Comparative Analysis on Mechanical Behaviour of Jute and Bagasse Fiber Reinforced Polymer Composites

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Abstract

In this work, mechanical properties of polymer reinforced with natural fiber were studied. A comparative analysis was performed on the mechanical properties resulting from the addition of jute and bagasse fibers in epoxy based polymer composites. The tensile strength, flexural strength, impact energy and hardness were assessed according to industrial norms. Both the fibers reported to increase the evaluated mechanical properties of the composites. Comparatively, jute fiber was proved more efficient as reinforcement of epoxy to increase its mechanical properties.

Keywords: Polymer Composite, Jute Fiber, Bagasse Fiber, Mechanical Properties

1. INTRODUCTION

The modification of the mechanical properties of polymers by the reinforcement of fibrous materials has shown a great promise and is the research area of significant interest. The fibrous reinforcements available worldwide includes metallic, organic, inorganic and natural. Due to the environmental concern, the possibility of using natural fiber to improve the mechanical properties of polymer composites has attracted the interest of material scientist worldwide [1-3]. Moreover, the diversity of natural fiber makes them to be used as a replacement of traditionally available synthetic fibers in various applications [4-9]. It is well known that the mechanical properties of unfilled polymers are very low, but higher magnitude of mechanical properties can be obtained by the addition of natural fibers as reinforcement [10]. Van et al. [11], reported that the mechanical properties of natural fibers such as jute are very good and making them competent with synthetic fibre such as glass. Sanjay et al. [12] reported the creep and dynamic mechanical behaviour of jute fiber reinforced epoxy composites. They concluded that incorporation of jute fiber is found to significantly improve the creep resistance and strain rate of composites. Lee et al. [13], fabricated jute fiber reinforced polypropylene composites and concluded that both tensile modulus and strength of reinforced polypropylene composites improved with increased fiber loading. Naguib et al. [14] evaluated different mechanical properties of bagasse fiber reinforced polyester composites. The experimental results revealed that a steep increase in flexural strength and Young's modulus was achieved with bagasse fiber. In a recent study, increase in the impact strength of bagasse fiber reinforced polyester composites was reported by Candido et al. [15].

In the present untenable environmental situations natural fibers are proving superior reinforcing material in terms of low cost, biodegradability, higher mechanical properties when compared to traditional materials. The main objective of this experimental study is to fabricate the natural (bagasse and jute) fibers reinforced epoxy composites and to evaluate their mechanical properties such as tensile strength, flexural strength and impact strength.

2. EXPERIMENTAL DETAILS

a. Materials And Composite Fabrication

For the fabrication of the composite, epoxy resin with corresponding polyamine hardener was taken as a matrix material while jute and bagasse fibers were taken as reinforcing constituent. Three composites with varying proportion of resin (80-95 wt.%) and corresponding fiber (5-20 wt.%) were fabricated by conventional hand-lay-up technique. For curing, hardener was added to the epoxy in the ratio of 10:1 by weight. Composites were fabricated in the form of plaque (150*150*10 mm dimension) through 24 h casting at room temperature. Finally these plaques were cut into required dimensions for the evaluation of mechanical properties.

b. Mechanical Characterization

The fabricated bagasse and jute fiber reinforced polymer composites were evaluated for their mechanical viz. Tensile strength, flexural strength, impact energy and hardness properties. The tensile strength was evaluated on universal testing machine (UTM) INSTRON 1195 following ASTM D3039-76 test standard. The flexural strength (represents the resistance of the composite to deformation under radial stresses) measurement was carried out as per as the ASTM D2344-84 standard on the same UTM. Impact energy (material ability to with stand sudden shock by rapid dissipation of the stress through the bulk of the composite material) tests were carried out on flat samples as per ASTM D 256 using an impact tester machine IT 504. Hardness (resistance to indentation under loads) was measured on a digital hardness tester on Rockwell-R scale. Tests were carried out at room temperature for five samples of each composition and mean is reported.

3. RESULTS AND DISCUSSION

a. Tensile strength

The variations in the tensile strength of the fabricated composites as a function of fiber content (wt.%) is presented in Figure 1. It can be seen that bagasse and jute fibers addition increases the tensile strength of the epoxy composites. This increase in tensile strength reaches a maximum value of 31.35 MPa and 35.53 MPa for 20 wt.% bagasse and jute fiber reinforced composites respectively.

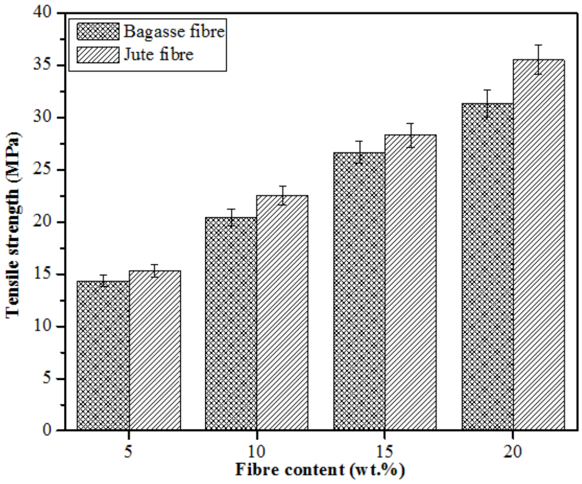

Figure 1 Tensile strength of the composites.

b. Flexural strength

The average flexural strength of the composites is seen in Figure 2. As expected, flexural strength considerably increased with increasing both the bagasse and jute fiber content. All of the composites with jute fiber were shown to have higher flexural strength than the composites with bagasse fiber. The bagasse fiber reinforced composites achieved flexural strengths in the range of 19 to 38 MPa. Using 20 wt.% jute fibers in the composite achieved a maximum increase in flexural strength of ~4% over 20 wt.% bagasse fiber reinforced composites.

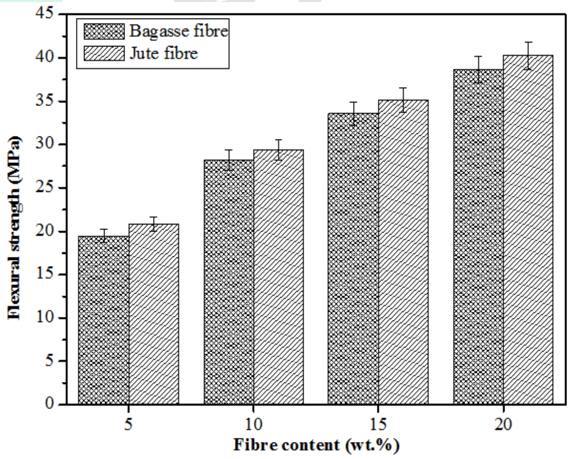

Figure 2 Flexural strength of the composites.

c. Impact strength

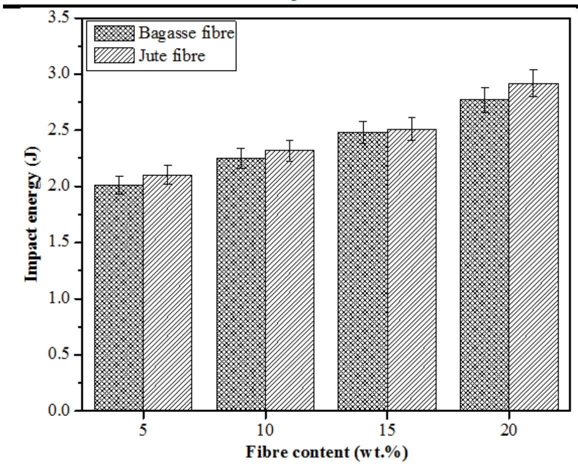

Figure 3 Impact energy of the composites.

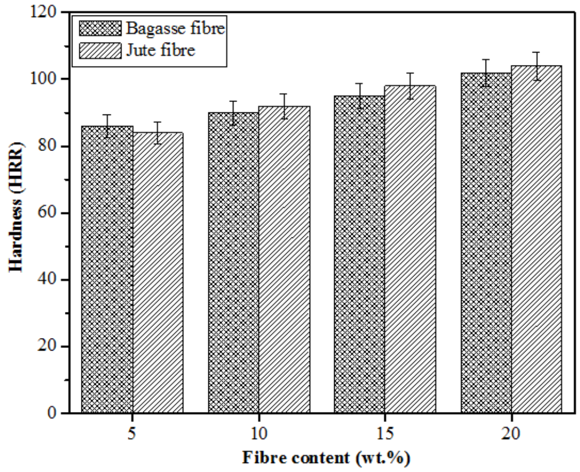

Figure 4 Hardness of the composites.

Figure 3 shows the variation of impact energy for the bagasse and jute fiber reinforced composites in accordance with ASTM D256. As expected, the impact energy increased as the level of bagasse and jute fiber content increased. The bagasse fiber reinforced composite presented impact energy improvement of ~38% with the addition of 20 wt.% fiber. The impact energy increased from 2.1 J to 2.92 J with the addition of jute fiber content from 5 to 20 wt.%. The increase in impact energy reaches a maximum value of 2.77 J and 2.92 J for 20 wt.% bagasse and jute fiber reinforced composites respectively.

d. Hardness

Figure 4 presents the results of hardness for the bagasse and jute fiber reinforced composite samples. Adding bagasse and jute fibers were found to influence the hardness positively. It is can be seen that for the composite with bagasse fiber, the value of hardness increases from 86 R-scale for 5 wt.% composite to 90, 95 and 102 for 10, 15 and 20 wt.% based composites (an increase of nearly 5%, 10%, and 20% of the hardness). Compared to the hardness of bagasse fiber reinforced composite, the hardness of the composite with jute fiber content of 5 wt.% (84), 10 wt.% (92), 15 wt.% (98) and 20 wt.% (104) shows greater value, and this means the jute fiber reinforced composites have of a greater hardness than bagasse fiber reinforced composites.

4. CONCLUSIONS

The experimental results of bagasse and jute fiber reinforced epoxy composites in the present study support the following conclusions:

Bagasse and jute fiber reinforced epoxy composites exhibit increased mechanical properties. The presence of bagasse and jute fiber improved the tensile strength, flexural strength, impact energy and hardness of the epoxy composites significantly. Bagasse fiber reinforced epoxy composites exhibit tensile strength of 14-31 MPa, flexural strength of 19-38 MPa, impact energy of 2-2.77 J and hardness of 86-102 on Rockwell R scale. Whereas, jute fiber reinforced epoxy composites exhibit tensile strength of 15-36 MPa, flexural strength of 20-40 MPa, impact energy of 2-2.92 J and hardness of 84-104 on Rockwell R scale. Jute fiber proved more efficient as reinforcement in epoxy composites with better mechanical results as compared to bagasse fiber reinforced epoxy composite.

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