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Evaluation of Mechanical Properties of Jute Fiber and Boron Carbide Reinforced With Epoxy Based Hybrid Composites

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***Abstract*—In this paper the effect of jute fiber on mechanical properties of Boron carbide reinforced epoxy resin composites is investigated. Boron carbide(B_4C) is 3rd hardest material and used as reinforcement materials in composites, its major use being the manufacture of components in the aerospace, ballistic industries. Boron carbide reinforced epoxy (lapox L12) composites filled with different weight proportions of jute fiber were fabricated by glass moulds. Materials added to the matrix help improving operating properties of a composite. This experimental study has targeted to study on Mechanical behavior. The flexure and hardness behavior of the composites have been studied and are carried out using Tensometer machine and Rockwell hardness tester. In Epoxy composite with jute fiber in the range of 0.5%, 1%, 1.5% and 2%, it was observed that, with increasing jute fiber content the surface hardness decreases but in Bending Test with increasing filler content bending strength is gradually increases. However, in this research article an attempt has been made to understand the mechanical behavior of boron carbide reinforced epoxy resin filled with jute fiber in the range of 0.5%, 1%, 1.5% and 2%. Boron carbide reinforced Epoxy composite without any filler has been compared with the jute fiber filled boron carbide Reinforced Epoxy resin composite.**

***Index Terms*— Boron carbide, Epoxy resin, jute fiber, flexure strength, Hardness.**

I. INTRODUCTION

The development of composite materials and their related design and manufacturing technologies is one of the most important advances in the history of materials. Composites are the material used in various fields having exclusive mechanical and physical properties and are developed for particular application Composite materials having a range of advantages over other conventional materials such as tensile strength, impact strength, flexural strengths, stiffness and fatigue characteristics. Because of their numerous advantages they are widely used in the aerospace industry, commercial mechanical applications, etc.

In order to estimate Hardness and Fluxure strength, structural materials are subjected to mechanical testing. Tests aimed at evaluating the mechanical characteristics of fibrous polymeric composites are the very foundation of technical specification of materials and for design purposes.

Composite materials in the context of high performance materials for structural applications have been used increasingly since the early 1960s. although materials such as boron corbide reinforced polymers were

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already being studied earlier. Initially conventional test methods originally developed for determining the mechanical properties of meterials and other homogenous and isotropic construction materials were used. It was soon recognized however that these new materials which are non homogenous and anisotropic (orthotropic) require special consideration for determining physical and mechanical properties . The uses of composite structures have proliferated recently to include a large number of new applications. Once only used for specialized parts or secondary members, composites are now considered to be competitive with other materials in many applications.

Boron carbide is the third hardest element and finds its application in abrasives, grit blasting nozzles, scratch and wear resisting coatings, etc. It is mainly used in the composite material to increase its hardness. And Jute fiber is easily available and finds its application in seats, bus flooring, window panes, etc. and is said to increase flexure strength of the composite material.

The performance of fiber reinforced polymer composites is affected by many factors such as properties of the fibers, orientation of the fibers, content of the fibers, properties of the matrix, fiber-matrix interfaces etc. Increase in volume content of reinforcements can increase the strength and stiffness of a composite to a point. If the volume content of reinforcements is too high then there will not be enough matrix to keep them separate, and they can become tangled. The mechanical properties of fiber reinforced composites are affected by the elastic and strength properties of the matrix, the fibers and the fiber-matrix bond which govern the stress transfer.

II. Manufacturing Of The Composites

A. Mould preparation

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

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

B. Fabrication selection

Following are the parameters considered while selecting the fabric.

- Strength (tensile, bending)
- Hardness
- Eco friendly
- Availability
- Cost

Design flexibility in fabric-reinforced composite, adding fabric layer to a resin matrix creates one material whose properties cannot be predicted by summing the properties of its components. In fact, one of the main advantages of polymer matrix composite is the complementary nature of the components. For example, thin glass fabric is quite strong. But it is also susceptible to damage. By carefully selecting the fabric, resin and manufacturing process, designers can tailor composites to meet final requirements that could not be achieved using other materials. While it is this combination of matrix, fabric and manufacturing process that gives composites their superior performance, it is essential to consider these elements separately.

TABLE I: TECHNICAL CHARACTERISTICS OF THE JUTE FIBER, EPOXY RESIN AND BORON CARBIDE

Material	Density	Young's Modulus	Hardness
Epoxy resin	1.13gm/cm^3	10500 N/mm^2	-
Jute fiber	1.3gm/cm^3	26.5GPa	-
Boron carbide	2.52gm/cm^3	460GPa	3811

C. Specimen preparation

Boron carbide (180Mesh size and 250 grain) were reinforced with Lapox L resin with jute fiber are manufactured by experimental method using glass moulds. The low temperature curing epoxy resin (Lapox L-12) and corresponding hardener (K6) were mixed in a ratio of 10:1 by weight. The epoxy resin and the hardener were supplied by Atul India Ltd. Gujrat, India.

The following procedure was adopted for preparation of specimen

1. Measuring the quantities such as epoxy resin, boron carbide, jute fiber and hardener.
2. Mixing 2% of boron carbide to epoxy resin and stirring it
3. Adding jute (in varying quantities like 0.5%, 1%, 1.5% & 2% for different specimens) to the mixture.
4. Mixing of hardener.
5. Pouring the mixture into the mould.
6. Allowing the mixture to dry for about 24 hrs.

TABLE II: 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%

III. TESTING OF THE COMPOSITES

A. Hardness Test

Hardness may be defined as the resistance to permanent indentation. Hardness test measure the resistance to plastic deformation of layers of metal near the surface of the specimen. In the process of hardness determination when the metal is indented by a special tip, the tip first overcomes the resistance of the metal to elastic deformation and then a small amount of plastic deformation. Upon indentation it overcomes large plastic deformation. Specimen must be chosen with care in order to obtain good results. The surface of specimen should be flat & reasonably polished.

B. Bending Test

This test is performed on a universal testing machine (tensile testing machine or tensile tester) with a 3 point. A static load is gradually applied, increasing from zero to its maximum value up to the failure of the specimen. Flexural test is to determine the capability of a material to withstand the bending before reaching the breaking point that is used to measure the Young’s modulus of a material in the shape of a beam. The beam, of length L, rests on two roller supports and is subject to a concentrated load P at its centre. ASTM D638, D790 is one of the most commonly used specifications in the plastics industry.

The specimen is placed on two supports and the actuator is applying a force in the exact middle of the two supports. Immediately before failure, the force (F) and a deformation is recorded. We need to determine the maximum flexural strength (σ), and Young’s Modulus (E) of the specimen.

Deflection measuring device: This can be the standard crosshead movement indicator or use an auxiliary deflection measuring devise such as a displacement transducer.

Testing software: Modern software performs all of these calculations automatically after the test. We used ADMET’s MTEST Quattro software.

Figure 1: Tensometer

IV. Results and Discussions

A. Hardness

The measured hardness test results of the Boron carbide reinforced epoxy with jute fiber composites are shown in figure 2. 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 III 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 III: 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	59
1.5% jute	58
2% jute	51

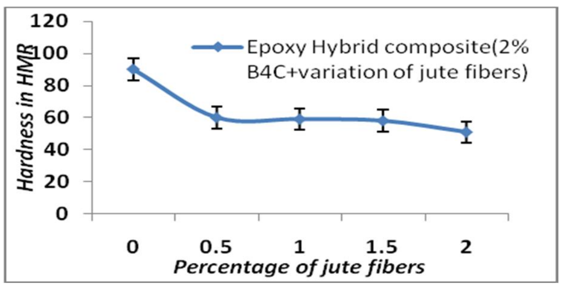

Figure. 2 Effect of percentage of jute on hardness

B. Flexural Strength

The Hybrid composite under study is exhibiting good bending strength

- With additional of the jute (natural) fibre there is a significant increase in break load
- Composite can take the maximum break load of 506.14 N When 2% jute is added to the composite.
- And the composite has a maximum break displacement of 2.3mm when 2% jute is added to the composite.

From fig. 3, it can be concluded that usage of natural jute fiber increases the bending strength and encourages the use of natural fibers which are eco-friendly cheap and available in abundance over synthetic fibers.

The results of breaking load, Break displacement as a function of jute content of various proportions with neat epoxy and their composites are shown in figure 3.

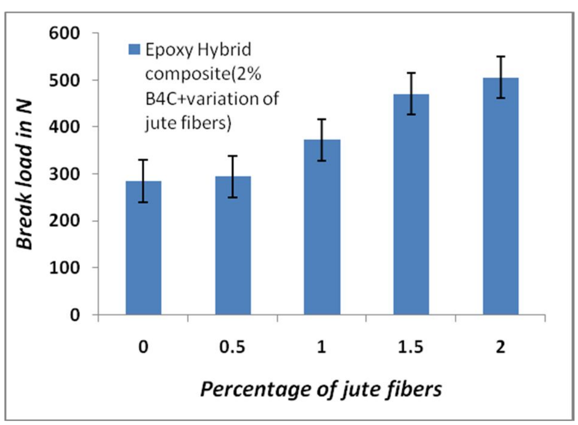

Figure. 3 Effect of percentage of jute on break load

TABLE IV: VARIATION OF JUTE IN COMPOSITE AND ITS PROPERTY

Sl no	Constituent materials-2% Boron Carbide & Jute Fiber variations.	Break load (N)	Break disp.(mm)	Eng. UTS
1	0% jute	284.403	1.18	2.587
2	0.5% jute	294.2	1.197	2.631
3	1% jute	372.266	1.298	3.493
4	1.5%	470.736	2.21	4.230
5	2% jute	506.14	2.3	4.293

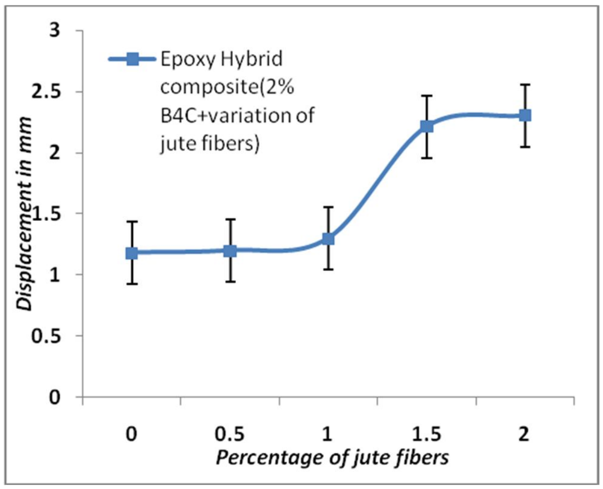

Figure. 4 Effect of percentage of jute on displacement

The effect of percentage of jute on displacement is shown in figure 4. The measured values of displacement of Boron carbide reinforced epoxy with jute fiber hybrid composites are shown in table IV. From figure 4 it can be observed that the displacement is maximum for 2% of jute fibers in addition with 2% B_4C in hybrid composite.

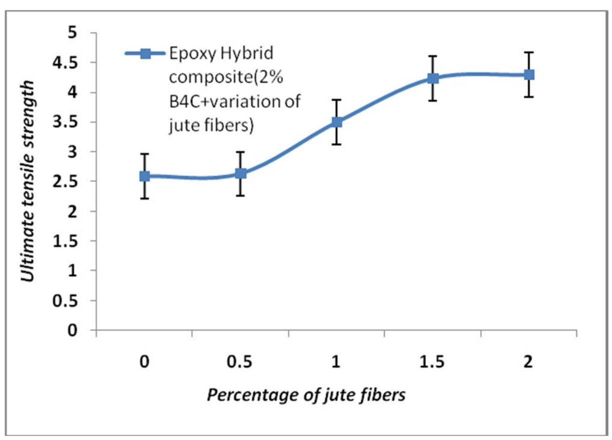

Figure. 5 Effect of percentage of jute on Ultimate tensile strength(UTS)

The measured UTS test results of the Boron carbide reinforced epoxy with jute fiber composites are shown in table IV. From figure 5 it is concluded that, UTS of Boron carbide reinforced epoxy with jute fiber hybrid composites increases by increasing the jute fiber content in the range of 0.5%, 1%, 1.5% and 2%.

V. Conclusion

Based on the analysis of experimental results and findings, the following conclusions can be drawn: This work shows that successful fabrication of a multi component hybrid composite (using epoxy as matrix, boron carbide and jute fiber as reinforcement) was possible by simple glass mould. Incorporation of this jute modifies the mechanical properties of the composites. A steady decline in the surface hardness and flexure property was noticed in the jute composites whereas the presence of this jute fiber has caused improvement in flexure strength with increasing the jute content. But in hardness is going to decrees increasing the jute fiber content.

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