Comparative analysis of MRR Glass Fibre Reinforced Titanium composite by addition of TiO2 nanoparticles compared with glass fibre composite by Drilling process.

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ABSTRACT

Aim: This research involves material removal rate of glass fibre reinforced titanium sheets Ti6Al4V filled with 5% and 10% of TiO2 nanoparticles and reinforced novel synthetic fibre compared with titanium epoxy composite. **Materials and methods:** Titanium sheet used in this research was Ti6Al4V. The experimental group in this study are novel synthetic glass fibre and reinforced titanium composite by addition of 5% and 10% of TiO2 nanoparticles which are classified into two groups and third group is titanium epoxy composite as a control group. the sample involved in this study is 20 samples per group were carried out for each group involved in these experiments. **Result:** Mean material removal rate obtained for drilling process of glass fibre reinforced titanium composite by addition of 5% and 10% of TiO2 nanoparticles respectively 23.2335 g/min and 12.762 g/min, whereas it is 8.2885 g/min for glass fibre reinforced titanium composite with significant value is 0.001 ($P<0.05$). **Conclusion:** From research, it was concluded that material removal rate of glass fibre reinforced titanium epoxy composite with 5% of filler was higher when compared with other groups involved in research.

Keywords: Material removal rate (MRR), Novel synthetic fibre, Natural fibre, Titanium sheet Ti6Al4V, Epoxy novel composite.

INTRODUCTION

Machining of synthetic composites is influenced by matrix, fibers, and also matching processes involved. This work describes comparison of material removal rate (MRR) in glass fibre reinforced hybrid titanium epoxy composites filled with 5%, 10%, and 0% of TiO2 nanoparticles as filler material machined by drilling processes (Kamaraj, Santhanakrishnan, and Muthu 2018). To reduce manufacturing lead time and increase productivity of components, an appropriate selection of machine tools is needed in the current scenario (Jayaganth et al. 2018). Metal matrix composites are widely recognized as advanced materials, it has enhanced mechanical and thermal properties that embrace good wear resistance and exceptional thermal conductivity (Sharma et al. 2020). Due to its light property and cost-cutting factor, these composite materials were used in the automotive industry, such as a hood, bumper, chassis support, and panels (Takahashi, Mori, and Takebe 2020).

In recent times many kinds of research have been found on glass fibre reinforced hybrid titanium epoxy composites evaluating MRR. 15,900 articles were published in google scholar and 1,498 articles were published in science direct. MRR evaluated on glass fiber reinforced titanium epoxy composites using metal drill bit using parameters like feed rate, rpm, depth of cut. In this work, maximum MRR obtained is 8.241 mm^3/sec (Kumar and Gururaja 2020). holes were made on unidirectional novel synthetic fiber composite using a drilling process and it was observed that cutting speed and feed rate significantly affect holes (Geier and Szalay 2017). In this study, an increase in feed rate causes an increase in delamination and surface roughness of specimens (Sikiru Oluwarotimi Ismail, Hom Nath Dhakal, Ivan Popov, Johnny Beaugrand 2016)**.**Previously our team has a rich experience in working on various research projects across multiple disciplines(Ezhilarasan et al. 2021; Balachandar et al. 2020; Muthukrishnan et al. 2020; Kavarthapu and Gurumoorthy 2021; Sarode et al. 2021; Hannah R et al. 2021; Sekar, Nallaswamy, and Lakshmanan 2020; Appavu et al. 2021; Menon et al. 2020; Gopalakrishnan et al. 2020; Arun Prakash et al. 2020)

Most of previous research works studied drilling of carbon fibre reinforced titanium epoxy composites. However, in proposed research material removal rate was compared in glass fibre reinforced hybrid titanium epoxy composite mixed with and without TiO2 nanoparticles by drilling process.

MATERIALS AND METHODS

The specimen used for research is a glass fibre reinforced titanium composite filled with 5% and 10% of TiO2 nanoparticles. The machining process was carried out by an advanced drilling machine. study was done in Saveetha Industries, Saveetha School of Engineering (SSE), Saveetha Institute of Medical and Technical Science (SIMATS). In this work, samples were made of 5% and 10% of TiO2 nanoparticles in glass fibre reinforced titanium composite as an experimental group, and drilling process with glass fibre reinforced titanium composite is a control group. The sample size used for this study is 20 for each group (Uttley 2019). specimens utilized for this investigation are done with 80% G power computation (Xu, Mili, and Zhao 2019). The least force of examination is fixed as 0.00 and the greatest acknowledged blunder is fixed as 0.5.

Laminates were prepared using bidirectional glass fiber fabrics (Supplied by Hayael Aerospace India Pvt. Ltd Poonamallee, Chennai) titanium alloy, epoxy resin (LY556), and hardener (HY951). TiO2 nanoparticles were mixed with epoxy resin to make a novel glass fibre reinforced titanium composite filled with 5% and 10% TiO2 nanoparticles using a hand layup process. a workpiece with a size of (300 X 300 X 12 mm) was fabricated. Fig. 2 shows a fabricated sample of glass fibre reinforced titanium composite filled with 5% of TiO2 nanoparticles. In this research, holes were made on glass fibre reinforced titanium composite filled with 5% and 10% of TiO2 nanoparticles. Fig. 3 shows drilling process on glass fibre reinforced titanium composite filled 10% of TiO2 nanoparticles.

Fabricated composite material using drilling machines with process parameters of feed rate (mm/rev), spindle speed (rpm), drill bit diameter(mm) (Abdullah and Sapuan 2019). Fig. 1 shows the drilling machine used for this investigation. A weight-loss method was used for measuring material removal rate in glass fibre reinforced titanium composite filled with TiO2 nanoparticles. Fig. 4 shows drilling process on glass fibre reinforced titanium composite filled 0 % of TiO2 nanoparticles.

Before making holes, the weight of the work specimen was measured by using a weighing machine. While drilling, machining time was recorded using a stopwatch. After machining, the weight of the specimen was noted. material removal rate was evaluated using following formula (1) (Jesthi and Nayak 2020).

$$Material\ Removal\ Rate\ (g/min) = (Wb - Wa)\ /\ Mt \quad ----- (1)$$

Where W_b -Weight before machining, W_a - Weight after machining, Mt - Machining Time, material removal rate was calculated using a weight-loss method for glass fibre reinforced titanium composite filled with TiO2 nanoparticles and glass fibre reinforced titanium composite machined using drilling process

Statistical analysis

Statistical programming SPSS V 2.6 was used to compute standard deviation, mean and standard blunder. importance esteem is recorded when significance $P<0.05$. In this examination, free factors are spindle speed, feed rate, drill diameter variable is material removal rate (MRR). An independent sample T-test was used to analyze the significance of the drilling process.

RESULTS

Material removal rate obtained for glass fibre reinforced titanium composite filled with 5% and 10% of TiO2 nanoparticles and glass fibre reinforced titanium composite is shown in Table 1. Higher MRR is obtained in glass fibre reinforced titanium composite filled with 5% of TiO2 nanoparticles which are machined using a drilling process.

In SPSS software, an independent sample T-Test was used among considered groups, and output values are shown in Table 2. sample machined by drilling process has a higher material removal rate with a 5 % filler mean of 23.2335 g/min and standard deviation value is 1.00495 and for 10 % filler mean value is12.762 g/min and standard deviation 1.29271. and without addition of filler, mean value is 8.2885 g/min and standard deviation 1.26461 Table 3 indicates outcomes from ANOVA test performed to determine quality of means for formulated hypothesis among experimental and control groups. From results, it was seen that a significant variance exists among considered two groups at level of significance value 0.001, which is below 0.05.

DISCUSSION

This research observed that maximum MRR was obtained in glass fibre reinforced titanium composite filled with 5% TiO2 nanoparticles machined with drilling process. Fisher value obtained for this study is 824.756 with a significance of 0.001 that is < 0.05 which shows that a significance exists between two processes. glass fibre reinforced titanium composite filled with 5% and 10% of TiO2 nanoparticles and glass fibre reinforced titanium composite machine with drilling. From bar chart Fig. 5 it is observed that higher MRR is obtained when a specimen is drilled by a drilling process.

Since there is a contract between boring apparatus and manufactured composites, TiO2 nanoparticles at a higher interfacial temperature prompt dissipated epoxy pitch and fiber breaks which thus increment MRR. Due to this material removal rate of fabricated composite decreased (Jani et al. 2016). According to (Kumar, Singh, and Zitoune 2016) spindle speed is a significant parameter for MRR in the drilling process. Previous research work noticed that interaction between process parameters significantly affects MRR with a minor percentage of contribution. findings of above authors are not in line with findings of this work. The reason for this is mainly due to combinations of process parameters considered by above authors, whereas constant process parameters are used in this work. In the drilling process, spindle speed, feed rate, and drill bit diameter are significant parameters for material removal rate.

In a study called (Kondo et al. 2019) it was found that material removal rate increases with test span length for specimens. This research (Natarajan et al. 2020) states that material removal rate is constant and offers improved mechanical properties depending upon constituents to be added. This author's work is in line with the scope of this study. In another study, (Azam and Afendi 2016) states that MRR specimens will have better performance in other properties. This author's work is not in line with work carried out in this study.

Limitation of this research work involved that when spindle speed is low, bottom peels up of fiber causing a reduction of machinability. In the future, the same study will compare material removal rate using waterjet and drilling process of glass fibre reinforced titanium composite filled with 5% and 10% of ceramic nanoparticles using a resin infusion process.

CONCLUSION

In the present study holes were made on glass fibre reinforced titanium composite filled with 5% of TiO_2 nanoparticles and glass fibre reinforced titanium composite using a drilling process to compare material removal rate. It was observed that the drilling process of glass fibre reinforced titanium composite filled with 5% of TiO_2 nanoparticles provides a higher material removal rate.

DECLARATIONS

Conflict of Interests
No conflict of interest in this manuscript.

Authors Contributions
Author VK was involved in data collection, data analysis, and manuscript writing. Author VSM was involved in conceptualization, data validation, and critical review of manuscript.

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Tables and Figures

Table 1. Comparative analysis of MRR glass fibre reinforced titanium composite by addition of TiO2 nanoparticles compared with glass fibre composite by Drilling process.

S	**Material Removal Rate(g/min)**		
eeeeeeeeeeee eeebnngngng h	**5% of filler**	**10% of filler**	**0% of filler**
1	24.85	12.96	6.92
2	22.79	11.05	9.22
3	24.68	14.55	9.3
4	22.92	14.36	7.65
5	22.81	13.56	8.04
6	22.72	12.13	6.69
7	22.9	10.86	9.17
8	22.66	11.53	8.34
9	24.47	14.37	6.67
10	22.04	14.84	6.69
11	23.55	13.24	9.96
12	24.91	14.43	9.7
13	22.72	10.83	10.1
14	21.97	12.4	9.39
15	23.39	11.96	6.59
16	21.89	13.07	8.95
17	24.35	11.53	8.51
18	24.27	12.03	9.7
19	22.45	12.39	6.84
20	22.33	13.15	7.34

Table 2. Group statistics: sample machined by drilling process have a higher material removal rate with 5 % of filler mean of 23.2335 g/min and standard deviation value is 1.00495 and for 10 % filler mean value is 12.762 g/min and standard deviation 1.29271. and without addition of filler, mean value is 8.2885 g/min and standard deviation 1.26461.

Descriptives				
MRR	N	Mean	Std. Deviation	Std. Error
5% of Filler	20	23.2335	1.00495	0.22471
10% of Filler	20	12.762	1.29271	0.28906
0% of Filler	20	8.2885	1.26461	0.28278
Total	60	14.7613	6.42397	0.82933

Table 3. ANOVA test: A significant difference between control and experimental group is observed - Significance value P=0.001 (P<0.05) and df value is 2, 57 & 59 and fisher value is 824.756.

ANOVA					
MRR					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2353.45	2	1176.725	824.756	0
Within Groups	81.325	57	1.427		
Total	2434.775	59			

Fig. 1. Drilling machine - drilling capacity - ⌀25 mm. Table size - 400 mm, range of speed 2000- rpm, feed rate-0.5 -1.5 mm/min, depth of cut - 0.3 to 0.7, tool diameter- 10 mm .

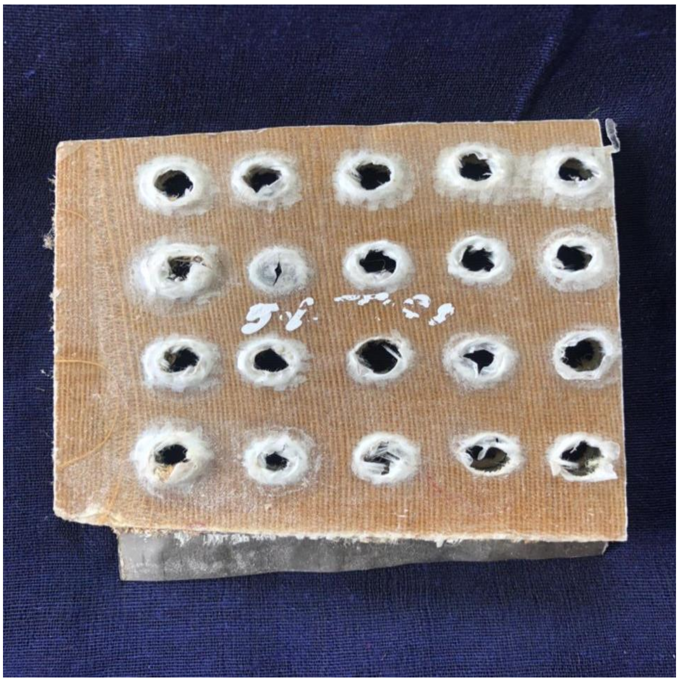

Fig. 2. Shows fabricated sample of glass fibre reinforced titanium composite filled with 5% of TiO2 nanoparticles.

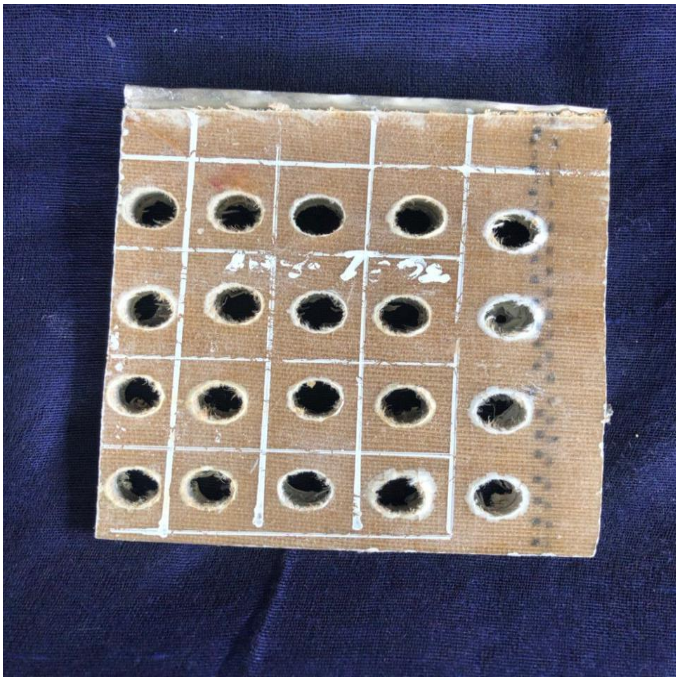

Fig. 3. Shows drilling process on glass fibre reinforced titanium composite filled 10% of TiO2 nanoparticles.

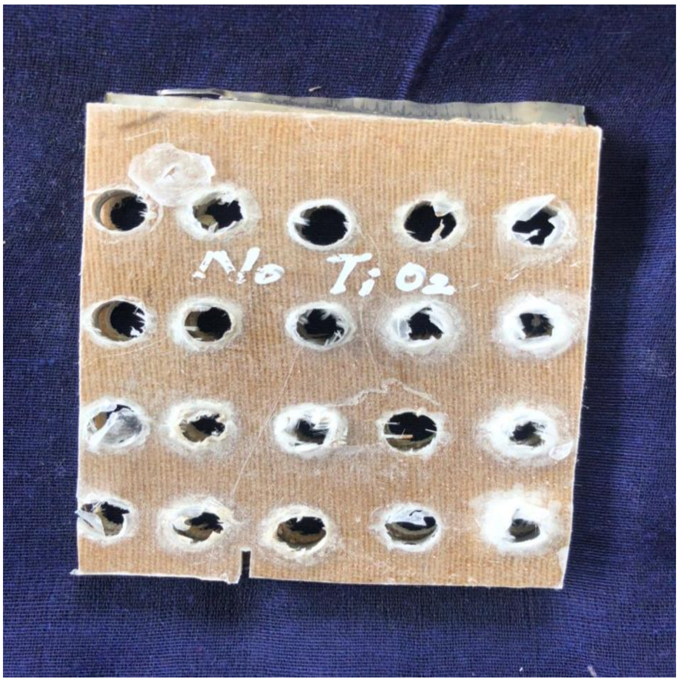

Fig. 4. Shows drilling process on glass fibre reinforced titanium composite filled 0 % of TiO2 nanoparticles.

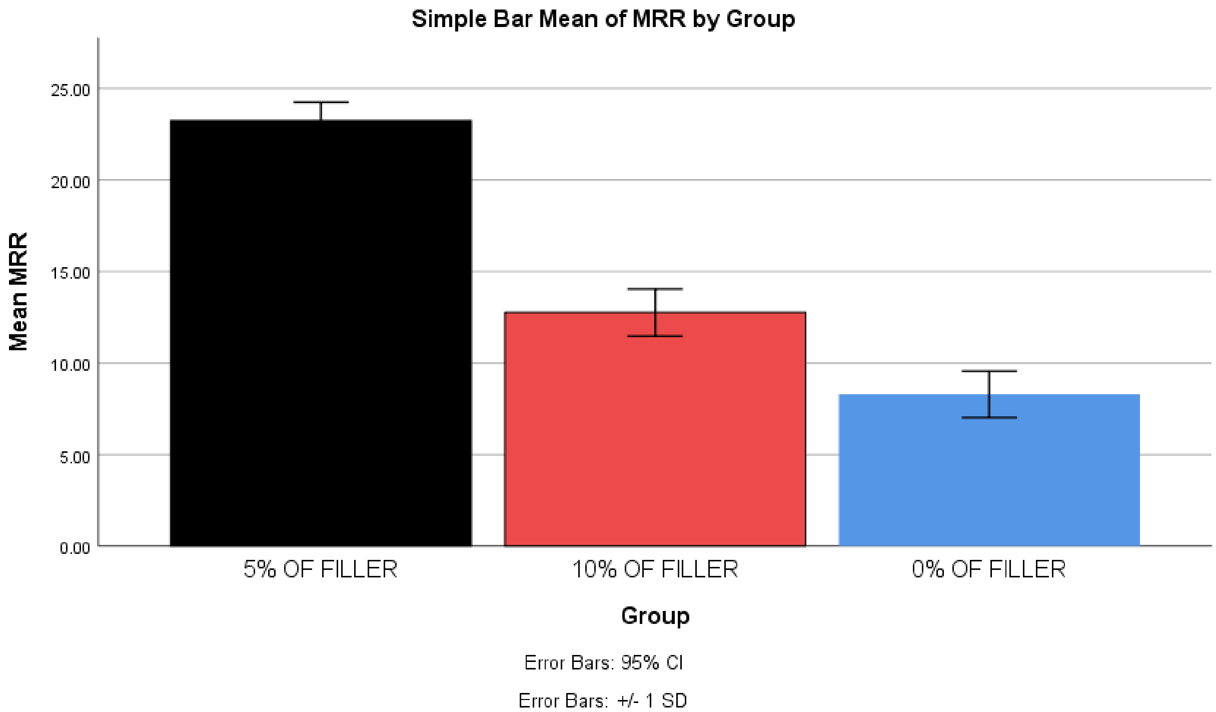

Fig. 5. Comparative analysis of MRR glass fibre reinforced titanium composite by addition of TiO2 nanoparticles compared with glass fibre composite by Drilling process.: Mean accuracy of detection $\pm$ 1 SD. The vast difference between Experimental group and control group implies that addition of filler materials in % of 5, 10 and 0. X-axis: Experimental and control groups, Y-axis: Mean material removal rate.