Original Article

Comparative Analysis of Delamination Factor in CNC Drilling of Novel Kenaf Fiber Reinforced Aluminum Wire Mesh Sandwich Composite and Kenaf Fiber Laminate with 45º/0º/45º Ply Orientation Angle

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Abstract

Aim: This research is to compare and analyze the delamination factor 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. **Material and Methods:** During the drilling of kenaf fiber reinforced composite, Delamination is a severe problem. The goal of this research is to determine the effect of cycle boundaries on delamination during penetration of (50%) kenaf fiber and (80%) epoxy supported aluminum wire mesh. The kenaf fiber reinforced composite was made using the hand layup process (kenaf+aluminum+kenaf+aluminum+kenaf). A tungsten carbide drilling device with an 8mm diameter was used to drill the manufactured sample. Feed rate (mm/rev), Speed rate (rpm) and drill bit diameter (mm) are the process characteristics that have been considered. The Celestron microcapture software was used to investigate the data collected by taking advantage of the various quantifiable metrics and graphs available. Sample sizes for each group were 20 with pre-test power of 80%, beta=0.05%, and CL 95%. **Results:** An experimental scan with 20 samples per group is chosen and the delamination factor was scaled for both the working sample and the analysis. During this examination, CNC bores and delamination factors were determined. The results obtained for independent T test statistical analyses in SPSS software was 0.025 ($P<0.050$). **Conclusion:** Within the limitations of this study, the analysis of Kenaf fiber laminate with (45º/0º/45º) ply orientation angle has produced a delamination factor of of 1.38949 for the samples reinforced with Aluminium mesh and the mean delamination factor of 1.65830 for samples reinforced without Aluminium mesh with an improvement of 16.2% in reducing delamination factor comparing base materials.

Keywords: Novel Kenaf Fiber, Aluminum Wire Mesh, Delamination Factor, Epoxy, Hardner, CNC Drilling.

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INTRODUCTION

This study compares and analyzes the delamination factor in CNC drilling of an unique kenaf fiber reinforced aluminum wire mesh sandwich composite and kenaf fiber laminate with 45º/45º/45º ply orientation angle (Thakur 2014). Because of their convenience and strength, kenaf fiber supported by aluminum wire mesh has a wide range of uses in our daily lives (Musa, Rozyanty, and Zhafer 2018). To reduce the need of modified filaments, ordinary strands are used. Regular fiber composite is extremely strong and less dense than traditional materials (Juliana et al. 2018). They have a higher weight-to-solidify ratio than designed kenaf fiber reinforced composites. Fiber composite is now used in a variety of industries, including automobiles, marine, aviation, and construction (Kumar, Madhan Kumar, and Jayakumar 2018). Drilling is one of the most important typical fiber composite machining operations. It is critical to identify the optimum penetration boundaries in order to cultivate a more modest sum delamination. In order to achieve high quality, advancing cycle boundaries is critical in the machining system. The kenaf fibers is one most used fibers in the automotive industry and also used in construction works and for packaging glass materials (Reddy and Dhoria 2018).

About 501 articles were published in Google scholar and 256 articles were published in Science Direct from the past 5 years. The identification of delamination and surface roughness in natural fiber using TiCN coated drill in CNC drilling machines (Suriani et al. 2021). Optimization of kenaf fiber with titanium coated insert for detection of delamination factor by drilling in tradu=itional drilling machine (Günay 2018). The identification of delamination factor in sisal fiber by varying its parameters and using the TiN coated tool for 40 samples in CNC drilling machine (Khan et al. 2020). The identification of material removal rate, surface roughness and delamination factor in natural fiber reinforced with epoxy and polymer using HSS tool in CNC turning machine (Paulo Davim 2017). The experimentation on woven Kenaf fiber reinforced with epoxy composite in drilling for obtaining the delamination factor using the carbide drills under the influence of Box Behnken experimental design (Suhaily et al. 2018). Above all the best research paper is ((Paulo Davim 2017).Our team has extensive knowledge and research experience that has translate into high quality publications(Bhansali et al. 2021; Jayanth et al. 2021; Sudhakar, Ravel, and Perumal 2021; Sathiyamoorthi et al. 2021; Deepanraj et al. 2021; Raju et al. 2021; Arun Prakash et al. 2020; Kamath et al. 2020; Shanmugam et al. 2021; Rajasekaran et al. 2020; Adhinarayanan et al. 2020; Rajesh et al. 2020; Aurtherson et al. 2021)

The novel natural fiber composites proposed in this study are new and its machinability investigation has not been reported in the literature so far. The machinability by drilling holes on proposed composite and holes surface roughness study did not address an unanswered question. The expertise in this research is theoretical and experimental knowledge on fabricating composite laminates.The aim of this research is about to compare and analysis of hole surface roughness of the mounded kenaf 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.

Material And Methods

The machining and the drilling process is administered at Saveetha Industries, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Thandalam, Chennai.There are 2 groups and sample size was calculated with use of mean 2.53 and 1.15 and SD of 0.1204 .Control groups are done using unidirectional Novel kenaf fiber in different angles without reinforcement of aluminum wire mesh (kenaf ($45^o/0^o/45^o/0^o/45^o$). As no human samples involved no ethical approval required. The G power 80% and alpha 0.05 set for calculating sample size (20 samples per group and 40 samples Total) (Khan et al. 2020).

For Group 1 sample preparation, In this trial, Three layers of unidirectional kenaf fiber mat were cut into (150 X 150) and two layers of aluminum wire mesh were cut into (150 X 150) and ordered sequentially, with a sandwich composite thickness of 5mm. A layer of polished wax is put on the mold to make it easier to remove the sample fabrication. The aluminum wire mesh was placed in the center, with both kenaf strands placed on the top and bottom, creating a sandwich-like structure with fiber directions of (kenaf+aluminum+kenaf+aluminum+kenaf). The hand lay-up method was employed to construct the kenaf fiber reinforced composite, which included (80%) epoxy, (40%) unidirectional kenaf fiber, and (40%) aluminum wire mesh.

For Group 2 sample preparation, In this experiment five layers of unidirectional kenaf fiber mat were cutted into (150 X 150) without aluminum wire mesh. Only the orientation angle ($45^o/0^o/45^o/0^o/45^o$) of the kenaf fiber is changed. The same procedure is followed for the fabrication of group 2 samples. Weights are placed on top of the setup and cured for 24 hours.

Testing setup to execute the damage quality of drilled surface was determined by placing the analyzed sample beneath the Celestron microcapture 2000 stereo microscope to detect the induced entry surface delamination, After the image has been captured, the software's tool measurements function is used to perform the measurement. For both the maximum and nominal diameters, a circle was formed using the draw tool in Dewinter material plus 2000 stereo microscope software. Equation was used to obtain the delamination factor from Dmax and D'Value. For comparing the delamination extent produced area to nominal area of the drill size is used as a n index. The n index is used to compare the extent of delamination caused by the drills.

The hand lay-up procedure was employed to create the novel kenaf fiber composite laminate having orientation angle of 0^o and 45^o. The composite laminate has a 5mm thickness. The parameters used in this study are drilling speed, feed rate, drill bit diameter to measure delamination factor. The equation (1) is used to determine the delamination factor of the composite laminate.

$$F_d = D_{max} / D_0 \quad (1)$$

Where, F_d = Delamination Factor

D_{max} = Maximum diameter of the hole at delaminated zone in mm

D_0 = Nominal diameter in mm

Statistical Analysis

Independent sample T-test was used to analyze the significance of with and without inclusion of aluminum wire mesh in kenaf fiber reinforced polymer composites. The statistical analysis SPSS V.26 was used to calculate the standard deviation, standard error, mean. In this experiment the independent variables are spindle speed, drill bit diameter, feed rate and the dependent variable is delamination factor (Rajamanickam et al. 2019).

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 done with the concerns of speed, feed rate, and drill diameter respectively. The corresponding Delamination factor values of group 1 and group 2 are given in Table 1. The Levene's test for equality of variances was given in Table 3 respectively. The group 1 sample (kenaf fiber reinforced composite laminate) was shown in Fig. 1. The group statistics of the delamination factor was shown in Table 2. The group 2 sample (kenaf fiber reinforced with aluminum wire mesh composite laminate) after CNC drilling and Delamination factor was presented in Fig. 2 respectively. The microscopic image for samples for identifying the Delamination factor was shown in Fig. 3. The graph for evaluating group 1 and group 2 samples has been proven in Fig. 4 respectively.

Discussion

The average mean of the delamination factor of kenaf fiber samples with Aluminum mesh is 1.3895 and the delamination factor of Kenaf fiber samples without Aluminum mesh is 1.65830 was found in the kenaf fiber with aluminum mesh. The result shows that the kenaf fiber with aluminum mesh has lower delamination factor as comprising to plain kenaf fiber composite.

The kenaf fiber is the most used fiber in automobile industries for manufacturing vehicle parts . This study determines the delamination factor obtained for Kenaf fiber and its errors. The TiN coated drill was used for drilling the Kenaf fiber reinforced with epoxy (Rajamanickam et al. 2019). The delamination factor of 1.024 was during the machining of Kenaf fiber with TiN coated drill in the CNC drilling center (Venkatasudhahar and Velu 2019). The drilling parameters of speed 1000 rpm and feed rate of 2 mm/min were used for obtaining a better finish during machining (Taib, Ariawan, and Ishak 2014). The delamination factor must be lower, for obtaining a good material (Faruk and Sain 2014). when The ANOVA (analysis of variance) was used for identifying the statistical test for Kenaf fiber (Khalina and Mohd Nurazzi 2018).

The limitation of this study is the formation of built in edges during drilling of kenaf fiber around the periphery of the drilled hole. Hence, the study can be focussed in the future to reduce the built-in edges. The investigation can further be elaborated to analyze process parameters in drilling a variety of natural fiber based sandwich metal laminates is considered to be future scope of present investigations.

Conclusion

Within the limitations of this study, using the carbide drill, the machining of Novel kenaf fiber composite reinforced samples with AA 6092 mesh has produced a mean delamination factor of 1.38949 and the novel kenaf fiber composite reinforced samples without AA 6092 mesh produced a mean Delamination factor of 1.65830. By considering the Independent T test in SPSS software the mean significance value of Novel kenaf fiber samples drilled using Carbide drill is 0.025 ($P<0.050$). This research concludes that the kenaf fiber samples reinforced without AA 6092 mesh have caused higher delamination than the kenaf fiber samples reinforced with AA 6092 mesh.

DECLARATIONS:

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 GRD was involved in conceptualization, data validation and critical review of the manuscript.

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TABLES AND FIGURES

Table 1. Delamination Factor for both experimental and control group

Trial No.	Delamination Factor	
	Kenaf fiber reinforced composite laminate	**Kenaf fiber reinforced with aluminum wire mesh composite laminate**
1	1.3099	1.7548
2	1.2549	1.6475
3	1.4568	1.0187
4	1.5256	1.7549
5	1.3108	1.9975
6	1.5314	1.9548
7	1.9552	1.6974
8	1.1814	1.8945

9	1.1567	1.6547
10	1.7548	1.8432
11	0.9102	1.4587
12	1.0198	1.3789
13	1.6849	1.5678
14	1.5432	1.2547
15	0.9821	1.6547
16	1.8794	1.3789
17	0.9213	1.7854
18	1.3257	1.6287
19	1.4987	1.9657
20	1.5871	1.8745

Table 2: The group statistics from the independent T-test analysis

T-TEST				
Group statistics				
Delamination factor	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Without Al	20	1.65830	.256255	.057300
With Al	20	1.38949	.306278	.068486

Table 3: The Levene's test for equality for variances has been shown

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 difference**	
	F	**Sig.**				**Mean difference**	**Std. Error Difference**	**Lower**	**Upper**

Equal variances assumed	1.282	0.025	3.010	38	.005	.268805	.089295	.089295	.449574
Equal variances not assumed	-	-	3.010	36.853	.005	.268805	.089295	.089295	.449759

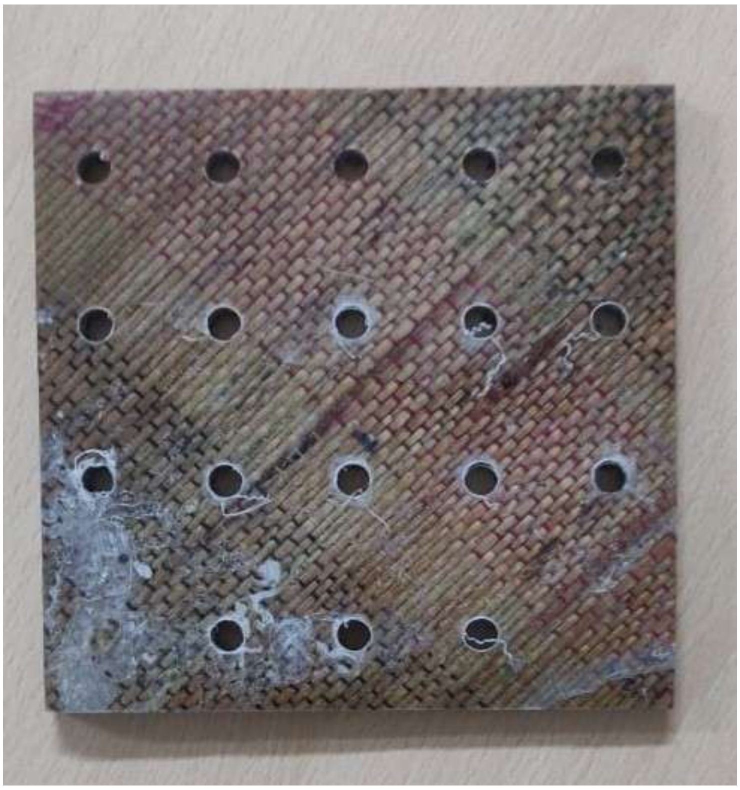

Fig. 1. Group 1(kenaf fiber with aluminum mesh)

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

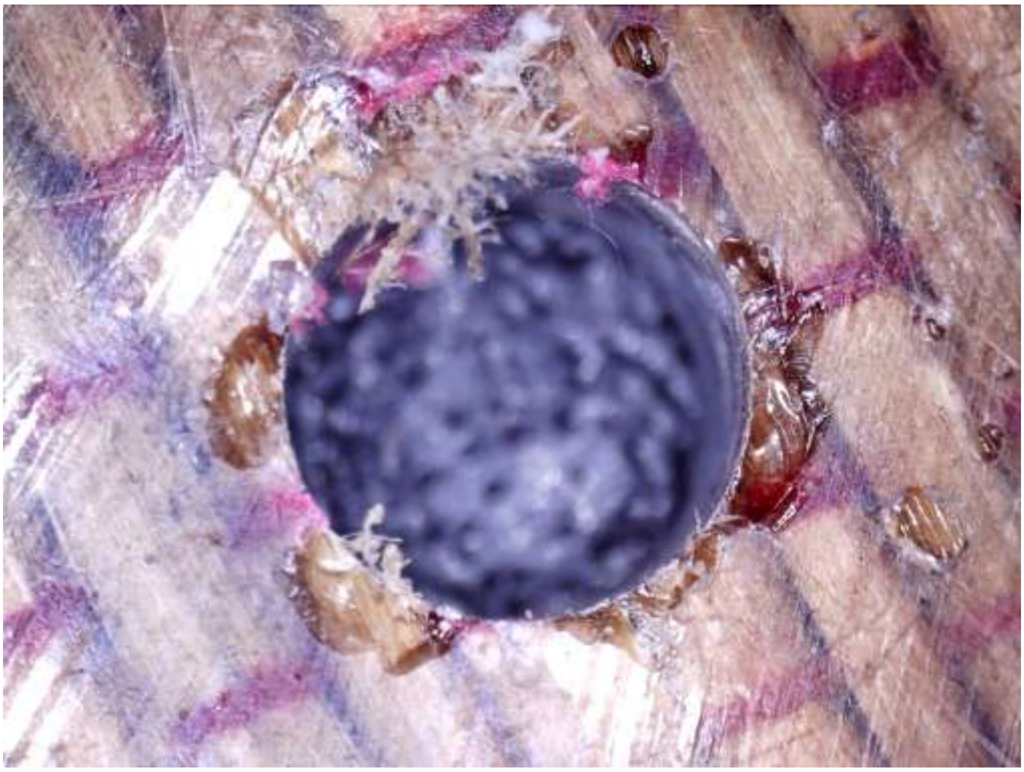

Fig. 3. Microscopic image of delamination factor.

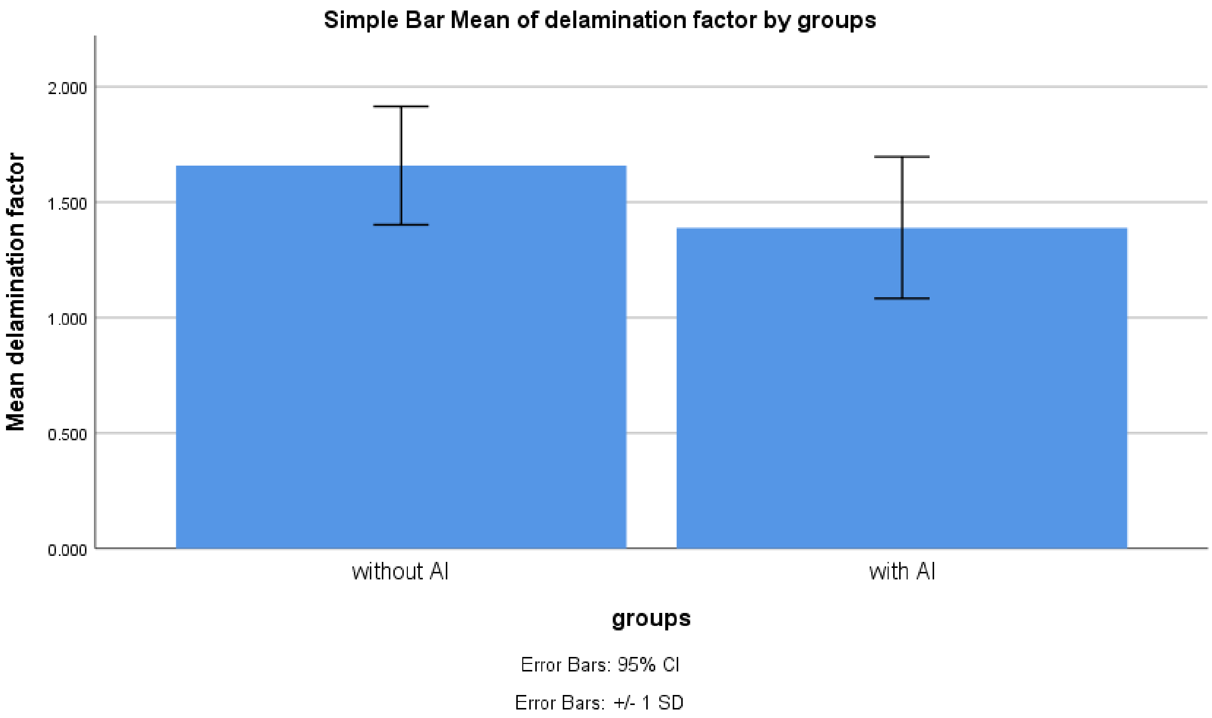

Fig. 4. The Bar chart shows the comparison between the mean delamination factor for Novel kenaf fiber of (45º/0º/45º) ply orientation angle samples reinforced with AA 6092 mesh and Novel kenaf fiber samples reinforced without AA 6092 mesh drilled using Carbide drill. The obtained mean values show that the samples of Novel kenaf fiber without AA 6092 mesh have higher delamination factor than the samples of Novel kenaf fiber with AA 6092 mesh. X-axis: Mean delamination factor of Novel kenaf fiber without AA 6092 mesh vs Novel kenaf fiber with AA 6092 mesh. Y-axis: Mean of groups ± 1 SD and error bars of 95% CI.