International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08, Special Issue | Oct 2021 www.irjet.net p-ISSN: 2395-0072

International Conference on Recent Trends in Science & Technology-2021 (ICRTST - 2021)

Organised by: ATME College of Engineering, Mysuru, INDIA

Evaluation of Mechanical Properties of Jute Fiber, Boron Carbide Reinforced Epoxy Hybrid Composites

Mr. Rohith.S[1], Mr. Yashwanth N[2], Dr. Rathnakar. G[3]

[1]Assistant Professor Department of Mech. Engg., ATME College of Engineering, Mysuru, India
[2]Assistant Professor Department of Mech. Engg, ATME College of Engineering, Mysuru, India
[3]Dean-Student affairs, ATME College of Engineering, Mysuru, India

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Abstract: **-** In the present research paper an effort is made to understand the effect of jute fiber and boron carbide reinforcement with epoxy resin on various mechanical properties of the complex composites are investigated. Boron carbide is considered as one of the hardest materials generally used in engineering materials applications. Boron carbide is used for reinforcement of composite materials in complex polymer composites, this complex composite has its major use in the manufacture of aerospace, marine, automobile polymer composites, and also in ballistic industries [1].

Boron carbide reinforced epoxy resin matrix (lapox L12) composites is mixed with different ratios in weighted proportions of jute fiber. These jute fibers, boron carbide reinforced resin matrix composite was fabricated by glass mold techniques [2]. The materials like jute, boron carbide was added to the resin matrix will help improve the operating properties of this new composite. The present experimental study focuses to study the Mechanical properties and its behavior of the polymer composite under various loading conditions with the varied degrees of reinforcement in the polymer. Different mechanical properties like flexure and hardness behavior of the composites have been studied. Various mechanical investigations and tests were carried out using tensometer to measure the tensile strength and rockwell hardness test to evaluate the hardness of the composite material. [3] The Epoxy resin (matrix) is mixed with processed jute fiber in proportion of variations of 0.5%, 1%, 1.5% and 2%. It can be seen that, with increase in the percentage of jute fiber content the surface hardness of the composite material decreases but the flexural strength of the laminate will increase. With the increase in filler content, will increase the flexural strength of the laminate. In this present research article on resin based reinforced composite material an attempt is made to understand the mechanical behavior on reinforced Epoxy composites. In this present study the epoxy based composite material was fabricated without any filler material and is compared with the jute fiber filled boron carbide Reinforced Epoxy resin composite.

Keyword*: *Boron carbide, Epoxy resin, Jute fiber, Flexure Strength, Hardness.

I. INTRODUCTION

In recent days the composites have gained more importance as its application was extensively enhanced in aerospace and automobile applications. The development of low weight, high strength with excellent mechanical properties and longevity of the polymers has made the polymer composites the first choice in various applications. The development of polymer composite materials has resulted in the advancement of several manufacturing sectors like aerospace, automobile and many more. These new polymeric composites have led to easy design, easy fabrication, and simplicity in manufacturing process. The advent of novel polymer composites plays a most important and vital role in the manufacturing sector and is widely used for applications beyond expected limits. Polymer composites are the materials that are being used in multi-faceted industrial application domains. Composite Polymers that are intended to have the requirement of exclusive mechanical and physical properties are developed for applications. Polymer Composite materials are found to be having verities of range of advantages over the other conventional engineering materials [4]. Polymer composites generally exhibit good mechanical properties like excellent tensile strength, high impact strength, and good flexural strength. Because of such numerous advantages polymer composites are widely used in various sectors like automobile industries, aerospace industry, marine industry, and telecom industries and used in domestic and commercial applications for manufacturing complex structures. To estimate the various mechanical properties like Hardness, strength, stiffness, and Flexural strength these polymer composite materials are subjected to Mechanical testing to validate for its mechanical strength.

The filler material Boron carbide is considered the third hardest element and finds its application in abrasive machining and as abrasive, grit blasting nozzles, scratch, and wear resisting coatings. Boron carbide is mainly used in the composite material to increase its hardness, in recent days it's being widely used in polymer composites also to enhance the hardness. Jute fiber is easily available and finds its application in various mechanical applications like for packing material, seats, bus flooring, windowpanes, etc., and now in recent decades it is widely used as reinforcement material in polymer composites. The presence of jute reinforcement is said to increase flexure strength of the composite material [5].

II. POLYMER COMPOSITE MANUFACTURING METHOD

A. Mold preparation

The preparation of the mould for the preparation of fiber reinforced composite specimen is done by using rectangular glasses with gasket.

- The resin paper is attached to the rectangular glass.
- Gasket is fixed on resin paper in 3 sides.
- Another rectangular glass is fixed in the top of gasket by using adhesive and clips.

Fig 1: Mold Preparation

B. Selection of reinforcement material for preparing polymer composite

Following were the parameters that were considered while selecting the fabric used for reinforcement of polymer composite.

- Strength of the reinforcement material - like tensile strength, bending strength.
- Hardness of the reinforcement material.
- Eco friendly of the reinforcement material.
- Easy availability of the reinforcement material.
- Cost of the fabricated composite.

The material that is selected should be Flexible to design any complicated components of the reinforced composite. The addition of the reinforced jute fabric layer to a resin matrix will create that material whose properties will be enhanced and cannot be predicted by just summing the characteristic properties of its individual components. The main advantage of fiber reinforced polymer matrix composite is in its complex complementary behavior of the components.

Table-1: Shows the specifications of the Epoxy resin, jute fiber, and Boron carbide

Material	Density	Young's Modules	Hardness
Epoxy resin	1.13 gm/cm3	10500 N/mm^2	-
Jute fiber	1.3 gm/cm3	26.5 GPa	-
Boron carbide	2.52 gm/cm3	460 GPa	3811

C. Specimen preparation for polymer composite:

Boron carbide (180Mesh size and 250 grain) were mixed in said proportions with Lapox L resin and jute fibers. The polymer composite was manufactured by hand layup technique using glass moulds. Epoxy resin (Lapox L-12) and corresponding hardener (K6) were mixed in the ratio of 100:10 or at a ratio of 10:1 by weight as suggested by the standard manufacturing procedure from ASTM standards [6]. The above-mentioned materials like epoxy resin, hardener, jute fiber, boron was procured from standard suppliers.

- A known quantity of epoxy resin, boron carbide, jute fiber and hardener were measured using electron weighing machine and were taken in the pre-defined proportions.
- Thoroughly mixing 2% of the boron carbide to epoxy resin and stirring it to achieve uniform mixing.
- Adding jute in varying quantities like 0.5%, 1%, 1.5% & 2% for different specimens to the mixture. Jute fiber acts as the reinforcement material
- Adding the hardener and mixing of hardener for uniform mixing.
- Pouring the mixture into the already cleaned mold.
- Allowing the mixture to dry for about 24 hrs. to obtain the consistent laminate.

Table-2: Reinforcements and Matrix percentages

Specimen No.	Epoxy resin	Boron carbide	Jute fiber
1.	98%	2%	0%
2.	97.5%	2%	0.5%
3.	97%	2%	1%
4.	96.5%	2%	1.5%
5.	96%	2%	2.0%

III. TESTING OF POLYMER COMPOSITES

A. Hardness Test of polymer composite:

Hardness is defined as the resistance to permanent indentation or permanent deformation or resistance to scratch, wear, and tear. Hardness test will help to identify the ability of material to resist the material to undergo scratch, Indentation, plastic flow, plastic deformation, permanent change in physical structure and change in the layers of the material near the surface. To determine the hardness of the specimen material is indented by a diamond tipped indenter. The indenter passes and tries to cause elastic damage continued by permanent deformation of the material. Upon continued indentation the material tries to overcome large plastic deformation the material with standing the force of the indentation for scratch or deformation is considered as the material with high hardness. The hardness teat is conducted on a Brunel's Hardness testing machine. Specimens as prepared as per ASTM standards and are chosen with care to obtain good results. The surface of specimen is ensured to be flat & reasonably with good surface finish.

Fig 2: Hardness Tester

B. Flexural Test of polymer composite:

Flexural test is performed on the laminated polymer composite material. Flexural test helps to determine the mechanical strength of the specimen. The flexural test is performed as per ASTM D790 Standards and the tension test is conducted as per ASTMD638.

The specimens were prepared as per ASTM recommended standards and the specimens were wire cut to the required shape and size as per the ASTM standards.

In tension test and flexural tests, a static load is applied continuously on the specimen. As the gradual load is increased from zero to a maximum load [6]. The specimen is subjected to loading till failure. Flexural test is conducted to understand the materials strength to withstand the bending forces. The polymer composite specimen is loaded to its maximum loading before reaching the breaking point. The Specimen is loaded as a simply supported beam and load is applied from the center in the opposite direction of that of the support provided. Flexural test is used to evaluate the young's modulus of the specimen. This will determine the mechanical strength of the specimen under flexural loading. Flexural testing machine is a standard device with a crosshead that will have the movement indicator to indicate the movement, the cross head uses an auxiliary deflection measuring devise such as a displacement transducer.

Testing software: this experimental set up is built with the Modern software. This modern software performs the required calculations automatically after conduction of the test. The software used in this experimental setup is ADMET's MTESTQuattro software.

Fig 3: Tensiometer

IV. RESULTS AND DISCUSSION

A. Hardness Test Results

The measured hardness test results of the Boron carbide reinforced epoxy with jute fiber composites are tabulated in the table. The surface hardness of Boron carbide reinforced epoxy with jute fiber composite decreases by increasing the jute fiber content in the range of 0.5%, 1%, 1.5% and 2%. With reference to the table, it is observed that addition of jute fiber is not improving its hardness and hence not recommended in applications where hardness of the component is crucial.

Table-3: percentage of jute in composite and hardness

Constituent materials 2% Boron Carbide & Jute Fiber variations	Hardness in HMR
0% jute	90
0.5% jute	60
1% jute	75
1.5 jute	58
2% jute	51

B. Flexure Test Results

- The reinforced Hybrid composite under study is exhibiting good bending strength.
- With the addition of the jute (natural) fiber there is a significant increase in break load.
- The composite can take the maximum breaking load of 506.14 N When 2% jute is added to the composite.
- The composite has a maximum break displacement of 2.3mm when 2% jute is added to the composite.

From the above analysis it can be observed and concluded that the usage of processed natural jute fiber increases the bending strength and encourages the use of natural fibers, that is easily available, which are eco-friendly, cheap and available in abundance over synthetic fibers, or artificially manufactured fibers.

Fig 4: Test Specimen

The results at fracture, breaking load, Break displacement is a function of jute content of various proportions with epoxy(matrix) and their composites are shown in figure.

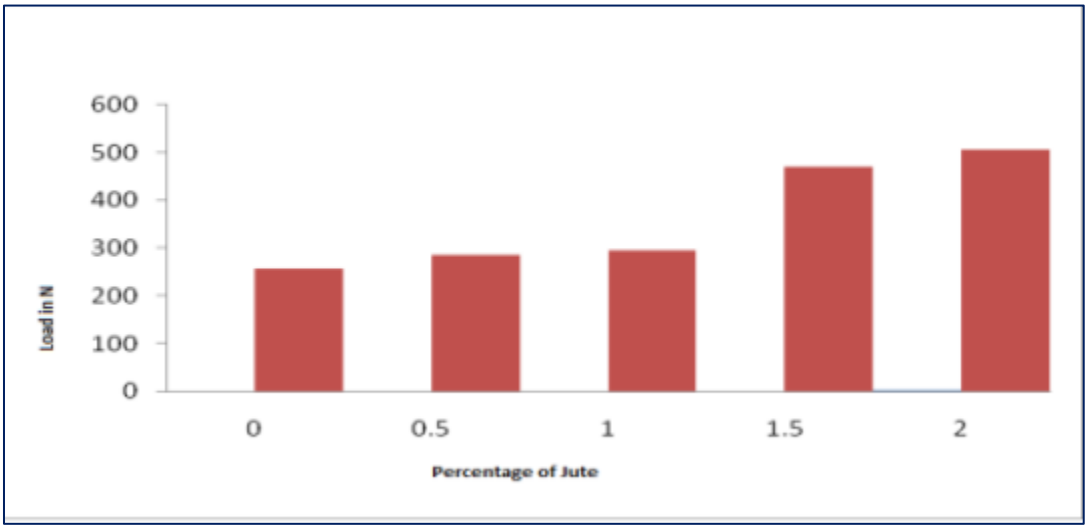

Fig 5: Variation of break load with respect to percentage of jute

Table-4: Variation of jute in composite and its property

Sl. No.	Reinforcement Material Boron	Reinforcement Material Jute	Break load in N	Break disp. in mm	Eng. UTS N/mm^2
1.	2%	0%	372.266	1.298	3.493
2.	2%	0.5%	394.403	1.45	2.631
3.	2%	1%	401.200	1.87	2.587
4.	2%	1.5%	470.736	2.21	4.230
5.	2%	2.0%	506.140	2.35	4.293

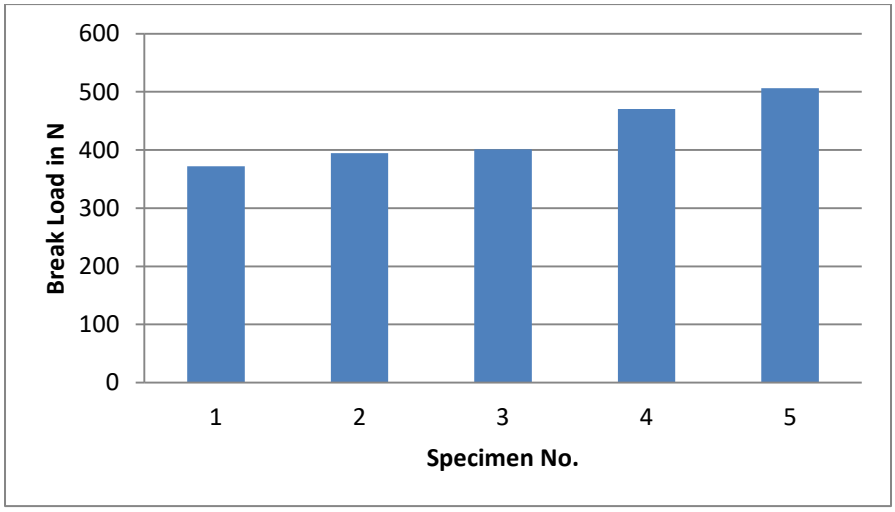

Fig 6: Graph showing the maximum load the specimen can with stand

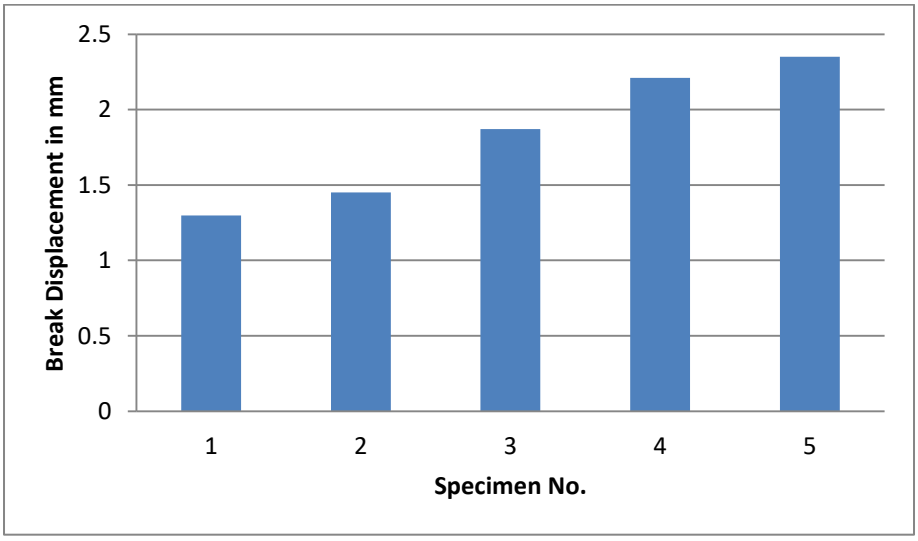

Fig 7: Graph showing the Maximum displacement the specimen can with stand

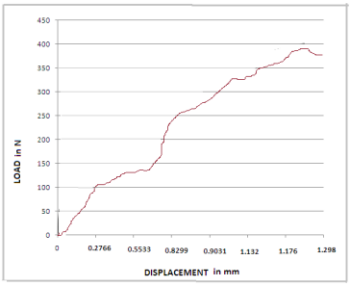

Fig 8: load vs displacement curve of the composite with 0% jute content

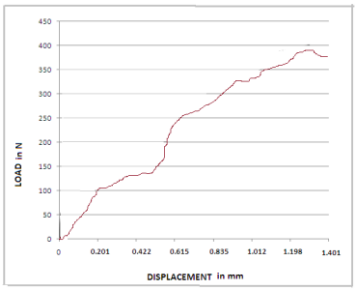

Fig 9: load vs displacement curve of the composite with 0.5 % jute content

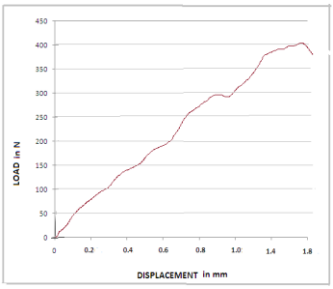

Fig 10: load vs displacement curve of the composite with 1% jute content

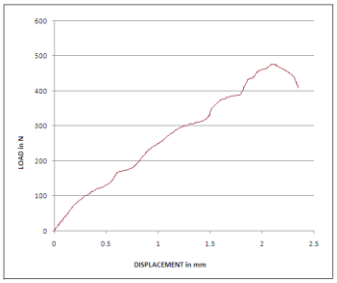

Fig 11: load vs displacement curve of the composite with 1.5% jute content

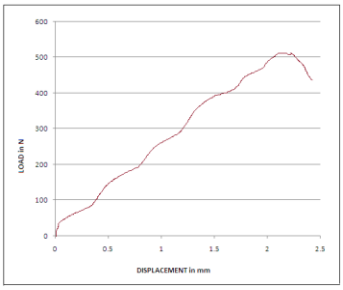

Fig 12: load vs displacement curve of the composite with 2% jute content

V. CONCLUSIONS

Based on the experimental results the following analysis of experimental results were made and findings are as follows. The following inferences and conclusions were drawn upon:

This experimental work indicates the successful fabrication of a multilayered component hybrid polymer composite using epoxy as matrix, Boron carbide and jute fiber as reinforcement material. The reinforced polymer composite was manufactured by using a simple glass molding technique.

The application of jute fiber as reinforced material will enhance the Mechanical properties of the composites and has shown increase in the flexural strength of the reinforced composite material.

There was a steady decline in the surface hardness of the material and variations in flexure property was noticed in the jute reinforced fiber composites.

The presence of this jute fiber has caused improvement in flexure strength with increase in the jute content. The presence of Boron carbide will enhance the hardness substantially. The hardness is going to decrease with the increase in the jute fiber content.

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