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Determination of tensile properties of sugarcane bagasse fiber reinforced with different proportions of polymer composite

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ABSTRACT

Now it had become necessary to search new materials and implementation of those materials for manufacturing industries due to huge consumer pressure and new environmental policies. Because of this, in the recent years, the use of natural fibers as reinforcement in thermoplastic and thermosetting matrices has gained much interest, due to their good qualities such as low cost, low density, huge availability, biodegradability quality, and renewability. So in this aspect sugarcane bagasse fiber is one of the best options due to its availability and also it is an end product in sugar industries. In this paper it is focused on the tensile strength of sugarcane bagasse in the mat form is reinforced with the epoxy resin matrix and how it can be achieved or replaced with existing that is sugarcane bagasse fiber in the discontinuous and random orientation fibers reinforced with the epoxy resin matrix. This study also compares the percentage of fibers reinforced with epoxy resin to increase the strength.

Keywords— *Sugarcane Bagasse Fibers (SBF's), Epoxy resin, Mat form, Sodium hydroxide, Cellulose*

1. INTRODUCTION

Generally, naturally available biodegradable fibers are used as raw materials in the paper industry because of its good binding strength or as combustible for energy production. Since it is a renewable resource, economic and is biodegradable. So it gained importance to improve the composite's mechanical physical and thermal properties. Natural composites are low cost raw materials while comparing with synthetic fiber, automotive and aerospace industries now focusing on interest in the sourcing of cheaper raw materials due to continuous research and the natural fiber composites have maintained a position at the top of the list [1].

Also it has been found some drawbacks, such as the incompatibility between fibers and polymer matrices, the tendency to form aggregates during processing and the poor resistance to moisture which reduces the use of natural fibers as reinforcements in polymers and to improve the strength we must remove the natural waxes present around the fibers surface and other non-cellulosic compounds. It can be done by using various chemical treatments such as alkali treatment, bleaching, silane treatment, esterification, use of compatibilizer, plasma treatment, acetylation, etc., before compounding to remove natural waxes.

In general, there are two functions will be possessed by chemical coupling agents. The first function is a reaction with hydroxyl groups of cellulose and the second is the reaction with functional groups of the matrix. [2][3]

Hydroxyl groups present around the fibers' surface can be removed by using chemical modifications either Esterification or by using maleic anhydride modified polypropylene (MAPP) as a coupling agent. For the alkali treatment of natural fibers the chemicals used are sodium hydroxide (NaOH, 98% purity, Sigma–Aldrich France) and acetic acid (CH3COOH, 99–100% purity, Riedel-de Haën).[4]

The polymer matrix is one of the popularly using inorganic fillers in the field of composite materials, which results in composite material with better mechanical and thermal properties. In recent years, organic fillers, such as cellulose-based fibers are slowly becoming the best suitable materials in the market to replace synthetic materials. Cellulose-based fibers (natural fibers) extracted from renewable and relatively inexpensive resources, and because of that, the addition of natural fibers, such as wood fibers, flax or sisal to polymeric matrices can result in feasible composites concerning mechanical and economic points of view. Composites based on natural fibers have environmentally superior qualities to those based on synthetic fibers, such as fiberglass. Recent studies reported that the reinforcement of composites with natural fibers uses 45% less energy, and results in lower air emissions. Another major factor is the recyclability and biodegradability properties of natural fibers composites and the major sources of natural fibers, which are renewable [5]. Poor interfacial adhesion property of natural fiber may decrease strength [6]. Natural fiber with surface modification will increase its overall strength [7, 8, 9] Removal of the lignin will increase the natural fiber strength [10]. There is a lot of provisions to develop natural fiber against hybrid fiber due to its availability and it is also treated as one of the future composite material fiber [10, 11, 12].

Non corrosion property of the natural fiber composites can be increased because few natural fibers which absorb less percentage of water [13]. Non-homogeneity of the fiber results in a reduction in the strength [14]. Natural fiber reinforced composites can also be used in structural building work [15]. Recently natural fiber reinforced with epoxy resin composite materials playing its vital role in the furniture works which leads to reduce the usage of wood directly from fruitful trees still which have life. By decreasing the usage of tree wood directly by making some alternatives, such as natural fibers reinforced (compulsorily it must be the end waste product) with epoxy resin will also increase the availability of oxygen in the atmospheric air which is essential for living human beings and animals. By this, it is possible to have a move with a natural phenomenon.

2. CHEMICAL TREATMENT OF THE NATURAL FIBERS

Sugarcane bagasse is constituted by three main components such as cellulose, lignin and hemicellulose. Cellulose which is a raw material obtained from cellulose derivatives manufactured products such as ethers and esters. Cellulignin which is a new and promising material and like cellulose, can be used as reinforcement of polymers due to its fibrous structure. To obtain proper fibers/matrix interactions, the whole fibers must be subjected to a chemical treatment to bleach and clean their surface. During this alkali treatment, extracted fibers are first washed thoroughly with water then kept for 48 h in a 1.6 mol/l sodium hydroxide [NaOH] aqueous solution. After removing the fibers from the caustic solution, it must be quickly reacted with acetic acid (100 ml) to neutralize the remaining caustic, after which they are air-dried for 24 hrs. This chemical treatment removes a certain amount of lignin, wax and oils that covers the external surface of fiber's cell wall.

In this work, both cellulose and cellulignin (fiber without hemicellulose) were obtained through the end product of sugarcane bagasse fiber safter extracting the juice. During soft hydrolysis, cellulignin was obtained from sugarcane bagasse, resulting in fibers with a high content of cellulose and lignin. After the removal of hemicellulose during the hydrolysis, the fiber shape was maintained as initial. In a later stage, the cellulignin was treated in the alkaline medium for lignin removal, obtaining the cellulose fiber.

3. MAT AND SPECIMEN PREPARATION FROM SUGARCANE

3.1 Bagasse fiber

Chemically treated sugarcane bagasse fibers were separated as short and long fibers as shown in figure 1(a). For the further process, only the long fibers were selected. Long fibers were straightened by the application of hot air. Mat preparation was done manually and finally able to get the mat as shown in the following figure 1(b)

(a) (b)

Fig. 1: (a) Surface modified SBF's, (b) Mat form of SBF's

Later this fiber mat is used to prepare a composite material by using hand layup process followed by vacuum bagging method.

During the hand layup process, mould surfaces were cleaned with acetone and allowed it to dry in the air to reduce the impurities. Then surfaces were applied with petroleum jelly for the easy removal of the specimen. Above the gel coat, a layer of epoxy resin was applied. Over which one mat layer was placed carefully, these process was repeated till getting required thickness with a proper proportion of 5% & 10% sugarcane bagasse fiber mat. A roller was used to obtain a neat surface.

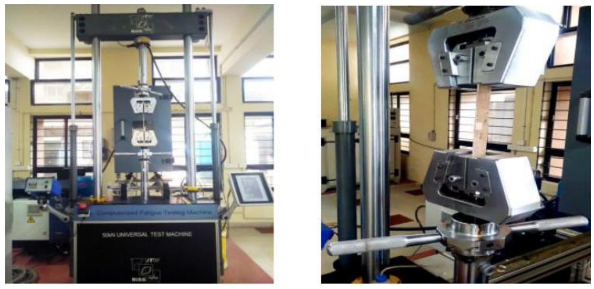
After a few minutes vacuum bagging sheets were placed properly to make air tight seal. The vacuum pump was used to trap air from the bagging region; this process was continued until space becomes a vacuum region. For proper curing of the specimen vacuum condition must be maintained for 24hrs. After removing the specimen from the mould expose this to the atmospheric air about 24hrs for proper cure. Figure 2(a) Shows specimen inside the Vacuum chamber and figure 2(b) shows obtained composite in a cured form.

(a) (b)

Fig. 2: (a) Vacuum bagging method, (b) Prepared composite

4. TEST METHODS

For all standard tests, composites were analyzed in BIS ITW 50kN Universal Testing Machine equipped with pneumatic claws.



(a) (b)

Fig. 3: (a) BIS ITW 50kN UTM. (b) Specimen under load

In the tensile tests, three specimens each of composites with fibers 5% and 10% were analyzed, with dimensions in according to the ASTM D3039 standard with dimension 252 mm/ min crosshead speed was maintained. During the test, the gauge length was maintained as 190mm. Readings were recorded in the digital form in the system.

5. RESULTS AND DISCUSSION

5.1 Tensile test results

The tensile test is one of the major tests for structural members. The tensile test is used to determine the Young's modulus (MPa) and tensile strength (MPa) of the composite materials. Tensile tests on various percentiles of sugarcane bagasse fibers of 5% and 10% reinforced with 95% and 90% of epoxy resin composites respectively are shown in the following results.

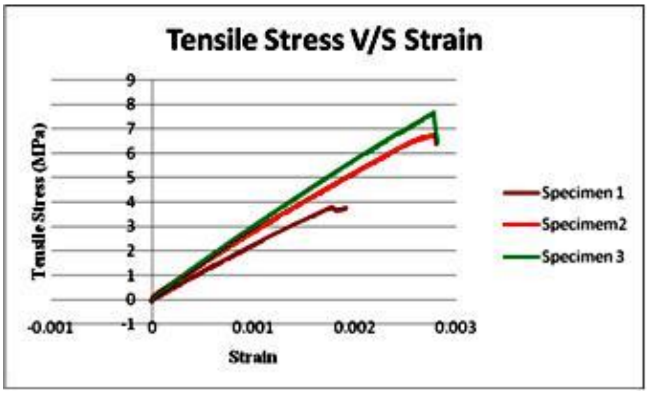


Fig. 4: Tensile stress V/S Strain curve for 5% SBF's with 95% epoxy resin composite material

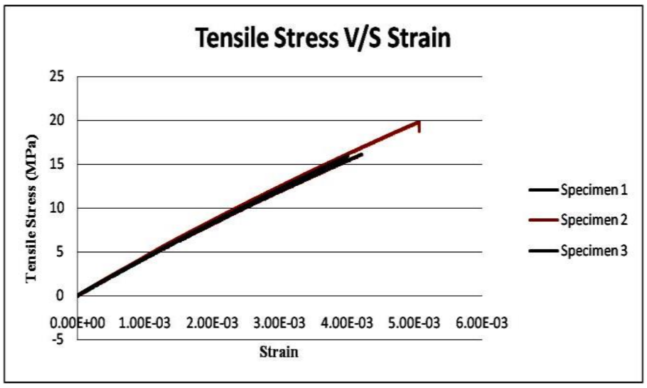


Fig. 5: Tensile stress V/S Strain curve for 10% SBF's with 90% epoxy resin composite material

By referring Fig 4 and Fig 5 it is clear that tensile stress increased with an increase in the fiber percentage. Also load carrying capacity in 10% fiber composite is more than that of 5% fiber composites. Further, it is noticed that the stress distribution curve is almost closer in case of 10% fiber composites due to the uniform distribution of the fiber in the mat.

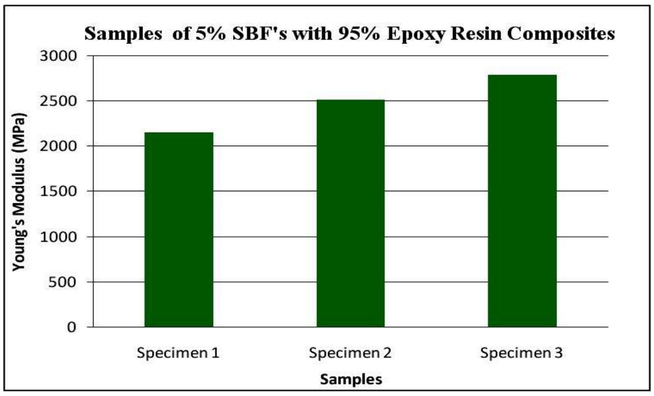


Fig. 6: Young's modulus for 5% SBF's reinforced with 95% epoxy resin composite material

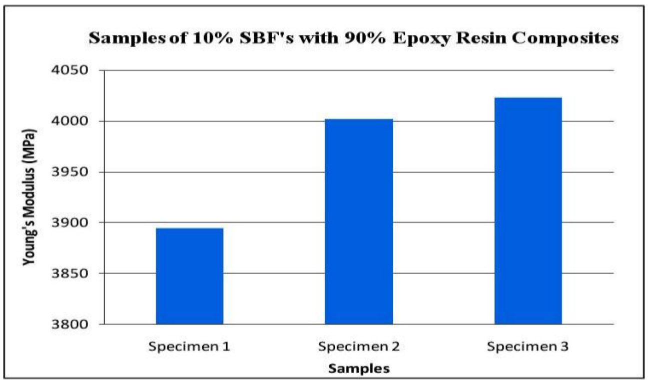


Fig. 7: Young's modulus for 10% SBF's reinforced with 90% Epoxy resin composite material

By referring figure 6 and figure 7 it is noticed that Young's modulus has increased with an increase in the percentage of fiber.

Considerably the Young's modulus has increased while comparing with compression moulding method and unwoven mat form of the fibers.

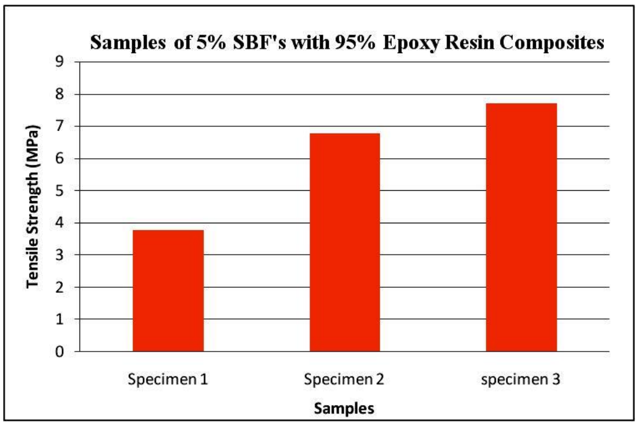


Fig. 8: Tensile strength for 5% SBF's reinforced with 95% epoxy resin composite material

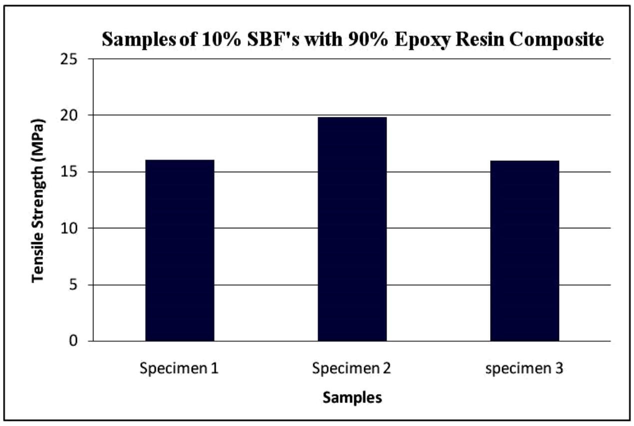


Fig. 9: Tensile strength for 10% SBF's reinforced with 90% epoxy resin composite material

From the above figure 8 and figure 9 it is clear that as the percentage of the sugarcane bagasse fiber in mat form is increased, it increases both the tensile strength as well as the tensile modulus. It is also evident that both the tensile strength and the tensile modulus increase, as the fibres in the normal linear form are replaced in the woven mat form.

6. CONCLUSIONS

Due to acute shortage in the metals, it becomes necessary to search alternative materials in that direction natural fiber reinforced materials are the best choice. By referring to the various journals related to the sugarcane bagasse natural fiber it is found that, after the proper surface modification of the fiber, the strength of the composite material will increases. It is also noticed that the woven mat form of the sugarcane bagasse fiber in the composite, shows its better strength over the unwoven form of sugarcane bagasse fiber in the composite. So young's modulus of the composite material has increased along with an increase in the tensile strength. Further, it is clear that as the percentage of the fiber increases it shows better strength.

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