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INVESTIGATION OF PROPERTIES AND MACHINABILITY OF LUFFA WITH GROUNDNUT SHELL FIBER REINFORCED EPOXY POLYMER HYBRID COMPOSITES

Panneerdhass R*, Manikandan D, Sivasubramaniyan K, Jayakumar R
Professor* & Assistant Professor, Department of Mechanical Engineering, A.R Engineering College, Villupuram-605601, India.
Email: panneerdhass@gmail.com

ABSTRACT

This paper presents the study of the mechanical, thermal properties and water absorption characteristics of the luffa with ground nut fiber reinforced epoxy polymer composites. luffa with ground nut fiber reinforced epoxy resin matrix composites have been developed by hand lay-up technique with varying process parameters such as fiber condition (treated, untreated), chopped randomly oriented and different volume fraction (30%, 40% and 50%). Tensile strength various from 18 Mpa to 23.5 Mpa, compressive strength varies from 41.5 MPa to 56.2 MPa, flexural strength varies from 61.22 MPa to 73.6 MPa and impact energy varies from 1.1 Joules to 1.6 Joules, as a function of fiber volume fraction. Effects of central open hole on the tensile and impact strengths of the composites were studied by five sets of tensile specimens containing central open holes of five different diameters. The machinability study was performed by drilling experiments using a CNC 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. The optimum mechanical properties were obtained in 40% of fiber volume fraction of the treated fiber composite. The fracture surface of the composite shows that pull out and de bonding of fiber is occurred.

Keywords*:* luffa / ground nut fiber hybrid, mechanical and thermal properties, open hole,machinability, SEM.

1. INTRODUCTION

Synthetic fiber reinforced composites are being widely used in polymer composites because of their high stiffness and strength properties. The natural fibers such as jute, ramie, sisal, coir, pineapple leaf, and kenaf have the potential to be used as a replacement for glass or other traditional reinforcement materials in composites. These fibers are abundant, cheap and renewable. Martinez-Lopez et al., aims to study the Polymer Concrete were reinforced with Loofah fibers in order to improve the compressive and flexural strength. Polymer concrete specimens were prepared with, 30% of polyester resin, 70% of silicious sand and various fiber concentrations (0.3, 0.6 and 0.9 vol%). The results show decrease in the values of mechanical properties including compressive strength, flexural strength and compression modulus of elasticity [1]. Valcineide et al., studied the chemical treatments used on sponge gourd **(**Luffa cylindrica) fibers of Brazil to prepare their composites with polyester resin. Production of short fiber-polymer composite as well as mat-polyester composites is presented here. Characterization of the composites in respect of the evaluation of density, water absorption, thermal stability, tensile properties and impact strength were made and the results are discussed. Observed impact strength and tensile properties are discussed based on the fractographic studies of the composites [2]. Niharika Mohanta et al., Investigate the effect of stacking sequence of mechanical properties of untreated luffa cylindrica and glass fibre reinforced epoxy hybrid composites has been investigated experimentally. All the composites were made with a total of 4 plies, by varying the number and position of glass layers so as to obtain six different stacking sequences. One group of neat epoxy samples was also fabricated for comparison purpose. Samples were analyzed for their mechanical and flexural properties to establish the effect of various stacking sequence [3]. Cerchiara et al., aim of this study was to describe the chemical composition, morphology and tensile properties of Spanish Broom fibres in comparison with flax. The morphology of both fibres was established by optical microscopy (OM). The chemical composition and tensile properties of Spanish Broom fibres were determined according to conventional methods. The results show that Spanish Broom fibres have a higher cellulose content (91.7%) and better tensile properties than flax fibres [4]. Panneerdhass et al., effect of optimum mechanical properties were obtained at 40% of fiber volume fraction of treated fiber composites [5].

Valcineide, et al., studied the different chemical treatments were conducted on the fibers with aqueous solutions of NaOH 2%, or methacrylamide (1–3%) at distinct treatment times. Luffa was characterized via chemical analysis and analytic techniques such as FTIR, XPS/ESCA, X-Ray, TGA and SEM. Methacrylamide 3% treatment for all times (60, 120 or 180 min) severely damaged the fibers [6]. Srinivasan, et al., natural fiber is Luffa aegyptiaca Fibers are alkaline treated and dried out in sunlight. The various wt % of discontinued fibers are laminated with epoxy resin and the laminates are prepared by hand lay-up process. The Mechanical properties of natural fiber composites such as tensile, compressive, impact and flexural strength have founded and compared. Then, SiO2 nano particles synthesized in sol-gel method and they are induced with epoxy to improve the certain mechanical property of the composite material [7]. Nekkaa et al., investigate the effect of broom fiber incorporation and its surface treatment with stearic acid on the mechanical and rheological properties of polymeric composites based on polypropylene/broom fiber. The result obtained show that in the case of composites with untreated broom fiber, the highest tensile and impact properties are obtained for a content between 10 – 20 wt% [8].

Nadendla Srinivasababu et al., investigated the untreated and chemically treated fibre is reinforced into the polyester matrix and the composites are fabricated to test their mechanical and dielectric properties. The high tensile strength of 82.39 MPa, modulus of 1.05 GPa is obtained for broom grass CT – 1, CT – 2 fibres respectively [9]. Tharaknath et al., effect on the fabrication of polymer matrix composites by using natural fibres like coir, and luffa which is in abundant nature in desired shapes by the help of various structures of patterns and calculating its material characteristics by conducting tests like tensile test, flexural test, hardness test, water absorption test, impact test, density test, SEM analysis [10].

Thiruchitrambalam et al., effect of alkali and SLS (Sodium Lauryl Sulphate) treatment on Banana/Kenaf Hybrid composites and woven hybrid composites. The fibers are 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 variation in the Mechanical properties and morphological changes are studied [11]. Verma et al., effect of mechanical properties of layered bamboo–epoxy composite laminates including tensile strength, compressive strength, flexural strength and screw holding capability have been evaluated [12]. Panneerdhass et al., Effects of volume fraction on the Tensile, Compressive, Flexural, Impact strength were studied. SEM analysis on the composite materials was performed. Tensile strength varies from 10.35 MPa to 19.31 MPa, compressive strength varies from 26.66 MPa to 52.22 MPa, flexural strength varies from 35.75 MPa to 58.95 MPa and impact energy varies from 0.6 Joules to 1.3 Joules, as a function of fiber volume fraction [14]. Raju et al., prepared the composite with different weight % of randomly distributed ground nut shell in polymer matrix. The addition of the ground nut shell to the polymer composite results reduced thermal conductivity and increases the glass transition temperature of the composites [15].

Nikki Sgriccia et al., Experiments were conducted to study the microwave processing of epoxy adhesive joints and their results stated that curing of epoxies using microwaves reduces curing time and could improve the mechanical properties. Their results also highlighted the high bond strength exhibited by MW cured epoxies as compared to ambient cured ones [16]. Joseph et al., the dielectric properties of the materials involved should be considered before experimenting. Research carried out in the past reveals that in microwave processing of fibre reinforced epoxy composites, the heating of matrix takes place prior to the heating of fibres. This is mainly because, the dielectric loss factors of matrix resins are high compared to most of the fibres [17]. Luis Miguel et al., performed the damage assessment method using radiographic images compared and correlated with experiments such as bearing test and delamination onset test. The results explained the relative importance of drilling tools and machining parameters to extend the life cycle of these laminates [18]. Salleh et al., performed open hole tensile testing with centrally drilled holes on the long kenaf composites and long kenaf/woven glass reinforced polyester resin composites and reported that the tensile strength of composites decreased with increasing of open hole diameter and also estimated the damage area of the composites [19]. Panneerdhasss et al., Luffa cylindrica (LC) is a tropical plant belonging to the family of Cucurbitaceous. The fibre obtained from the dried fruit of this plant can be used as natural fiber reinforcement in the polymer composites. The fabrication procedure and mechanical properties of luffa fiber reinforced epoxy polymer composites were reported elsewhere [20].

Drilling is the most important machining operation performed in fibre reinforced composites for joining in assembly operations. At present, conventional drilling involves material removal from contact with a rotating metallic drill tool (mostly twist drill) is the widely used drilling process because of its simplicity and low cost involved. A lot of research on the drilling of fibre reinforced composites (FRPs) has been carried out in the past. Syed Azuan et al., investigated the effects of drilling parameter by drilling the holes on the coconut meat husks reinforced polyester composites and evaluate its hole quality by measuring delamination. Drilling process is carried out for three spindle speed (1500 rpm, 2000 rpm and 2500 rpm) and three feed rate (0.1 mm/rev, 0.2 mm/rev and 0.3 mm/rev) by using a carbide twist drill. The results indicate that by using the lower feed rate, it can obtain minimum delamination while effect of increasing spindle speed showed less influenced [21]. Dilli Babu et al., evaluating the cutting parameters (cutting velocity and feed rate) and the influence of the fibers under delamination factor (F d). The approach is based on a combination of Taguchi techniques and on the analysis of variance (ANOVA). An experimental plan was performed involving drilling with cutting parameters in Natural Fiber Reinforced Plastic (NFRP) using a cemented carbide drill. The results of NFRP composite delamination factor (Fd) were compared with Glass Fiber Reinforced Plastic (GFRP) composites [22].

Ramesha, et al., the drilling characteristics of sisal/GFRP hybrid composite were studied by employing drills made of different materials among which solid carbide proved to be the best tool material as it resulted in the lowest thrust force values [23]. Tsao et al., In an attempt to study the delamination characteristics of bamboo-polyester composite it was observed that low diameter of drills and low feeds resulted in low delamination and better hole quality [24]. Khashaba et al., influence of various parameters on peel-up and push-out delaminations was analysed. The results indicated that increase of the fiber volume fraction increases the thrust force which in turn leads to increase in delamination [25]. Dharan et al., study of the material removal mechanism established that the cutting process in epoxy composites is entirely based on fracture mechanics, unlike shearing in the case of metals [26]. Dilli Babu et al., study the drilling characteristics of natural fibre reinforced polymer composites. The effects of drilling parameters on delamination of hemp fiber reinforced composites were studied to find out conditions for minimum delamination using Taguchi and ANOVA methods [27].

The scarcity of literature on morphologically different natural reinforced composites directs us towards the development of luffa and luffa-ground nut shell–epoxy hybrid composite. In this work, epoxy based polymer composites were prepared with single luffa fiber and ground nut fibre as the reinforcing materials. The tensile, compressive, impact and flexural tests and thermal properties of ground nut and broom fibre reinforced epoxy composite, its efficiency in terms of energy and time, and thermal characteristics in comparison with those of conventionally cured composite and SEM analysis of fractured surfaces of the composite were performed. Machinability was evaluated by a study of drilling process parameters. Input parameters, cutting speed and feed rate and an output parameter thrust force were employed to study the drilling process. The tool and input parameter value, selection were done based on the literature stated above.

2. EXPERIMENTAL

2.1. Materials

The raw materials for manufacturing the composites are epoxy resin, luffa mat Fiber, Luffa single Fiber, Groundnut shell fiber, Hardener, and Mansion Wax. A room temperature-cured semi flexible epoxy resin as matrix LY556 and HY951 as hardener were used in the study. Luffa and groundnut shell fiber are randomly oriented in polymer matrix. Two sets of samples are to be prepared. One set without chemically treated fibers and a second set with alkali treated fibers. Luffa and groundnut shell fiber were alkali-treated in 2% NaOH solution for 30 min to remove any greasy material and hemi cellulose, and then dried at sun light. The single fiber was used in making the luffa and groundnut shell fiber epoxy composite.

2.2. Preparation of Materials

Luffa cylindrica (LC) is a tropical plant belonging to the family of Cucurbitaceous, with a fruit possessing netting like fibrous vascular system. Figure1 (a) shows the luffa cylindrica plant with fruit and dried luffa fruit with partial removed of outer layer respectively. Figure 1 (b) shows the sponge guard and the hollow micro channels. In this work LC fibers were cut to rectangular mat like after opening the outer core and the micro channel portion as shown in Figure 1(c) from the sponge guard neglecting the end portion to keep the thickness same for the mat and have been used for manufacturing the layered composite [3]. Raw luffa fibers were cut lengthwise and the middle part was removed. Finally the fiber was cut to 8mm to 22mm long segments as shown in figure 1(c).

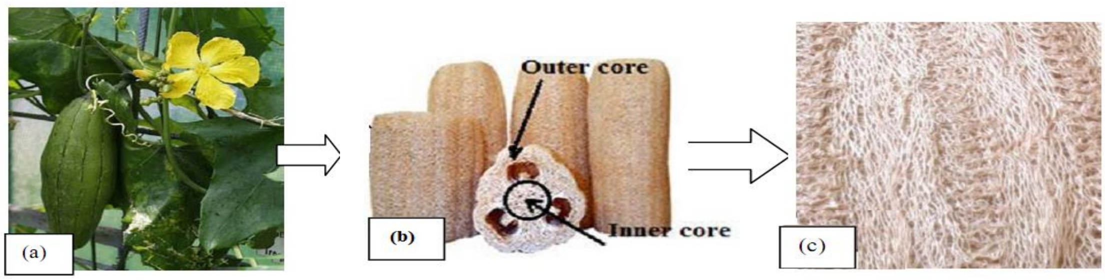

Figure 1. (a) The luffa cylindrica fruit (b)Sponge guard with hollow micro channels (c) The rectangular portion used for making composite.

Botanical name of the groundnut is Arachis hypogeal which belongs to Leguminosae family, as shown in fig 2(a) and 2(b). Groundnut shell is protecting cover of the pod is also known as a seed, former one having higher mechanical properties. The reported average length, thickness and density of the groundnut shell were 38 mm, 0.25 mm and 1.06 g/cm^3 respectively [15].

Figure 2. (a) Groundnut shell **(b) Groundnut shell fiber used for making composite.**

2.3. Volume fraction of fiber and Orientation of fibers

The composites were fabricated with 30%, 40% and 50% fiber and ground nut shell in the ratio of 1:1 as in volume fractions. The untreated and treated fibers were taken with required volume fractions laid in to the mould of same size 300 mm x 300 mm x 5 mm and care is taken to ensure that the fibers are pressed to form the size of the mould. Then the top mould is closed and bolts are tightened. Then the mould is transferred to a compression press and placed under pressure for about an hour such that it compresses and forms a thin laminate shape**.** Orientation is termed as the alignment of fiber in the mould along with the resin mix. This also defines the properties of composites to be fabricated. In this work, the discontinuous fiber mat has oriented in longitudinal axis and discontinuous single fiber materials are in random orientation.

3. PREPARATION OF THE SPECIMEN

3.1. Mould

A mould made up of GI (gauge 25) sheet of dimension 300x300x5 mm is prepared. Casting of the composite materials is done in this mould by hand lay-up process. Later the specimens are cut from the prepared casting according to the ASTM (D 638 M) Standard.

3.2. Weight fraction of the fiber

The weight of the matrix was calculated by multiplying density of the matrix and the volume (volume in the mould). Corresponding to the weight of the matrix the specified weight percentage of fibers is taken.

3.3. Specimen

Mixing the Epoxy resin CY-230 and the hardener HY-951 with a ratio of 10:1. This solution is used as matrix and the different types of natural fibers are used as reinforcements the types of composites manufactured are Luffa and groundnut shell - Epoxy CY-230. The natural fibers are used in varying weight percentages of 30%, 40% and 50%.

3.4. Open hole test

Drilling of holes was performed using a radial drilling machine. HSS twist drill with a point angle of 118º, a standard drill is used in this experiment. Considering the purpose of this work with the effects of stress concentration five different drill diameters 3mm, 5mm, 7mm, 9mm, 10mm were used. The composite was fixed on the machine table using an appropriate clamping device without sacrificial plates under the composite.

4. CHARACTERIZATIONS OF COMPOSITE MATERIALS

4.1. Determination of Water Absorption behavior of Composite

The water absorption characteristics of luffa and Groundnut shell fibre reinforced polymer composites were carried out. To measure water uptake capacity of composite, the specimens (5mm x 5mm) are prepared as per ASTM D-570 by immersion in distilled water at room temperature. From the difference of final and initial weights before and after immersion in water bath for 24 hours, the percentage of water uptake was calculated. In each test and type of composite, 5 specimens were tested and the average values were reported. The testing was carried out until the percentage of water uptake reach equilibrium [13].

4.2. Tensile and compressive test

The tensile tests were conducted according to ASTM D 3039-76 standard on a computerized Universal Testing Machine. The loading arrangement for the specimen and the photograph of the machine are used shown in fig.3. Ten rectangular specimens of each fiber content were cut from the manufactured composite laminates. The specimens with dimensions of length 250mm x 25mm x 5mm were used. Universal testing machine with a load cell of 30 kN was used with a crosshead speed 2 mm/min. In each case, 5 samples were used and the average values were reported as a result. The compressive strength is usually obtained experimentally by means of a compressive test by using UTM.

Fig. 3. UTM machine Sample loaded condition for tensile testing

Fig. 4. UTM machine Sample loaded condition for Flexural testing.

4.3. Flexural and Impact Test

Flexural test were conducted according to ASTM D790-03 to determine the flexural properties of the luffa with ground nut shell fiber composites. Universal testing machine was used to carry out a three-point bending tests, with a span of 60mm between supports and a cross head speed applied of 2mm/min. The loading arrangement for the specimen and the photograph of the machine are used shown in fig 4. Ten rectangular specimens of each fibre content were cut from the manufactured composite laminates. All the composite specimens were of rectangular shape having length 80mm x 15mm x 5mm. In each case, 5 samples were used and the average values were reported as a result. The flexural strength of the composites is determined.

$$\text{Flexural strength, } \sigma = 3PL/2bt^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The impact strength values were calculated by charpy impact test using specimens of dimension 75mm x 12mm x 5mm. A V-notch is provided having an included angle of 45° at the centre of the specimen, and at 90° to the sample axis [14].

4.4. Thermo gravimetric analysis (TGA)

TGA was used to determine the degradation temperatures of natural fibre composites. The decomposition characteristics of the composites were used to compare the extent of cure between the conventionally cured and microwave cured samples. All the samples were heated in a TA Instruments TGA to 600^0C at a heating rate of 10^0C/min in an N_2 atmosphere.

4.5. Scanning electron microscopy (SEM)

A scanning electron microscope (SEM) at 20 kV accelerating voltage was used to study the microstructure of the composite. The samples were coated with a thin film of gold to increase the electrical conductance for the analysis as shown in fig 5 and 6.

Fig. 5. Sample coating process

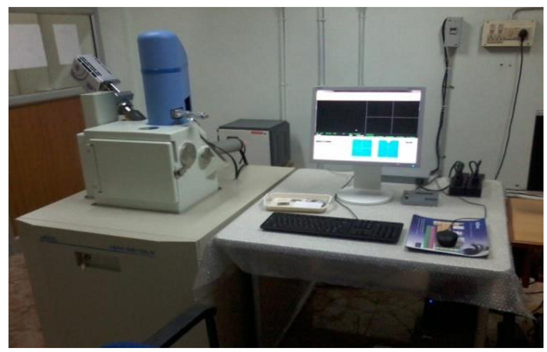

Fig. 6. Scanning electron microscope

4.6. Machining

Rectangular plates of these materials, measuring 5mm in thickness were prepared for drilling. An 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) of point angle 140 and diameter 5 mm were employed for the drilling operation. The laminate was sandwiched between the front and back plates of the machining fixture. The high speed drilling tests were conducted on a having spindle speed of 60-5000rpm and a maximum feed rate of 4000mm/min. Machining tests were conducted under dry conditions and the cutting forces were recorded using a Kistler Quartz 3-Component dynamometer (type9257B).

4.7. Process parameters

The combinations of input process parameters cutting speed and feed rate were formed. 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	0.05	2500
5	0.20	900
6	0.20	1500
7	0.20	2100
8	0.20	2500
9	0.35	900
10	0.35	1500
11	0.35	2100
12	0.35	2500

5. RESULTS AND DISCUSSION

5.1. Water Absorption behavior of Composite

Water absorption is one of the major concerns in using natural fiber composites in many applications. The water absorption in hybrid composites in 24 hours, maximum and minimum water uptake was shown in the fig 7. Water absorption after 10 hrs increases at the rate of 1% - 5.5% [14]. Saturation water absorption values and the diffusion coefficients calculated for water immersed specimens at room temperature. The results show that the diffusion coefficient and maximum water content values increase as the fiber content increases. Samples with higher fiber content have a greater diffusion coefficient, due to the fact that absorption of water is higher, as a result of a higher content of cellulose.

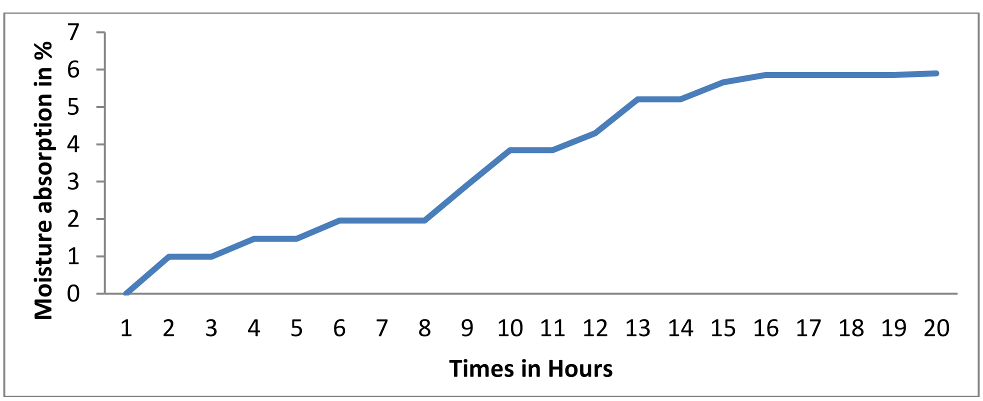

Fig.7. Water Absorption behavior of Luffa with ground nut fiber Composite

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5.2. Tensile and Flexural strength

Fiber content and fiber strength are influencing parameters for the strength related properties of the composite. Hence the strength variation with different volume fractions of fibre loading showed differently. This variation in tensile and flexural strength of the composites with 30%, 40% and 50% of fibre content are shown in fig 8 and 9 respectively. These figures clearly indicate the gradual increase in both tensile strength and flexural strength of 30% and 40% fibre content. However, there is a decrease in both tensile and flexural strength of the composite with 50% fibre content. Similar observations were reported by Thiruchitrambalam et al. When they experimented with banana/kenaf polyester hybrid composites [11].

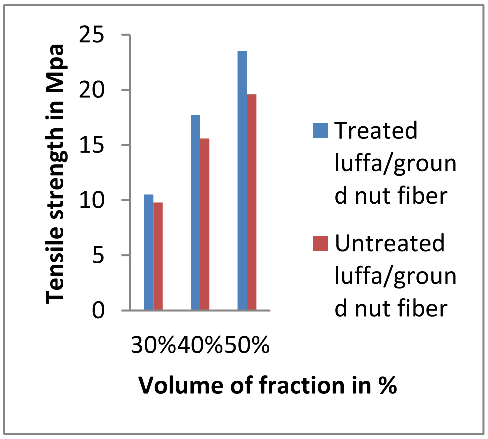

Fig.8.Tensile Strength

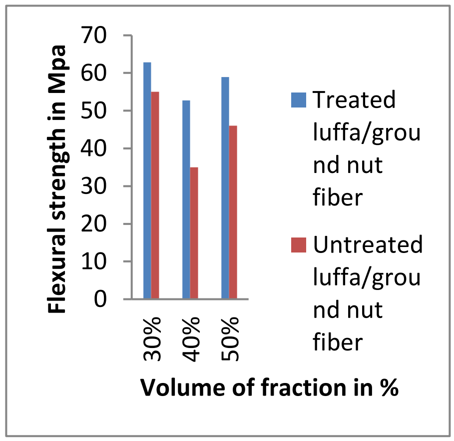

Fig.9. Flexural Strength

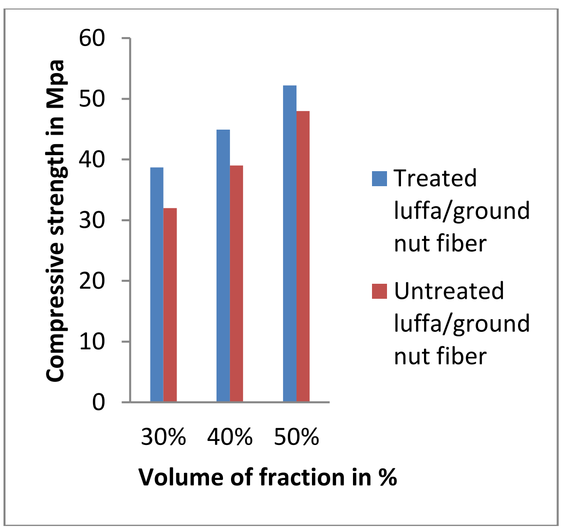

Fig.10.Compressive Strength

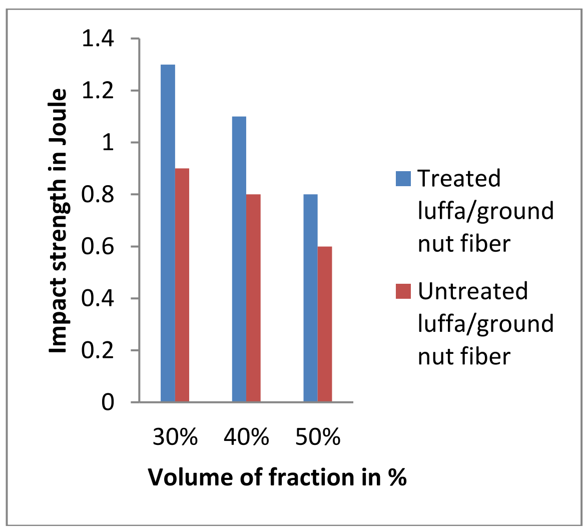

Fig.11. Impact Strength

5.3. Compressive strength

The variation of compressive strength with the fiber content on the alkali treated composites is shown in Fig 10. The luffa-ground nut fiber composite material was tested and the compressive strength was found. Five specimens are tested, with different fiber volume fractions and average compressive strength was reported. The compressive strength was increasing steadily up to 30% and beyond that the change was very marginal. The compressive strength of the luffa with ground nut fiber varies from 38.6 MPa to 64.95 MPa. Similar observations were reported by Thiruchitrambalam et al., when they experimented with banana/kenaf polyester hybrid composites [11].

5.4. Impact strength

The variation of and impact strength with the fibre content, in case of luffa with ground nut fiber composite are presented in Fig 11. In this case also, the ground nut fiber-luffa composites exhibited better impact properties. The impact strength increases with increasing volume fraction of fibres, reaching a maximum value of 30%. Beyond 30% the impact strength shows a decreasing trend. The maximum impact strength of the composites varies between 1.1 to 1.9 Joules. Alkali treated luffa and broom fibers showed improved impact strength. This result was in line with the findings of Verma et al., and Zahari et al., the researchers by whom characterization of bamboo and Ijuk Fiber composites was carried out [12,13].

5.5. Cure and Thermal characteristics

In this work, TGA was used to cure and thermal characterization. The thermal degradation characteristics can be used to confirm the presence of cured networks. The thermal degradation of cured epoxy-amine networks start roughly at 390^0C [28] and the MW cured luffa-epoxy sample, the matrix of which contains the same network started degrading at 388^0C, indicating the attainment of cure. A similar approach was adopted in the work done by Amanda L. Higginbotham et al [29].

Table.2. Thermal properties of the composites

Material	Initial Decomposition Temperature (°C)	Decomposition Temperature 50% weight loss (°C)	Final Decomposition Temp (°C)
Luffa/ground nut epoxy composite cured at room temp	363	468	600

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Volume 4 Issue 4 – www.ijrmmae.in – Pages 61-80

Microwave cured luffa / ground nut epoxy composite	388	468.5	600

In case of the conventionally (room temp) cured and MW cured composites, it is seen that the start of the decomposition of MW cured composite is prolonged. The delay in the decomposition start by 25^0C compared to the room temperature cured composite indicates the presence of higher crosslink density or improved cure and also higher thermal stability in the microwave cured sample. Therefore, it is evident that, as a result of volumetric heating, MW curing results in a better extent of cure shown in table.2. The initial degradation temperatures of both the conventionally and MW cured composites fall between the initial degradation temperature of neat epoxy (cured) and the luffa fibre. A similar trend was observed in the experiments carried out on curing of natural fibre composites by P.V. Joseph et al., [28].

5.6. Tensile Strength for open hole

It is well known that fiber content and fibre-matrix adhesion are mainly responsible for tensile properties of a fibre reinforced composite. The variation in the open hole tensile strength of the composites with 30% and 40% of volume fractions of fibres is shown in fig 12. The results show a decrease in open hole tensile strength value with an increase in hole diameter and the values corresponding to a hole diameter of 3mm are very close to the unnotched tensile strengths which are 19.2 MPa and 20.8 Mpa for samples with 30% and 40% fibre contents respectively.

Similar observations were reported by Z. Salleha et al., [30] in a study of two different types of reinforced plates, glass reinforced epoxy plate and Kenaf fiber reinforced epoxy plate.

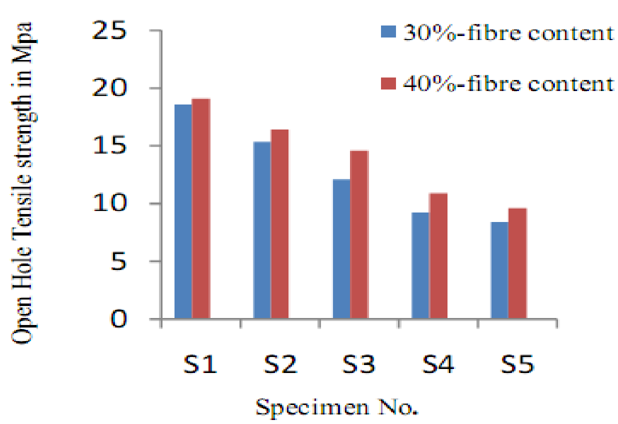

Fig. 12.Open hole tensile strength

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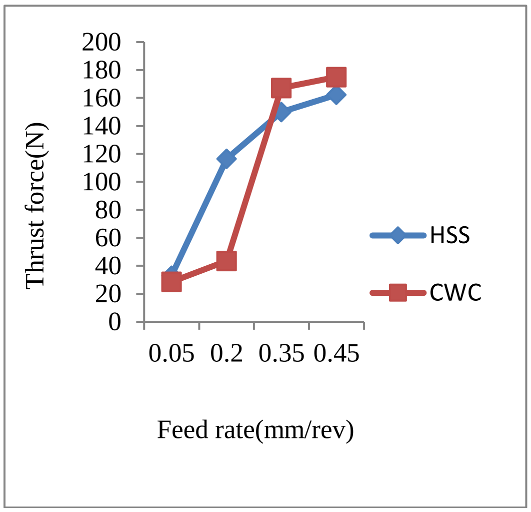
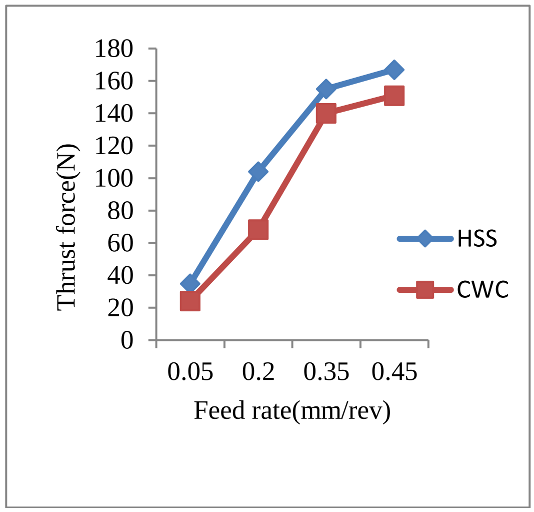
The theoretical open hole tensile strength values are close to the experimental values and the deviation increases with increasing hole diameter. Till 5mm diameter, very good similarity is present between the theoretical values and experimental values. Hole diameters exceeding 5mm are practically undesirable as the corresponding tensile strength values are very low.

5.7. Machining Performance

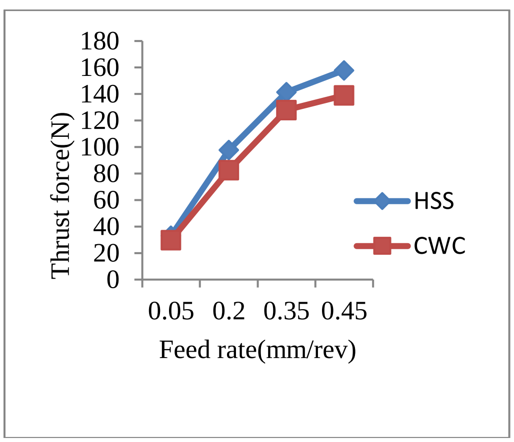
The thrust force was recorded using the drill tool dynamometer as shown in Fig. 13 and Fig.14.

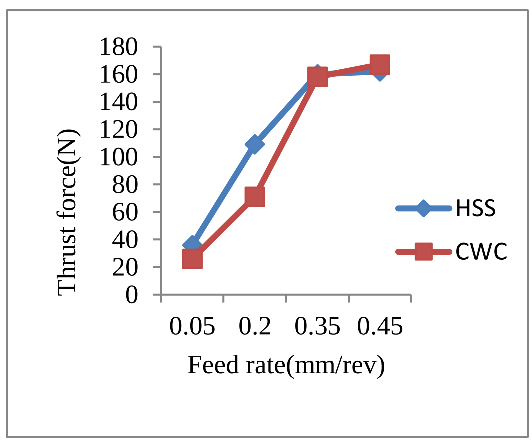




(a)At 900 rpm

(b)At 1500 rpm





(c)At 2100 rpm

(d) At 2500 rpm

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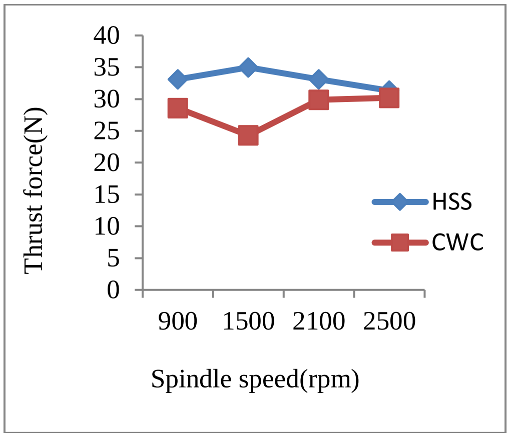
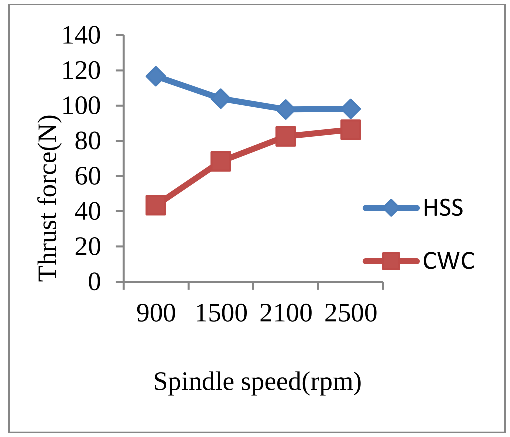
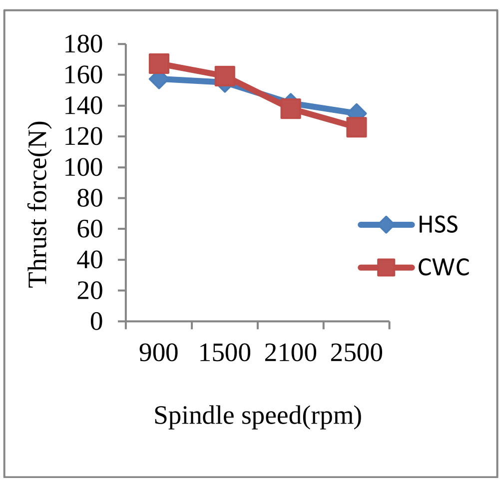
Fig.13. (a),(b),(c), (d) -Thrust force vs feed rate



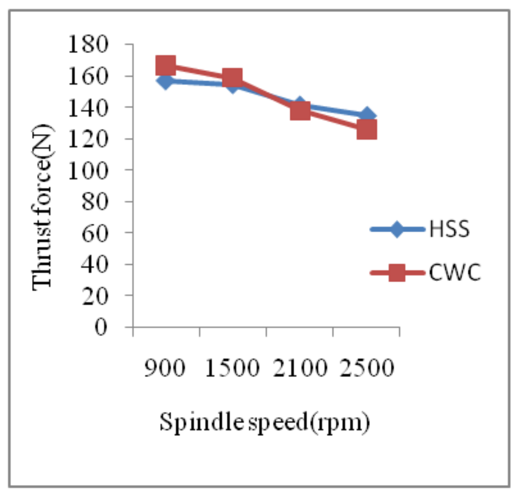
(e) At 0.05 mm/rev



(f) At 0.2 mm/rev



(g) At 0.35 mm/rev



(h) At 0.45 mm/rev

Fig. 14. (e),(f),(g),(h) -Thrust force vs spindle speed

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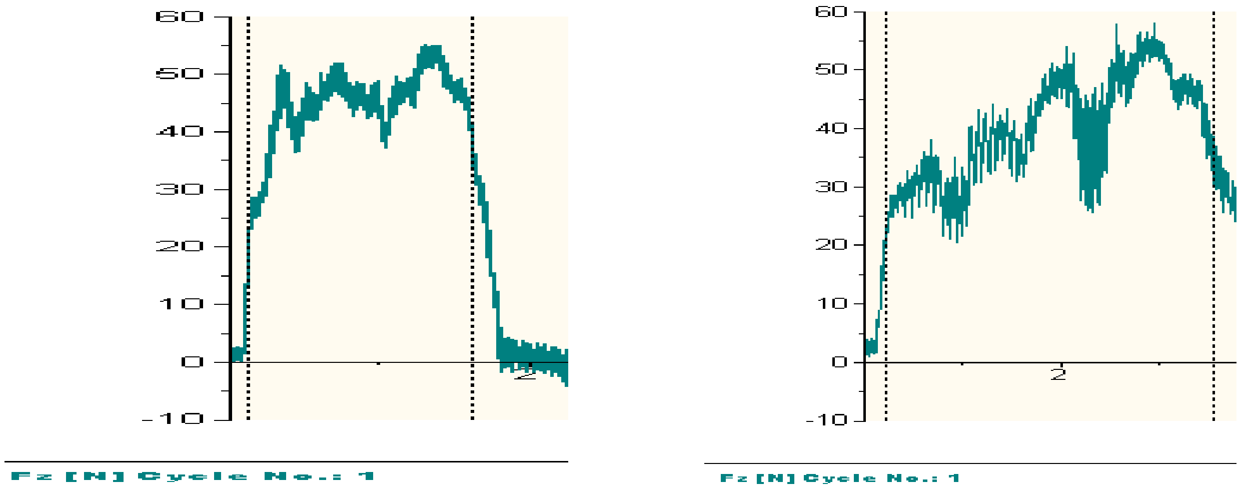

Fig.15. Thrust force(N) vs time(s)(a-HSS drill, b-Solid carbide drill)

From the graphs presented in Fig.13 and Fig.14, 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 (Fig d and h). 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 Fig.15, a sudden increase in the thrust force is 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.

5.8. Microscopy observations SEM

The analysis of the micrograph composites filled with untreated luffa with ground nut fiber air bubbles was observed in most samples which are formed due to the residual moisture in the luffa with ground nut fiber reinforced polymer composites. For the treated composites with alkali treated luffa with broom fiber reinforced polymer composites are presented in fig 16 shows a better adhesion between the two phases and a formation of a certain interface. These fractography were recorded at two different regions at x35 and x500 magnifications. From these micrographs, it is clearly evident that the surface of the fibers becomes rough after alkali treatment. As a result of improvement in fibre matrix adhesion, fibre pullout is reduced.

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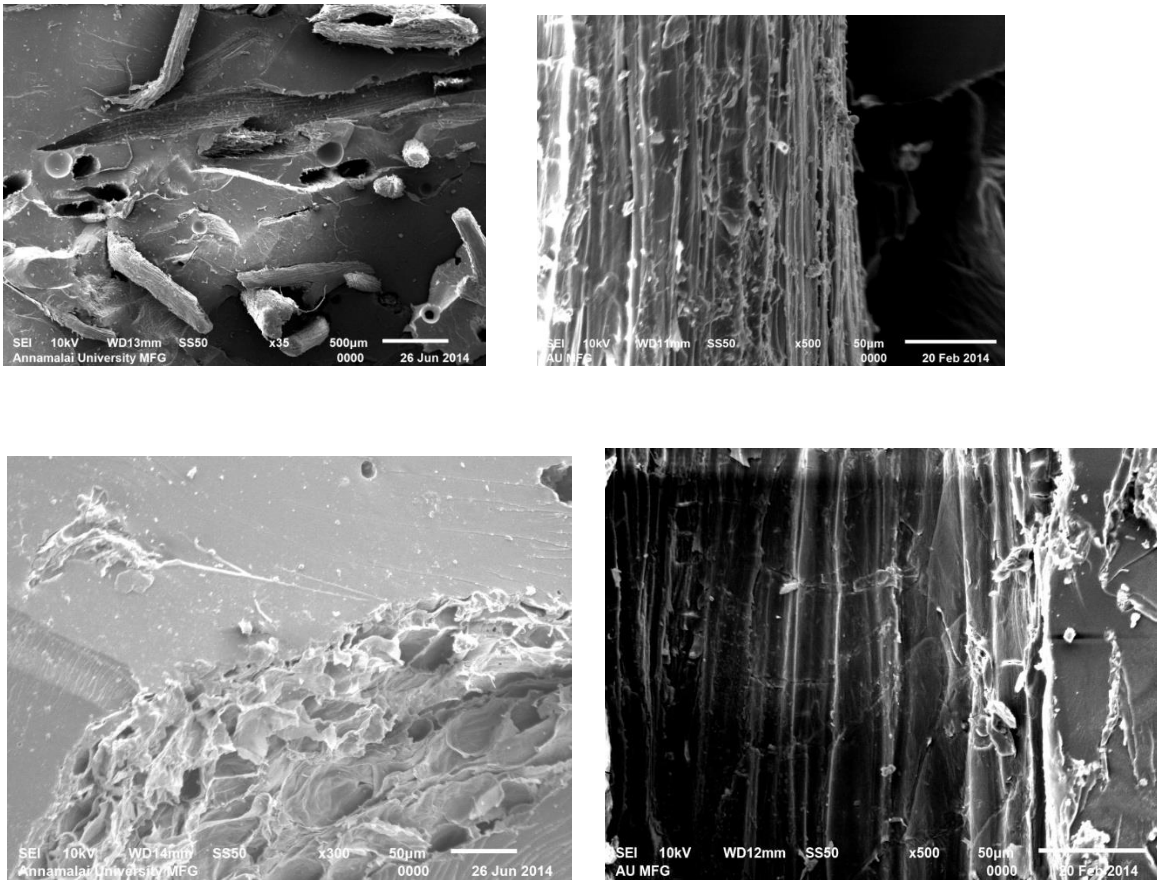
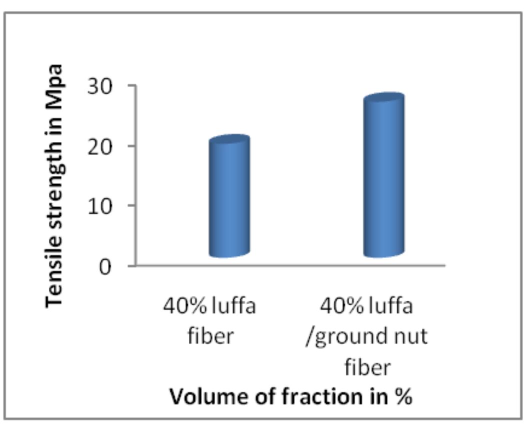


Fig.16. SEM image of impact fractured surface of Luffa and groundnut fiber composites

5.9. Comparison for mono poly with hybrid polymer composites



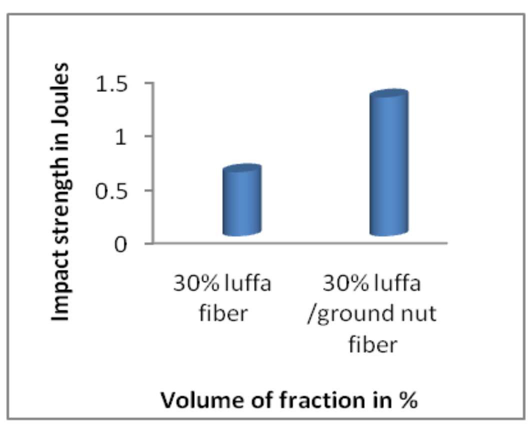


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Fig.17. Tensile strength for luffa

Fig.18. Impact strength for luffa

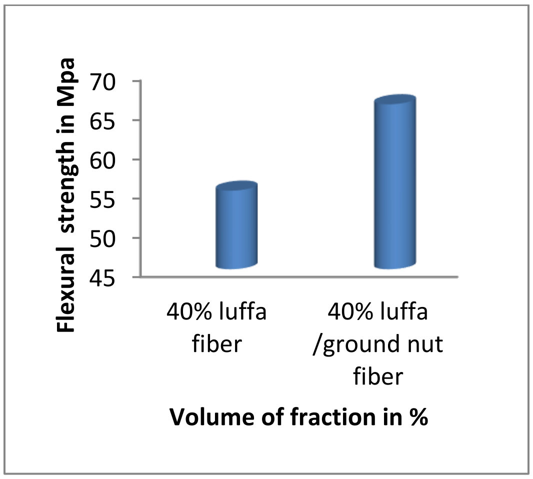

Fig.19. Flexural strength for luffa

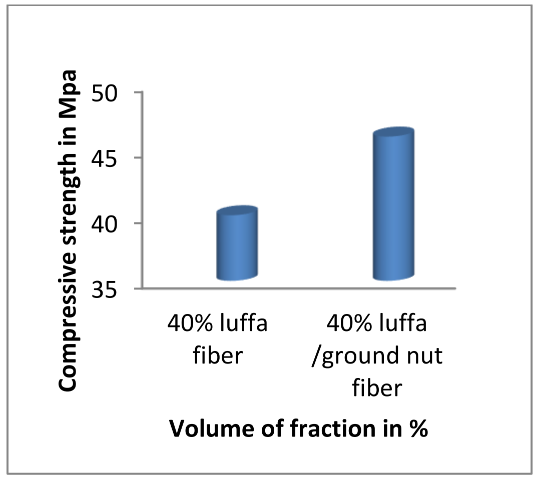

Fig. 20. Compressive strength for luffa

It clearly shows Fig.17, Fig.18, Fig.19 and Fig.20 that luffa with ground nut fiber polymer exhibited higher mechanical properties when compared to luffa and ground nut fiber polymer composites. These figures clearly indicate that there is a marginal increase in tensile, flexural, compressive and impact strength for 30% and 40% volume fractions of fibres.

6. CONCLUSION

The variation of tensile, compressive, impact, flexural properties and water absorption of the luffa with broom fiber reinforced epoxy polymer hybrid composites for 30%, 40%, and 50% fibers content were studied as a function of alkali treatment. It is reported that composites having 40% treated fiber content exhibited higher values for the fore mentioned properties than luffa with ground nut fiber polymer composites with 30% and 50% fibre contents. The mechanical property values of luffa with ground nut fiber reinforced composite were slightly higher than that of luffa fiber reinforced composite. After the alkali treatment, it was found that, treated composites possessed higher values of aforementioned mechanical properties because the alkali treatment improves the adhesive characteristics of the surface of the luffa with ground nut fibers by removal of hemicellulose, waxes, impurities and lignin from the fibers. In the present work, it was found that optimum values and significant improvements were at 40% treated fiber reinforced composites.

The hole sensitivity was found to increase with increasing hole diameter and a very negligible hole sensitivity was observed for a hole diameter of 3mm. It was observed that composites having 40% fiber content possess higher open hole tensile strength values than those with 30% fiber content.

The feasibility of drilling the composite by conventionally used twist drills has been established. There are good chances of optimal drilling(with low thrust force values) at feed rates upto 0.35mm/rev. Feed rate has proved to be the most influential parameter on the thrust force, than spindle speed.The morphology of fractured surface observed by SEM suggests that the networking of structure restricts the pull out of fiber, which is responsible for higher mechanical properties for 40 % fiber content. The decrease in strength at 50% fiber content is due to insufficient wetting of fiber with the matrix.

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