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Investigation on Material Removal Rate of 5% Pineapple Fiber and 5% Novel Nano Carbon Particles Made of Custard Apple Seeds Reinforced Hybrid Epoxy Composites During Drilling Process

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Abstract

This work's main objective is to assess MRR (Material removal rate) of novel hybrid epoxy composites reinforced with sustainable natural fiber (5%) and nano sized carbon particles (5%) in comparison to plain epoxy during CNC drilling. The samples for both groups were made by a simple layup method. The work samples were prepared in accordance with the specifications, and drilling was carried out using a vertical CNC machine for a total of 20 experiments, in order to evaluate and compare the MRR of the samples, with a pretest G-power of 80%. T-independent tests were conducted using the SPSS (Statistical Package for the Social Sciences) statistical software to evaluate the material clearance rate. The average material removal rate for group 1 pineapple fiber mat nano carbon particles (5%) was 0.3739 mm^3/sec, compared to 0.1283 mm^3/sec for group 2 (Plain epoxy). Based on the findings of the t-test statistical analysis, it is concluded that the mean variance of MRR between groups 1 and 2 under study is statistically different (Significant of $p = 0.002$, which is $p < 0.05$). It is clear, within the constraints of this investigation, that adding reinforcements like pineapple fiber and nano carbon particles has a significant effect on raising MRR.

Keywords

Novel hybrid epoxy composites, CNC drilling, Epoxy, Sustainable natural fiber, Pineapple Fiber, nano carbon particles, Material removal rate

Introduction

In this study, the MRR of epoxy (90%), pineapple fiber (5%), nano-sized carbon particles (5%), and plain epoxy will be examined [1]. Synthetic or natural reinforced composites offer a wide range of applications because of their dependable traits and high strength. Natural fibers are used to offset the use of synthetic fibers [2]. When compared to conventional fibers, natural fiber composites have low density and excellent mechanical properties. Natural fiber reinforced outperforms conventional FRPs in terms of weight to strength ratio [3]. These materials have several uses in the building, automotive, aerospace, and marine industries, among others.

There are more than 1800 articles in Google Scholar database and over 2450 in Science Direct database due to the more than five years of research and literature on polymer composites. The fundamental influence of CNC drilling parameters on output parameters, such as composite MRR, has been studied. These factors include speed in rpm, feed in rev/sec, and drill diameter in mm. This research investigates optimal drilling parameters, ideal conditions for getting a greater MRR. The impact of the epoxy/hardener ratio, and percentage of reinforcement (fiber) over the MRR of epoxy have all been studied in sustainable pineapple fiber

reinforced composites. One of the best works of literature is a study on the influence of speed, temperature, and fiber on the MRR of epoxy related composites.

Sustainable pineapple fiber is a naturally existing fiber, and it has been noticed that outstanding study has been conducted on composites using sustainable pineapple fiber [4]. The impact of drilling factors on MRR on epoxy reinforced with sustainable natural fiber and nano carbon particles [5], and also plain epoxy, was examined in this study.

Materials and Method

The sample preparation and the experimental study were carried out at Saveetha Engineering Industries, SIMATS, Chennai (Tamil Nadu, India). This study takes into account an experimental group under supervision. The control group utilizes standard epoxy, whereas the experimental group uses a novel hybrid epoxy composite made of epoxy (90%), pineapple fiber (5%), and nanosized carbon particles (5%). With a pretest G-power of 80%, drilling was done using CNC with one repetition per group, yielding 20 experiments in each sample/group [6]. Group 1 sample is made up of three layers of pineapple fiber mat, glass fiber mat, and nano carbon particles applied in three layers till the necessary thickness is attained. Required loads were placed over the setup and allowed for curing for around 72 h.

Apply the wax at every nook and corners of the wooden box to prepare the group 2 sample of plain epoxy (Mold). The sample is prepared using the traditional hand-layup method using a 10:1 mixture of the hardener (HY951) and epoxy (LY556). When stirring, care should be given to avoid the production of bubbles [7]. This epoxy mixture is carefully and steadily poured in 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 [2].

The composites are machined (Drilling) using a vertical machining center equipped with a Siemens controller. The testing method entails using drill bits to make circular cross-section holes in the samples that correspond to the test design. Drilling time is seen in the FANUC data from the vertical machining center machine. The volume-to-time ratio after drilling is used to calculate the MRR.

Statistical analysis

A t-test is performed on the MRR observations obtained for the research samples using the SPSS statistical program. Input parameters like speed, feed rate, and drill diameter are considered as independent factors, whereas the MRR is considered as dependent variable [8].

Results

Table 1 shows three processes for CNC machining (Drilling) on sample group 1 (Fiber reinforced epoxy) and sample group 2 (Plain epoxy) materials. Drill diameter, speed (rpm), and feed (rev/sec) are all taken into consideration (mm). In table 2, the pertinent MRR values are displayed. The group data, including the number of samples per group, the mean MRR, standard deviation, and standard error, are shown in table 3 based on the statistical analysis (Independent t-test).

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

Parameters	Levels		
	L1	L2	L3
Speed (rpm)	120	180	240
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	120	0.15	4	0.165	0.028
2	240	0.15	4	0.216	0.118
3	120	0.35	4	0.231	0.199
4	240	0.35	4	0.315	0.101
5	120	0.15	6	0.332	0.090
6	240	0.15	6	0.426	0.161
7	120	0.35	6	0.563	0.242
8	240	0.35	6	0.665	0.126
9	120	0.25	5	0.240	0.219
10	240	0.25	5	0.274	0.027
11	180	0.15	5	0.302	0.116
12	180	0.35	5	0.187	0.050
13	180	0.25	4	0.506	0.199
14	180	0.25	6	0.372	0.080
15	180	0.25	5	0.411	0.158
16	180	0.25	5	0.445	0.140
17	180	0.25	5	0.461	0.105
18	180	0.25	5	0.456	0.137
19	180	0.25	5	0.454	0.133
20	180	0.25	5	0.457	0.136

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	0.3739	0.13317	0.02978
	Plain epoxy (Group-2)	20	0.1283	0.05858	0.01310



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



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

CNC-drilled samples for group 2 (Plain epoxy) and group 1 (Fiber reinforced epoxy) are shown in figure 1 and figure 2, respectively. Figure 3 shows the G-graph of MRR, which is displayed based on mean or average accuracy of detection (95% CI).

Discussion

The extension of the epoxy reinforcements led to a fundamental improvement in the MRR. According to the group statistical findings (Table 3), the mean MRR of ordinary epoxy and fiber- reinforced epoxy are, respectively, 0.1283 mm^3/sec and 0.3739 mm^3/sec. Understanding an independent sample of a t-test with fairness of means is made easier by table 4.

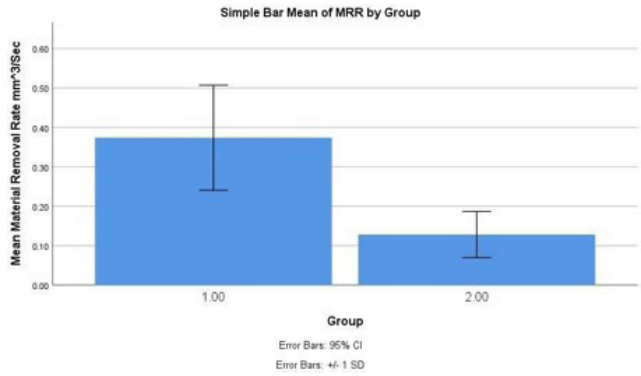


Figure 3: Graphical representation of MRR (mm^3/sec) for group-1 (Epoxy (90%), sustainable pineapple fiber (5%), nano carbon particles (5%) and group-2 (Plain epoxy), X-axis: Material groups, Y-axis: MRR (mm^3/sec) with mean accuracy of detection 95% CI and +/-1 standard deviation.

Levene's test results show that there is a substantial and appreciable statistical variation in the variance of the MRR among the study groups under study, with a p-value less than 0.05 (achieved p = 0.002). So, it is determined that the alternative hypothesis of uneven variance is appropriate. The composites with fiber reinforced epoxy (Group 1) have a mean/average MRR that is larger than that of plain epoxy, according to the negative t value (Group 2).

With this inquiry, similar and extraordinary works have been identified. Analysts have proposed a study with numerous samples on which CNC drilling is carried out and their weight% reinforcement variation as suggested to the process [9]. The final results demonstrate important disparities between fiber reinforced epoxy and conventional epoxy. According to the research, fiber reinforced epoxy performs better than normal epoxy [10]. Work has been completed using reinforcing materials including pineapple fiber mat and nano carbon particles, which significantly improved outcomes for various drilling situations [2]. Researchers have also suggested using nano carbon particles and pineapple fiber with properties to improve the qualities, and it has been found that these proposals are generally in agreement with this study and don't include any major discrepancies [11]. The formation of air bubbles and lumps during sample preparation is recognized as a drawback, which in turn impedes the required machining of the com-

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	14.060	0.01	7.551	38	0.002	0.245	0.032	0.1797	0.31
	Equal variance not assumed			7.551	26.1	0.002	0.245	0.032	0.1787	0.312

posite, hence regarded as a minor setback here. As a result, it becomes necessary to create new procedures or improve on those that already exist. Therefore, the goal of this research is to improvise a present method that might confront the challenges and increase the scope of the sample materials [12].

Conclusion

The investigation on MRR during CNC machining (Drilling) of epoxy-based new fiber reinforced epoxy including pineapple fiber (5%) and nano carbon particles (5%) and plain epoxy. In comparison to regular epoxy, the innovative hybrid reinforced epoxy's mean MRR (0.3739 mm^3/sec) is 0.28 mm^3/sec higher. The mean/average MRR is found significantly and statistically different between the two material groups under study, as per the t-test statistical analysis of the MRR of fiber reinforced epoxy and plain epoxy (t 26.087 = 7.551, p = 0.002). This study found that pineapple 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.

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None.

Conflict of Interest

None.

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