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EFFECT OF FIBER VOLUME FRACTION ON THE MECHANICAL PROPERTIES OF COCONUT SHEATH/USP COMPOSITE

***Siva I[1], Winowlin Jappes J T[2], Sankar I[3], Amico S C[4] and Ravindran D[3]**

[1]Centre for Composite Materials, Kalasalingam University, Krishnankoil, Tamilnadu- 626 126, India.
[2]Centre for Advanced Materials, CAPE Institute of Technology, Tirunelveli Tamilnadu-627114, India.
[3]Department of Mechanical Engineering, National Engineering College, Kovilpatti, Tamilnadu -628503, India.
[4]Department of Mechanical Engineering, UFRGS, Porto Alegre/RS, Brazil.

ABSTRACT

Natural fibers and their composites are the emerging trends in material science which are the replacements for the synthetic reinforcements. Because of their high specific strength and less processing requirements most of the plant based fibers are become center of research. This work used one of the novel reinforcements viz. “coconut sheath”. This reinforcement is directly drawn from the bottom portions of the coconut tree followed by minimum pre-processing before being used. Fiber volume fraction (FVF) is one of the most important factor when composite is in concern. The optimal level of reinforcement only can exhibit good bearing property. In this work, there four different fiber volumes were practiced in order to find the optimal fiber volume fraction. Density and hardness were taken as a measure for rheological properties, where flexural, ILSS and impact tests for mechanical properties. Result shows that, the trend in all the properties increased as a function of increase in fiber volume fraction except for impact strength.

Keywords: *Coconut Sheath, Polyester Composite, Fiber Volume Fraction and Mechanical Test.*

1. Introduction

The growing global environmental concern, high rate of depletion of petroleum resources, as well as new environmental regulations have forced the search for new fiber reinforced composite materials that are compatible with the environment [1]. Natural fibers exemplify environmentally friendly alternative reinforcements to conventional reinforcing fibers, due to the following advantages; they are abundantly available renewable resources, nontoxic, inherent biodegradability, low density, less cost, a range of mechanical properties, and less abrasiveness [2-6].Interestingly, several types of natural fibers which are abundantly available like oil palm, banana, sisal, jute, wheat, flax straw, sugarcane, cotton, silk, bamboo and coconut have proved to be good and effective reinforcement in the thermo-set and thermoplastic matrices [7-14]. Among the natural fibers, coir could be used as reinforcement, because of its hard-wearing quality, durability and other advantages, for any type of the polymer matrix [15]. Mat of coir loose fibers extracted from the coconut husk performed well compared to the stand alone glass mat reinforcements [16]. Coconut sheath is a naturally woven-type fiber that can be found in the branches of the coconut tree. Only preliminary studies of coconut leaf sheath fibers have been reported in the literature [17].

Fiber volume fraction is one of the major factors which vary the composite strength. Increase in fiber volume fraction may improve the mechanical strength up to some extend; many works reported to supported this statement [18-21]. Hence in this work, the effect of fiber volume fraction on the mechanical and rheological properties of the novel reinforced polyester composite was investigated.

2. Experimental Details

2.1. Materials

Unsaturated Polyester (General Purpose grade) was used as a matrix. Unsaturated polyester resin, Methyl Ethyl Ketone Peroxide (MEKP) as catalyst and Cobalt-Naphthenate as accelerator were used. Coconut sheath was used as reinforcement with minimum processing like washing, drying, etc. Commercially available E-Glass chopped strand mat was also used as reinforcement for comparison purposes.

**Corresponding Author - E- mail: isiva@ymail.com*

2.2. Fabrication and characterizations

As received naturally woven coconut sheath is used as reinforcement to the unsaturated polyester resin. Catalyzed resin was poured in the mold cavity which was initially protected with wax followed by the stacking of consequent coconut sheath layers. Composites were fabricated in four different fiber volume fractions as 21, 29, 33 and 41%.

All the composites were fabricated under 50 kg/cm2 with uniform thickness of 3mm each. Density of the fabricated composites measured under Archimedes principles and hardness of the composites measured through Durometer (Shore D-ASTM D2240). Flexural, ILSS and Impact tests were conducted as per ASTM D790, 2344 and 256 respectively.

3. Results and Discussion

3.1. Effect of fiber volume on density and hardness

Density of the composite greatly enhances the specific strength of the composite. Figure 1 illustrates the variation of density as a function of the fiber volume fraction. Initially, the addition of naturally woven coconut sheath produces very less density composite. Further addition of the coconut sheath with 31 and 34% made a little increase in the density. With 42% of fiber volume peek density was recorded. Samples were observed in the optical microscope for understanding the laminate structure. Incorporation of 41% fiber volume made agglomeration in the composite structure. Since a large mass of fiber packed in the fixed composite volume, high density value observed.

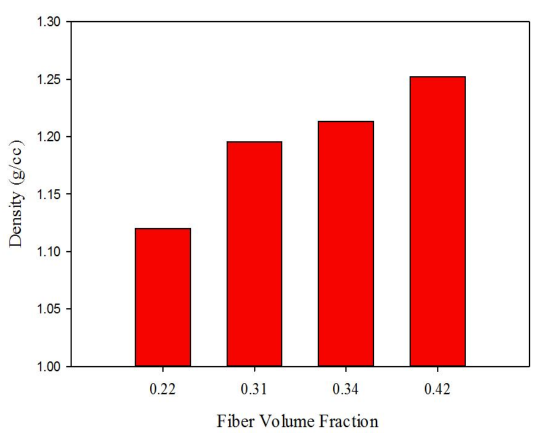

Fig. 1 Effect of Fiber Volume Fraction on Density

Figure 2 shows the variation in the hardness with respect to the fiber volume fraction. Uneven change in hardness was observed with the increase in fiber content was noted in the fabricated composites. For the volume fraction of 31, 34 and 42% hardness varies from 76 to 77. However, the thickness of the composite is little higher for 42% fiber volume composite.

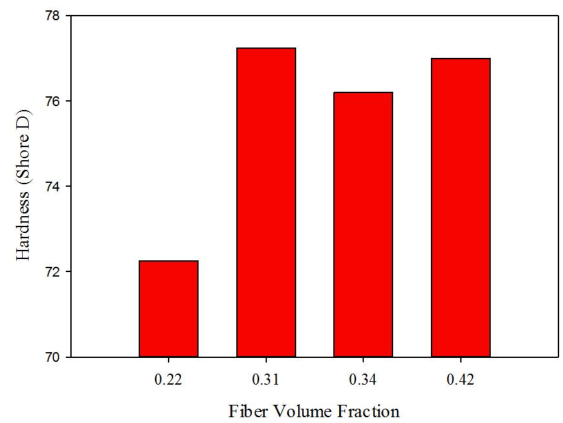

Fig. 2 Effect of fiber volume fraction on Hardness

3.2. Effect of fiber volume on flexural strength

Three point bending was conducted as per ASTM D790. Figure 3 shows the change of flexural strength with respect to increase in fiber volume fraction. An increasing trend was recorded with the increase in the fiber volume fraction. Since the composite prepared with higher volume fraction than the 42 made agglomeration those were not listed here.

However, the composite with 42% volume fraction was also higher thick with higher density; the composite with 34% volume can be preferred. The fractured specimens of 42% fiber volume appeared with more delamination compared to other composites.

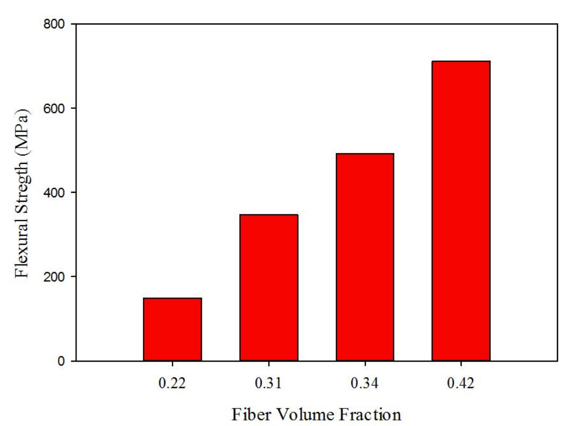

Fig. 3 Effect of Fiber Volume Fraction on Flexural Strength

3.3 Effect of fiber volume on inter-laminar shear strength

Three point bending was conducted as per ASTM D2344. Figure 4 shows the change of inter-laminar shear strength with respect to increase in fiber volume fraction. As similar to bending strength, inter laminar behavior also follows the same trend of increase in values with respect to fiber volume fraction. However, the increase is little high at 42% volume. Perhaps, more de-laminations were noted in the tested composite specimen.

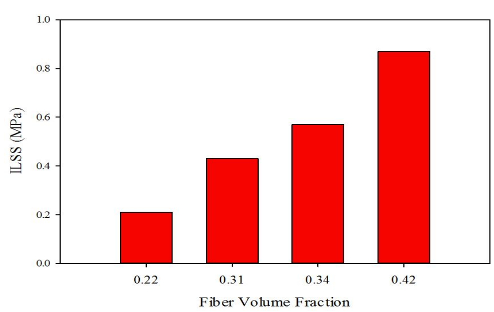

Fig. 4 Effect of Fiber Volume Fraction on Inter-Laminar Shear Strength

3.3 Effect of fiber volume on impact strength

Three point bending was conducted as per ASTM D256. Figure 5 shows the change of impact strength with respect to increase in fiber volume fraction. Compare to the last two fiber volumes, 0.22 and 0.31 were having less significance in the improvement of impact strength. The reinforcing effect on impact strength can be enhanced due the 'spongy' nature of the natural fiber. These structures absorb more impact loads compared to the solid fibers. Hence such good energy absorption achieved with this new kind of reinforcement. A little difference was noted between the 0.34 and 0.42 fiber volumes. However, larger de-laminations noted with the 0.42 fiber volume composite.

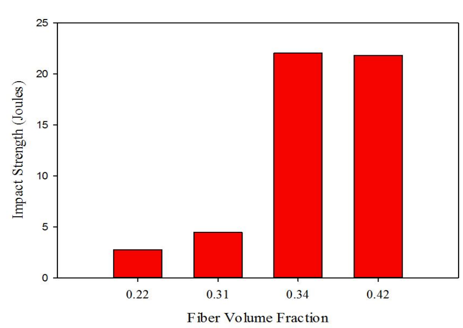

Fig. 5 Effect of Fiber Volume Fraction on Inter-Laminar Shear Strength

4. Conclusions

i. Based on the experiment, the following conclusion were made,
ii. An increasing trend in strength was observed with respect to increase in fiber volume fraction.
iii. Formation of agglomeration happened beyond the 0.42 volume fraction of fiber
iv. 0.42 fiber volume fraction exhibits a greater mechanical strength
v. However, due to higher density, thickness and more de-laminations, 0.42 fiber volume fraction cannot be the good for the coconut sheath reinforced polyester composite
vi. Based on the observations fiber volume fraction of 0.34 can be optimum for the novel naturally woven coconut sheath/polyester composite

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