Physical Performance of kenaf/jute mat Reinforced Epoxy Hybrid Composites

K. Tabrej, M.T.H. Sultan, M. Jawaid

Abstract: ***This paper deals about physical properties of jute/kenaf/jute (J/K/J) and kenaf/jute/kenaf (K/J/K) hybrid composites, exposed for seven week water immersion. Kenaf/jute hybrid composites fabricated by hand lay-up technique while maintaining total fibre loading of 30 wt%. An investigation of density, water absorption and thickness swelling of hybrid composites with three layering patterns, and pure epoxy matrix samples were carried out. The composites were immersed in distilled water for a period of 49 days and the desired readings were recorded. The data collections were taken at every odd day for the first week, namely days 0, 1, 3, 5, 7 days and following that every 7th day until the 7th week. The water absorption results showed that J/K/J absorbed less water compared to K/J/K composites. The thickness swelling also showed similar behavior of investigated composites. The density of hybrid composites are showed the almost slightly similar values of all composites specimens. We concluded that J/K/J hybrid composites show better dimensional stability and suitable for further study to fabricate suitable products from it.***

Index Term: Jute fibre, kenaf fibre, hybrid composite, water absorption, thickness swelling, density

I. INTRODUCTION

Natural fibres are globally used for reinforcement in polymer composites. They have some advantages and disadvantage [1]. Few of the advantages of natural fibres include that they are derived from renewable sources, eco-friendly, and low cost and easy to harvest [2]. On the other hand, they also have some disadvantages such as weak mechanical, thermal and physical properties [3]. Natural fibre are separated into some categories such as straw, bast, leaf, seed, fruit and glass fibres [4]. Natural fibres such as kenaf, jute, hemp, sisal and coir has good potential to use in the manufacturing component [5].

Revised Manuscript Received on May 30, 2019

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Nowadays natural fibres are used in various applications such as aerospace manufacturing, marine industry, automotive sector, and construction industry [6], [7]. Previous study found that mechanical properties of composites can improved by doing hybridisation of fibres [8], [9]. Hybridization has two type which is natural fibre by natural fibre and other is natural fibre with synthetic fibre [10]. Previous study found that kenaf and jute has high content of cellulose and lignin which is the region why composites absorb more water [11]. Natural fibre has a poor matrices adhesion, it's the effects of interfacial bonding among hydrophilic fibres and hydrophobic matrices [12].

Kenaf fibre are one of the globally used natural fibres which has good mechanical properties and it is used in various engineering component [13]. Kenaf (Hibiscus cannabinus) fibre is a yearly crop, similar to cotton and jute [14]. Knaf fiber has good potential to use in household and other Jute fibres belongs from genus Corchorus family [15]-[16]. Jute fibres has two types first one is white and other is brown in colour, In this study brown colour jute fibre is used because it has good mechanical properties[17]-[18] . Jute fiber is normally extracted from stem of jute plant; which is commonly found in Eastern India and Bangladesh [19]. Jute fibres grow from 2.5 to 3.5m in height within 4-5 months. These fibre are obtained by drying in sunlight [20]. Jute fibres mechanical properties are given in the Table 1.The water absorption and thickness swelling of biocomposites badly impress the mechanical properties and also affect characteristics of composites [21].

It is significant investigation of natural composites, it is also estimated the resulting effects on the biocomposite mechanisms. Such investigation help to understand the effects and develop techniques for controlling and minimizing water absorption. Physical investigation of kenaf/jute bio composite has been studied [22]. Investigation of water absorption in natural composites is essential for many application such as outdoor, waste water, packaging and construction industries [23]. There are three methods to identify the water absorption in biocomposites; diffusion, capillary flow and storage of water [24].

Previous researches have been exhibited on the water absorption and thickness swelling, already some investigation state that the stabilities of different type of fibre composites and deliberated the problem associate with water absorption and

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thickness swelling in composites [25].

In this research investigation the main objective of kenaf/jute hybrid composites enhanced from water absorption and thickness swelling investigated. In this research, density, water absorption and thickness swelling behaviors of kenaf/jute reinforced hybrid composites have been investigate on layering patterns, fibre fraction and time duration. This study will contributed in future study of mechanical and thermal behavior of hybrid composites [26].

II. MATERIALS AND METHODOLOGY

Materials

In this research, kenaf and jute woven mat fibers were used as reinforcement for the composite and supplied by Indersen Shamlal Pvt. Ltd. India. Density and chemical composition of kenaf and jute fibre were displayed in Table 1. Epoxy resin (Epoxymate) was used with epoxy hardener, purchased from Mecha Solve Engineering Sdn. Bhd, Selangor, Malaysia. The epoxy and hardener were mixed in a ratio of 3:1 respectively, as per supplier's recommendation.

Composites fabrication

Two different layering patterns such as K/J/K and J/K/J hybrid composites consisting of woven mat fibres, as shown in Figure 1A). Before immersed in distilled water and 1B). After immersed in distilled water, were fabricated using hand lay-up technique. Weight of the fibres was kept constant. All the composites were prepared at 30% (w/w) of fibre (kenaf and jute) and 70% (w/w) of epoxy resin. There are three types of hybrid composites which is K/J/K, J/K/J and 100% epoxy sample (as control) were left to cure for 24 hours at room temperature. The cured composites together with the neat epoxy composites were prepared with fixed dimensions of 20×20×3 mm according to ASTM standards.

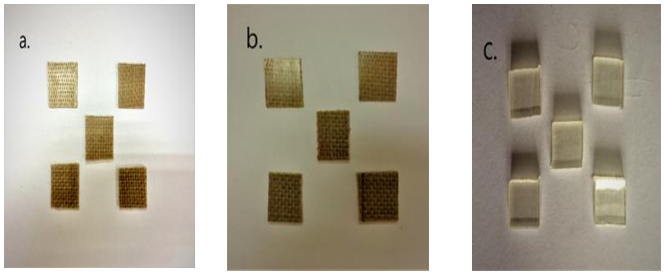

Fig. 1A: Prepared specimens of a.) J/K/J b.) K/J/K c.) Epoxy. (Before immersed in distilled water).

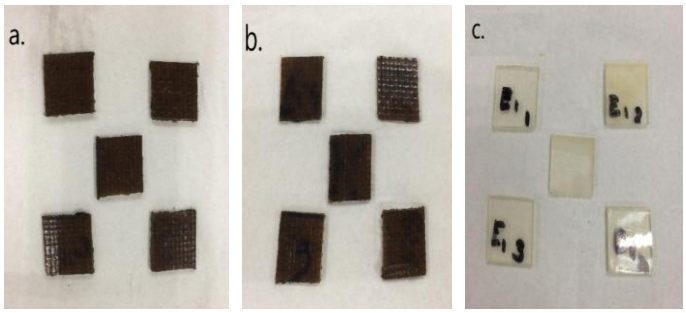

Fig. 1B: Prepared specimens of a.) J/K/J b.) K/J/K c.) Epoxy. (Before immersed in distilled water).

Table 1: Density and chemical composition of kenaf and jute fibre [27].

S. No.	Properties	Kenaf fiber	Jute fiber
1	Density (g/cc)	1.4	1.3
2	Cellulose content (%)	53-57	61-70
3	Hemi Cellulose (%)	15-19	13.6-16
4	Lignin Content (%)	5-11	12-13

Determination of the hybrid composites density

Three hybrid composites specimens were cut as per test standards which is square shape with dimension 10 x10 x 3 mm. The volume was calculated from the measured dimension. The all hybrid composites specimens' density was then recorded and showed in Figure 4. Density was measured by using ASTM D 1895 standard. The density of the samples was calculated by using following equation 1.

$$Density\ (\rho)\frac{mass\ (m)}{volume(v)} \qquad (1)$$

Water absorption test and thickness swelling

In this study, three specimens were used which is K/J/K, J/K/J and epoxy. Five samples each configuration were tested according to the ASTM D570 standard, each specimen was immersed in distilled water at room temperature. After a desired period of time, the samples were removed from the water, properly wiped with a clean cotton cloth or tissue paper and the weight was measured. The percentage of water absorption was calculated from Equation (2).

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$$WA\ (\%)\frac{m_f - m_i}{m_i} \times 100 \quad (2)$$

Where:
m_f = Mass of sample after immersion (g)
m_i = Mass of sample before immersion (g)
WA = Water absorption

The thickness swelling of kenaf/Jute hybrid composites thickness swelling was calculated according to ASTM D570 by using Equation 3.

$$TS\ (\%)\frac{t_f - t_i}{t_i} \times 100 \quad (3)$$

Where:
t_f = Thickness of sample after immersion (mm)
t_i = Thickness of sample before immersion (mm)
TS = Thickness swelling

III. RESULTS AND DISCUSSIONS

Water absorption

Figure 2 illustrated the percentage of water absorption of hybrid composites (J/K/J and K/J/K) and epoxy sample (as control). It clear seen from Figure 2 that K/J/K hybrid composites display high amount of water absorption as compared with other hybrid and epoxy samples composites due to week bonding between epoxy and fibers. It is shows the K/J/K specimen has tend to more water absorption as compared to J/K/J and epoxy specimen. However, low water absorption of pure epoxy specimen its might be attributed to hard surface and J/K/J composites which has the good bonding between fibers and matrix. The similar investigation was found hydroxyl group of kenaf natural fibre has more water absorption due to high cellulose and lignin content. K/J/K giving high water absorption values due to absorb more water. Hybrid composites J/K/J has low water absorption values due to less cellulose and lignin content. Pure Epoxy specimen has no cellulose and lignin content thereby giving lower water absorptions values, previous research also found the similar behaviour [28].

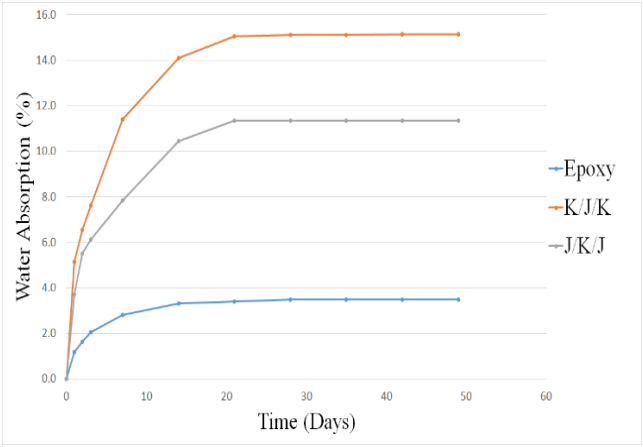

Fig. 2: Water absorption behaviour of natural hybrid composites

Thickness swelling

The Figure 3 shows the percentage of thickness swelling of J/K/J and K/J/K hybrid composites and epoxy matrix sample. The thickness swelling behaviour of the K/J/K composites increased with the water absorption and it is alike representing the relation among thickness swelling and composites weight increased due to the week bonding between fibers and resin. Epoxy specimen no cellulose and lignin contend so it has lower thickness swelling. Hybrid composites J/K/J has low thickness welling due to good bonding between resin and fibres content as compared to K/J/K composites. Similar investigation found the increased in thickness swelling of K/J/K composites was also reported by other researchers [29].

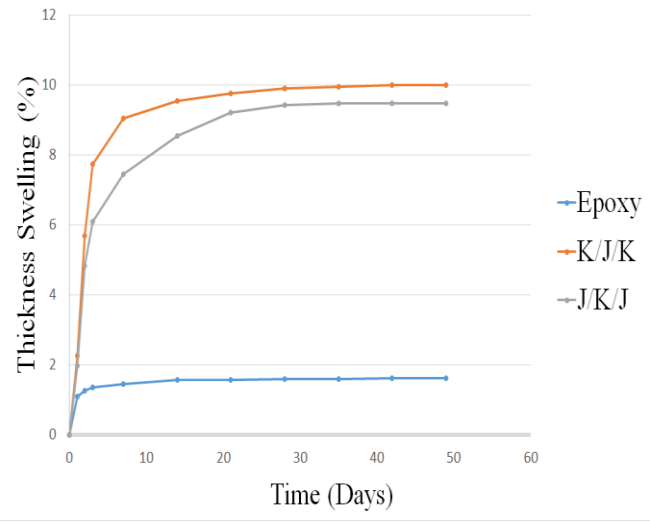

Fig. 3: Thickness swelling behaviour of natural hybrid composites

Density of hybrid composites

Figure 4 illustrates the density of kenaf/jute hybrid composites. In this density investi-

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gation of kenaf/jute hybrid composites, density was recorded Epoxy 1.12, K/J/K 1.13 and J/K/J 1.13 g/cm3 respectively. The density of hybrid composites are shows the high of the K/J/K and almost slightly similar values of Epoxy and J/K/J composites samples. Pure epoxy is not completely wet due to hard surface of epoxy core. The density results shows that the fibre samples does not affected the characteristics of pure epoxy, and K/J/K, J/K/J hybrid composites[29].

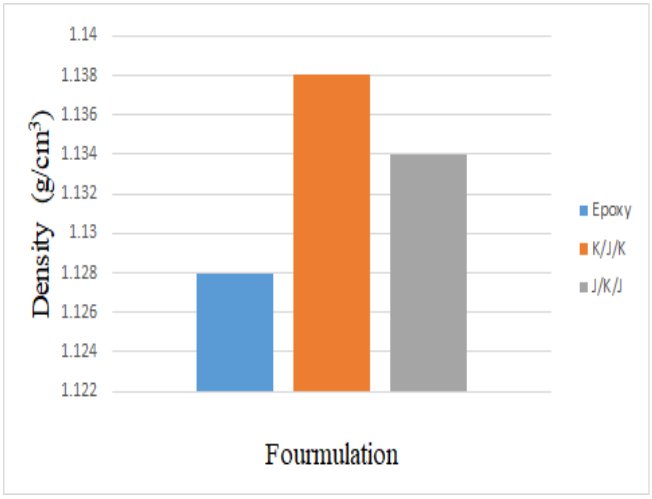

Fig. 4: Density of kenaf/Jute hybrid composites

IV. CONCLUSIONS

In this research work density, water absorption and thickness swelling of pure epoxy and hybrid composites were evaluated.

1. The investigation of water absorption and thickness swelling behavior of kenaf/jute reinforced hybrid composites showed that the increase with in immersion duration. After a certain amount of water absorption, a saturation point will be reached and no more water absorb by specimens at certain point. Thickness swelling and water absorption of K/J/K hybrid composites due to weak bonding between fibers and matrix.
2. The water absorption and thickens swelling of J/K/J hybrid composite are slightly better than K/J/K composites because of fibers and resin are properly bonded with each other. Epoxy samples shows very negotiable effect due to hard surface.

ACKNOWLEDGEMENT

This work is supported by UPM under GP-IPS grant, 9486400 and Newton Fund, 6300896. The authors would like to express their gratitude and sincere appreciation to the Department of Aerospace Engineering, Faculty of Engineering, Universiti Putra Malaysia and Laboratory of Biocomposite Technology, Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia (HiCOE) for the close collaboration in this work.

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