

Axial Energy Absorption of Kenaf Yarn Winding Cylindrical Composites

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Abstract. This present work investigates the composites reinforced with kenaf fiber to fabricate the cylindrical tubes. According to the literature survey, it is found that lack of study research of producing the cylindrical composites with filament winding method using kenaf fiber. Therefore, this work used long fiber wetted with epoxy resin and then wound around the cylindrical mould. Three different winding angle orientations are used such as 0° , 5° , and 10° . Then, the tubes are compressed Quasi-statically using a constant speed 1.5 mm/min crosshead displacement. Force displacement curve are obtained and the area under the curve represented the energy absorption performance. It is found that the capability of energy absorption decrease when higher winding angles is used. At the same time, the collapse mechanisms are almost similar with different types of fiber orientations angle.

Introduction

For the preceding vehicle design, full metal is used as the energy absorbing element. However, since the mechanical properties of the metal itself, there is a weakness for the needs of lightweight materials and high energy absorbing capability. The result shows that the energy absorber made from steel mostly failure of bending and fracture, and hence leads to the absorption of energy produced is low [1]. In the automotive industry, the main thing that is taken into account for each vehicle component design is low cost, lightweight materials without sacrificing performance and meets sustainability aspects. This is why the composite material interest in the design of automotive structures for the mechanical properties of hard and brittle and has a characteristic strength to weight and stiffness to weight ratio, corrosion and fatigue resistance [2]. The magnitude and the rate of energy absorption is dependent on the specific material and structural characteristics of micro fiber/matrix and different orientations for the fabrication of a reinforced composite, for example a glass fiber-reinforced composite materials using fabrication processes such as weaving, thread, random and so on [3]. Kenaf fiber, which is made from a plant called kenaf plant, is a plant species of the hibiscus family are shrubs that only require a period of about five months to harvest [4].

This study are conducted using a composite material made from kenaf fibers to reinforce a composite structure materials in different tubes which on different types of fiber orientation and dimensions of architectural forms used for the fabrication of composite materials research. Kenaf fiber reinforced composite tubular imposed axial compressive quasi-static verticals for optimum energy absorption due to the mechanism of the destruction of the compression process [5].

Recently, many studies have been carried out to determine the effects of various variables on energy absorption capability of composites material especially composites tubes such as geometry shape [6, 7], fiber orientation stacking sequence and fiber reinforcement types [8,9]. In this paper, inclusive experimental work are implemented to study the response of energy absorption of kenaf fiber reinforced using filament winding cylindrical mould with different angle orientation such as 0° , 5° and 10° .

Theoretical background

Composite materials have a much lower density compared to conventional materials. This provides important implications in the context of use for the composite strength and specific stiffness higher than conventional materials. The second implication is that composite products produced will have a lower weight than metal. Weight reduction is an important aspect in manufacturing industries such as automobile and aerospace. This is because it relates to fuel economy [10]. Figure 1 shows the experimental results where the load versus displacement of the tube facing the devastation stable. The curve starts with a linear region at the beginning of the line load is applied to the maximum peak load P , as a result of failure on the part of the surface of the composite tube. Refer to number 1 in the figure. After laminar bending modes occur at peak load, steady disintegration of the region is reflected in the graph fluctuate irregularly shaped serrations [11].

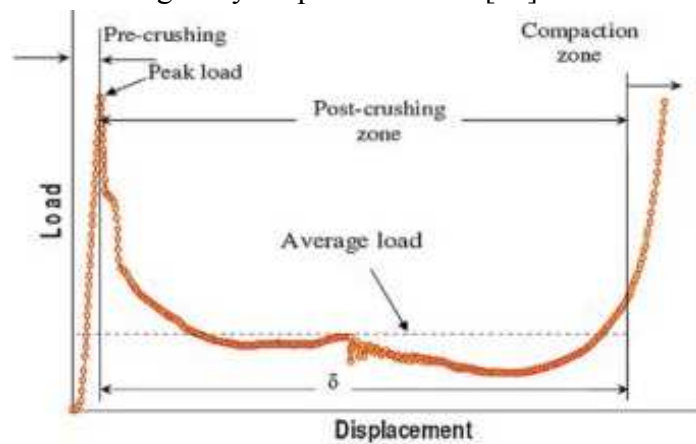


Figure 1 The experimental results where the load versus displacement of the tube facing the devastation stable.

Area under the force versus displacement curve gives the energy absorption for components specific to the loading direction, namely:

$$E(d) = \int_0^d f(d) dx \quad (1)$$

The area shown in the figure 1 of the displacement d there is crush length, in the case of lightweight structural design, specific energy absorption (SEA) is an important design criterion, and is given by [12]:

$$SAE(d) = \frac{1}{mc} \int_0^d f(d) dx \quad (2)$$

where m is the mass of the component. If the absorption of energy $E(d)$ is divided by displacement d , the mean collapse load is obtained [12].

$$Fm(d) = \int_0^d f(d) dx \quad (3)$$

Mean and initial collapse load are two design parameters of the most important in the design of energy absorption, as it is directly related to security agents that could protect the vehicle occupants [12]

Experimental Work

Long yarn kenaf fiber is used to wind around the cylindrical mould as in figure 2. Three winding angle orientation are used such as 0, 5, and 10. Once the winding process is completed, the fibers are wetted with epoxy resin. Around 24 hours, the hardened composites tubes are removed from the

cylindrical mould. The specimens are placed vertically at the UTM (*universal testing machine*) crosshead displacement, and then it is compressed Quasi-statically with constant speed 1.5 mm/min. The graph force vs. displacement is obtained automatically [15]. The areas under the curve represented the energy absorption or it can be calculated using Eq. 1[16,17]. Finally, the collapse mechanism is observed and related with the energy absorption [18].

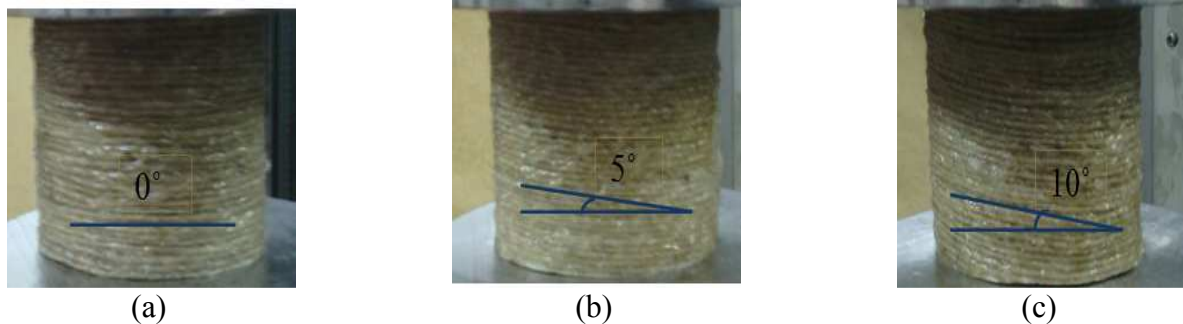


Figure 2 Circumferential orientation angle (a) 0° (b) 5° (c) 10°

Result and discussion

Figure 3(a) shows the graph of energy absorption of yarn kenaf with 1 mm diameter with one winding of circumferential orientation angle 0° , 5° and 10° . This graph shows angle orientation that gives high impact of force-displacement is 5° , around 10 until 30 mm displacement the average result. Figure 3(b) shows the two layer of yarn winding with different angle orientation as shows as in figure; the angle that affects most of the result of force-displacement is 5° , around 10 until 30 mm displacement the average result. Figure 4 is the result of the layer kenaf winding with angle orientation such as 0° , 5° , and 10° . The highest value of force vs. displacement obtained in the Figure 5 is the three layer of kenaf winding with angle orientation 5° .

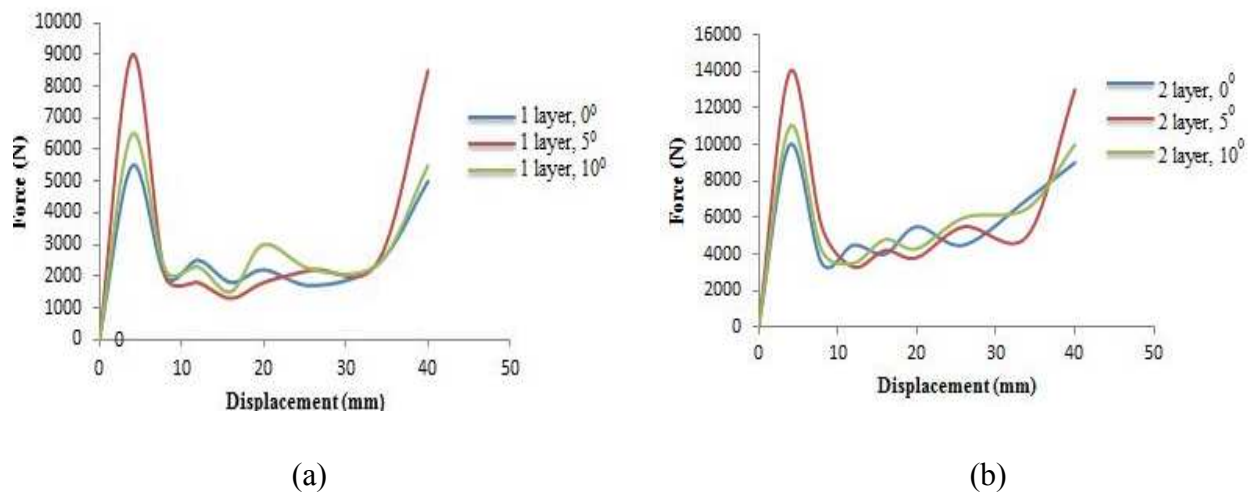


Figure 3 Force-displacement curves, (a) 1 layer and (b) 2 layers kenaf fiber for different fiber orientations.

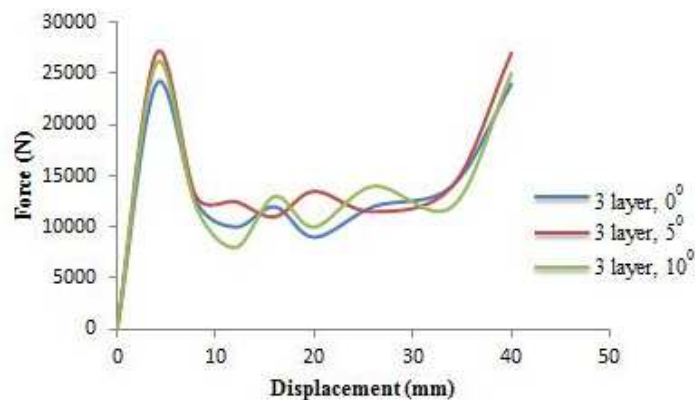


Figure 4 Three layers with different angle orientation kenaf winding

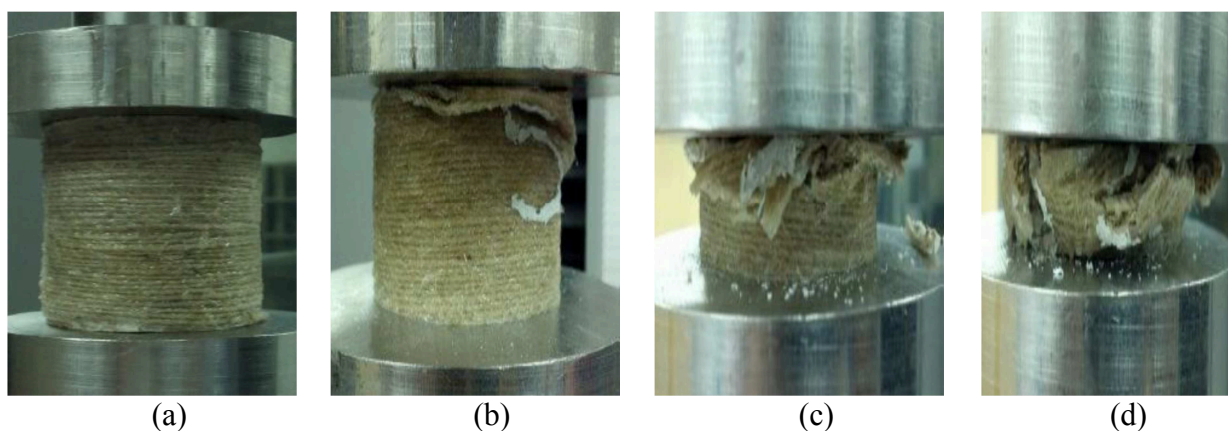


Figure 5 Collapse Modes for cylindrical tubes of one layer with 0° fiber alignment.

Table 1 Results for cylindrical tubes

Sample (Layers, Orientation)	Energy absorption (kJ)	Mass (kg)	Specific energy absorp- tion (kJ/kg)
1, 0°	0.0776	0.03271	2.372
1, 5°	0.0883	0.03265	2.704
1, 10°	0.0861	0.03273	2.631
2, 0°	0.1671	0.04168	4.009
2, 5°	0.1770	0.04176	4.239
2, 10°	0.1727	0.04182	4.130
3, 0°	0.4007	0.05178	7.739
3, 5°	0.4392	0.05192	8.459
3, 10°	0.4071	0.05193	7.839

Conclusion

Based on experimental works, the angle that gives the highest impact of energy absorption is at the angle of 5° with 3 layers. Kenaf fiber has more particular strength compared to glass fiber. Kenaf fiber can substitute glass fiber to be used in the automotive industry to reduce the use of glass fibers. The use of natural materials can also reduce the harmful effects to the human.

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