Nano World Journal

https://doi.org/10.17756/nwj.2023-s3-023

Research Article Open Access

Investigation on Material Removal Rate of Composites like Epoxy Reinforced with 5% Fiber and 5% Novel Nano Carbon Particles Made of Peanut Husk During Drilling Process

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Received: July 26, 2023
Accepted: September 28, 2023
Published: October 04, 2023

Citation: Charan P, Kumar DS. 2023. Investigation on Material Removal Rate of Composites like Epoxy Reinforced with 5% Fiber and 5% Novel Nano Carbon Particles Made of Peanut Husk During Drilling Process. *NanoWorld J* 9(S3): S123-S126.

Published by United Scientific Group

Abstract

This study's primary objective is to compare the material removal rate (MRR) of advanced hybrid epoxy composites reinforced with novel natural fiber (5%) and nano carbon (5%) to plain epoxy. The samples were created utilizing the layup method for both groups. The samples were made in accordance with the requirements, and drilling was done on a vertical CNC machine with an evaluated pretest G-power of 80%. The MRR of the work samples was investigated among the groups using a total of 20 tests (each with one repeat) per group. To assess the material clearance rate, t-independent tests were carried out using the statistical programs SPSS (Statistical Package for the Social Sciences). Sustainable ramie fiber (5 wt.%), nano carbon particles (5 wt.%), and group 1 (75 wt.%) had an average MRR of 0.38145 mm3/sec as opposed to 0.12490 mm3/sec for group 2. (plain epoxy). The mean variance of MRR between groups 1 and 2 is different, according to the results of the t-test statistical analysis (significant at $p = 0.00$, which is $p < 0.05$), it is inferred that there exists a significant statistical difference among the two groups under study. From the study, it is evident that using reinforcements like sustainable ramie fiber and nano carbon particles considerably enhances MRR.

Keywords

CNC drilling, Epoxy, Sustainable natural fiber, Sustainable ramie fiber, Nano carbon particles, Material removal rate, Hybrid epoxy composites

Introduction

This study will examine the MRR of epoxy (75% weight), sustainable ramie fiber (5% weight), nano carbon particles (5% weight), and plain epoxy [1]. Synthetic fiber usage is compensated for by the application of natural fibers. Sustainable natural fiber-based composites are less dense than conventional fibers and have superior mechanical characteristics. In terms of weight to strength ratio, sustainable natural fiber reinforced surpasses conventional FRPs. The building, automotive, aerospace, and marine sectors, among others, employ these materials for a variety of purposes.

Given more than five years of study and literature on polymer composites, there are over 2495 papers in Science Direct and more than 2600 papers in Google Scholar, which is not a tiny quantity. The rate at which composite material is removed, among other output factors, has been examined in relation to CNC drilling settings. Drill diameter in mm, feed in rev/sec, and speed in rpm are some examples of these variables. The optimal drilling settings and parameters for speeding the MRR are examined in this study. Researchers have examined the impact of the epoxy liquid/hardener ratio, and fiber fraction on the MRR of epoxy by using sustainable ramie fiber incorporated composites.

Sustainable ramie fiber reinforced/incorporated composite's MMR has been studied in connection to feed rate, point angle, and chisel edge width [2]. One of the better pieces of literature is an investigation on the effects of speed, temperature, and fiber over the MRR [2, 3] from epoxy-based materials [1, 4].

Materials and Method

The extensive knowledge and research skills of our experts have produced publications of the highest caliber. It has been highlighted that excellent research has been done on composites using sustainable ramie fiber. Sustainable ramie fiber is a naturally occurring fiber [5]. In this work, the drilling parameters were compared to the amount of material removed from regular epoxy and epoxy [5] enhanced with sustainable ramie fiber and nano carbon particles.

The performance of the work sample during CNC machining (drilling) of the samples were carried out at the facility available at Saveetha Engineering Industries, SIMATS, Chennai (Tamil Nadu, India). A controlled experimental group is considered in this study. The experimental group uses a unique hybrid epoxy composite comprised of epoxy (75% percent), sustainable ramie fiber (5% percent), and nano carbon particles (5% percent), as opposed to the control group, which uses ordinary epoxy [6]. Drilling was carried out with 20 experiments for each sample/group and 80% pretest G-power. The needed thickness in the group 1 sample is achieved by applying three layers: Sustainable ramie fiber mat, epoxy hardener, and nano carbon particles. The arrangement also includes weights, which are similarly added and left for 72 h.

Apply the wax to the four corners of the wooden box to prepare the group 2 sample of plain epoxy (Mold). The work sample is made through a simple hand-layup method at 10:1 mixture ratio of the hardener (HY951) and epoxy (LY556). This mixture is slowly poured into a mold box with dimensions of 300 mm in width by 300 mm in height. The setup is given the appropriate weights, which are then kept there unaltered for roughly 72 h to produce a composite with advantageous properties [7, 8].

The drilling of the composites is done in a VMC (Vertical machining center) enabled with Siemens controller. Using drill bits to generate circular cross-section holes in the samples in line with the test design is part of the testing procedure. Drilling time is seen in the FANUC data from the VMC machine. The volume-to-time ratio is used to calculate the MRR following drilling [9].

Statistical analysis

SPSS tool is used to perform investigation on MRR [6]. Accordingly, the percentage, speed, feed rate, and drill diameter are taken as independent variables [10] while the MRR is considered a dependent variable.

Results

CNC machining (drilling) on group 1 (Fiber reinforced epoxy) and group 2 (Plain epoxy) materials is done in three steps, as illustrated in table 1, with speed (rpm), feed (rev/sec), and drill diameter all taken into account (mm). The relevant MRR values are shown in table 2. According to the indepen-

Table 1: Input parameters and their levels for CNC drilling.

Parameters	Levels		
	L1	L2	L3
Speed (rpm)	110	270	320
Feed (rev/min)	0.15	0.25	0.35
Diameter (mm)	4	5	6

Table 2: MRR of group 1 and group 2.

S. No.	Parameters			Group 1	Group 2
	Speed (rpm)	Feed (rev/min)	Drill diameter (mm)	MRR (mm^3/sec)	MRR (mm^3/sec)
1	110	0.15	4	0.164	0.034
2	320	0.35	6	0.210	0.060
3	110	0.15	4	0.251	0.078
4	320	0.35	6	0.313	0.083
5	110	0.15	4	0.361	0.089
6	320	0.35	6	0.475	0.119
7	110	0.15	4	0.564	0.152
8	320	0.35	6	0.702	0.275
9	110	0.15	4	0.243	0.073
10	270	0.25	5	0.264	0.093
11	270	0.25	5	0.286	0.110
12	270	0.25	5	0.308	0.106
13	270	0.25	5	0.196	0.045
14	270	0.25	5	0.508	0.179
15	270	0.25	5	0.379	0.138
16	270	0.25	5	0.501	0.159
17	270	0.25	5	0.449	0.163
18	270	0.25	5	0.469	0.168
19	270	0.25	5	0.494	0.179
20	270	0.25	5	0.492	0.195

Table 3: Group statistics on MRR (mm^3/sec) values for the groups.

Group		N	Mean	Std. deviation	Std. error mean
MRR (mm^3/sec)	Fiber reinforced epoxy (Group 1)	20	0.38145	0.143805	0.32156
	Plain epoxy (Group-2)	20	0.12490	0.59429	0.13289

Table 4: Independent t-test for equality of means of the MRR (mm^3/sec) values for the group.

		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% CI of the difference	
									Lower	Upper
MRR (mm^3/sec)	Equal variance assumed	17.943	0.00	7.374	38	0.00	0.2566	0.03479	0.186	0.326
	Equal variance not assumed			7.374	25.30	0.00	0.2566	0.03479	0.184	0.328

dent statistical t-test analysis, group statistics are presented in table 3, which comprise the total samples per group, the group's average/mean MRR, standard deviation, and standard error. The results of the independent statistical t-test with correspondence of averages/means, as well as the Levene's test ($p < 0.05$), are shown in table 4.

CNC drilled samples for group 2 (Plain epoxy) is presented in figure 1 and group 1 (Fiber reinforced epoxy) is presented in figure 2, whereas the G-graph for MRR in mm^3/sec is shown in figure 3, which is also plotted based on mean/average accuracy of detection (95% CI).

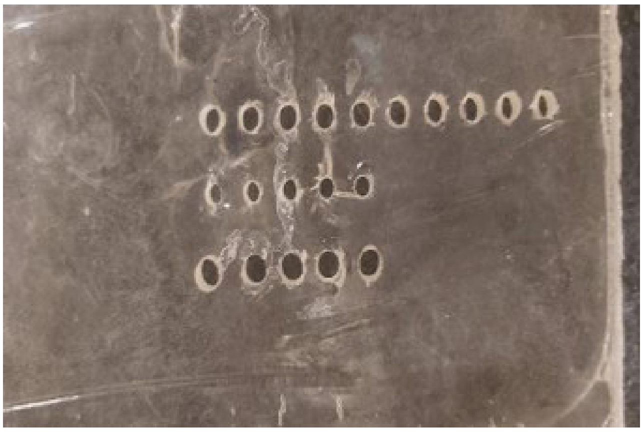

Figure 1: CNC drilling on plain epoxy (Group 2).

Figure 2: CNC drilling on novel hybrid reinforced epoxy (Group 1).

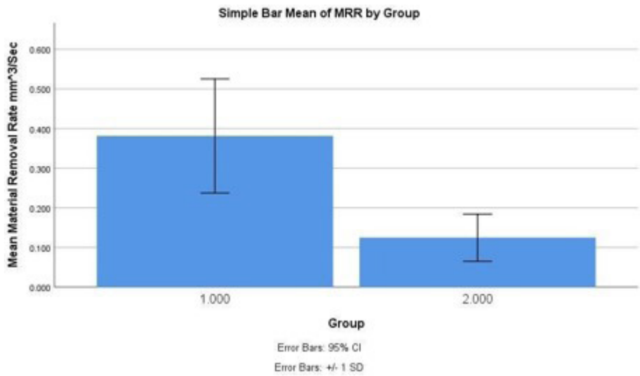

Figure 3: Graphical representation of MRR (mm^3/sec) for group-1 (Epoxy (75%), sustainable Ramie fiber (5%), nano carbon particles (5%) and group-2 (Plain epoxy), X-axis: Material groups, Y-axis: MRR (mm^3/sec) with mean accuracy of detection 95% CI and +/-1 standard deviation.

Discussion

A basic improvement in the MRR was found because of expansion of reinforcements in epoxy. Based on statistical results (as shown in table 3), it is tracked that the mean MRR of fiber reinforced epoxy [11], and plain epoxy are 0.38145 mm 3/sec and 0.12490 mm3/sec, respectively [11]. Table 4 helps with understanding an independent sample of t-test with fairness of means. P-value is found less than 0.05 (achieved $p = 0.001$) in Levene's test demonstrating the presence of significant and statistical difference in the variances of the MRR of groups under study [12] among the groups under study. Thus, an alternate hypothesis representing unequal variance is considered appropriate. The negative value of t indicates that the mean/average MRR [13] of the composites of fiber reinforced epoxy (Group 1) is higher than that of plain epoxy (Group 2) [14].

This analysis identifies both comparable and outstanding works. Analysts have proposed a study with a variety of samples that have undergone CNC drilling and their weight% reinforcement variation that corresponds to the process. An-other investigation has shown the unique mechanisms behind CNC drilling. The final findings highlight significant differences between fiber reinforced epoxy and conventional epoxy [15]. In the research, it was discovered that fiber reinforced epoxy performed better than normal epoxy. Work has been completed using reinforcing materials including sustainable ramie fiber [16] mat and nano carbon particles, which significantly increase drilling results. Researchers have also suggested working with sustainable ramie fiber and nano carbon particles and properties to improve the qualities, which is discovered to be in reasonable agreement with the work and no major discrepancies [17].

The air bubbles cum lumps developed during the preparation of the samples are seen as setbacks during sample preparation, which ultimately impedes the machining (Drilling) of the composite. The need to create new procedures or improve existing ones results from this. Therefore, the goal of this research going forward is to prepare or improve a traditional method to overcome hindrances, and this sample material will be useful in the production of many mechanical elements [18, 19].

Conclusion

The inquiry on MRR during CNC machining (Drilling) of developed epoxy composites incorporated with fiber (Sustainable ramie fiber) (5 wt.%) and nano carbon particles (5 wt.%) and plain epoxy. In comparison to regular epoxy, the innovative hybrid reinforced epoxy's mean MRR (0.38145) is 0.124 mm3/sec more. The mean or average MRR is significantly different between the material sample groups under study, as per the considered independent t-test of the observed MRR of fiber reinforced epoxy and plain epoxy (t 22.582 = 7.374, p = 0.00). This study found that sustainable ramie fiber mat and nano carbon particles added to epoxy-based composites to strengthen them with natural fibers perform better in MRR tests than epoxy alone.

Acknowledgements

None.

Conflict of Interest

None.

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