Incorporating sea sand particles into a plain epoxy composite and analysing metal removal rate using CNC machining

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ABSTRACT

Aim: To research the comparative analysis on Material removal rate of plain epoxy composite with reinforced (15%) of oyster shell powder particles novel composite using CNC machining. **Materials and Methods:** The samples of both the groups were fabricated by hand-layup technique.Experiment conducted for two groups , Group1 sample preparation for experimental group will be done using plain epoxy composite mixed with oyster shell of (15%). Group 2 sample preparation for the control group will be done using plain epoxy composite without oyster shell. A total of 16 samples were machined in each group. G-power calculated and pre-test power is 80% mean value and standard deviation are 0.5 and 0.1 for without filler and 0.2 and 0.06 for filler respectively. Statistical analysis was performed using the SPSS Statistical tool. R**esults:** From the obtained values, group 1 has a high Material removal rate when compared to group 2. The SPSS software used for independent T test values show that the obtained mean significance was 0.021 ($p<0.05$). **Conclusion:** Within the limitations of this study, the 15 wt % oyster shell powder reinforced composite has better material removal rate than the plain epoxy composite with the mean value of 2.40975 mm^3/min) and 1.71400 mm^3/min.

Keywords: NovelOyster shell powder, Plain epoxy composite, Material removal rate, SPSS software, High Speed Steel drill bit, CNC drilling.

INTRODUCTION

The research of this study is comparative analysis on Material removal rate of plain epoxy composite and (15%) of oyster shell is used as filler. Composite materials are used in a variety of industries including automobiles, packaging, furniture, and home appliances, as well as airplanes, shipping, defense applications, and windmills (Silva et al. 2021). There has been a lot of interest in using polymer-based composites for a variety of lightweight applications that demand a high strength-to-weight ratio (Oliveira et al. 2021). Synthetic fiber composites such as glass composite, carbon fiber, and aramid fiber have been utilized as reinforcement in polymer composites for decades (Dhakal and Sain 2019). Due to environmental concerns and the carbon footprint of synthetic material, a lot of study has recently been done on the use of natural fibers and fillers as a suitable alternative to synthetic reinforcement. Natural fibers and fillers have the advantage of being readily available, simple to process, low cost, higher strength, recyclable and low environmental impact. Additionally, several studies have shown that natural fibers and fillers can be a better alternative to synthetic material in

terms of mechanical properties of polymer composites (Hu et al. 2019).

About 466 articles were published in Google Scholar and 337 articles were published in Science Direct from the past 5 years. The identification of surface roughness and delamination factor for cellulose fiber reinforced plain weave epoxy composite in the traditional drilling machine using High Speed Steel drill (Yu and Yang 2021). The performance optimization of Ramie fiber reinforced with Graphene-oxide for obtaining a strong matrix composite and higher material removal rate in lathe machines (Pereira et al. 2020). The determination of toughness of a palin carbon-epoxy composite in CNC turning operation and calculating the test results with Finite Element Analysis software (Martínez-Figueroa et al. 2014). The investigation of flexural fatigue for a plain epoxy composite reinforced with 12 wt % of egg shell and drilled using a carbide tool in a CNC drilling machine (Chhorn and Jung 2021). Considered that the filler material has a major impact on the overall mechanical properties of novel polymer composites and can be used to improve mechanical properties which was identified as the best study in their research findings (Chhorn and Jung 2021).(Parakh et al. 2020; Pham et al. 2021; Perumal, Antony, and Muthuramalingam 2021; Sathiyamoorthi et al. 2021; Devarajan et al. 2021; Dhanraj and Rajeshkumar 2021; Uganya, Radhika, and Vijayaraj 2021; Tesfaye Jule et al. 2021; Nandhini, Ezhilarasan, and Rajeshkumar 2020; Kamath et al. 2020)

The research is about comparing and analysis of holefor identifying the Material removal rate reinforced with oyster shell powder by drilling 16 number of holes on the composite using tungsten carbide drill bit. The perfect holes are done using drilling operations in a drilling machine (CNC). There is more research and work being made to test the machinability of reinforced oyster shell powder in plain epoxy composite and its drilling characteristics.

MATERIALS AND METHODS

The machining and drilling process is administered at Saveetha Industries, Institute of Mechanical Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai. For froming the composite epoxy LY-556 and hardener LH-556 which is used in 10:1 ratio collected from Hayavel Aerospace India Pvt Ltd, Chennai, India. It measured the metal removal rate of the plain epoxy reinforced with Oyster shell powder composite. The oyster shell is used (15%) in plain epoxy composite (Zheng et al. 2022). Two groups were selected for experimental investigation. Group 1 is Plain Epoxy Resin composites and Group 2 is 15% of oyster shell powder reinforced epoxy composites. (Palaniappan et al. 2020) Sample size is 32 (16 for each group) was calculated using g-power calculated and pre-test power is 80% mean value and standard deviation are 0.5 and 0.1 for without filler and 0.2 and 0.06 for filler respectively.

For Group 1 sample preparation, the plain epoxy composite reinforced with oyster shell is the hand layup method. Dimension of the composite is 150 x 200 and the density of the composite is 1mm. Polished wax is applied over the mold to remove the sample easily. Fabrication of one sample (60%) of epoxy is used in (15%) of oyster shells. After fabrication

weight is placed on top of the setup and waited for 48 hours for curing time.

For Group 2 sample preparation we are repeating the same fabrication method as preparation for group 1, as a hand layup method plain epoxy without using oyster shell powder. We have to find metal removal rate in plain epoxy composite (70%) of epoxy composite. The curing time takes up to 7-8 hours to get an excellent finish.

In preparation for putting the composite to quotidian bio use. For protection and solidity, several of the properties were to be scaled, analyzed, and compared. By comparing the data, we can determine metal removal rate. By comparing the data, the material is ensured to have a high metal removal rate. The metal removal rate quality of the material is compared to that of the experimental group and control group.

The Material Removal Rate for specimens was computed by the equation (1),

$MRR = W_f / t \times W_i$ ———— (1)

Where,

W_f = final weight of the specimen

W_i = initial weight of the specimen

t = time taken for machining the specimen

The material's machining process is carried out in accordance with ASTM specifications. Drilling is done to determine the metal removal rate (MRR) of the composite material. To demonstrate how machining parameters such as feed rate (mm/min) and speed rate (rpm) may be varied to produce a wide range of metal removal rate values in drilled holes. Drilling holes in reinforced composite material is done with a coated Tungsten Carbide drill bit with an 8mm diameter.

Statistical analysis

The statistical analysis was conducted. The standard deviation, standard error, and mean were calculated using SPSS Software V.26. The significance value was also reported as P 0.005. The independent factors in this experiment are spindle speed, drill bit diameter, and feed rate, while the dependent variable is material removal rate (mm). The relevance of with and without oyster shell powder in plain epoxy composite was investigated using an independent sample T-test as shown in Fig.3.

RESULTS

In Table 1, the obtained mean value of material removal rate for the samples made of 15 wt % oyster reinforced epoxy composite was 2.40975 mm^3/min. In Table 2 the mean value of material removal rate for the samples made of plain epoxy composite was 1.71400 mm^3/min. In Table 3, the group statistics obtained for both groups were drawn, the standard deviation and the mean for both groups were identified. In Table 4, the significance value of 0.021 was obtained. Figure.1 and Figure. 2 show the graph difference between the sea oyster reinforced samples and the palin epoxy composite. It shows that the oyster reinforced composite has a higher material removal rate than the plain epoxy composite.

DISCUSSION

Table 1 represents the mean value of 15 wt % oyster reinforced composite and Table 2 represents the mean value of plain epoxy composite. It is proved that

the oyster reinforced composite has a higher material removal rate than the plain epoxy composite.

The materials made using the method of polymer matrix composite (PMC) have better strength and toughness than non-composite materials (Lu et al. 2018). Those materials were used for manufacturing automobile parts, doors, windows, etc. These are the largest manufactured materials (Bertagnolli et al. 2017). The machining done for plain epoxy composite using a High Speed Steel drill tool in a computerized drilling machine (Debnath and Singh 2017). The machining was done with the parameters with speed of 250 (rpm) and the feed rate of 2.5 min/rev (Chatterjee et al. 2018).

This project fabrication process required skilled labour and the hand layup technique is used for preparing the Novel composite material. The hand layup technique is a time taking process. This technique is not applicable for bulk production. No protection against moisture, structural strength will decrease; there will be no fire protection. Delamination occurs between the layers and moreover improper bonding for 15 wt % novel oyster shell powder reinforced composite (Mugahed Amran et al. 2020). The speed of 1200 rpm was used in the turning machine for this research (Mu et al. 2021). The independent t-test analysis reports through SPSS statistical analysis revealed that Cylindricity tolerance during drilling of composite was reduced significantly by the addition of reinforcement materials to it and the resultant t-table showing the mean and standard deviation of and the drilling is are 2.4 and 0.14 for 15 wt % novel oyster shell powder reinforced composite. The material removal rate of 1.963 mm^3/min was obtained for plain epoxy composites (Lapo et al. 2019).

The epoxy composite is a soft composite; it must be machined with good care and takes more time. This is the limitation of this research. The change of reinforcement material and the tool can be developed in the future research.

CONCLUSION

Within the limitations of the study, the drilling studies on plain epoxy composite and 15 wt % oyster shell powder reinforced composite using High drill bit and the performance of these materials were evaluated based on the measured material removal rate. Outcome of these experiments show that 15 wt % novel oyster shell powder reinforced composite exhibits better material removal rate than plain epoxy composites. The results of conducted experiments show the depth of cut, speed and feed rate are the most significant factors of material removal rate.

DECLARATION

Conflict of interest

The authors declare no conflicts of interest

Author's contribution

Author SA was involved in data collection, data analysis and manuscript writing. Author TMD was involved in conceptualization, data validation and critical review of the manuscript.

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TABLES AND FIGURES

Table 1. shows obtained material removal rate values of 15 wt % oyster shell reinforced epoxy composite.

S. no.	SPEED	FEED	MRR

	(m/min)	**(mm/rev)**	**(mm^3/min)**
1	200	2	2.123
2	200	2.5	2.175
3	200	3	2.238
4	200	3.5	2.392
5	300	2	2.397
6	300	2.5	2.316
7	300	3	2.354
8	300	3.5	2.378
9	400	2	2.399
10	400	2.5	2.442
11	400	3	2.486
12	400	3.5	2.523
13	500	2	2.551
14	500	2.5	2.578
15	500	3	2.591
16	500	3.5	2.613

Table 2. Shows obtained material removal rate values of plain epoxy composite.

S. no.	**SPEED (m/min)**	**FEED (mm/rev)**	**MRR (mm^3/min)**
1	200	2	1.525
2	200	2.5	1.549
3	200	3	1.565
4	200	3.5	1.578
5	300	2	1.623

6	300	2.5	1.652
7	300	3	1.683
8	300	3.5	1.701
9	400	2	1.732
10	400	2.5	1.756
11	400	3	1.782
12	400	3.5	1.796
13	500	2	1.824
14	500	2.5	1.861
15	500	3	1.885
16	500	3.5	1.912

Table 3. The values of mean and standard deviation in group statistics for the oyster composite has higher MRR than plain epoxy composite.

Group Statistics					
	Groups	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
MRR	15 wt % of oyster shell reinforced composite	16	2.40975	.146613	.036653
	Plain epoxy composite	16	1.71400	.124496	.31124

Table 4. Values of independent T statistical test for oyster shell reinforced and plain epoxy composite. The statistical significance value of 0.021 was obtained which must be less than 0.050.

Independent Samples Test

		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**
MRR	Equal variances assumed	.140	.021	14.469	30	.001	.6957500	.048085	.597547	.793953
	Equal variances not assumed			14.469	29.232	.001	.695750	.048085	.597439	.794061

Fig. 1. Plain epoxy

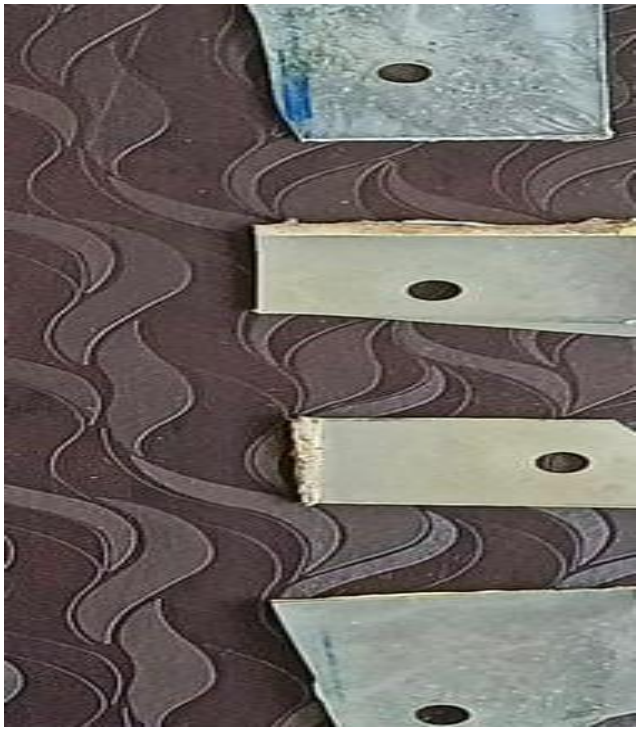

Fig. 2. Epoxy with 15% of oyster shell

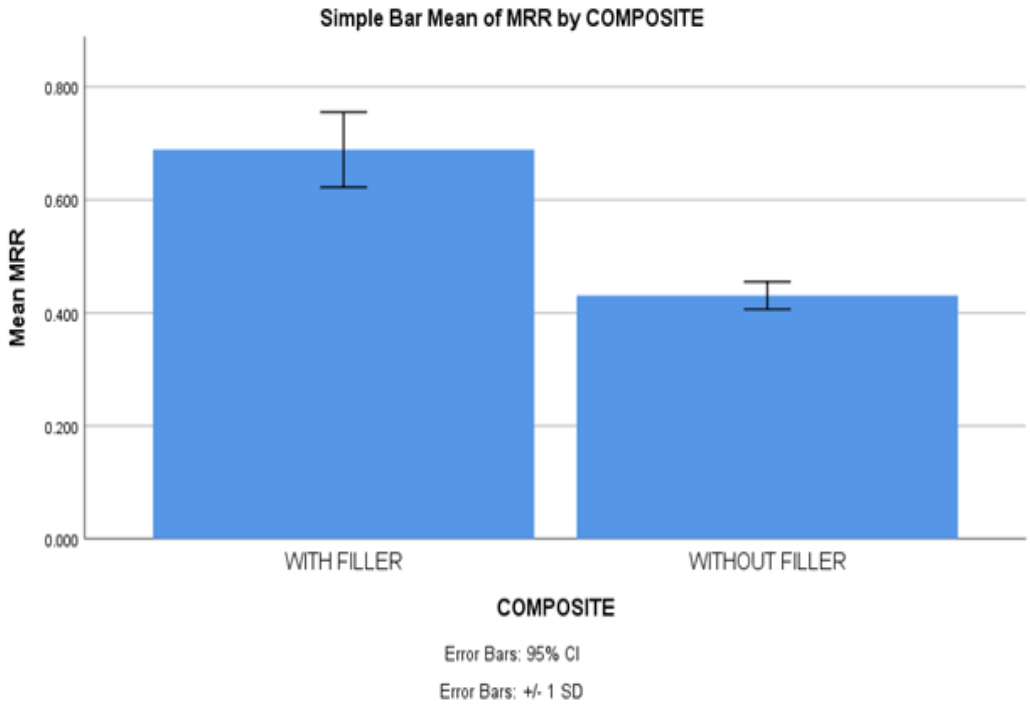

Fig. 3. Comparison of reinforced oyster shell powder composites (With filler) or Plain Epoxy composites (Without filler) in terms of mean accuracy. The Mean accuracy of reinforced 15% of oyster shell powder composites (With filler) better than Plain Epoxy composites (Without filler). The standard deviation of reinforced 15% of oyster shell composite is slightly better than Plain Epoxy composites. X Axis: With VS without filler, Y Axis: Mean accuracy of detection ± 1SD.