Using CNC drilling, compare the hole surface roughness between a special sandwich composite made of kenaf fibers and aluminum wire and a kenaf laminate with a ply orientation angle.

K.Bineshwar[1] G.Ramya Devi[2*]

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

[2*]Project Guide, Corresponding Author, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu, India, Pincode: 602105.

ABSTRACT

Aim: The purpose of present work is to correlate and examine the hole surface roughness in CNC drilling of novel kenaf fiber reinforced with aluminum wire mesh sandwich composite and kenaf fiber laminate with 45º/0º/45º ply orientation angle. **Materials and Methods:** Experiment was conducted for two groups, Group1 specimen is prepared by using unidirectional kenaf fiber reinforced with aluminum wire mesh grade AA6092 (kenaf + aluminum + kenaf + aluminum + kenaf). In specimen preparation for the control group will be done using unidirectional kenaf fiber in different angles without reinforcement of aluminum wire mesh. Kenaf (45^0/0º/45º/0º/45º). The type of drill used for drilling operation Tungsten carbide drill. The three input variables are drill speed (rpm), cutting rate (mm/rev), and drill dia (mm). Sample sizes for each group were 20 with pre-test power of 80%, beta=0.05%, and CL 95%. **Results:** An experimental investigation was done with 20 samples per group and surface roughness was measured for both the work sample and analyzed. The results acquired in T-independent statistical analyses in SPSS software was 0.040 ($P<0.050$). **Conclusion:** Within the limitations of this study, the kenaf fiber laminate with (45º/0º/45º) ply orientation angle reinforced samples without aluminium wire mesh composite laminate exhibits surface roughness of 2.6663 μm and the samples with aluminium wire mesh composite exhibits surface roughness of 1.7428μm with an improvement of 34.6% in reducing surface roughness.

Keywords: Novel Kenaf Fiber, Aluminum Wire Mesh, Surface Roughness, SPSS Software, Epoxy, Hardener

INTRODUCTION

The research purpose is to compare and examine the surface roughness of Novel kenaf fiber samples reinforced with AA 6092 wire mesh and without wire mesh in the CNC drilling operation using Tungsten Carbide coated drill (Majid, Jamal, and Manan 2018). The composite production has enhanced the machining of their materials based on their properties for manufacturing . The large number of composite manufactures are moved to kenaf fiber reinforced composites (KFRC) because of its soft nature and wear produced by tool is also less when compared to other polymer materials The kenaf fibers is one most used fibers in the automotive industry and also used in construction works and for packaging glass materials .

About 6780 articles were published in Google Scholar and 7650 were published in Sciencedirect for the past few years. (Suhaily et al. 2018) has made research by conducting the epoxy used for the polymer matrix preparation because of its less hazardous nature and ease for handling. The milling operation was conducted on the natural fiber composites for identifying its surface roughness using a tungsten carbide drill. (Venkategowda et al. 2021) has done an investigation on kenaf fiber cellulose for identifying its mechanical properties in the slotting machine and obtaining a lower surface finish by comparing it with plain epoxy coated natural fiber. It was investigated that kenaf fiber has better surface finish when drilled with carbide coated drill and found the better wear resistance and temperature produced in drill . The author also found that machining at high drilling speed and cutting rate will produce better surface finish It was investigated that the micro friction effects between the cutting tool and composite material in fiber by using the numerical modeling and experiments and (Mohd Izwan et al. 2021) was also considered as the best study for this research.Previously our team has a rich experience in working on various research projects across multiple disciplines(Balusamy et al. 2020; Arvind and Jain 2021; Zhao et al. 2020; Hani et al. 2020)

The fibre metal composites investigated in this research are novel and their machining characteristics has not been reported in the literature so far. The drilling parameters impact on the output responses of these laminates are unanswered in the survey. The expertise in this research is theoretical and experimental knowledge on fabricating composite laminates. The objective of this work is about to correlate and analyze hole surface roughness of the kenaf fibre reinforced with aluminum wire mesh AA6092 in between kenaf in between the kenaf layer as (kenaf aluminum + kenaf + aluminum + kenaf) by drilling the 20 number of holes on the composite using tungsten carbide drill.

The novel composites proposed in this research are new and its machinability investigation has not been reported in the literature so far. The machinability by drilling holes on proposed composite and investigation on surface roughness of holes produced on such laminates are also limited. The research is about to compare and analysis of hole surface roughness of the kenaf fibre reinforced with aluminum wire mesh AA6092 sandwich laminate as (kenaf + aluminum + kenaf + aluminum + kenaf) by drilling the 20 number of holes on the composite using tungsten carbide drill.

MATERIALS AND METHODS

The machining and drilling process is administered at Saveetha Industries, Saveetha school of Engineering (SSE), Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai. Unidirectional kenaf fiber hand stitched by fiber region, Chennai, India. For forming the composite epoxy LY-556 and hardener LH-556 which is used in 10:1 ratio which is collected from Hayavel aerospace india pvt ltd, Chennai, India. The G power of 80% was used for this investigation and the standard deviation of 0.34056 and the mean value of 2.666 (Loganathan et al. 2021).

For Group 1 sample preparation, the composite material reinforced with aluminum wire mesh is the hand layup method. Dimension of composite is 150 × 150 and the density of the composite is 5mm. Polished wax is applied over the mold to remove the sample after fabrication with ease. Fabricating one sample, (80%) of epoxy is used in (40%) of kenaf fiber and aluminum wire mesh. After fabrication, appropriate weights are placed on top of the setup and kept undisturbed for 24 hours for its curing time for good bonding strength.

For Group 2 sample preparation, the same procedure is repeated. In this group, aluminum wire mesh is not used. Only orientation angle of the unidirectional kenaf fiber is changed ply by ply ($45^o/0^o/45^o$) and the curing time takes up to 24 hours.

Drilling was performed on the samples under the distinctive machining conditions, for example, feed rate (mm/min) and speed (rpm). All the samples are drilled for analyzing the surface roughness of the drill hole. The tungsten carbide of 8 mm diameter was utilized to drill the holes using a CNC vertical machining centre as shown in Fig. 3. The surface roughness measurement was carried out using the roughness testing machine (mitutoyo) shown in Fig. 4 to compare the experimental and control groups in order to determine which group has the best surface quality.

Standard of machining process of the material is done as per the ASTM standards. To measure the surface roughness of the composite material drilling operation is performed. To show the variation on the machining parameters like feed rate (mm/min) and speed rate (rpm) so that we can show a variety of values in surface roughness of drilled holes. Coated tungsten carbide drill bit of 8mm diameter is used in drilling the holes in reinforced composite material.

STATISTICAL ANALYSIS

The statistical analysis SPSS V26 was used to calculate the standard deviation, standard error,mean. Also with the probability value of $P<0.005$ was recorded as the significance value, In this project work, the independent variables are speed, drill diameter, feed rate and the dependent variable is surface roughness (μm). SPS tool T-test was used to investigate the significance of with and without aluminum wire mesh in kenaf fiber reinforced composites (Juliana et al. 2018).

RESULT

The CNC drilling on group 1 (kenaf fiber reinforced composite laminate) and group 2 (kenaf fiber reinforced with aluminum wire mesh composite laminate) are drilled with the considerations of speed, feed rate, and drill diameter respectively. The obtained mean values for kenaf fiber samples reinforced with Aluminum mesh and samples without Aluminum mesh was 2.6663 μm and 1.7428 μm. The corresponding surface roughness values of group 1 and group 2 is shown in Table 1. The group statistics from the independent t-test analysis has been shown in Table 2. Levene's test for equality for variances was 0.040 ($P<0.050$) has been shown in Table 3 respectively. The group 1 sample (kenaf fiber reinforced composite laminate) after CNC drilling and surface roughness has been shown in Fig. 1. The group 2 sample (kenaf fiber reinforced with aluminum wire mesh composite laminate) after CNC drilling and surface roughness has been shown in Fig. 2 respectively.The graph for comparing means of group 1 and group 2 samples' observations is shown in Fig. 5.

DISCUSSIONS

The average mean of the surface roughness of the kenaf fiber is obtained up to 1.7428 µm on plain kenaf composite. The 2.6663 µm was found in kenaf fiber with aluminum mesh. The results show that the kenaf fiber with aluminum mesh has lower surface roughness as compared to plain kenaf fiber composite.

The drilling of kenaf fiber with aluminum mesh with epoxy to produce low friction exterior surfaces, the best surface roughness depends on cutting speed and feed rate (Suhaily et al. 2018). The drilling of kenaf fiber with plastic composite with carbide drill has surface roughness of 0.60µm then without plastic composite (Majid, Jamal, and Manan 2018). Stating that the statistical investigation has revealed that machining parameters have a significant impact on variance in machined surface finish and force produced while cutting (Leksycki et al. 2020). The surface roughness was revealed toa minimum by employing the aluminum mesh with 55% value fraction of kenaf fiber with drill tool of 8mm at spindle speed of 150 and feed rate of 2.5 (Sathishkumar, Ramakrishnan, and Navaneethakrishnan 2021). The chemical treatment can be improved by drilling (Ibrahim et al. 2021).

The limitations of this study is the delamination during the machining, and the present of voids and cracks in the delaminated zone. Hence as the future scope, the alternate fabrication process such as compression molding method can be adopted to avoid formation of voids, cracks and blow holes between the inter laminar layers and also improve bonding strength and prevent delamination.

CONCLUSION

Within the limitation of this study, the Carbide tool was used for machining of Novel kenaf fiber reinforced composite with addition of AA 6092 mesh has produced a mean surface roughness of 2.6663 µm and the Novel kenaf fiber samples reinforced composite without addition of AA 6092 mesh has produced mean surface roughness of 1.7428 µm. By considering the Independent T test in SPSS software the mean significance value of Novel kenaf fiber samples drilled using Carbide drill is 0.040 ($P<0.050$). This research concludes that the kenaf fiber samples reinforced with AA 6092 mesh have lesser surface roughness than the kenaf fiber samples reinforced without AA 6092 mesh with an improvement of 34.6% in reducing surface roughness.

DECLARATION

Conflict of Interest

The authors declare no conflicts of interest.

Author's Contribution

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

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TABLES AND FIGURES

Table 1. Value of Surface Roughness

Exp. No.	**Surface Roughness, Ra**	
	Kenaf fiber reinforced composite laminate	**Kenaf fiber reinforced with aluminum wire mesh composite laminate**
1	2.250	1.684
2	2.432	1.692
3	2.206	1.732
4	2.561	1.662
5	2.346	1.462
6	2.120	1.102
7	2.491	1.892
8	2.516	1.997
9	2.594	1.562
10	2.614	1.012
11	2.759	1.632
12	2.795	1.419
13	2.883	1.656
14	2.901	1.294
15	2.964	1.558
16	3.081	2.782
17	3.162	2.878
18	3.318	2.355
19	3.128	2.108

20	3.253	1.936

Table 2. GroupStatistics from the Independent T-test Analysis

T-TEST				
Group statistics				
Surface roughness	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Without Al	20	2.6663	.34056	.08027
With Al	20	1.7428	.50055	.11798

Table 3. Levene's test for equality for variances

Independent samples test									
	Levene's test for equality for variances		**t**	**df**	**Sig. (2-tailed)**	**T-test for equality of means**		**95% confidence interval of the difference**	
	F	**Sig.**				**Mean difference**	**Std. Error Difference**	**Lower**	**Upper**
Equal variances assumed	0.641	0.040	6.471	34	.000	.92344	.14270	.63344	1.21345
Equal variances not assumed			6.471	29.961	.000	.92344	.14270	.63200	1.21489

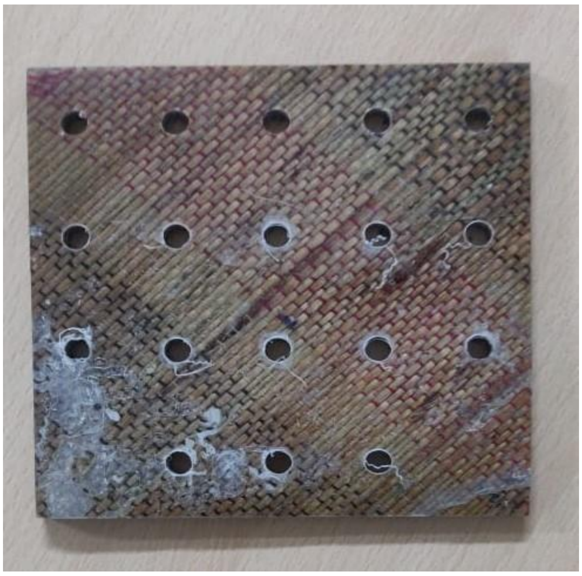

Fig. 1. Group 1(kenaf fiber with aluminum mesh)

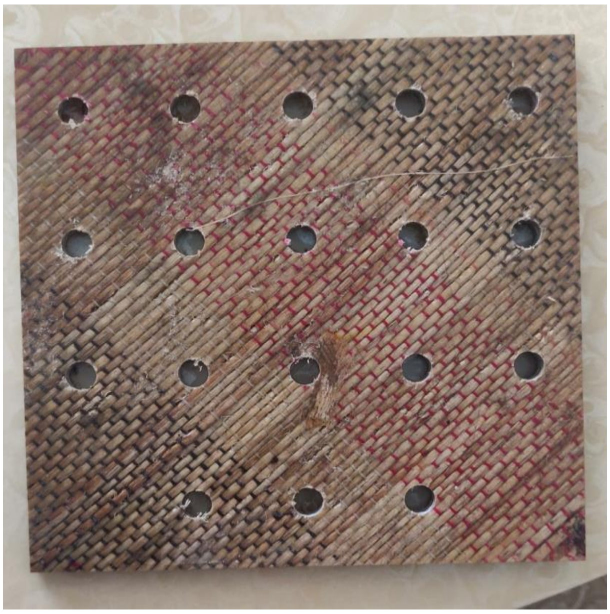

Fig. 2. Group 2 (kenaf fiber without aluminum mesh)

Fig. 3. Vertical CNC machine


Fig. 4. Surface roughness testing machine

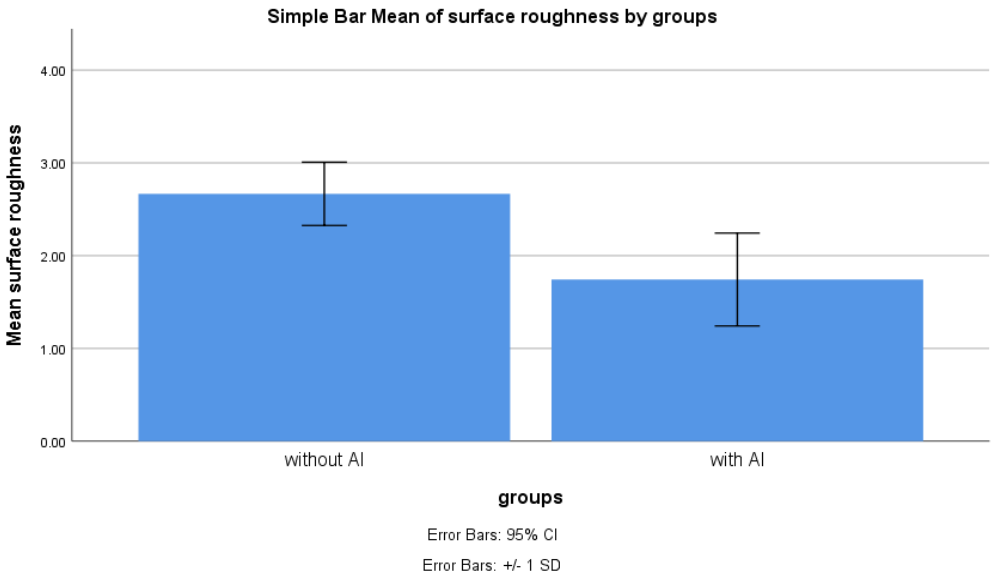

Fig. 5. The above Bar chart shows the comparison between the mean surface roughness of Novel kenaf fiber samples reinforced with AA 6092 mesh and Novel kenaf fiber samples reinforced without AA 6092 mesh. X-axis: Mean surface roughness of Novel kenaf fiber without AA 6092 mesh vs Novel kenaf fiber with AA 6092 mesh. Y-axis: Mean of groups ± 1SD and error bars of 95% CI.