ISSN: 0974-5823 Vol. 7 (Special Issue, Jan.-Mar. 2022)

International Journal of Mechanical Engineering

Comparative assessment of surface roughness for bamboo fiber aluminium laminate by addition of scenedesmus dimorphus filler with bamboo aluminium composite using drilling process.

Ashwin G Prakash[1] , S. Madhu[2]

[1]Research Scholar, Department of Automobile Engineering ,
Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences,
Saveetha University, Chennai, Tamilnadu. India. Pincode : 602105

[2]Project Guide, Corresponding Author,
Department of Automobile Engineering , Saveetha School of Engineering,
Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu. India.

ABSTRACT

Aim: This experimental work compares the surface roughness in the drilling of bamboo fibre reinforced aluminium with and without the addition of scenedesmus dimorphus filler to obtain lower surface roughness. **Materials and methods:** The material involved in this work is bamboo fibre reinforced aluminium composite filled with scenedesmus dimorphus filler. In this work bamboo fibre reinforced aluminium composite without addition of filler is set as the control group and bamboo fibre with addition of scenedesmus dimorphus filler (5, 10 wt.%) aluminium composites is the experimental group. Totally 60 samples were measured by surface roughness. **Results:** The mean surface roughness obtained for the bamboo fibre without the addition of filler is 3.3405 µm. The mean surface roughness obtained for 5 wt.% is 0.4830 µm. and for 10 wt.% is 1.160 µm. The significance value obtained among the experimental and control group is 0.002 ($P<0.05$). **Conclusion:** Within the limits of this study, the outcome of the research shows that surface roughness is minimum when the 5 wt. % filler material added with bamboo fibre reinforced aluminium composite.

Keywords: Surface roughness, Novel bamboo fiber, Hand layup process, Scenedesmus dimorphus filler, Hand layup process.

INTRODUCTION

Bamboo fiber is a characteristic fiber separated from the external husk of bamboo and utilized for various applications such as floor mats, mats, brushes and sleeping cushions (Chang, Zhao, and He 2019). The aim of the study is to reduce the surface roughness of the novel bamboo fiber composite reinforced with aluminium mixed with scenedesmus dimorphus filler (Chen et al. 2018). Bamboo fibre composite is fabricated and surface roughness is evaluated. From this work it was seen that the addition of filler reduced the surface roughness. Bamboo fibre reinforced epoxy composites used for various applications such as making of wraps, covers, automotive body panels. Due to its low weight and high impact strength these composites are used as vibration dampers and sound absorbing material. These composites are used for various structural and furniture applications (Imadi, Mahmood, and Kazi 2014); (Jawaid, Rangappa, and Siengchin 2020).

From the earlier research the article observed in google scholar is 3310 and in science direct is 890. Decrease in surface roughness results in better bonding between matrix and the fiber. Bamboo fibre reinforced epoxy composites fabricated and treated with NaOH for eliminating the hemicellulose, wax, lignin, oils and other debasements that encompass the external surface of the fiber. From this work it was seen that NaOH treated bamboo fibre reduced the surface roughness (Salih, Zulkifli, and Azhari 2020). Due to its high aspect ratio and strong mechanical properties, bamboo fibers are very promising reinforcement for production of polymer composite. In this work mechanical properties were evaluated. From this work it was observed that shot bamboo fibre offered better tensile strength (Rasheed, Jawaid, and Parveez, n.d.). Bamboo fibre reinforced epoxy composites fabricated. Bamboo fibre used for this investigation is treated with NaOH solution to remove wax and other impurities. From this result it was noted that chemically treated bamboo fibre reinforced composites offer better mechanical strength (Wang et al. 2019). The surface roughness of the bamboo based composites were investigated. From this work it was noted that incorporating of filler in bamboo composites decrease the surface roughness significantly (Khalil et al. 2018).

Previous literature focused on finding the effect of drilling parameters on surface roughness (Ra) of various composite materials. So far limited work has been conducted for evaluating the surface roughness in bamboo fibre reinforced aluminium composites. The aim of this research is to compare the surface roughness (Ra) in the machining of bamboo fibre reinforced aluminium epoxy composite with and without the addition of scenedesmus dimorphus filler.

MATERIALS AND METHOD

The workpiece material used for this research is novel bamboo fiber reinforced aluminium composite with and without addition of scenedesmus dimorphus filler. The study was carried out in Saveetha Industries, Saveetha School of Engineering (SSE), Saveetha Institute of Medical and Technical Sciences (SIMATS). In this research holes were made on fabricated novel composite filled with scenedesmus dimorphus filler (5 and 10 wt.%) is set as an experimental group and without filler is set as a control group. Total number of groups involved in this work is 3. The total sample size for this investigation was 40 (Tan, Azmi, and Muhammad 2015). A clinical online sample size calculator was used to calculate the sample size with 80% g power. Samples used for this analysis are done using G power calculation. The minimum power for the analysis is fixed as 0.8 and the maximum accepted error is fixed as 0.05 (Ramana, Venkata Ramana, and Kumar 2018).

The laminates were prepared using bidirectional bamboo fibre, aluminium sheet, epoxy resin (LY556) and hardener (HY951) supplied by Hayael Aerospace India Pvt. Ltd Poonamallee, Chennai. 5,10 wt.% of scenedesmus dimorphus filler mixed in the epoxy resin. The hand layup process was used to fabricate the workpiece with the size of 300 X 300 X 5 mm.

In this work, holes were made on novel bamboo fibre reinforced aluminium epoxy composite mixed with scenedesmus dimorphus filler using an abrasive drilling process with the parameters of Feed rate (mm/min), Spindle speed (rpm) and drill diameter (Ay and Ay 2016). Fig. 1 shows the samples used for measuring surface roughness.

After the drilling, the samples were prepared for measuring surface roughness. The Mitutoyo- SJ-410 surface roughness instrument was used for measuring the surface roughness. The specification of this surface roughness tester includes: Measuring range X-axis - 25 mm; Measuring force - 0.75 mN, parameters - Ra, Rq and Rz and cutoff length - 0.25 mm.

Statistical Analysis

The statistical SPSS V 26 software used to calculate the standard deviation, mean and standard error. The significance value is seen when the probability value $P<0.05$. In this study the independent variables are the percentage of scenedesmus dimorphus fille and the dependent variable is surface roughness (Ra). The independent sample T-test was used to analyze the significance of with and without addition of scenedesmus dimorphus filler in bamboo fibre reinforced aluminium composite.

RESULTS

The measured surface roughness for bamboo fibre reinforced aluminium with and without filler material is shown in Table 1. Lower surface roughness was obtained when the bamboo fibre reinforced aluminium composite filled with 5 wt.% of scenedesmus dimorphus filler.

In SPSS statistical software, an independent sample T-Test was utilized among groups and the output values are shown in Table 2. A significant difference between the control and experimental group is observed Significance value P=0.002 (P<0.05) and df value is 2, 57 & 59. The descriptive table explains that the mean of the surface roughness is lowest (0.4830) for 5 wt.% scenedesmus dimorphus filled bamboo fiber composite 0.5526 and 0.01236 are the standard deviation and standard error respectively. Table 3 shows the result of Levene's test performed to determine the quality of means for the formulated hypothesis among the experimental and control groups. From the result, it was observed that the significant variance exists among the considered two groups as the level of significance value 0.002, which is below 0.05.

DISCUSSION

Figure 2 explains the surface roughness of the bamboo fibre reinforced aluminium composite with and without filer. In this research it was seen that lower surface roughness of 0.4830 µm was obtained in bamboo fiber reinforced aluminum epoxy composite filled in with 5 wt. % scenedesmus dimorphus filler. It was obtained with the significance of $P < 0.05$. From the experimental result, it was seen that the lower surface roughness was recorded when the sample is filled with 5 wt. % of scenedesmus dimorphus filler. Figure 3 shows the comparison of surface roughness obtained in the bamboo fibre reinforced aluminium composite with and without scenedesmus dimorphus filler.

The conclusions derived from the research work carried out by (Pashmforoush, Zinati, and Maleki 2020) is inline with the current research. It is observed that lower surface roughness is obtained when the specimen is filled with 10 wt. % of portunus filler. During machining the portunus filler produced lubricant properties which inturn reduced the surface roughness. Carbon fibre reinforced titanium laminates fabricated and surface roughness was investigated in cryogenic drilling conditions. From this work it was noted due to the cryogenic, less fibre pull out and delamination occurred during drilling which inturn increased the surface roughness of the composites (Kumar, Gururaja, and Jawahir 2020). Flax fibre reinforced polymer composites machined using a drilling process. Increasing the drill bit size leads to maximum surface roughness (Maleki et al. 2019). This works in line with the current research.

Due to the presence of aluminum matrix, it makes it hard to drill, which increases the tool wear and also more chip formation that affects the surface roughness. Due to the increased porosity nature of the workpiece, the workpiece gets damaged by applying more force (Rajesh et al. 2021). Types of fiber have a positive effect on surface roughness, and the length of the fiber type of resin have a negative impact on surface roughness (Khan et al. 2013). The findings of the above researchers are not in compliance with this work. The reason for this conflict may be due to drilling process parameters and fillers.

The limitation of this work is the formation of fibre crack and delamination, as a result of this the crack occurred on the bamboo fibre reinforced aluminium samples machined by drilling process. In the future, the same study will compare the surface roughness using waterjet and the composites are fabricated using a resin transfer process.

CONCLUSION

Within the limits of this study, the surface roughness of the bamboo fibre aluminium composite filled with 5 wt % of produced a lower surface roughness of (0.4830 µm when compared with the bamboo fibre composite without addition of scenedesmus dimorphus filler (3.3405 µm).

DECLARATION

Conflict of interests

No conflict of interest in this manuscript

Authors Contributions

Author AGP was involved in data collection, data analysis, manuscript writing. Author MS was involved in conceptualization, data validation, and critical review of manuscript.

Acknowledgements

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding

We thank our financial sponsors for the following organizations for providing financial support

1. Hayael Aerospace India Pvt. Ltd, Chennai.
2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences
4. Saveetha School of Engineering

REFERENCES

1. Ay, M., and İ. Ay. 2016. "The Prediction and Optimization of the Effects of Abrasive Waterjet Cutting Parameters On Kerf." *Acta Physica Polonica A*. https://doi.org/10.12693/aphyspola.129.762.
2. Chang, Qiuxiang, Haojie Zhao, and Runqin He. 2019. "An Investigation on the Effect of Surface Treatment of Bamboo Fiber-Filled PMMA Composite." *Journal of Thermoplastic Composite Materials*. https://doi.org/10.1177/0892705717743294.
3. Chen, Hong, Wenfu Zhang, Xuehua Wang, Hankun Wang, Yan Wu, Tuhua Zhong, and Benhua Fei. 2018. "Effect of Alkali Treatment on Wettability and Thermal Stability of Individual Bamboo Fibers." *Journal of Wood Science*. https://doi.org/10.1007/s10086-018-1713-0.
4. Imadi, Sameen Ruqia, Isra Mahmood, and Alvina Gul Kazi. 2014. "Bamboo Fiber Processing, Properties, and Applications." *Biomass and Bioenergy*. https://doi.org/10.1007/978-3-319-07641-6_2.
5. Jawaid, Mohammad, Sanjay Mavinkere Rangappa, and Suchart Siengchin. 2020. *Bamboo Fiber Composites: Processing, Properties and Applications*. Springer Nature.
6. Khalil, H. P. S. Abdul, H. P. Abdul Khalil, Hazwan C. Che Mohamad, A. R. Khairunnisa, F. A. T. Owolabi, M. Asniza, Samsul Rizal, M. R. Nurul Fazita, and M. T. Paridah. 2018. "Development and Characterization of Bamboo Fiber Reinforced Biopolymer Films." *Materials Research Express*. https://doi.org/10.1088/2053-1591/aad2a0.
7. Khan, G. M. Arifuzzaman, G. M. Arifuzzaman Khan, M. S. Alam Shams, Md R. Kabir, M. A. Gafur, M. Terano, and M. S. Alam. 2013. "Influence of Chemical Treatment on the Properties of Banana Stem Fiber and Banana Stem Fiber/coir Hybrid Fiber Reinforced Maleic Anhydride Grafted Polypropylene/low-Density Polyethylene Composites." *Journal of Applied Polymer Science*. https://doi.org/10.1002/app.38197.
8. Kumar, D., S. Gururaja, and I. S. Jawahir. 2020. "Machinability and Surface Integrity of Adhesively Bonded Ti/CFRP/Ti Hybrid Composite Laminates under Dry and Cryogenic Conditions." *Journal of Manufacturing Processes*. https://doi.org/10.1016/j.jmapro.2020.08.064.
9. Maleki, H. Rezghi, H. Rezghi Maleki, M. Hamedi, M. Kubouchi, and Y. Arao. 2019. "Experimental Investigation on Drilling of Natural Flax Fiber-Reinforced Composites." *Materials and Manufacturing Processes*. https://doi.org/10.1080/10426914.2018.1532584.
10. Pashmforoush, Farzad, Reza Farshbaf Zinati, and Davoud Maleki. 2020. "Investigation of Ultrasonic

Vibration on Thrust Force, Surface Integrity, and Geometrical Tolerances during Drilling of Natural Filler Reinforced Composites." *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*. https://doi.org/10.1177/0954406220920320.
11. Rajesh, M. Arun, M. Arun Rajesh, S. S. Bala Kumar, R. Ashok, and K. S. Vijay Sekar. 2021. "Experimental Investigations on the Drilling of Titanium Metal Matrix Composite." *IOP Conference Series: Materials Science and Engineering*. https://doi.org/10.1088/1757-899x/1128/1/012029.
12. Ramana, M. Venkata, M. Venkata Ramana, and Goutham Kumar. 2018. "Optimization of Material Removal Rate in Turning of AISI 321 Stainless Steel Using Taguchi Methodology." *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2017.12.074.
13. Rasheed, Masrat, Mohammad Jawaid, and Bisma Parveez. n.d. "Biodegradable Composites from Bamboo Fibers - Mechanical and Morphological Study." https://doi.org/10.21203/rs.3.rs-298057/v1.
14. Salih, Abeer Adel, Rozli Zulkifli, and Che Husna Azhari. 2020. "Tensile Properties and Microstructure of Single-Cellulosic Bamboo Fiber Strips after Alkali Treatment." *Fibers*. https://doi.org/10.3390/fib8050026.
15. Tan, Chye Lih, Azwan Iskandar Azmi, and Noorhafiza Muhammad. 2015. "Surface Roughness Analysis of Carbon/Glass Hybrid Polymer Composites in Drilling Process Based on Taguchi and Response Surface Methodology." *Advanced Materials Research*. https://doi.org/10.4028/www.scientific.net/amr.1119.622.
16. Wang, Dong, Tian Bai, Wanli Cheng, Can Xu, Ge Wang, Haitao Cheng, and Guangping Han. 2019. "Surface Modification of Bamboo Fibers to Enhance the Interfacial Adhesion of Epoxy Resin-Based Composites Prepared by Resin Transfer Molding." *Polymers* 11 (12). https://doi.org/10.3390/polym11122107.

TABLES AND FIGURES

Table 1 Represents the surface roughness of bamboo fibre reinforced aluminium composite with and without the addition of scenedesmus dimorphus filler.

Experiment No	0 wt. %	5 wt. %	10 wt. %
1	3.58	0.59	1.2
2	3.09	0.54	1.12
3	3.36	0.51	1.22
4	3.22	0.46	1.05
5	3.4	0.44	1.04
6	3.47	0.43	1.01
7	3.51	0.56	1.09
8	3.54	0.4	1.05
9	3.43	0.44	1.15
10	3.34	0.41	1.08
11	3.1	0.44	1.21
12	3.24	0.44	1.17
13	3.09	0.48	1.01
14	3.2	0.53	1.24

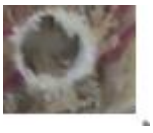
15	3.34	0.49	1.11
16	3.36	0.53	1.23
17	3.39	0.55	1.18
18	3.49	0.51	1
19	3.3	0.42	1.03
20	3.36	0.49	1.13

Table 2. Group statistics: The specimen fabricated with 5 wt.% of scenedesmus dimorphus filler has a lower surface roughness with a mean of 0.4830 and the standard deviation value is 0.05526 and for 10 wt.% of scenedesmus dimorphus filler the mean value is 1.1160 and the standard deviation 0.08055.

	N	Mean	Std. Deviation	Std. Error
0	20	3.3405	.14681	.03283
5	20	.4830	.05526	.01236
10	20	1.1160	.08055	.01801
Total	60	1.6465	1.23978	.16006

Table 3 Represents the anova of bamboo fibre reinforced aluminium composite with addition of scenedesmus dimorphus filler. A significant difference between the control and experimental group is observed. Significance value P=0.002 (P<0.05) and df value is 2, 57 & 59.

ANOVA					
Surface_Roughness					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	85.301	2	42.65	451.356	0.002
Within Groups	5.386	57	0.094		
Total	90.687	59			

Sample Number	0 wt. % of filer	5 wt. % of filler	10 wt. % of filler
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

12			
13			
14			
15			
16			
17			
18			
19			
20			

Fig. 1. represents the holes made on 0, 5, 10 wt. % of scenedesmus dimorphus filled bamboo fibre reinforced aluminium composite

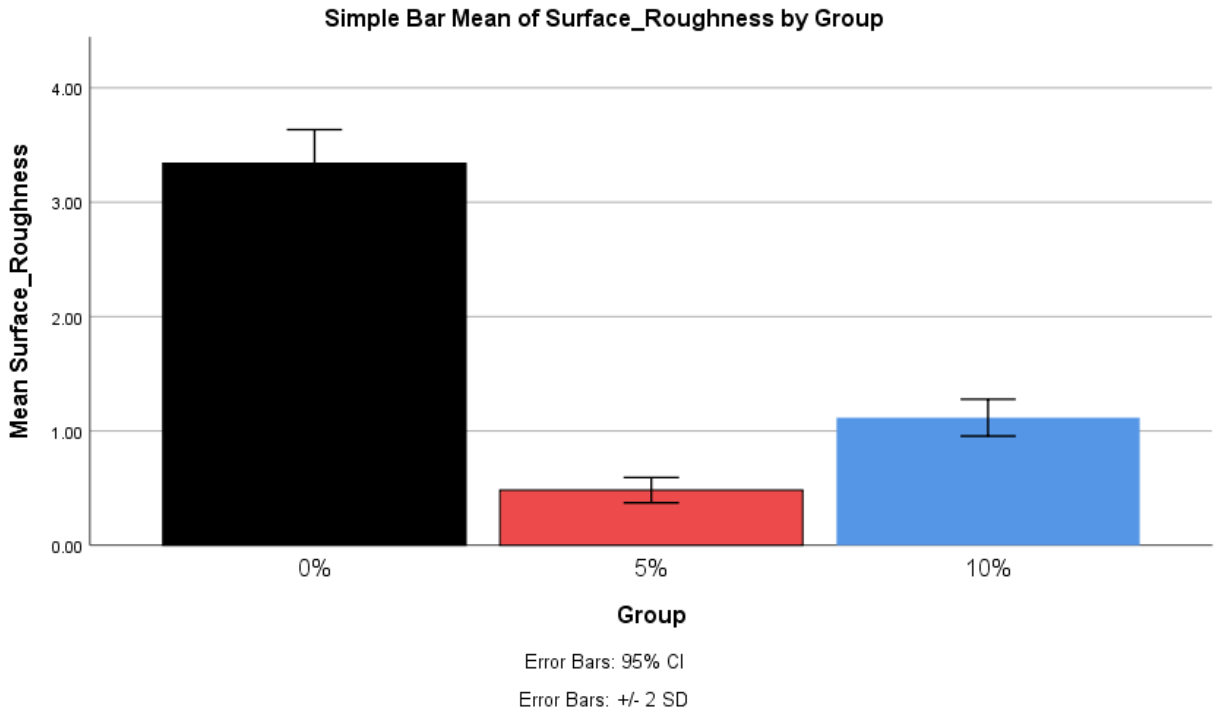


Fig. 2 shows the bar chart, representing the surface roughness of the bamboo fibre reinforced aluminium composite with and without filer. The addition of 5 wt% of scenedesmus dimorphus fillerin bamboo fibre reinforced aluminium composite surface roughness has a as compared with the 0 wt% of scenedesmus dimorphus filler in bamboo fibre reinforced aluminium composite and 10 wt% of scenedesmus dimorphus filler in bamboo fibre reinforced aluminium composite. Standard deviation of X -Axis : 5 wt. % of scenedesmus dimorphus filler vs 10 wt. % of scenedesmus dimorphus filler vs 0% of scenedesmus dimorphus filler. Y Axis : Mean accuracy of detection $\pm$ 1 SD.

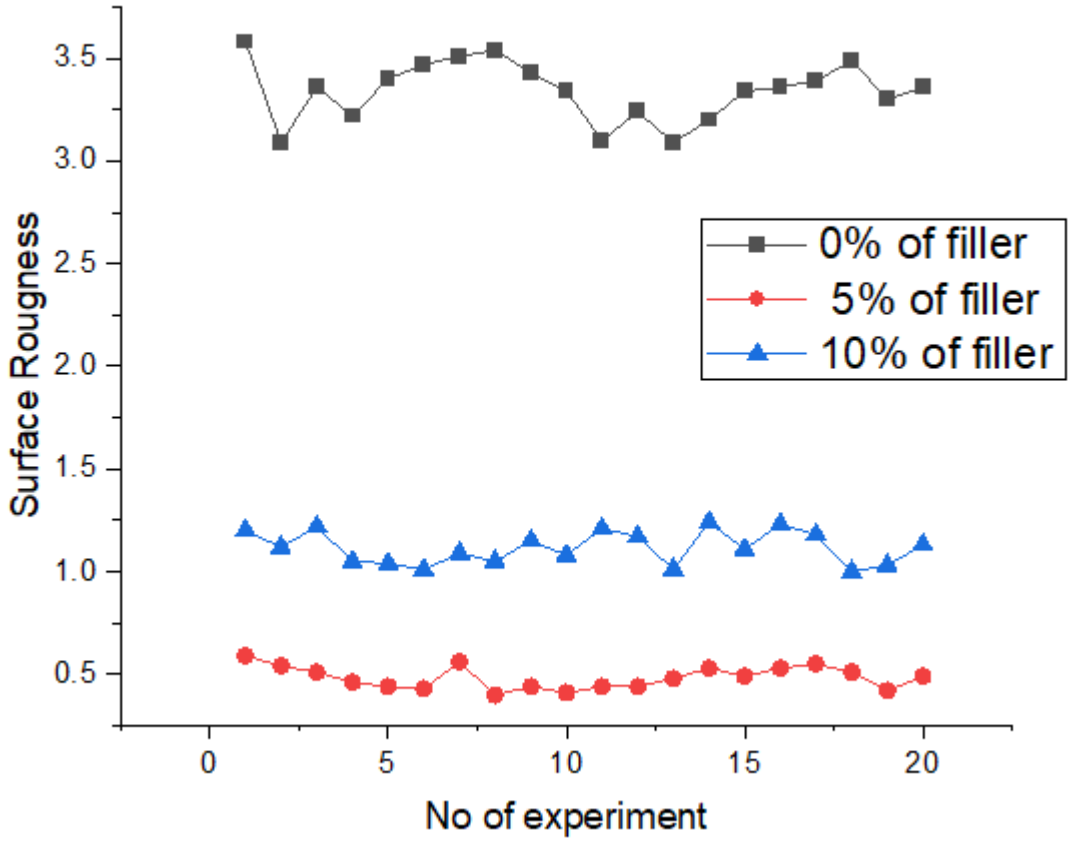


Fig.3 Comparison of surface roughness obtained in the bamboo fibre reinforced aluminium composite with and without scenedesmus dimorphus filler.