Investigation on the mechanical characteristic of Ramie / Banana reinforced hybrid epoxy composite

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Abstract –The aim of the present study is to investigate and compare the mechanical properties of natural fiber which Ramie fiber and Banana fiber reinforcement epoxy hybrid composite. To improve the mechanical properties Ramie fiber was hybridized with Banana fiber. The Ramie and Banana fibers were prepared with different stacking sequence [Banana-Ramie-Banana], [Ramie-Banana-Ramie] two composite sample is developed. And then incorporated into the epoxy matrix (LY556 and HY951) by hand layup method to form composite. The tensile, flexural, impact, compression, hardness tests were carried out as per ASTM using hybrid composite samples. This study shows that stacking sequence of [Ramie-Banana-Ramie] composite sample that two surface layer of Ramie and a core layer of Banana fiber produced good mechanical properties.

Keyword- Natural fibre, Hybrid, handlayup, Ramie, Banana, mechanical properties, LY556, HY951

1. INTRODUCTION

The necessity of the low-cost materials and environmentally friendly materials have made researchersto carry out their research in natural fiber when compared with synthetic fiber. The natural fibers are replacing several conventional materials for numerous. The natural fibers derived from the plantslike banana, oil palm, jute, cotton, sugarcane, and many more The resultsof the previous literature survey concluded that the properties of the fiber reinforced compositesdepend upon the selection of fiber and matrix and the effective stress transfer between them. Inrecent years combining two or more fibers to manufacture composite materials have by several researchers due to the improvement in their properties. The dynamic and static mechanical properties of short banana /Ramie hybrid polyester composites by varying the volume fraction of both the fibers was studied. The banana fiber was taken as a core material, and ramie fiber was taken as a skin material, and vice versa was also prepared. They concluded that when high strength fibers were used as a core material, there was an increase in properties. the techniques for the fabrication of banana-fiber-cement composites They also concluded that when strong fiber was usedas a core material the strength of the composite, there will be an increase in properties. The stacking sequence of glass/bamboo composites on erosive wear behavior was studied They concluded that there was enhanced wear resistance when glass fiber was used as a skin material. Several authors have also treated the natural fibers by various methods and so found there was an improvement in properties. Concluded that pre-treatment of fibers with NaOH for a time of less than 10 min could improve the fiber properties. reinforced polypropylene with treated and untreated abaca fibers and found that property was increased when treated fiber was used found that when data ramie fiber was treated with NaOH, the mechanical properties were increased while a decrease in properties was found when the fiber was treated HCl. The mechanical properties like tensile, flexural, and shear of short fiber laminates increased when silane treatment was carried out. There is numerous literature which is available regarding the characterization of several natural fibers, but there are no works related to the characterization of bananal-ramie fibers. The composite was fabricated by varying the ramie, and banana fiber layers by hand lay-up processes. The developed composite was characterized by tensile, flexural, impact, compression, barcol hardness, and tests.

2. MATERIAL IS TO BE USED

Resin and Hardener

Araldite LY556 (Manufacturer: Huntsman) was used as an epoxy resin which has a density of 1.2 g/cc and the hardener used in the study is HY951 which has a density of 0.98 g/cc. Epoxy and hardener were mixed in the ratio of 10:1.

Banana Fibre

Banana which is also termed as Bambusa found in regions of South America. It is found in different forms like water bamboo husk, strip form and the form of fibres. The raw banana are gathered and cut into stripsThey are steamed and crushed. Biological enzymes are added for degumming; then banana fibres are carded and spun into yarn. It is sent to industries for making mats. The diameter of the bamboo fibre thread was ranging from 60 to 90 microns while the distance between the banana fibre threads in the mats was 120 to 150 microns. The jute and banana materials are taken in the form of bi woven mat

Ramie

Ramie is a plant of the Urticaceae family, derived from the bast of Bohemia nivea. The fibers are obtained from the outer part of the stem and have been used for centuries as a textile fiber in China, Japan and Malay Peninsula the exceptional tensile strength of the ramie fiber has motivated its application in composites.

Figure 1

Figure 2

ramie fiber in a thermosetting matrix using dynamic mechanical analysis revealed an increase in the storage modulus or stiffness of the composite as the fiber is incorporate The behavior of natural fiber-reinforced polymer composites might be improved by the incorporation of glass fiber. Thus, the incorporation of two or more fibers into a matrix has led to development of hybrid composites.

3. Method of composite developed

The composite materials were fabricated using the Hand lay-up process. Initially, the raw material was dried in sunlight for the removal of moisture. The resin and hardener were mixed in the ratio of 10:1. For uniform distribution of the mixture of resin and hardener rollers were used. First, a layer of resin was applied over the smooth surface, then, the fiber layer was placed over it. the layer of banana fiber was placed followed by the application of resin and rolling using a roller. Then, a layer of sisal was placed over it in the form of mat, further resin was applied and rolled usinga roller. Finally, a layer of banana fibers was placed, then, a layer of resin was applied followed by levelling using a roller. The process of manufacturing.

Figure 3

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Figure 4

Once the stacking gets completed, it was kept under the load of 25 kg and allowed it for curing at room temperature at room temperature under constant pressure. The resin which was in excess was squeezed out during the compression process

Figure 5

Figure 6

Figure 7

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Once the developed composites get dried, the testing samples were cut according to ASTM. The sample code for the developed composites

Characterization of the developed composites

The characterization of the developed composites was carried out by tensile, flexural, compression, impact and barcol hardness according to ASTM. For confirmation of the results, all tests done for five times, and the average values are noted down. The tensile strength of the developed composites was carried out according to ASTM D638 The test was carried out at room temperature and strain rate of 5 mm/min in the universal testing machine. The dog bone shape samples for tensile tests were cut using a saw cutter. The dog bone shaped samples were fixed between the grippers, and the load was applied until the failure occurs. The flexural strength was carried according to ASTM D790 using a three-point setup in the universal testing machine. The crosshead speed of the test was kept at 2 mm/min during the testing. During the testing process, the samples were subjected to load in the middle, and the values are noted until there is a fracture. The impact tests for the developed composites were done according to ASTM A370 using an Izod impact machine. The hammer angle was kept at 150° initially, and the notched specimen was kept in the sample holder. The energy absorbed during the fracture was noted. The compression properties of the developed composites were carried out according to ASTM D795 in the universal testing machine. Barcol hardness evaluated the hardness of the developed composites as per ASTM-D2583. The hardened steel rod with 1.25 mm in diameter was used as an indenter, and it has a conical angle of 30°. The load applied during the testing was 4.550 kg.

4.Results and discussions

In the current investigation, the manufacturing of the fiber reinforced samples was carried out by hand lay-up techniques were carried out. The main aim of the current investigation is to find the tensile, flexural, impact, compression tests, Shore D hardness, water absorption and biodegradation tests of the manufactured composites. The finding of the results is discussed in the following sections

TABULER COLUMN

Sl.no	Stacking Sequences	Sample/ specimen
1	Banana-ramie-banana	A
2	Ramie-banana-ramie	B

Tensile properties of the developed composites

The mechanical properties of the composites depend upon several factors like mechanical interlocking, types of bonds and van der Waals force. The strength of any developed composites depends upon the initiation of crack followed by propagation of crack on the matrix surface, and it depends upon the shape and orientation of the matrix surface. The ultimate tensile strength of the various manufactured composite samples was found out using a tensile test. The ultimate tensile strength was noted for all the specimens, and , their stress-strain graphs it canbe seen that when the load increases the displacement also increases simultaneously. The stacking sequence B has a maximum load-bearing capacity when compared to other manufactured composites. The ultimate tensile strength of ramie – banana – ramie composites are superior when compared to the remaining manufactured composite specimens. The increase in the ultimate tensile strength of Ramie – Banana– Ramie is due to the presence of the lignin content of the core layer which makes the fiber stiffer and tougher. The horizontal orientation of the Ramie fiber increased strength. The increase in the ultimate tensile strength may also be due to the proper adhesion between the matrix and the epoxy matrix. The developed composite B has a maximum strength of 24.56MPa followed by 19.97MPa for stacking sequence of specimen A developed composites. The debonding of the ramie fiber takes place very slowly when compared to remaining manufactured composites which increased ultimate tensile strength. The increase in the load-bearing capacity of the banana fiber. The reduction for the reduction of ultimate tensile strength in the case of other manufactured composites is due to the improper adhesion between the resin and the matrix. Thus, the developed Ramie – Banana – Ramie can be used where load-bearing capacity is applicable.

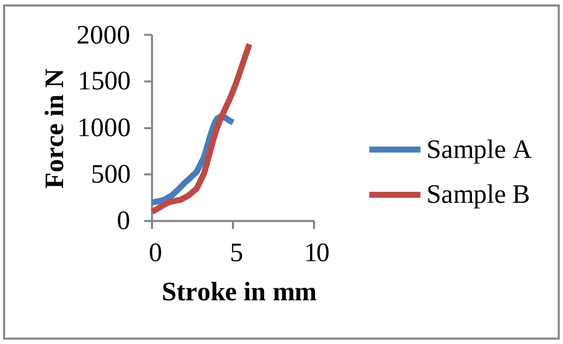

Figure 8

Flexural properties of the developed composites

The flexural strength is a property which measures the stiffness of the developed composites. The flexural strength of the manufactured composites is depicted The failure begins to develop when the crack was initiated at the tension side. The flexural strength of the ramie-banana-ramie is more when compared to the remaining composites. The sample B has a maximum strength of 0.50 MPa and sample A have a load of 0.27 MPa. The reason for the increase in flexural strength in B sample is due to the presence of stiffer ramie fiber which as a skin material, and it has enhanced load-bearing capacity. The higher surface roughness of the sisal fiber ensures that there is a perfect adhesion between the resin and matrix which resulted in increases in flexural strength. The proper adhesionbetween the matrix and the epoxy matrix has enlarged the stiffness of the matrix. The improper adhesion between the matrix and epoxy resulted in a reduction of stiffness in the remaining developed composites. The stress-strain graph of the laminated composites the good distribution of stress since the impurities and brittleness causing elements are removed leading to theenhanced flexural strength. when there is a proper adhesion between matrix and fiber.

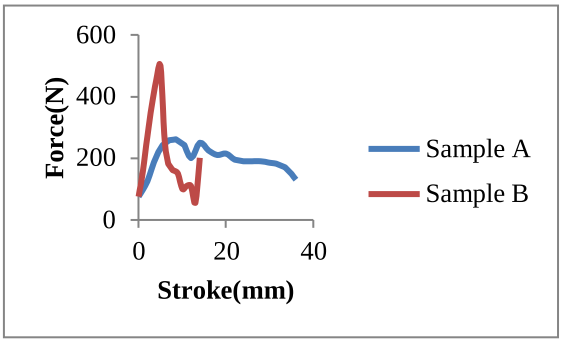

Figure 9

Barcol hardness properties of the developed composites

The hardness of the material is the resistance of any material to indentation. The Barcol hardness of the manufactured composites is given Barcol hardness Ramie-banana-Rame is more followed by banana-ramie-bananal. The increase in Barcol hardness is due to the resistance to penetration. The increase in values of Shore D hardness is due to the arrangement of the different fibers layer by layer.

Impact properties of the developed composites

There are many numbers of impact tests, but it is not always possible for the correlation of results of impact strength with material performance during service conditions. The standard impact tests are usually applied for evaluating the toughness of different materials under the same test conditions, and it cannot be applied for the prediction of the actual behavior of products. Therefore, the results of the tests cannot be used to express the correct toughness of the materials. The most commonly used tests for calculating toughness is Izod impact test which provides the. The impact strength of any material is the energy absorbed by the material before fracture. Impact strength is used for comparing several materials to find out the brittleness nature of the material. The impact strength of any composites depends upon the factors like crack and growth initiation, breakage of fibers, pull out of fibers, and delamination of the fibers. The impact strength values are depicted in. The impact strength for B sample was 3 J followed by 2 J for A samples. The impact strength was superior in the case of ramie-banana-ramie composites which is due to the fiber arrangement where the tough ramie fibers were present as the skin material. The increase in the composition of the ramie fibers increased impact strength property of the composites which is due to the enhanced shock absorbing capacity of the bagasse fibers. The increase in impact strength is due to the multiple ramie fiber arrangements in the stack layer. Similar kind of observations in impact strength The decrease in impact strength in A is due to the improper adhesion between the matrix and fiber and less energy absorbing capacity of fibers.

Compression properties of the developed composites

The ultimate compressive strength of the developed composites and their stress-strain values When compared with all developed composites ramie - banana-ramie composites had superior compressive strength when compared to other developed composites. The improvement in ultimate compressive strength is due to the excellent adhesion between the fiber and matrix. The same kind of increase in ultimate compressive strength

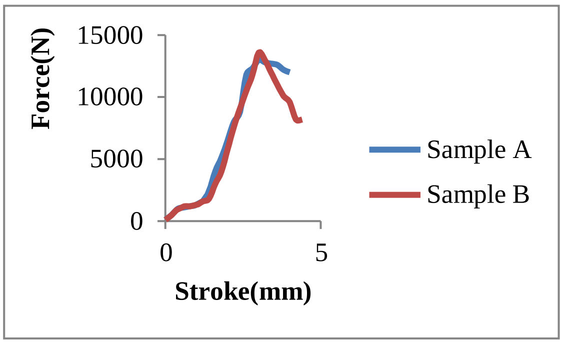

Figure 10

4. Test Report


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Test Report

Test Results

5. Conclusions

The hybrid composites sisal/bagasse fibers were produced by the hand lay-up process. The produced composites were characterized by tensile, flexural, impact, barcol hardness, and compression tests.

(i) Three layers of banana fibers resulted in enhanced ultimate tensile strength and impact strength due to the presence of three layers sisal fibers at the center and also due to better adhesion between matrix and banana fiber.

(ii) The core layer of banana and an outer skin layer of ramie composites increased flexural strength, barcol hardness and ultimate compressive strength due to the presence of banana layer at the middle. The fractography studies revealed the absence of cracks and pores which increased flexural and barcol hardness characteristics.

REFERANCE

1. D, J. D. J., Sai Krishnan, G., & Velmurugan, P. (2019). Investigation on the characteristics of bamboo/jute reinforced hybrid epoxy polymer composites. Materials Research Express.
2. James D, J. D., Manoharan, S., Saikrishnan, G., & Arjun, S. (2019). Influence of Bagasse/Sisal Fibre Stacking Sequence on the Mechanical Characteristics of Hybrid-Epoxy Composites. Journal of Natural Fibers, 1– 11.
3. Venkateshwaran, N., ElayaPerumal, A., & Jagatheeshwaran, M. S. (2011). Effect of fiber length and fiber content on mechanical properties of banana fiber/epoxy composite. Journal of Reinforced Plastics and Composites, 30(19), 1621–1627.
4. Park, J.-M., Son, T. Q., Jung, J.-G., & Hwang, B.-S.Interfacial evaluation of single Ramie and Kenaf fiber/epoxy resin composites using micromechanical test and nondestructive acoustic emission. Composite Interfaces, 13(2-3), 105–129.
5. Romanzini, D., Ornaghi, H. L., Amico, S. C., & Zattera, A. J. (2012). Influence of fiber hybridization on the dynamic mechanical properties of glass/ramie fiber- reinforced polyester composites. Journal of Reinforced Plastics and Composites, 31(23), 1652–1661.
6. Boopalan, M., Niranjanaa, M., & Umapathy, M. J. (2013). Study on the mechanical properties and thermal properties of jute and banana fiber reinforced epoxy hybrid composites. Composites Part B: Engineering, 51, 54– 57.