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Mechanical Characterization of Jute and Rubber Particles Reinforced Epoxy Polymer Composites

Madhusudhan T[1] , SenthiL Kumar M[2] ,
1Research Scholar, PRIST University, Thanjavur,Tamil Nadu,
Email : t.madhusudan50@gmail.com, +919844106203

Abstract:- In an attempt to determine the characterization of Bio-degradable hybrid polymer composites, the jute fiber and natural rubber particle combination was tested to assess the critical weight percentage combination for tensile strength, flexural strength and ductility. Specially prepared specimens by hand layup technique were subjected to mechanical characterization process including SEM micrograph analysis to determine the optimum combination of the material system. The results so obtained reflected on typical characters of jute and rubber combination leading to estimate their usage criteria for different applications.

I. INTRODUCTION

While exploring the usage of different combination of materials for engineering application, the recycling and bio degradability plays a vital role due to environment concern. Hence the study on usage of natural fibers and particles combination to replace the conventional synthetic system would be of importance. The studies reveal that the natural fiber combination has acceptable strength to weight ratio along with other characteristics like low abrasion strength, enhanced thermal properties and has improved energy recovery and causes less damage to skin and respiratory disorders[1,2,3,4]. In recent years many researchers have focused on natural fiber reinforced composites and one of those natural fibers which is highly used is jute fiber [5]. Natural fibers have higher mechanical properties such as stiffness, flexibility and higher modulus in comparison with synthetic fibers [6]. The disadvantages of natural fiber composites are poor interface bonding between the fibers and matrix along with moisture affect [7, 8]. Some works have shown that treated jute fibers are of slightly higher strength compared to untreated jute fibers [9]. The use of natural fibers instead of glass or carbon fibers will reduce the cost of composites by around 50% which makes them cheaper and available at ease for the costumers [10]. The strength of the natural fiber composites can be improved by treating the fibers with chemical or physical methods with the help of coupling agents [11, 12, 13]. The use of jute fiber composites as an alternative for furniture will have significant impact on the usage of wood supporting the environment concern. Also the tiles manufactured using jute fiber are of less weight and easy to handle [14]. Unfortunately the work on evaluation of mechanical properties in combination with jute and rubber particles is very less, though this combination can be of great use in ductility requirement related applications. Usually in hybrid composites the combination of fiber-fiber, fiber-particulate, fiber-flakes etc are used. The particulate fillers used are either ceramic or metallic. In this work jute fiber-natural rubber particles have been studied on the weight percentage ratio. The objective of this work is to evaluate the tensile and flexural strength and ductility of natural fiber and rubber particles reinforced polymer composites and their variations based on different weight percentage of reinforcement. The SEM analysis of these composites was investigated to study the micro structural distribution of rubber particles with natural fibers and the intermolecular bonding between matrix and the reinforcement.

2.1 Materials used and preparation of laminates.

Bi directional woven jute fabric is obtained from Naga Jute Creations. The method adopted by the vendor for preparation of jute fabric is; the jute fibers are subjected to alkali treatment to remove the lignin deposited on the fiber. Then the fibers are arranged in proper manner and are weaved into closed net form or according to required pattern. Natural rubber in the form of powder was commercially obtained from Karnataka rubber Pvt Ltd and epoxy resin Lapox L12 and hardener K-6 (in the form of liquid). Jute fiber is cut according to the required dimension and a measured quantity of jute fiber based on the weight is calculated & used. Rubber particles are mixed with acetone and this mixture is added to the epoxy resin. The prepared matrix is used as filler material in between two jute fiber layers. In such way the composite laminates are fabricated by hand layup technique till the required thickness. As the laminates get exposed to the room temperature acetone gets evaporated. The variety of laminate combinations were fabricated by varying jute fiber by weight percentage in the ratio of 10,20,30,40,50 & 60 to overall weight of laminate. The laminates so prepared are cured at room temperature for duration of 24-48 hours.

2.2 Evaluation of mechanical properties

The laminates so fabricated are cut and dimensioned according to required ASTM standards and are subjected to tensile and flexural tests. The tensile test was conducted by using special fixture on Lloyds Instrument LR50 K computer controlled universal testing machine of 1000N capacity at normal temperature. Tensile strength, Young's modulus and ductility of these laminates are determined as per ASTM D-3039 standards.

Bending test / flexural test is also conducted on same universal testing machine using fixture 29/3 as per ASTM standard D790 at normal room temperature.

SEM analysis

The samples of laminates from each combination were cleaned and coated with 10-15nm thickness of copper with sputtering device. These specimens were inspected by scanning electron microscope to study the distribution of rubber particles in the laminates and to trace the voids and other imperfections present

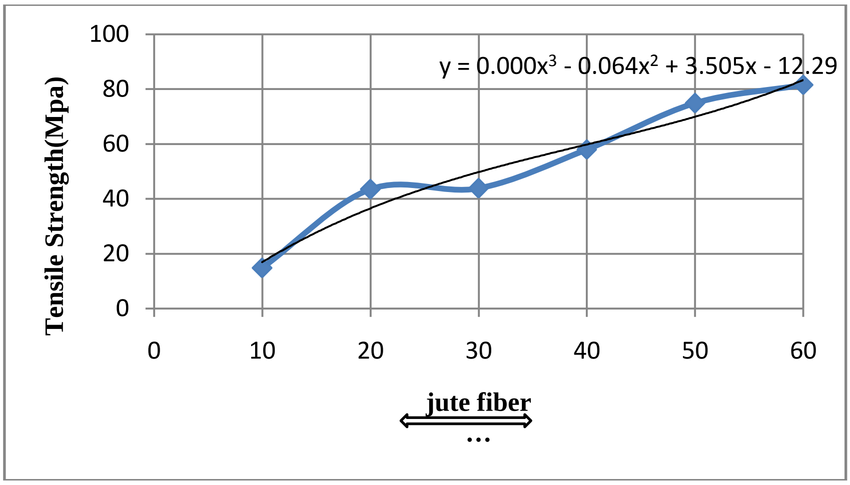
II. 3. RESULTS

Below are the tabulated values of results obtained under different tests.

Table: 3.1 Mechanical test results

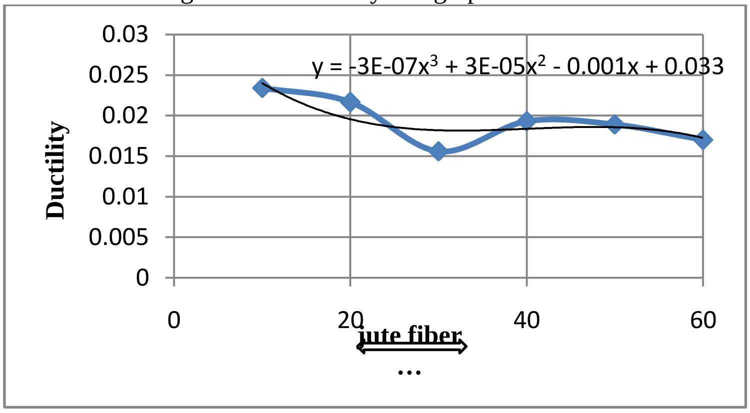
Jute %	10	20	30	40	50	60
Rubber %	50	40	30	20	10	0
Tensile	14.73	43.42	43.78	57.93	74.81	81.55
Ductility	0.02341	0.02165	0.0156	0.0193	0.0189	0.017
E(Gpa)	0.68	1.778	2.69	3.014	3.364	3.672
Flexural	28.36	68.22	108.99	145.16	157.42	167.52
G	0.2615	0.6838	1.0346	1.1592	1.2938	1.4123

Figure: 3.1Tensile test graph



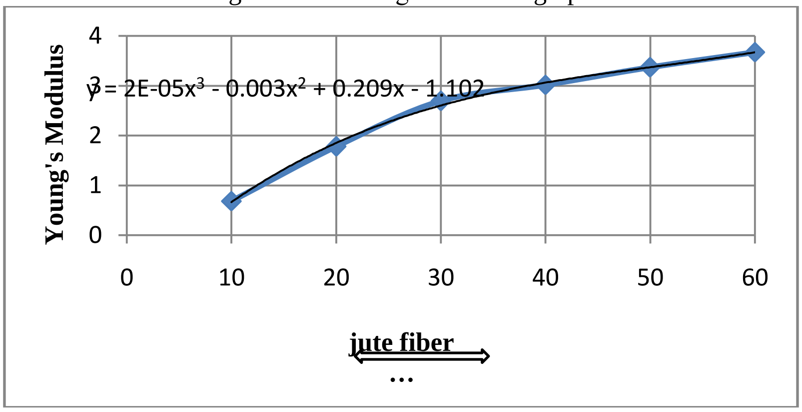
The results show that the tensile strength of the composites increases with increase in content of jute fiber and shows that higher the % of jute fiber higher is the tensile strength. This has been evidently depicted in the graph as the maximum tensile strength is at 60% jute fiber while convincing the 60-40% combination of traditional composition of composites. The regression curve obtained from the graph followed a linear path which confirms the valid points with variations of tensile strength satisfying the R values of 0.05. The slight dropping of tensile strength at 30-30% substantiates the critical combination. Also voids are observed in SEM analysis in this combination.

Figure: 3.2. Ductility test graph



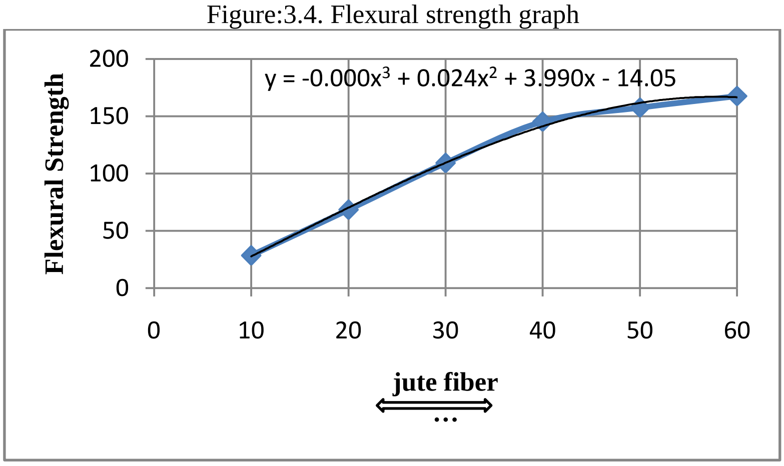
Ductility test results show that ductility increases with increase in quantity of rubber. 10-50% jute – rubber combination portray highest ductility. Once again the 30 -30 % jute – rubber compositions convince the critical combination with drop at that point. The 10 -50 % of rubber – jute composition show least ductility. Ductility and tensile strength of the composites are inversely related convincing low yield strength. It can be concluded from graph that the ductility of the component increases with increase in rubber particle content in the laminates.

Figure: 3.3. Young's modulus graph

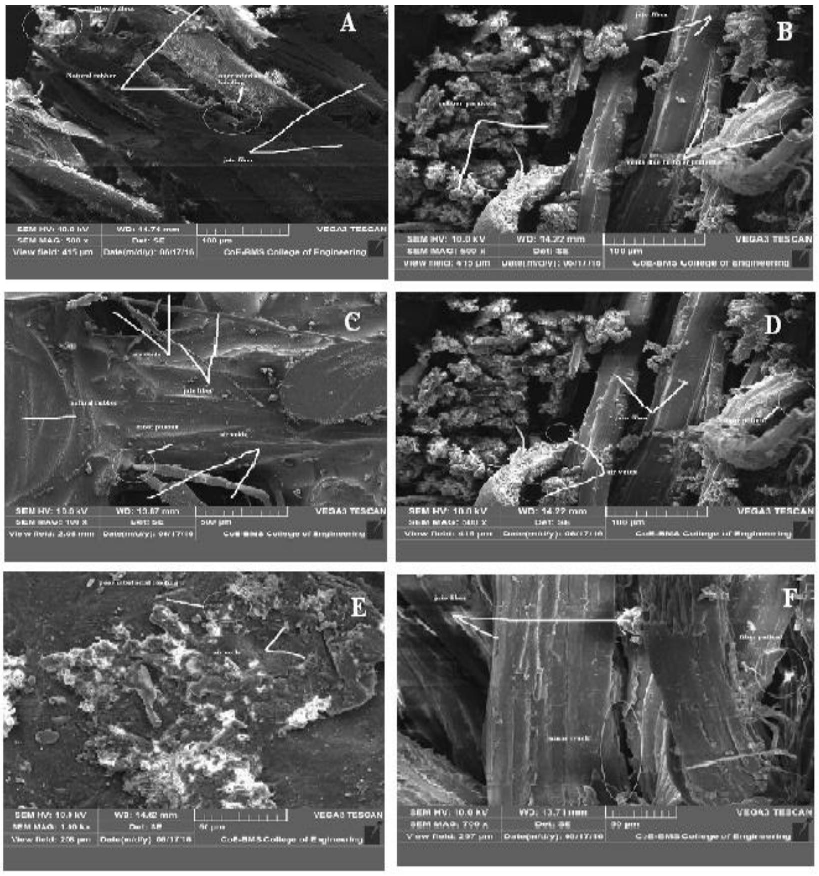


From the graph we can conclude that the variation of young's modulus is predominately dependent upon jute fiber. From the study it is clear that in the combination of rubber and jute fiber, jute is main factor which influences the young's modulus which can be defined by rule of mixture value [15].The variation of young's modulus satisfactorily follow the regression curve fit.

Figure:3.4. Flexural strength graph



The results from flexural tests reveal that flexural strength of the composites increases with increase in percentage of jute fiber content. The regression analysis was also valid without much variation in theoretical and experimental values.



The variation of bonding between rubber particles and jute fibers is analysed using SEM micrographs. The increases in fiber percentage decrease the amount of void formation as well the size of the voids due to fiber pull out. Fig. A shows the dispersion of compositions in the laminates for least jute fibers and maximum rubber particle %ge combination. Here we can observe larger & more voids indicating improper wetting & poor interface bonding between the fiber and matrix. This could be the cause for lower tensile strength. While the figure B indicates that there was notable interaction between rubber particles and jute fibers with reduced size and number of voids. This is because of reduced bonding in-between the rubber particles among themselves.

The Figure C indicates the SEM images for 30% rubber and 30% jute fiber the critical combination, where air voids are also observed along with voids due to fiber pullout. This could be the reason for sudden drop in tensile strength and ductility. The figure D indicates the SEM images of 40% fiber and 20% rubber particles. There was further decrease in the number and size of voids as the rubber particles content is decreased. It is observed that the fibers are properly wetted as there was sufficient amount of matrix for proper adhesion of the fibers with the matrix. The figure E shows the SEM images of 50%jute fiber and 10% rubber particles this image reveal very poor bonding in-between the rubber particles and enhanced bonding between fiber and matrix. This has resulted in decrease in the ductility of the composites. The figure F shows 60% jute fiber reinforced polymer composites. The SEM micrograph images show that the good interface bonding between the fiber and matrix. However presence of few micro cracks was observed. But this has not hindered the tensile strength of the composites. This is because of bi-directional fiber orientation. The strong interface bonding between the fiber and matrix resulted in decrease in the ductility of the composites.

III. CONCLUSIONS

A systematic investigation on mechanical characterization of jute and rubber particles reinforced polymer composites was conducted in this work. The results concluded as follows: The tensile and flexural property of the hybrid composites majorly depends on the composition. The tensile and flexural properties are very much influenced by the fiber composition rather than the rubber particulate. The ductility property for composites is greatly dependent upon the rubber particulate content. Thus this combination of higher ductility property material in polymer composites can be used as the alternative for any synthetic fiber filled polymer composites. On the other hand hybrid composite fabricated is one of eco friendly composites. Since the material is bio degradable it can be used in making any of the household application items also.

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