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PREPARATION, PROPERTIES AND MACHINABILITY STUDY OF LUFFA FIBER - GROUNDNUT SHELL REINFORCED EPOXY COMPOSITE

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Abstract

The need for eco-friendly materials and non-polluting processing techniques has made natural fibre reinforced polymer composites as potential candidates to replace GFRPs and CFRPs in semi structural applications. Ground nut shell and luffa fibre are easily available in the market at low cost. Polymer composites consisting of 30%, and 40% volume fractions of a hybrid reinforcement containing groundnut shell and luffa fibre in epoxy resin were fabricated by hand lay-up technique with varying process parameters, The variation in the mechanical properties such as Tensile, Compressive, Flexure and Impact strength are studied. The optimum mechanical properties were obtained in 40% of fiber volume fraction of treated fiber composites The machinability study was performed by drilling experiments using a drilling machine with drill tool dynamometer. Two input parameters, cutting speed and feed rate and the one output parameter, thrust force, were used for the drilling process. TiAlN coated solid carbide and HSS drills were employed in the drilling experiments and a comparative study was made based on the output parameters. Solid carbide resulted in lower thrust force values and feed rate proved to be the most influential parameter on thrust force.

Keywords: Natural fibre, hand layup, mechanical properties, thrust force, feed rate, open hole, solid carbide tool, drilling.

INTRODUCTION

Environmental awareness programmers induced researchers to design materials which are more compatible to the environment. The natural fibers such as sisal, coir, jute, ramie, pineapple leaf, and kenaf are as enough potential to replace the glass or other traditional reinforcement materials. These fibers are abundant, cheap and renewable. Thiruchitrambalam et al., investigated effect of alkali and sodium Lauryl Sulfate treatment on natural fiber composite consisted of Banana and Kenaf hybrid composites. Fibers were treated with 10% of sodium hydroxide (NaOH) and 10% Sodium Lauryl Sulfate (SLS) for 30 minutes. The fiber content in the composite is kept constant at 40 %. The variables in the mechanical properties and morphological changes were studied. Raju et al., investigated mechanical properties fabricated polymer composite reinforced with various percentage of groundnut

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shell particles. It is reported that as 40% fiber composite shows a maximum tensile strength was 28.09 MPa. The impact test results showed that steady increase in impact strength up to 50% weight of filler addition. Moisture content of ground net shell composite varies from 1.92 to 4.96% and water absorption was only in the range of 1.51–8.82% for 15 days. Onuegbu et al., reported that pulverized ground nut husk has improved the tensile strength, modulus, flexural strength and impact strength of the polymer composites and these properties as increased by increasing filler contents and decreasing in mechanical properties by increasing filler particle size. This result indicated that the critical size selection of filler particle size.

Marissa et al., experimentally showed that mechanical properties of the composite were function of luffa fiber preparation methods. A mechanical property of the luffa fiber reinforced with unsaturated polyester is an anisotropic material because of the luffa is controlled by the 3D network of fibers. Martinez-Lopez et al., prepared a polymer concrete with reinforced luffa fibers in order to enhance the compressive and flexural strength. Polymer concrete was prepared with 70% of silicious sand, 30% of polyester resin and various fiber concentrations (0.3, 0.6 and 0.9 volume %). The results showed a decrease in mechanical properties as increased in fiber content.

Drilling is the most frequently employed operation in machining of fiber reinforced material owing to the need for joining structures. Presently very small piece knowledge acquired by the researcher on the interaction between the drilling tool and the material by changing types and size of drills, need an in-depth investigation. Naveen et al., investigated the effects of the drilling parameters such as speed and feed on the damage factor in drilling composites of the glass, hemp & sandwich fibers with different fiber volume fractions (10%, 20% & 30%) in the polymer composite. They conducted drilling experiments by varying the three speeds, four feeds and three volume fractions.

Hussein m ali et al., used statistical approach to understand the effects of the control parameters on the drilling and milling machining parameters for hole making process of the woven laminated GFRP material. The results showed that milling process is more suitable for a large hole making than the drilling at higher cutting speed and lower feed rate. Khashaba et al., investigated drilling on the composite by varying the machining parameters on peel-up and push-out delaminations. The results indicated that the increase of the fiber volume fraction increases the thrust force which in turn increases delamination. Dharan et al., showed that material removal mechanism in the epoxy based composites by mechanical cutting process is entirely based on fracture mechanics, unlike shearing in case of metals.

Ramesha et al., effect of drilling characteristics of sisal/GFRP hybrid composite were studied using a drill made of different materials. Solid carbide among the used tools established the best tool material by resulting lowest thrust force. Tsao., studied delamination factor (DF) of bamboo-polyester composite and DF observed to be lower when using a smaller diameter drills and low feed rate. Panneerdhass et al., chemically treated luffa fiber-ground nut fiber reinforced epoxy polymer composite relatively showed higher mechanical properties.

The objective of this paper is to minimize the damage factor of composite by selecting optimized fiber volume fractions and drilling parameters.

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EXPERIMENTAL PROCEDURE

Materials

The raw materials used for fabrication of composites were epoxy LY 556 resin along with hardener HY 951, Luffa fiber, and groundnut shell.

Fabrication Process

The ground nut shells were sieved to small pieces and fibre extracted fiber. These two natural fillers were subjected to alkaline treatment by immersing in NaOH for 12 hours and then washed away chemically deadsorbed particle by distilled water. This chemical treatment induced the fibre-matrix adhesion that can improve interface integrity. Then, hand layups of two separate composite samples each containing 30% and 40% of fiber volume fraction were made in a compression mould.

Mechanical characterization

Tensile and compressive property studied by preparing the composite sample according to ASTM D 3039/D 3039M standard using a Universal Testing Machine (Instron 3369).Test samples were prepared as per ASTM standard EN ISO 14125 (1998) for flexural property using a three-point bending. The standard charpy impact test was used to determine the impact strength.

Machining

A HSS twist drill of point angle 118 and diameter 5 mm, which is a commonly used inexpensive drill and a TiAlN coated solid carbide twist drill (CWC) point angle 140 and diameter 5 mm were employed for the drilling on the 5mm thickness composite plate. The composite plate was sandwiched between the front and back plates of the machining fixture. The high speed drilling tests were conducted on a range of spindle speed 900-2100 mm/rev. Machining tests were conducted under dry conditions and the cutting forces were recorded using a Kistler Quartz 3-Component dynamometer (type9257B).

Process parameters

The combinations of input process parameters cutting speed and feed rate were formulated and plan of experiments is shown in Table 1.

Table 1. Plan of experiment

R.No	Feed rate (mm/rev)	Spindle speed (RPM)
1	0.05	900
2	0.05	1500
3	0.05	2100
4	0.2	900

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5	0.2	1500
6	0.2	2100
7	0.35	900
8	0.35	1500
9	0.35	2100

RESULTS AND DISCUSSION

Mechanical Properties

The variation of tensile strength and compressive strength of the composite as function of fiber content is shown in Figure 1 and 2 respectively. Five specimens are tested for mechanical properties and average values were reported. The tensile strength is seen to vary from 14.56 MPa to 19.31 MPa . The tensile and compressive strength of 40% composite showed higher tensile strength compared to the 30% composite. The reason believed to be relatively more load transferred to the fiber as fiber fraction increased.

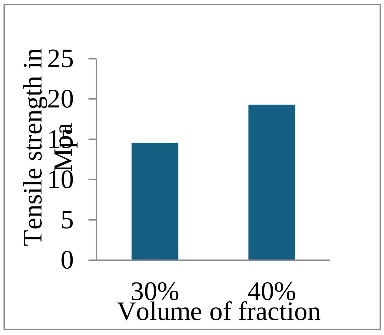

Figure.1. Tensile strength

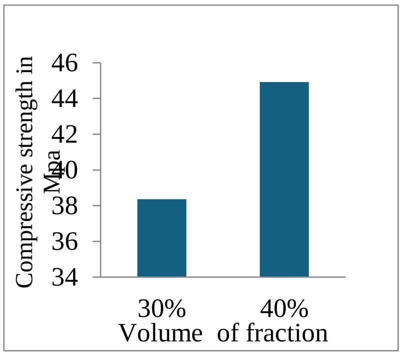

Figure.2. Compressive strength

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The flexural strength shows a reversible trend to the tensile and compressive strengths, as shown in Figure 3. It is observed that the groundnut shell reinforcement in this composite consist of discontinuous random pieces which paves way for non-uniform stress distribution and hence poor resistance to bending. This could be the reason for the decrease in flexural strength with increasing fibre volume percentage. The impact strength is low for both the samples. The results showed that 40% fiber content composite is fairly better than the 30% composite when compromise on the other mechanical properties. Hence the drilling operation was carried out only on the 40% composite plate.

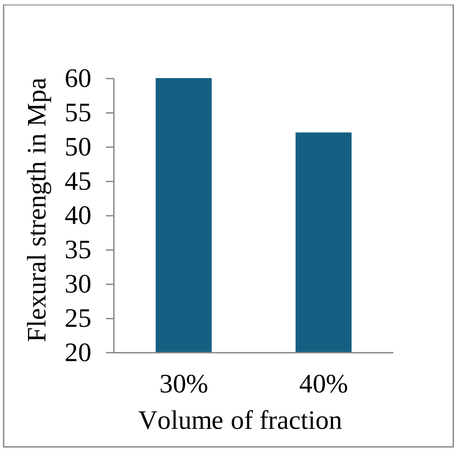

Figure.3. Flexural strength

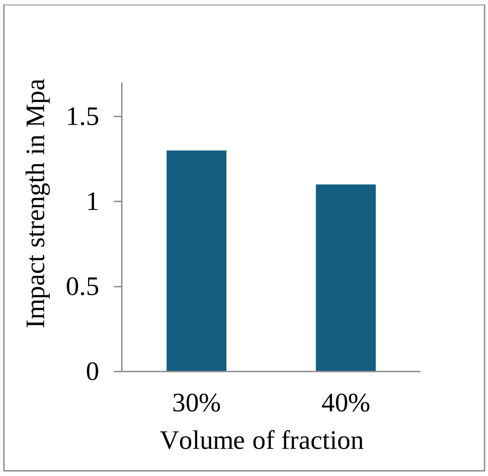

Figure.4. Impact strength

MACHINING PERFORMANCE

The thrust force was recorded using the drill tool dynamometer, as presented in Table 2. The drilled composite plate is shown in Figure 5.

Table 2. Thrust force values of the drilled composite

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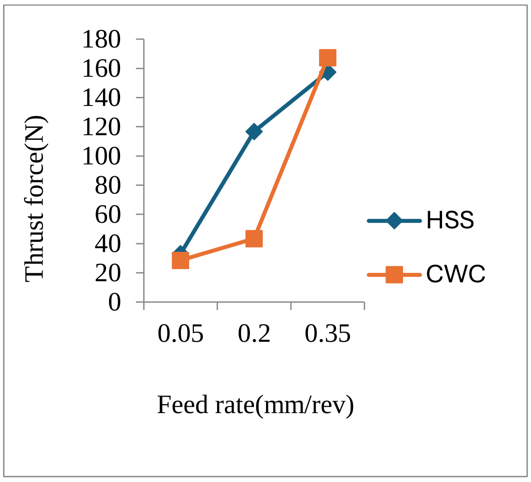
R.No	Feed rate (mm/rev)	Spindle speed (rpm)	Thrust force (N)	
			HSS	CWC
1	0.05	900	33.12	28.59
2	0.05	1500	34.98	24.28
3	0.05	2100	33.12	29.87
4	0.20	900	116.7	43.45
5	0.20	1500	104.1	68.34
6	0.20	2100	97.88	82.63
7	0.35	900	157.4	167.3
8	0.35	1500	155.01	140.3
9	0.35	2100	141.6	138.1

Figure.5. Drilled composite.



(a) At 900rpm

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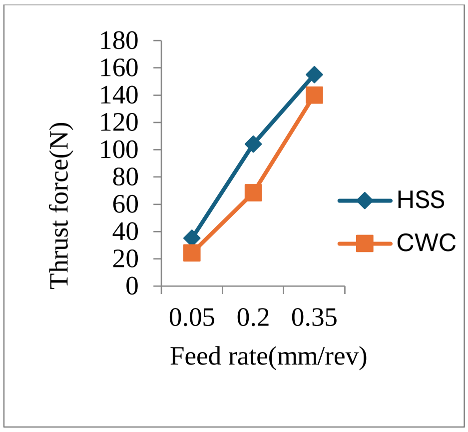
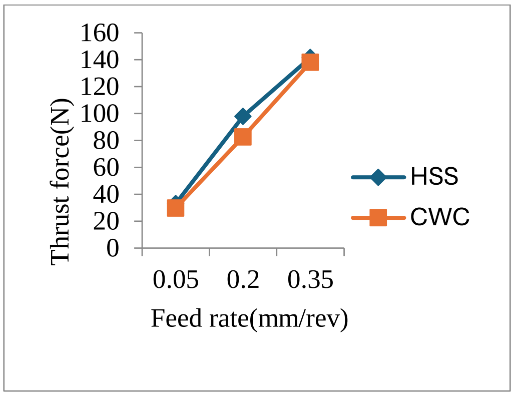
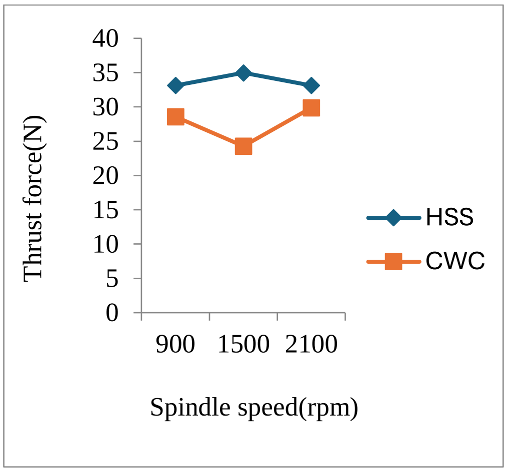


(b)At 1500rpm



(c) At 2100rpm

Figure.6. (a),(b),(c)-Thrust force vs feed rate



(d) At 0.05 mm/rev

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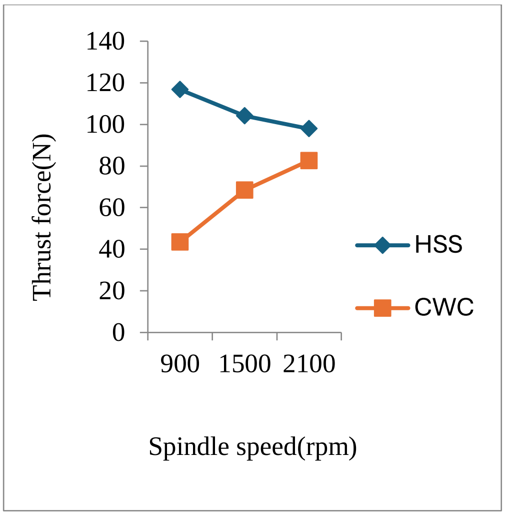
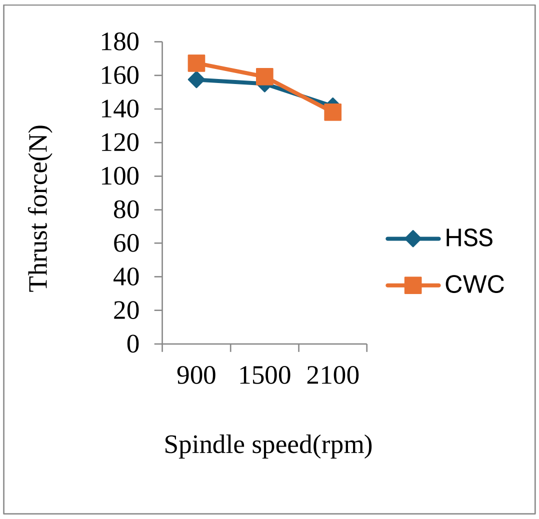


(e) At 0.20 mm/rev



(f) At 0.35 mm/rev

Figure.7. (d),(e),(f)-Thrust force vs spindle speed

From the graphs presented in Figure.6 and Figure 7, it is very clear that feed rate is the most influential parameter than spindle speed. In most of the cases, the CWC drill has resulted in lower thrust force. Exceptionally, the HSS drill has recorded thrust force values lower than the solid carbide drill for the highest feed and spindle speeds (Figure c and f). The TiAlN coated solid carbide drill tool seems to be the best for drilling at normal speeds and feeds. At the thrust force as function of time signals shown in Figure 8, a sudden increase in the thrust force are observed in a time close to 5 seconds. This trend is similar for all the input parameter combinations. The reason for this sudden increase could be the transition of the chisel edge of a layer of resin matrix to the reinforcement layer.

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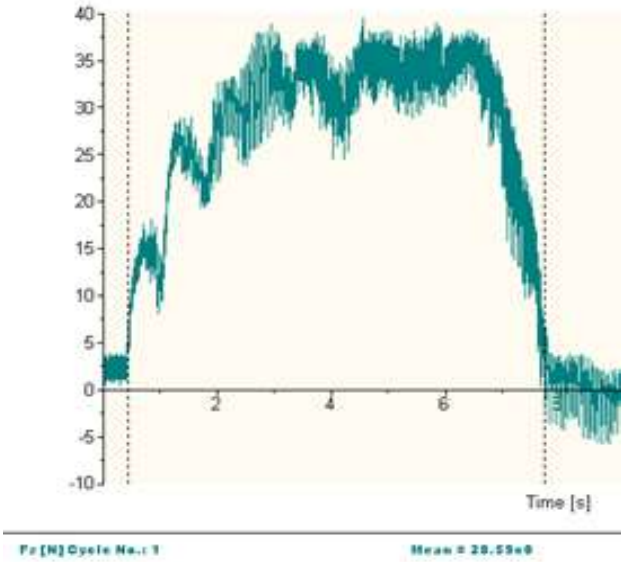

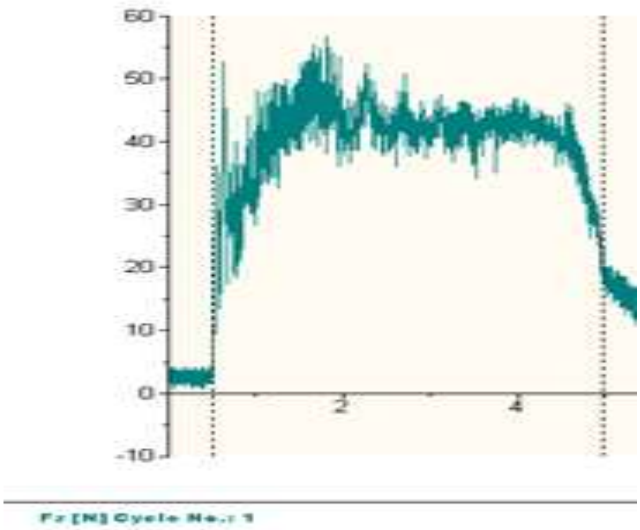

Figure.8. Thrust force(N) vs time(s)

(a-HSS drill, b-Solid carbide drill)

CONCLUSIONS

The hybrid natural fibre composites were fabricated and characterized successfully. The feasibility of drilling the composite by conventionally used twist drills such as HSS and solid carbide tool have been established. There are optimal drilling (with low thrust force values) at feed rates up to 0.35mm/rev.

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Feed rate has proved that most determined effect on the thrust force, than spindle speed. It is observed that solid carbide tool is relatively showed better performance over the HSS drill for machining natural fiber reinforced composite.

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