hybrid composites are collected for each phase. The 95% confidence interval of the difference at lower value is 1.35567 and the upper value is 1.77443 in the MRR of the equal variances are considered. The 95% confidence interval of the difference at the lower value is 1.35458 and the upper value is 1.77552 in the MRR of the equal vacancies are not assumed [36].

Discussion

This study compares two different types of composites and finds that pure Al7075 has the highest MRR. Using Al7075 at 0 RPM under the influence of 0 RPM of speed, 0 mm of the depth of cut, and 0.5 mm/min of feed rate, the maximum MRR was attained.

Figure 1: AA7075 pure alloy after wiring electric discharge machining.

The minimum MRR measured was 0 mm^3/min. When compared to Al7075 and Al7075/5%B4C + 2% Mg Hybrid composites, Al7075 provides the maximum surface roughness [37]. With a significance value of 0, the use of reinforced composites greatly improved the composite's surface roughness when compared to Al7075 hybrid composites [38-40]. Other elements that affect MRR include feed rate and cut depth. MRR increases as feed rate and cuts depth increase. These results indicate a 32% increase in the MRR. Al7075, these are necessary for this composite to have a better surface finish and a smaller depth of cut. No opposing research analysis is discovered in the MRR findings [41].

This study only looked at Al7075/5%B4C + 2% Mg Hybrid composites. This is a novel reinforced composite (Al7075/5%B4C + 2% Mg Hybrid composites) with a higher surface finish and a lower cut depth [42]. This study compares two types of composites and discovers that pure Al7075 has the highest MRR.

Table 3: MRR Test of Al7075/5%B4C + 2% Mg hybrid composites and Al7075 alloy on independent samples during WEDM with a p value of 0.000 (p 0.05), these findings demonstrated a statistically significant difference between the two groups.

Independent samples test										
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
MRR	Equal variances assumed	5.686	0.022	15.131	38	0.000	1.56505	0.10343	1.35567	1.77443
	Equal variances not assumed	-	-	15.131	32.839	0.000	1.56505	0.10343	1.35458	1.77552

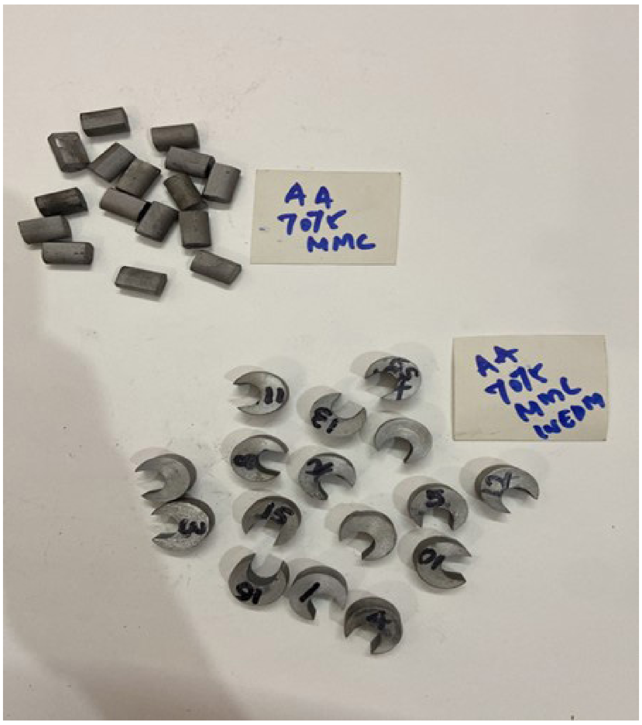

Figure 2: Al7075/5%B_4C + 2% Mg after wire electric discharge machining.

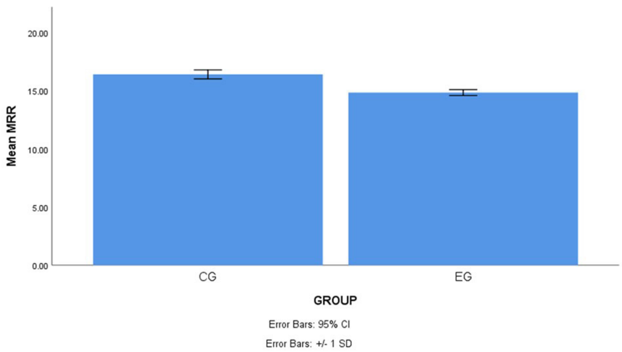

Figure 3: Graph on the mean value of MRR during WEDM of Al7075/5%B_4C + 2% Mg Hybrid composites and Al7075 alloy.

Conclusion

Within the confines of the investigation, Wire Electrical Machining milled slot studies were performed using an HSS milling cutting tool on Pure Al7075 and reinforced metal matrix composites. Based on the measured material clearance rate, the effectiveness of these materials was evaluated. These tests' findings show that casting voids cause the MRR of pure Al 7075 to increase the most at the same process parameter. The results of the tests show that the three main factors influencing the rate of material removal are feed rate, speed, and depth of cut.

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None.

Conflict of Interest

None.

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