Analysis of Mechanical Properties of Jute Fiber Reinforced Epoxy And Polyester Composites

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Abstract- *The advantages of composite materials over the traditional material have encouraged us to use composite material in place of traditional material. Scientist and researchers have found the composite materials have way better mechanical properties also they are light weight, easy to handle and most peculiar advantage is that they are renewable and nontoxic. Natural Fiber Composites (NFCs) have natural fiber as the reinforcement material in composites.*

In this study jute fiber is used as the reinforced material and epoxy and polyester resins as the matrix material. The woven jute fiber is used as the reinforcement material and which is reinforced into the epoxy resin and polyester resin with specified percentage by volume. The composition of the fiber into the composite is maintained in specific percentage of (12%, 24%, 36%, 48%, and 60%) by volume and mechanical properties viz. flexural and impact strength of specimens are calculated and compared at different fiber loading.

Keywords- Natural Fiber Composites (NFCs), Composite material, Jute Fiber, Epoxy resin, Polyester resin, Flexural strength, Impact Strength

I. INTRODUCTION

The invention of Composite materials and their manufacturing process has been proven a boon for the engineering and manufacturing science. They have preferable mechanical properties viz. impact properties, tensile properties, and flexural properties in comparison with former conventional materials. For these advantages they are predominantly used in the automobile industry, aerospace industry and construction industry.

Two or more materials of different physical and chemical properties compounded to make a third material which is known as composite material. Composite material may have different properties than that of the parents materials but they have specific properties for the certain purpose for example they may be tougher, lighter, conductive or resistant to heat or electricity, permeable or impermeable to water and other better mechanical properties like strength and stiffness etc. Composite material have two constituent one is reinforcement material which is generally a tougher material and other is matrix which generally lighter material. Matrix provides the mechanical support to the reinforced material and also helpful in transferring force among the reinforced material. Reinforcement helps in improving the mechanical properties viz. Flexural properties, impact properties, stiffness and tensile properties of the composites material.

On the basis of matrix material, composites are of three types

1. Metal Matrix Composites
2. Ceramic Matrix Composites
3. Polymer Matrix Composites

Jute fiber

Jute is soft, shiny and long fiber in corchorus genus of Malvaceae family. Jute fibers are biodegradable and affordable that is vastly produced in tropical and subtropical region and mainly produced in India, Bangladesh and China. Jute fiber is a bast fiber that means obtained from the phloem of plant. A natural microbial process known as retting is used to obtain jute fiber from the mature stem of jute plant. Jute stems tied in bundles are allowed to steep in the pond or ditch water for 18 to 30 days. Due to the microbial effect decomposition of sugar, pectin and hemicelluloses under the favorable condition takes place. This microbial effect loosens and softens the fibers from the woody stalk and the non fibrous tissues. Fibers are extracted manually with jute fiber extractor from the jute stalks and hung to dry. The extracted fibers are then dipped in tamarind water to remove their dark colour and then conditioned with conditioners..

(a) Jute Plant

(b) Jute Fiber

Figure 1.1

II. LITERATURE REVIEW

There is a large increase in the production of natural fiber based composites in recent years because of their various attractive features like availability, low cost, flexibility etc. various experiments are performed by different researchers to improve the mechanical and chemical properties of natural fiber based polymer composites.

Cazauranget et al. (2003) studied the mechanical behavior of henequen fiber and concluded that these fibers were suitable for reinforcement in thermoplastic resin.

Chawla and Bastos (2009) studied the effect of fiber volume fraction on young's modulus, tensile strength and impact strength and impact strength of untreated jute fiber in unsaturated polyester resin.

Patnaik A. et al. (2009) Study the Tribo-Performance of Polyester Hybrid Composites: Damage Assessment and Parameter Optimization using Taguchi Design and find the effect of different factor on the erosive behavior of polymer composite material.

Biswas S. et al., (2010) studied the Effect of Ceramic Fillers on Mechanical Properties of Bamboo Fiber Reinforced Epoxy Composites and find that the effect of filler content and type of filler on the performance of hybrid composite based on polymeric matrix.

Pothan et al (2010) studied the banana-glass hybrid composites and conclude that layering pattern or the geometry of the composites has a great effect on the dynamic properties of the composites.

K. Z. M. Abdul Motaleb (2018) jute and pineapple fabric reinforced polyester resin composites were manufactured. The influence of alkali treatment on the mechanical properties i.e. tensile strength, elongation at break and young's modulus of composites were investigated after treating the jute and pineapple fabrics with various concentrations of NaOH.

III. EXPERIMENTAL SETUP

The choice of material of reinforcement and the matrix with binder is wisely decided and simple hand lay-up technique is used for the fabrication of the composites. This chapter also discuss about the testing performed on the specimen for determining its mechanical properties. We discuss the two main properties viz. flexural and impact properties of the specimen by testing then on the desired load. The numbers of specimen are kept more than the number of the test performed and size is according to the standard size. The woven jute fiber is used as the reinforcement material and which is reinforced into the epoxy resin and polyester resin specified percentage by volume in different specimen. The composition of the fiber into the composite is maintained in specific percentage of (12%, 24%, 36%, 48%, and 60%) by volume to test the properties of specimens with different fiber loading.

(a) Jute-Polyester specimen

(b) Jute-Epoxy specimen

Figure 3.1

Mechanical testing

Flexural test

Universal testing machine is used to find out the flexural strength of the composites. The speed of the machine for the test is maintained constant at 2.38 mm/min. Where the humidity is 45% and temperature is 37 °C. For each composition two samples are taken and average is recorded as per ASTM D790-03 the dimension of the specimen for flexural strength is 150 × 30 × 7 mm.

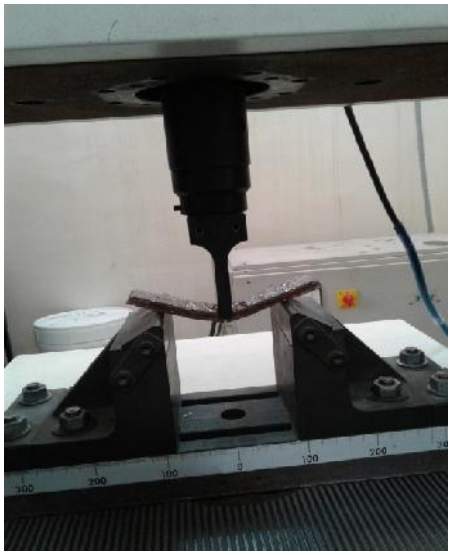


Figure: -3.5 Universal Testing Machines

The flexural strength of the material is expressed as the stress at the instant of failure on the outermost fiber of the specimen. In conventional test three points simply supported bending equipment is used and value is given in MPa.

Impact Test

The test is performed on the specimen on Tinius Olsen an impact testing machine. The specimen is manufactured according to ASTM D256. On the composite specimen Izod impact test is to be performed which is the preferred test for the plastic or polymer specimen. Minimum five individual reading are required to get the good average of the impact strength. Material, size of the test specimen, shape and the length of the specimen are the key factors that affect the reading of the impact energy.

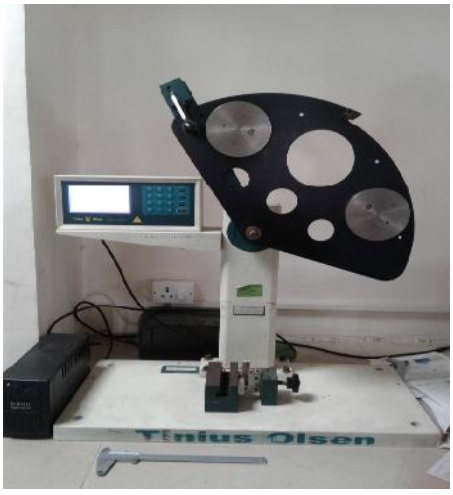


Figure: - 3.6 Tinius olson Machine for testing Impact strength

The pendulum hammer has a constant capacity of 25.157 J. The energy absorbed in two way in the fracture one is the form of work of plastic deformation of the specimen and other one is in the form of work required to make fracture in the specimen.

IV. RESULT AND DISCUSSION

In this study the flexural and impact strengths are evaluated and compared and their value in the result are shown in the following tables.

4.1 Flexural strength

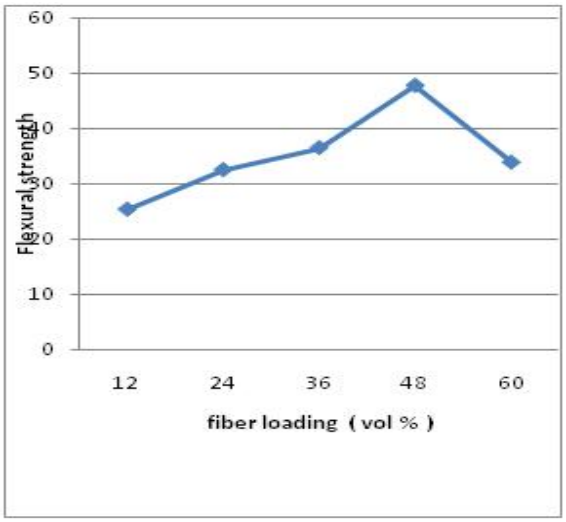
In Table 4.1 it is clearly shown that at the different weight percentage of jute fiber loading there is different value of flexural strength for both epoxy and polyester composites. From the table it can be calculated that with the increase in fiber loading the result of the flexural strength becomes better up to 48% by volume fiber loading and after that flexural strength starts to decrease as loading with 60 % has shown a sharp drop in flexural strength as the specimen starts yielding even with a lesser force.

Table: 4.1 Flexural Strength at different jute fiber loading

Specimen	Flexural strength in N/mm²
EJ_1	25.32
EJ_2	32.48
EJ_3	36.46
EJ_4	47.68
EJ_5	33.83
PJ_1	12.78
PJ_2	14.72
PJ_3	17.04
PJ_4	20.24
PJ_5	19.90

4.1.1Effect of fiber volume on flexural strength in case of Jute Epoxy Composite

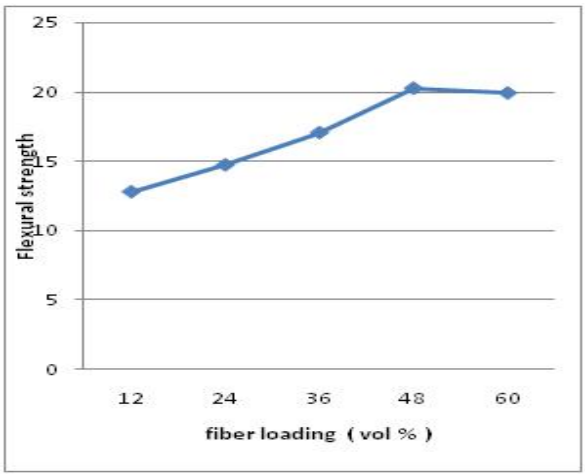
The line graph in Graph 4.1 shows the values of force at which the specimen begins to yield or the flexural strength of the jute epoxy composite. The flexural strength in case of the jute epoxy composite increases with the increase in fiber loading but with the further increase after 48% loading its value decreased drastically. Maximum value of flexural strength is 47..67 N/mm² at 48% by volume loading of jute fiber and minimum flexural strength of 25.31 N/mm² at 11% by volume loading of jute fiber.



Graph 4.1 Flexural Strength of Jute-Epoxy Composite

4.1.2 Effect of fiber loading on flexural strength in case of Jute Polyester Composite

From the line graph in Graph 4.2 it is clearly visible that in case of jute polyester composite the pattern of line graph remains almost the same but the values for the flexural strength are much lesser than the jute epoxy composite. The flexural strength increases first with the increase in fiber loading but decreases with further increase after 48% of fiber loading. The maximum and the minimum flexural strength recorded in case of jute polyester composite are 20.24 N/mm² and 12.78 N/mm² when the fiber loading are 48% and 12% respectively.

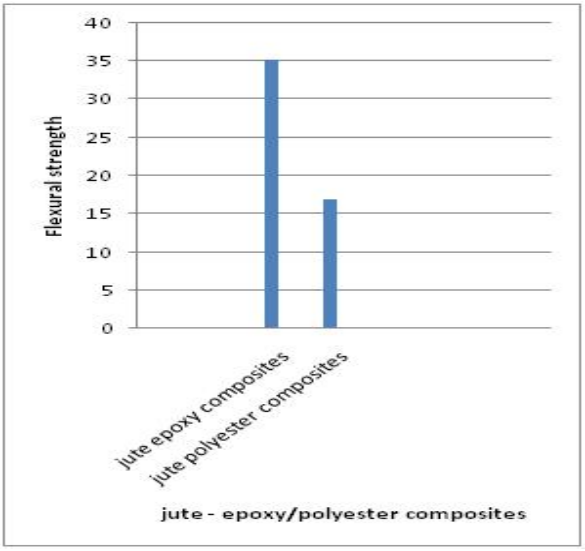


Graph 4.2Flexural Strength of Jute-Polyester Composite

4.1.3 Comparison

For the assessment of flexural strengths between jute epoxy composite and jute polyester composite their average of the flexural strength is calculated. The calculated average flexural strength in case of jute epoxy composite is 35.15 N/mm² and in case of jute polyester composite it is 16.94 N/mm². It can be clearly seen in the Bar Graph 4.3 that the flexural strength for the jute epoxy composite is greater than the jute polyester composite. Therefore it means that the jute epoxy composite can endure more bending force than jute polyester composite.

Flexural strength in case of jute epoxy composites (σ) = (25.32+32.48+36.46+47.68+33.83)/5 = 35.15 N/mm²
Flexural strength in case of jute-polyester composites (σ) = (12.78+14.72+17.04+20.24+19.90)/5 = 16.94 N/mm²



Graph 4.3 Comparison of Flexural Strength

4.2 Impact strength:-

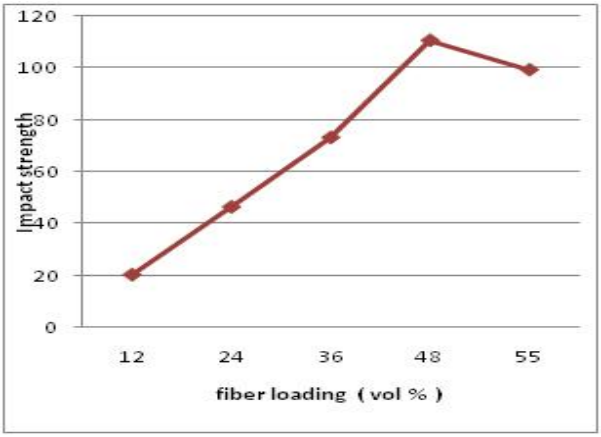
In the Table 4.2 below impact strength for the different loading condition is shown. The value of the impact strength is the value of the energy of the pendulum when the specimen starts to yield. It is clearly seen that for both type of composite the value of impact strength increases with the increase in the percentage volume of the jute fiber in the specimen and after a specific loading condition it starts to fall rapidly. From the table we can conclude that value of the maximum impact strength obtained is at 48% by volume loading of jute fiber. And on further increasing the fiber loading the value of the impact strength starts decreasing suddenly.

Table 4.2: Impact Strength at different jute fiber loading

Specimen	Impact strength in J/m²
EJ_1	20.40
EJ_2	46.56
EJ_3	73.34
EJ_4	110.75
EJ_5	99.43
PJ_1	81.75
PJ_2	108.55
PJ_3	132.84
PJ_4	148.59
PJ_5	119.71

4.2.1Effect of fiber loading on the impact strength of the Jute-Epoxy Composite:

The line graph shown in the Graph 4.4 shows that the impact strength for the jute epoxy composite is minimum at 12 % fiber loading and increases with the any further enhancement in the fiber loading up to 48%. The maximum impact strength recorded for the jute epoxy composite at 48% fiber loading in recorded to be 110.75 J/m². Moreover from the line graph it can be seen that any enhancement in the fiber loading the value of impact strength for the specimen starts to decrease after 48% fiber loading.

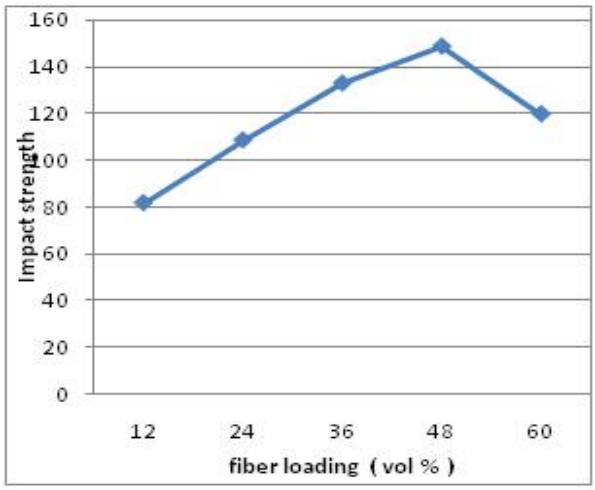


Graph 4.4Impact Strength for Jute Epoxy Composite

4.2.2 Effect of fiber loading on the impact strength of the Jute Polyester Composite:

The impact strength of the jute polyester composite shows the same behavior as the jute epoxy composite. The line graph in the Graph 4.4 shows that impact strength increases

when enhancement in loading and also it's highest with 48% fiber loading. Moreover it decreases with further increase in fiber loading as the impact strength with 60% loading is lower than the impact with 48% loading. The maximum and minimum value of impact strength in case of jute polyester composite are obtained as 148.59 J/m² and 81.75 J/m² with 48% and 12% fiber loading by volume.



Graph 4.5Impact strength for jute-polyester composite

4.2.3 Comparison

Like in flexural strength test the average of impact strength of all the specimens is calculated to understand the different behavior of the both types of composites in impact test. The value of impact strength for the jute epoxy composite appears lesser in comparison with the jute polyester composite. The average impact strength is case of jute-epoxy composite is seen to be 70.10 J/m². Whereas the average impact strength for the jute-polyester composites is seen to be 118.29 J/m². The bar graph in the Figure 4.6 clearly shows that the jute polyester composites have higher impact strength that means they can endure a high impact or sudden force as compared to the jute epoxy composites. Though both the composites shows maximum impact strength at 48% fiber loading.

Impact Strength for jute-polyester composites = 81.75+108.55+132.84+148.59+119.71 = 118.29 J/m²
Impact Strength for jute-epoxy composites = 20.40+46.56+73.34+110.75+99.43 = 70.1 J/m²

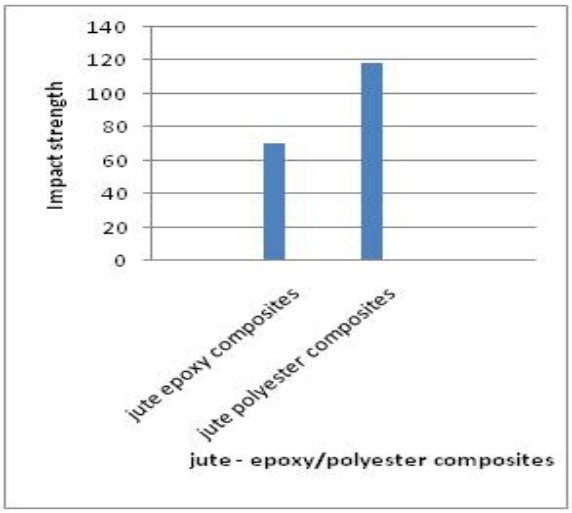


Figure 4.6 Comparisons of Impact Strengths

V. CONCLUSIONS

The average flexural endurance strength limit for the jute-epoxy and jute-polyester composite are evaluated to be 35.15N/mm² and 16.94N/mm². And the average impact endurance strength limit for jute-epoxy and jute-polyester composite are evaluated to be 118.29 J/m² and 70.1 J/m². After they are detailed analyzed and compared the following conclusion are made based on these experiments.

1. In both cases it has been found that with the increase in fiber volume there is increase in the flexural and impact properties of both the composites up to a certain fiber volume (48%) and decreases with further increase in fiber loading.
2. The average flexural strength and the maximum flexural strength in case of jute reinforced epoxy composite are seen to be 35.15N/mm² and 47.68N/mm² respectively. And in case of jute reinforced polyester composite these are seen to be 16.94N/mm² and 20.24N/mm² respectively.
3. Therefore the results of the tests show that the jute epoxy-composite has the better flexural properties in comparison with the jute-polyester composites.
4. In case of the impact properties the average and the maximum impact strength in case of the jute reinforced epoxy composite are found to be 70.1 J/m² and 110.75 J/m² respectively. And in case of the jute reinforced polyester composite are found to be 118.29 J/m² and 148.59 J/m² respectively.
5. The result of the test for the impact properties of the composites shows that the jute polyester composites have the better results than that of the jute-epoxy composites.

5.1 Scope for future work

This research work on jute fiber reinforced epoxy and polyester composites is limited to the flexural and impact properties of the composites due to the limited time. But due to lack of time many different tests and experiments have been left this gives many ample opportunities and broad scope for the future researchers and scholars to work on the various characteristics and properties of these composites. Scholars can go through the following recommendations for the further studies.

1. Researchers and the scholars can further widen the research work by using other techniques for fabrication.
2. Other natural or synthetic fibers can be used for reinforcement with different polymer resins. Filler materials can also be used for development of hybrid composites.
3. Work can be done on testing mechanical properties other than flexural and impact properties.
4. To study the wear behavior, erosion test or the other wear techniques such as abrasion and sliding wear can be performed.

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