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Research Article

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Characterization of Kenaf fibre reinforced composites

Chandra Mohan D.* and Murali B.

Department of Mechanical Engineering, Vel Tech. (RS Trust), Avadi, Chennai, Tamil Nadu, India

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ABSTRACT

The rapidly expanding usage of composite components in automotive, construction, sports and leisure has attracted attention on continuous production techniques with the optimum properties. One of the techniques for manufacturing structural profiles from composites is pultrusion process. Pultruded composites are traditionally manufactured using thermosetting resin systems. These profiles are produced by pulling a carefully specified mass of wetted-out reinforcement material through a heated metal die containing a cavity of the desired cross-section. The intention of this project is to study the locally available kenaf fiber which is much cheaper than synthetic fibers such as glass, aramid and carbon fibers in an attempt to reduce the cost of producing composites and hence become more competitive than conventional materials such as galvanized steel and etc.

Keywords: kenaf fiber; chemical treatment; Biodegradable polymer; Mechanical properties.

INTRODUCTION

Environmentally friendly composites are today highly required by utilizing natural fibers as reinforcement combined with biodegradable polymer as matrices. Depending on the natural fiber used, the composite exhibited specific properties equivalent to the properties of glass fiber reinforced composites. This makes the natural fibers such as sisal, coir, jute, ramie, pineapple leaf (PALF), and kenaf are appropriate alternative candidates to replace glass or other traditional reinforcement materials in composites [1]. Manufacturing high performance composites from natural fibers is currently being pursued by researchers across the globe. The ecological benefits of this material are clearly saved valuable resources which are environmentally sound and do not cause health problems [2-3].

EXPERIMENTAL SECTION

Kenaf raw fibers used in this work and it was further processed into yarn with Tex unit of 2200 g/km. Unsaturated polyester resin (Reversol P-9941) grade was used for pultrusion. The curing temperature for this process was $120^{o}C$ with the pulling rate of 12mm/min.

A. Fiber treatment
Alkaline Treatment

Alkaline treatment or mercerization is one of the most used chemical treatment of natural fibers when used to reinforce thermoplastics and thermosets. The important modification done by alkaline treatment is the disruption of hydrogen bonding in the network structure, thereby increasing surface roughness. This treatment removes a certain amount of lignin, wax and oils covering the external surface of the fiber cell wall, depolymerizes cellulose and exposes the short length crystallites. Addition of aqueous sodium hydroxide (NaOH) to natural fiber promotes the ionization of the hydroxyl group to the alkoxide. A glass beaker is taken and 5% NaOH is added and 80% of distilled water is added and a solution is made. After adequate drying of the fibers in normal shading for 2 to 3 hours, the fibers are taken and soaked in the prepared NaOH solution. Soaking is carried out for different time intervals depending upon the strength of fiber required. In this study, the fibers are soaked in the solution for three hours. After the fibers are taken out and washed in running water, these are dried for another 2 hours. The fibers are then taken for the next fabrication process namely the Procasting process.

It is reported that alkaline treatment has two effects on the fiber and it increases surface roughness resulting in better mechanical interlocking; Murali 2014 [6] states that,it increases the amount of cellulose exposed on the fiber surface, thus increasing the number of possible reaction sites Alkaline treatment also significantly improved the mechanical, impact fatigue and dynamic mechanical behaviors of fiber-reinforced composites.

Acrylonitrile Treatment

A solution was made of 3% acrylonitrile, 0.5 hydrogen peroxide, and 96.5% ethanol (all % weight) and stirred in a covered beaker for 3 hours[6]. In Acrylonitrile Treatment, fibers are immersed in 5% aqueous NaOH solution for 1h at room temperature.The fibers were oriented in the mould, and the mold placed in the solution and allowed to soak for 15 minutes. The fibers were then drained and allowed to dry under the hood for 30 minutes.

Benzoylation Treatment

Benzoylation is an important transformation in organic synthesis. Benzoyl chloride is most often used in fiber treatment. Benzoyl chloride includes benzoyl which is attributed to the decreased hydrophilic nature of the treated fiber and improved interaction with the hydrophobic PS matrix. Benzoylation of fiber improves fiber matrix adhesion, thereby considerably increasing the strength of composite, decreasing its water absorption and improving its thermal stability. The isolated fibers were then soaked in ethanol for1 hour to remove the benzoyl chloride and finally was washed with water and dried in the oven at 80°C for 24 h.

B. Mechanical Testing

Density was measured using digital density meter (pycnometer) in accordance to ASTM D 792. The rod profile specimens with the diameter of 12.7 mm and length 10 mm are weighted first to the nearest 0.0001g. Three-point flexural test of pultruded composites was carried out in accordance to (ASTM D 4476-03). Specimens were cut into two parts so that the cross section of each part is smaller than a half-round section and the span was 100 mm.

RESULTS AND DISCUSSION

Table 1 shows the effect of varying fiber loading on density of composites density in comparison to the theoretical density calculated from measured density of UP (1.12 g/cm^3) and kenaf fiber (1.44 g/cm^3). It is apparent from Table 1 that theoretical and experimental density of PKFRC increased with increasing fiber loading. This is anticipated as the density of PKFRC is higher than neat UP itself. It is also notable that experimental density values are slightly lower than theoretical density values. This can be attributed to presence of voids in the fiber-matrix interface.

Table 1 Measured densities of PKFRC at different fiber loading

Fiber Loading (%)	Theoretical Density (g/cm^3)	Actual Density (g/cm^3)	Void Content (%)
Neat UP	-	1.12	-
50 %	1.28	1.26	1.56
60 %	1.31	1.293	1.29
65 %	1.33	1.317	0.97
70 %	1.34	1.33	0.74
75 %	1.36	1.342	1.32

Figure 1 reflects the effect of kenaf fiber content at 50%, 60%, 65%, 70% and 75% of volume fiber on flexural properties of the composites, respectively. The flexural properties of neat unsaturated polyester resin (UP) were used as references. Mechanical properties of composite increased with the increase of fibre content. The maximum value of flexural properties was exhibited at the fibre content of 70% v/v. Pothana et al., 2003 [5] states that, when the fiber concentration is lower, the packing of the fibers will not be efficient in the composite. This leads to matrix rich regions and thereby easier failure of the bonding at the interfacial region. When there is closer packing of the fibers crack propagation will be prevented by the neighboring fibers. The decreasing of mechanical properties for the composite with the fibre content above 70% is due to the insufficient filling of the matrix resin and it was represented by composites with 75% of fiber volume content.

CONCLUSION

The development of high performance composite structures using pultrusion process has been demonstrated using locally available kenaf fibers.

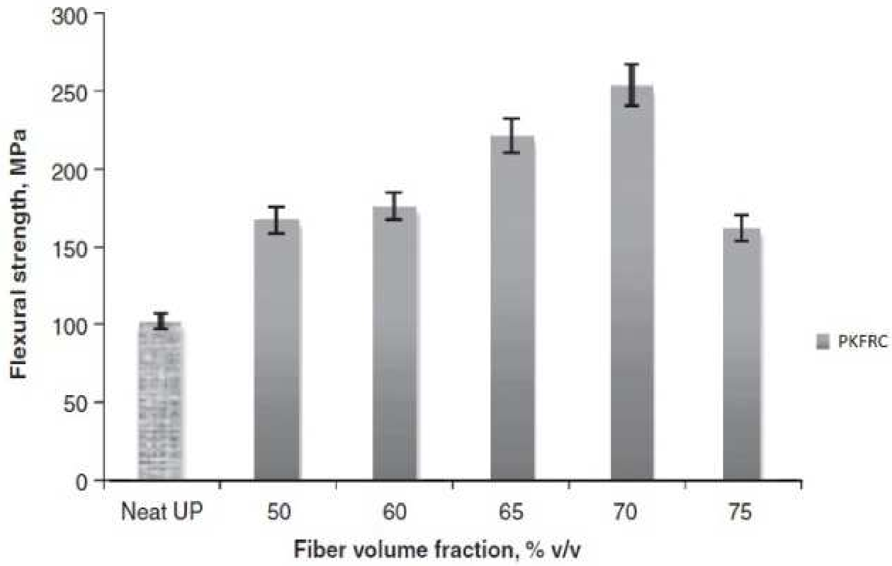

Figure 1 Comparison of flexural strength of PKFRC

From the results and discussion above, it can be concluded that the addition of higher amount of fiber loading results in higher flexural properties of the kenaf fiber–reinforced polyester composites, with 70% of fiber volume fraction give maximum performance.

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