JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ANALYSIS OF MECHANICAL BEHAVIOUR OF SUGARCANE BAGASSE/EPOXY AND GRAPHITE POWDER/EPOXY COMPOSITE

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ABSTRACT

This analysis deals with the preparation of composites materials made from epoxy resin (Di glycidyl ether of Bisphenol-A/LY554/6) and hardener (Triethylenetetramine/HY951) reinforced with graphite powder (90% graphite+10%lead) and sugarcane bagasse. The objective is to determine the impact strength, tensile strength, and flexural strength of the composite material fabricated. Epoxy resin LY 554/6 and Hardener HY951 were used as the matrix material in a weight ratio of 10:1. The utilization of natural fibers, such as sugarcane bagasse, as reinforcement in polymer composites has gained substantial attention due to their recyclable nature and potential as alternatives to synthetic fibers. The traditional hand-lay-up method was used to fabricate the composite samples. The findings of this study contribute to the growing body of knowledge on natural fiber reinforcement in polymer composites. The results provide valuable insights for material to scientists, engineers, and manufacturers, enabling them to make informed decisions regarding the use of natural fibers and epoxy resin in composite materials. These composites can be utilized as an optional material for existing plastic materials and can be used as a replacement of wood.

Keywords: Polymer matrix, Sugarcane bagasse, Graphite powder, Epoxy, Impact strength, Tensile strength, Flexural strength.

1. Introduction

The objective of this research is to find the impact strength, tensile strength, and flexural strength, of graphite powder and sugarcane bagasse-reinforced polymer composite. Graphite powder (wt%20) and sugarcane bagasse (strip wt%15 and small piece wt%25) are selected as reinforcing elements with Epoxy Resin LY 554/6 and Hardener HY951(10:1). Graphite powder is selected as a reinforcing element in the composite due to its high impact strength and conductivity properties. The addition of graphite powder can enhance the mechanical and electrical properties of the polymer composite [1-3].

Sugarcane bagasse, a by-product of the sugar industry, is chosen as a natural fiber reinforcement due to its abundance, low cost, and eco-friendly nature. Utilizing sugarcane bagasse as a reinforcement helps in reducing waste and utilizing renewable resources [4]. The interest and applications of natural fiber-reinforced polymers have increased in recent years due to the emphasis on sustainable and environmentally friendly materials. By utilizing renewable resources like natural fibers, researchers aim to reduce reliance on non-renewable resources and address concerns related to waste disposal and environmental impact [5-7].

Numerous research studies have been conducted on the reinforcement of natural fibers in polymer composites. These studies explore the potential of natural fibers as substitutes or alternatives to synthetic fibers, focusing on various aspects such as mechanical properties, processing techniques, and compatibility with different matrix materials.

The combination of graphite powder and sugarcane bagasse in the polymer composite offers the possibility of achieving a synergistic effect, where the resulting composite exhibits enhanced mechanical properties, such as impact strength, tensile strength, and flexural strength, comparedto the pure epoxy resin [8].

Traditional hand-lay-up method was used for preparing the samples. Epoxy resin is one of the important classes of thermoset polymer, which is widely used in polymer composites because of its excellent chemical resistance properties, mechanical properties, thermal properties, and low cost [9].

It has been written in the literature that the reinforcement of natural fibers (sugarcane bagasse) is also the most attractive way to modify epoxy resin. During the last few years, the interest, and applications of using natural fibers as reinforcement in polymers have increased dramatically in both areas of engineering and research. Researchers and scientists also show more emphasis on the use of renewable resources based on the issues of a safer environment, waste disposal, and disposal of non-renewable resources [10,11]. Many research studies have been carried out based on the reinforcement of natural fibers which are potential substitutes or alternative for syntheticfiber in composite materials [12-15].

1.1 Mechanical properties

1.1.1 Tensile strength

Tensile strength is the maximum stress that a material can withstand before it breaks or undergoes permanent deformation when subjected to tension or pulling forces. In other words, it is the ability of a material to resist being stretched or pulled apart. Tensile strength is measured in units of force per unit of cross-sectional areas, such as pounds per square inch (psi) or megapascals (MPa).

Fig 1: Tensile testing

1.1.1.2 Significance of tensile strength

Tensile strength is a measure of a material's ability to withstand tensile (pulling or stretching) forces without breaking or deforming permanently. It is an important mechanical property used to assess the strength and durability of various materials. Tensile strength is crucial in determining the structural stability of load-bearing components and structures. Materials with high tensile strength can resist applied forces and maintain their shape and integrity, reducing the risk of failure or collapse. Understanding the tensile strength of materials ensures the safety and reliability of products and structures. By testing materials and ensuring they meet or exceed required tensile strength specifications, manufacturers can produce reliable and durable products that can withstand expected operating conditions. Knowledge of a material's tensile strength helps determine the maximum forces or stresses it can endure during these processes without causing defects or failures.

1.1.2 Impact strength

Impact strength refers to the ability of a material to resist breaking under sudden, high-stress loads. It is a measure of the energy required to fracture a material when a force is applied suddenly, such as in a sudden impact or shock.

Fig 2: Impact testing

1.1.2.2 Significance of impact strength

Unlike metals composite materials failed with little yielding before totally collapsing in a disastrous way [16]. Impact strength is to determine whether the material is brittle or ductile in nature [17]. It is very important to have a minimum impact force to induce a crack into a composite material. Impact strength states about total amount of energy absorbed by the material before fracture [18-23]. That energy describes about the material toughness and temperature dependent brittle- ductile transmission.

1.1.3 Flexural strength

Flexural strength, also known as bending strength, is a measure of a material's ability to resist bending or breaking under applied loads. It is the maximum stress that a material can withstand before it fails in a flexural (bending) mode [24].

Fig 3: Flexural Testing

1.1.3.2 Significance of flexural strength

Flexural strength states about maximum bending stress that can be endure by the material before it yields [25-26]. The flexural strength states the maximum bending stress that can be endured by the material before it yields. Flexural strength is also known as bending strength, modulus of rupture or transverse rupture strength [27-28]. Flexural or compressive strength is the mechanical property for the measurement of maximum load bearing capability of materials without any permanent deformation [29].

2. Materials and methods

2.1 Materials

Di glycidyl–ether of bisphenol-A (DGEBA, LY 554/6) for the fabrication of composite.
Triethylenetetramine Hardener (TETA, HY 951) used as a curing agent.

2.1.2 Reinforced materials

2.1.3 Graphite powder

Graphite powder can be used as a composite material in various applications. When incorporated into a composite matrix, such as a polymer, metal, or ceramic, graphite powder can enhance the properties and performance of the resulting composite material. Graphite powder can act as a reinforcing agent in composites, providing improved mechanical properties. It enhances the strength, stiffness, and durability of the material, making it suitable forstructural applications.

2.1.4 Sugarcane bagasse

Sugarcane bagasse fibers are often mixed with a polymer matrix, such as epoxy or polypropylene, to create a reinforced composite. The bagasse fibers act as reinforcements, providing strength and stiffness to the composite, while the polymer matrix holds the fibers together and provides a cohesive structure. The resulting sugarcane bagasse composite material exhibits several desirable characteristics, including high strength, low density, good thermal insulation, and improved sustainability compared to traditional composites that rely on non- renewable resources.

Sugarcane bagasse material used in two forms:

1. Long strip of 150 mm x 10mm
2. Small square of 10mm x 10mm

2.2 Methods

The composite plates were prepared by the hand layup process. Epoxy resin and hardener were mixed in the ratio of 10:1 by volume [30]. The composite plates were prepared by the hand lay- up process on a square mould. The mould used was made from stainless steel. The purpose for using stainless steel was to get smooth surface finish of composite plate. To make mould dust free a soft handy brush is used to remove the dust particles. A layer of grease was applied for easy removal of composite plate samples from mould without any sticking after curing occurs. Epoxy resin of class LY 554/6 and hardener HY951 were taken in specified ratio and mixed homogeneously in beaker. The first layer of epoxy resin mixture is laid down on grease and uniformly coated, later sugarcane bagasse (15% of whole volume) was placed in the mould above epoxy and the again epoxy resin mixture was poured on the top of it mat for uniform distribution. After that mould was closed and compressed for cured time of 48 hr. For graphite reinforced composite we need to mix epoxy resin and hardener in the same ratio of 10:1 and simultaneously add graphite powder (wt%20) and then poured into the mould.

After 48 hr, when composite plates are cured, the prepared plates are cut into the standard sizes according to ASTM standards and tested. Fabrication process requires 4 processes they are as follows:

3. SAMPLE DISCRIPTION

Table 1: Sample description

Samples	**Sample Description**
Sample 1	Simple Epoxy composite
Sample 2	Graphite powder-Epoxy composite
Sample 3	Sugarcane bagasse (long strip)-Epoxy composite
Sample 4	Sugarcane bagasse (small pieces)-Epoxy composite

(a) Sample 1 (b) Sample 2 (c) Sample 3 (d) Sample 4Fig 4: final form of fabricated composites

4. Result and discussion

Table 2: Types of test as per ASTM standard

S. No.	Type of Test	ASTM Standards
1	Tensile Strength	ASTM D 638
2	Impact Strength	ASTM D 256
3	Flexural Strength	ASTM D 790

Table 3 Test results

Sample	Tensile strength (MPa)	Impact strength (Izod) (KJ/m^2)	Flexural strength (MPa)
Sample 1	14.33	7.62	51.33
Sample 2	20.18	2.41	29.54
Sample 3	**20.67**	**9.40**	**72.44**
Sample 4	8.80	1.09	66.84

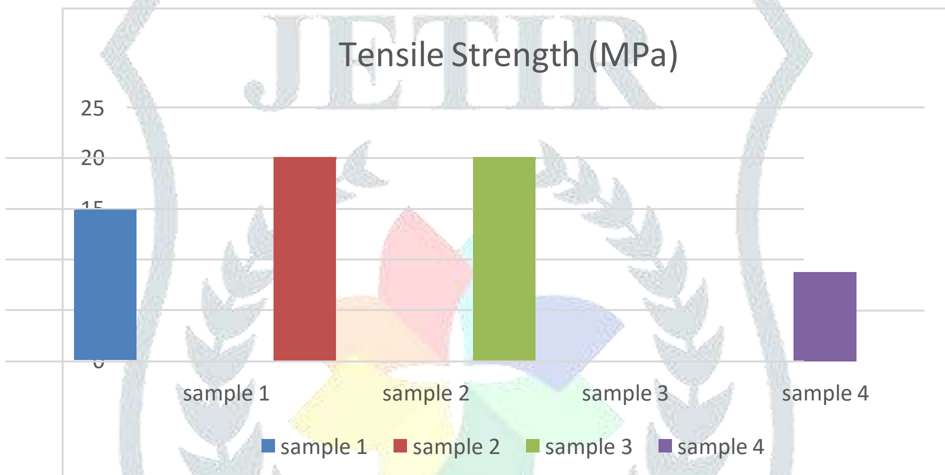

Fig 5: Tensile Strength

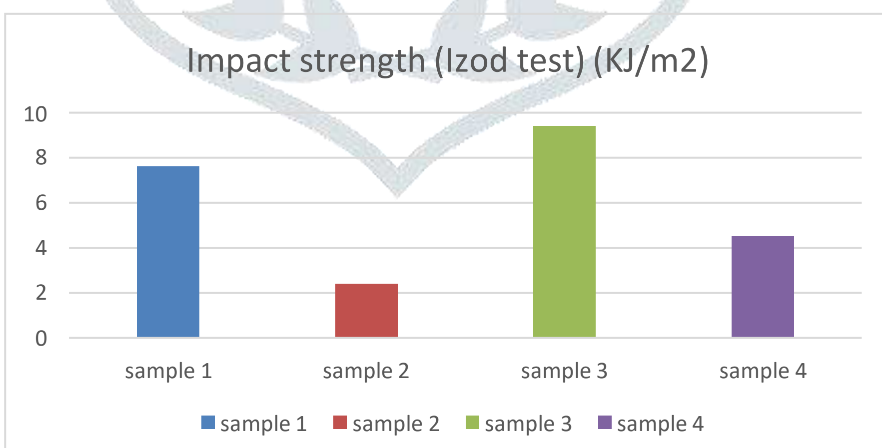

Fig 6: Impact Strength

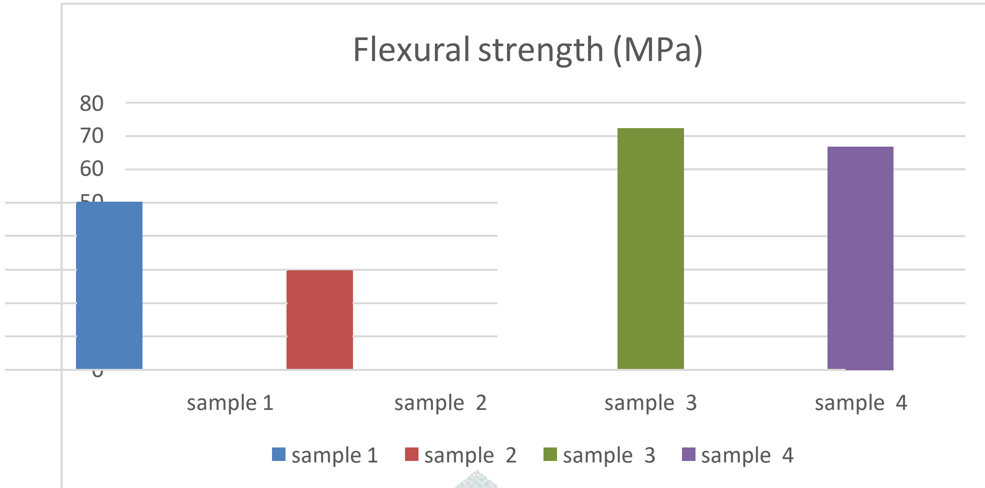

Fig 7: Flexural Strength

All three samples are tested as per tests given in Table 2. These tests are carried out under typical laboratory conditions and results are summarized in Table 3. Test results are also shown by bar graph for all the four samples in Figs. 5–7. All test results show that the sugarcane bagasse with long strip reinforced polymer specimens (sample 3) is considerably stronger than others.

From Fig. 5-7 sample 3 have highest tensile strength, impact strength and flexural strength because it consists of natural fiber which is made of cellulose and lignin which contains alkanes (28.83%), ester (66.26%), fatty acids (4.58%), aldehyde (0.11%), and alcohol (0.22%). As we can see that composite reinforced with graphite powder proves weak in impact and flexural strength because the presence of clay and lead in graphite powder prevents complete bonding between epoxy resin and carbon that leads matrix so weak.

5. Conclusion

This study explored the use of graphite powder and sugarcane bagasse as reinforcements in a polymer composite to enhance its mechanical properties. The results demonstrated that the combination of these two materials yielded positive outcomes. Specifically, the sample reinforced with sugarcane bagasse in long strip form exhibited the highest tensile strength, impact strength, and flexural strength among all the samples tested. Sample 1, 2, 3 and 4 composites have been fabricated by using hand lay-up process. The obtained results show that flexural strength of sample 3 (hemp + sugarcane bagasse long strip) is 72.44 MPa which is 41.12% more than sample 1 (simple epoxy), 145.22% more than sample 2 (graphite powder + epoxy) and 8.3% more than sample 4 (sugarcane bagasse small piece + epoxy). It has also highest impact strength of 9.40 KJ/m^2 which is 23.35% more than sample 1 and approximately 4 times more than sample 2 and 8.5 times more than sample 4. If tensile strength is taken into

consideration than sample 3 gives results 20.67 MPa which is 44.24% more than sample 1 and 2.4% more than sample 2 and 134.88% more than sample 4. Overall, the research aims to investigate the impact, tensile, and flexural strengths of a composite material consisting of graphite powder and sugarcane bagasse-reinforced epoxy resin. The findings of this research highlight the potential of using natural fiber reinforcements, such as sugarcane bagasse, in composite materials. Sugarcane bagasse offers several advantages, including its eco-friendliness and cost-effectiveness, making it a sustainable alternative to non-renewable resources. The utilization of natural fibers and the chosen reinforcing elements hold promise for developing environmentally friendly, cost-effective, and mechanically strong composite materials. Overall, this study contributes to the development of eco-friendly and high-performance polymer composites with potential applications in various industries.

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