POTENTIALITY OF UTILISING NON-WOVEN KENAF FIBRE COMPOSITE FOR CAR DOOR MAP POCKET

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ABSTRACT: Natural fibres have become an alternative solution of fibrous material in this millennium due to increasing population. In this study, an experimental investigation was conducted to explore the potential of non-woven kenaf as door map pocket reinforced composite. The composite was made by non-woven kenaf as a reinforcement and epoxy resin as a matrix material. The composite was fabricated by hand lay-up process and followed by vacuum bagging process. The composite was made with their thickness or layers of fibre increased, starting with one layer (L1) until six layers (L6). The results revealed that the L2 produced the best optimum tensile strength and flexural strength, increased by 114 % and 19 % respectively, compared to actual product. The highest tensile and flexural strength were L6, about 5.531 kN and 1.041 kN respectively. The evidence from this study suggests that the non-woven kenaf for door map pocket reinforced composite shows good tensile and flexural property as a potential to replace the petroleum-based composite or synthetic thermoplastics.

KEYWORDS: *Non-Woven Kenaf; Mechanical Behaviour; Car Door Map Pocket*

1.0 INTRODUCTION

Composites are two or more materials made of matrix reinforced by fibres, combining the high mechanical and physical performance of the fibres and matrix [1-2]. Over the last few years in the manufacturing industry, there has been an increasing demand of product based on composites. Various products in the world have been experimentally studied as composite materials since they improve the product's performance in many ways such as stiffness, toughness, corrosion resistance, minimised weight and strength. In fact, researchers also claimed that there has been a rapid increase in composite application in aerospace, defence, transportation, power, electronics, recreation, sporting and numerous other commercial and consumer products [3-5]. Moreover, economic and environmental concerns in the composites sector have stimulated researchers in designing new substances to replace the existing materials or reduce the synthetic fibre development. Over the past 10 years more information has become available on replacement of synthetic fibre reinforced composites by natural plant fibre such as jute, flax and abaca [5-7]. In order to replace the synthetic fibre, Alves et al. [5] have performed life cycle assessment (LCA) to achieve the environmental goals in their project. Thus, their work through LCA method demonstrated the possibility of using natural fibres through a case study design which investigated the environmental improvements related to the replacement of glass fibres with natural jute fibres.

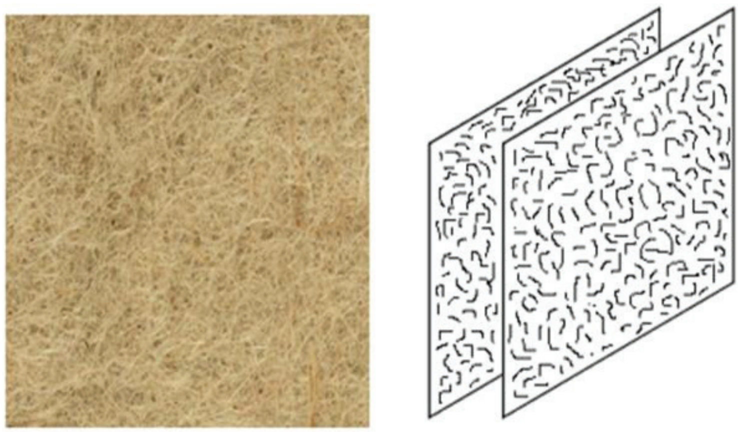
The term kenaf originated from Persian language which is a plant native from Africa. The results of scientific research, kenaf fibre belongs to species of Hibiscus Cannabinus where genus is Hibiscus and family Malvaceae obtained from stems of plants [8]. Kenaf fibre contains of cellulose between 56 – 64 wt. %, hemicellulose between 21 – 35 wt. %, lignin between 8 – 14 wt. % and small amounts of extractives and ash [9 – 10]. Kenaf is characterized by two distinct core and fibres bast comprising 65 % and 35 % respectively [11]. The core and bark fibres, considered as two distinct types of raw materials that have great potential to use as automotive, construction and etc. materials, are due to the long fibres derived from outer fibrous bark, the bast. Aisyah et al. [12] studied the properties of medium density fibreboard (MDF) from kenaf (Hibiscus Cannabinus L.) core as a function of refining conditions. They found that the refining condition was crucial in order to have better properties of MDF. The fibres refined with 7 bar pressure for 5 min refining resulted in ideal mechanical and physical properties. In the same area of study on core kenaf fibre panels, Ali et al. [13] concluded that kenaf is a promising fibre source which can be used as an alternative to wood fibres for the production of fibreboards particularly for high density and high strength panels.

In addition, Hoa and his co-worker investigated the kenaf/polypropylene nonwoven on acoustical performance. It was found that an adhesive-free sandwich structure has excellent sound absorption and insulation performance [14]. An increasing industrial interest in applications of non-woven kenaf fibres for making engineering parts has grown because of their excellent strength and renewability. Kenaf fibres can also be applied in automotive interior parts. More recent studies have confirmed the advantages of using natural fibres such as kenaf, jute, flax, ramie, hemp, cotton and etc. for automotive composite applications. From a technical perspective, these natural fibre composites will improve mechanical properties and acoustic performance, decrease material weight and processing time, reduce manufacture cost and improve biodegradability for the auto interior parts. The transformation of these natural fibres into automotive parts will benefit the establishment of a sustainable and friendly environment resource base for the industry. A novel investigation by [15] on bio-composites of kenaf fibres in polylactide: Role of improved interfacial adhesion in the carding process, found that the effect of silane coupling agent on the mechanical properties of the kenaf fibre reinforced PLA bio-composites is shown to be highly beneficial. Moreover, they proved that non-woven kenaf has been successfully utilized to manufacture automotive headliners. In addition to the work of Lee et al. [15], Chen et al. [16] provides hybrid natural fibre for automotive headliners. The nonwovens kenaf and ramie fibre were used with ratio 70:30 in two different binders which are polyvinyl alcohol (PVA) and acrylic copolymer. The results revealed that the binder of acrylic copolymer was significantly anisotropic in both tensile and bending deformation while the binder of PVA was significantly anisotropic only in bending deformation. In another study on non-woven kenaf, Ramaswamy et al. [17] investigated the potential of making non-woven textiles with kenaf fibres that can be used in laminated applications. The kenaf fibres were mixed with polypropylene with a ratio of 80:20, and batts were prepared using a modified cotton card in regular widths. The substrates were made of the batts that had been either calendared or needle punched before being cured in an oven. Many kinds of overlays such as polyester wood grain, phenolic resin impregnated kraft paper, and decorative vinyl were used to laminate the substrates. They concluded that these substrates can be used to make wall-covering, laminated upholstery, and other domestic textiles materials.

On the basis of the comprehensive literature review, the incorporating non-woven kenaf fibre laminated with epoxy resin by vacuum bagging had been rarely reported. Therefore, the main objective of this study is to investigate and develop mechanical properties of non-woven kenaf composite for car door map pocket application.

2.0 MATERIALS AND METHOD

In this research, epoxy auto-fix 1345-A and auto-fix 1345-B was used and supplied by Chemibond Enterprise Sdn. Bhd. For the material preparation, the resin was measured with the digital scale with ratio of epoxy 50:50. The non-woven kenaf fibre was supplied by National Kenaf and Tobacco Board Malaysia as shown in Figure 1 (a). The non-woven kenaf fibre was cut and placed according to mould size. After that, the door map pocket was fabricated by hand lay-up process and followed by vacuum bagging process. Vacuum pump RA 0100 F 503 with brand BUSCH was used with capacity V_{max} 100 m3/h and P_{abs} 0.1 hPa (mbar). After the bagging process, the sample was kept at room temperature for 48 hours for the curing process. The purpose of this process was to stabilize the sample to make sure the sample was 100 % cured. The tensile and flexural test was conducted as per ASTM standards with cross head speed of 2 mm/min by using Shimadzu Universal Testing Machine. The sequences of composites are as shown in Figure 1 (b). Figure 2 shows the sample of door map pocket from non-woven kenaf fibre and polypropylene (existing product).



(a) (b)

Figure 1: (a) non-woven kenaf (b) example of layup sequences of composites

(a)

(b)

Figure 2: Sample of door map pocket made from (a) non-woven kenaf (b) polypropylene (PP)

3.0 RESULT AND DISCUSSION

3.1 Tensile performance

The average of five samples was recorded for tensile test with 25 x 250 mm^2 and crosshead speed of 2 mm/min according to ASTM D3039. The door map pocket composites were made from non-woven kenaf and epoxy resin with their thickness increased, starting with one layer (L1) until six layers (L6). Result of PP as a benchmark due to existing product. Figure 3 presents the maximum tensile strength of composites. It can be seen, as expected, that the properties of the composites are strongly influenced by the thickness. As illustrated in Figure 3, an increase in thickness lead to the value rise of tensile strength. The lowest and the highest tensile strengths were L1 and L6, about 0.613 kN and 5.531 kN respectively. Based on Figure 3, it shows that the strength value of L6 is 5.531 kN, which is 414.511 % higher than that of PP. However, in automotive context it is not appropriate due to the slight thickness compared to PP. Moreover, it will increase the density of composites. The increasing density will increase the fuel consumption. As shown in Figure 3, the most appropriate for door map pocket was L2 due to 114.046 % higher than PP in tensile strength and the density of L2 most similar with PP. L1 is lighter than L2 and PP; however, in terms of tensile strength it is lower than L2 and PP. It can be concluded that the increasing layer or thickness will increase the tensile strength. The finding is consistent with findings of past studies by Abdellaoui et al. [18], which found the mechanical properties increase with the increasing number of layers. The correlation between layers and strength of composites is interesting because of the thickness and the strength of composites can be controlled.

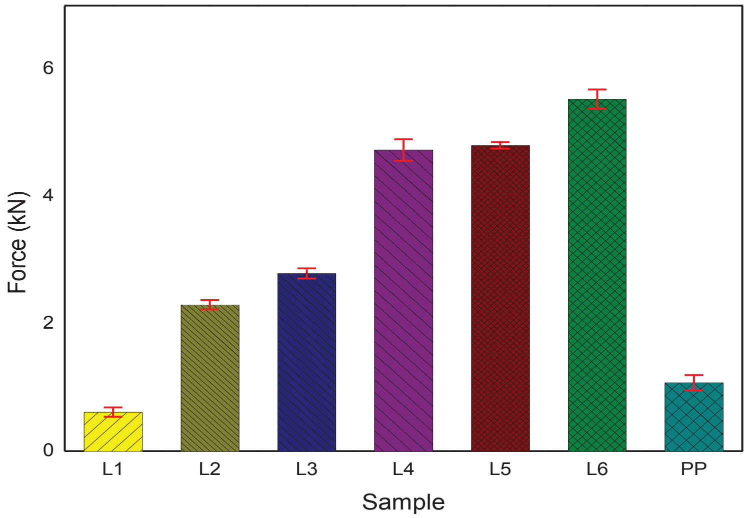


Figure 3: Tensile strength of composites

3.2 Flexural performance

The average of four samples was recorded for flexural test with 15 x 100 mm^2 and crosshead speed of 2 mm/min referred to ASTM D790. Figure 4 demonstrates that the flexural strength increased by increasing the thickness respectively. Similar trends were observed in tensile strength. Figure 4, however, surprisingly shows the flexural strength of L5 was lower than L4, about 34.125 %. From the observation, L5 has lack of fibre in several parts and has not fully covered the entire sample, which leads to the decreasing thickness of L5 compared to L4. Apart from that L5 cannot withstand higher loads compare to L4 due to the thickness of composites. As illustrated in Figure 4, the lowest and the highest flexural strength was L1 and L6, about 0.057 kN and 1.041 kN as expected. Also, it was found that L1 is weaker than PP by about 43 % because L1 is the thinnest layer of composites compared to others. In addition, it can be noted that L6 was stronger 941 % than PP due to the capability of laminated composites to withstand the bending before reaching the breaking point [19]. As demonstrated in Figure 4 and tabulated in Table 1, the flexural strength, density and thickness of L2 was close to PP that makes L2 the most ideal layer for car door map pocket. It can be concluded that the flexural strength increase with increasing the number of layer of composites.

Table 1: Mechanical properties of composite

Samples	Areal density (Kg/m^2)	Thickness (mm)	Tensile strength (kN)	Flexural strength (kN)
L1	1.77	1.94	0.613	0.057
L2	2.81	3.86	2.301	0.119
L3	3.66	5.86	2.793	0.263
L4	5.89	8.38	4.732	0.621
L5	5.21	7.94	4.805	0.463
L6	7.74	9.22	5.531	1.041
PP	2.51	3.00	1.075	0.100

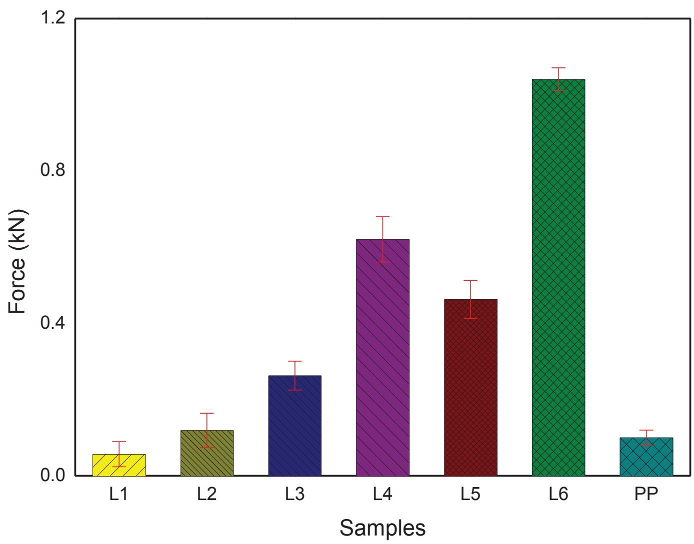


Figure 4: Flexural strength of composite

4.0 CONCLUSION

This project was undertaken to develop the potential of non-woven kenaf for car door map pocket composite by evaluating the tensile strength and flexural strength. This study has shown that L2 is the most appropriate for the car door map pocket since it is 114 % higher than PP in tensile strength and the density of L2 is most similar with PP (only 11.952 % heavier). The flexural strength of L6 which is 941 % stronger than PP is the second major finding in the study due to the capability of laminated composites to withstand the bending before reaching the breaking point. Also, it was found that the average mechanical properties value for L1 is weaker than PP (about 36.241 %) because L1 is the thinnest layer of composites compared to others. One of the most significant findings to emerge from this is that the tensile strength and flexural strength increased by increasing the number of layer of composites. The evidence from this study suggests that the non-woven kenaf for car door map pocket reinforced composite shows good agreement on tensile and flexural property as a potential to replace the petroleum-based composite.

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