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INVESTIGATION OF MECHANICAL PROPERTIES ON BANANA FIBER AND SILICON CARBIDE WITH EPOXY RESIN

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ABSTRACT

World is as of now concentrating on alternate material sources that are environment agreeable and biodegradable in nature. Because of the expanding natural concerns, bio composite produced out of regular fiber and polymeric resin, is one of the late advancements in the business and constitutes the present extent of experimental work. The use of composite materials field is increasing gradually in engineering. The composite consists of mainly two phases i.e. matrix and fiber. To develop and commercialize materials containing vegetal fibers has grown in order to reduce environmental impact. A pack of fibers are mounted or braced on a stick to encourage isolation. Every fiber is divided as per fiber sizes and assembled appropriately. By retting process thin fibers can be extracted from green and wet condition of the stem for better mechanical properties. This work describe the fabrication and the mechanical behavior of banana fiber reinforced polymer composite with that of silicon carbide at varying composition, also the test such as the tensile test, hardness test and the bending test are carried out and the mechanical properties of the composite material are studied.

1. INTRODUCTION

Natural fibers have been used to reinforce materials for over thousand years. Recently, they have been employed in combination with plastics. Natural fibers are environmentally friendly, fully biodegradable, abundantly available, renewable and cheap and have less density. Natural fibers possess no health hazards and, finally, provide a solution to environmental pollution by finding new uses for waste materials. Currently, many types of natural fibers have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, wheat, cane (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, water, hyacinth, pennywort, kapok, banana fiber, pineapple leaf fiber. Fibers obtained from the various parts of the plants are known as vegetable fibers. Animals can also provide a source of fibers. A wide variety of properties can be achieved through proper selection of fiber type, fiber orientation and fiber reinforcement form.The mechanical behavior of a natural fiber based polymer composite depends on numerous factors, for example, fiber length and quality, matrix, fiber-matrix adhesion bond quality and so forth. A good interface bond is required for effective stress transfer from the matrix to the fiber where by maximum utilization of the fiber strength in the composite is achieved . Modification to the fiber also improves resistance to moisture induced degradation of the interface and the composite properties. Mechanical properties of natural fibers, especially flax, hemp, jute, banana and very good and many complete with glass fiber in specific strength and modulus. A number of investigations have been conducted on several types of natural fibers such as bamboo, banana and jute to study the effects of these fibers on the mechanical properties of composite materials. Information on the usage of banana fibers in reinforcing polymers is limited in the literature. In dynamic mechanical analysis, it have investigated banana fiber reinforced polyester composites and found that the optimum content of banana fiber is 40%. Mechanical properties of banana-fiber-cement composites were investigated physically and mechanically.Development of polymer composites with natural fibers and fillers as a sustainable alternative material for some engineering applications, particularly in aerospace applications and automobile applications are being developed. Natural fibers show superior mechanical properties such as stiffness, flexibility and modulus compared to glass fibers. Some of the natural fibers are sisal, Jute, hemp, coir, bamboo and other fibrous materials. The main advantages of natural fibers are of low cost, light weight, easy production and friendly to environment. Composite materials are intended to combine desired characteristics of two or more distinct materials. The reinforcement can be synthetic (e.g. glass, carbon, boron and aramid) or of natural sources (e.g. cur aua, sisal, jute, piassava, hemp, coir, flax and banana). The main benefits of exploitation of natural fibers are: abundance and renewability, low cost, non-abrasiveness, simple process, non-toxicity, high flexibility, acoustic insulation and low density. On the other hand, there are some drawbacks such as their poor mechanical properties and high moisture absorption. The latter is due to their hydrophilic nature that is detrimental to many properties, including dimensional stability. Nevertheless, some composite components (e.g. for the automotive sector), previously manufactured with glass fibers are now produced with natural fibers. Applications including door panels, trunk liners, instrument panels, interior roofs, parcel shelves, among other interior components, are already in use in European cars due to the more favorable economic, environmental and social aspects of the vegetable fibers. It have been observed that the effect of fiber length and weight percentage increases the flexural modulus and impact strength when increase in length of fiber and weight percentage of fiber. It is investigated on apparent density, apparent porosity and water absorption property on sisal fiber and silica micro particles, they concluded that the low level of volume fraction of fibers provided not only higher modulus of elasticity and mechanical strength under tensile and flexural loadings but also have values of apparent density, apparent porosity and water absorption. In the studies the thermal conductivity of epoxy nano composites filled with single filler system and hybrid filler system was performed. The applications of hybrid filler system not only obtain higher thermal conductivity of epoxy composites but also resistance the existence of big filler agglomeration. The addition of filler consisting of a combination of Silicon and carbon black powders decrease the negligible amount residual free Silicon but increased the amount of internal reaction bonded SIC and filler reduced the flexural strength indicating damage to the fiber but it drastically improved the wear resistance characteristics of the composites. The maximum strength is achieved when the length of the fiber in the laminate is equal to the critical fiber length. The strength of short fiber composites depends on the type of fiber matrix, fiber length, fiber orientation, fiber concentration and the bonding between the fiber and matrix. The results show that the tensile strength, young's modulus and water absorption of polyester composites increased with the increasing polyester content but elongation at break

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decreased. Morphology studied indicates that the tendency of filler- matrix interaction improved with the increasing filler in polyester matrix.

1.1 ADVANTAGES OF COMPOSITE MATERIAL

Light Weight - Composites are light in weight, compared to most metals. Their lightness is important in aircraft, where less weight means better fuel efficiency (more miles to the gallon).

Strength Related to Weight - Strength-to-weight ratio is a material's strength in relation to how much it weighs. Some materials are very strong and heavy, such as steel. Composite materials can be designed to be both strong and light. This property is why composites are used to build airplanes—which need a very high strength material at the lowest possible weight.

Corrosion Resistance - Composites resist damage from the weather and from harsh chemicals that can eat away at other materials. Outdoors, they stand up to severe weather and wide changes in temperature.

Design Flexibility - Composites can be molded into complicated shapes more easily than most other materials. This gives designers the freedom to create almost any shape or form.

Part Consolidation - A single piece made of composite materials can replace an entire assembly of metal parts. Reducing the number of parts in a machine or a structure saves time and cuts down on the maintenance needed over the life of the item.

Dimensional Stability - Composites retain their shape and size when they are hot or cool, wet or dry. They are used in aircraft wings, for example, so that the wing shape and size do not change as the plane gains or loses altitude.

Radar Transparent - Radar signals pass right through composites, a property that makes composites ideal materials for use anywhere radar equipment is operating, whether on the ground or in the air. Composites play a key role in stealth aircraft, such as the U.S. Air Force's B-2 stealth bomber, which is nearly invisible to radar.

Durable - Structures made of composites have a long life and need little maintenance. We do not know how long composites last, because we have not come to the end of the life of many original composites. Many composites have been in service for half a century.

1.2 DISADVANTAGES OF COMPOSITE MATERIAL

Delamination - Since composites are often constructed of different ply layers into a laminate structure, they can "delaminate" between layers where they are weaker.

High Cost - They are a relatively new material, and as such have a high cost.

Complex Fabrication - The fabrication process is usually labor intensive and complex, which further increases cost.

Damage inspection - Delamination and cracks in composites are mostly internal and hence require complicated inspection techniques for detection.

Composite to metal joining - Metals expand and contract more on variations in temperature as compared to composites. This may cause an imbalance at joinery and may lead to failure.

Barring for the few disadvantages, composite materials are an almost perfect material for aircraft and fulfill most of the structural requirements. With further research progress in composite material damage control, the existing problems could also be controlled.

2. DESCRIPTION OF EQUIPMENTS

2.1 MATERIALS DETAILS

In the present investigation for our project we have used following three materials as the main ingredients for the project work.

- Banana Fiber
- Silicon Carbide
- Epoxy Resin

The materials are investigated in details manner regarding their physical properties and material quality before using them as the project material. The brief details about the materials are presented in this topic.

BANANA FIBER :

Fig 2.1: Banana Fiber

Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. There has been lot of research on use of natural fibers in reinforcements. Banana fiber, a ligno-cellulosic fiber, obtained from the pseudo-stem of banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. Banana plant is a large perennial herb with leaf sheaths that form pseudo stem.

Characteristics of Banana Fibers:

Banana fiber has its own physical and chemical characteristics and many other properties that make it a fine quality fiber.

- The chemical composition of banana fiber is cellulose, hemicellulose, and lignin.
- It is highly strong fiber and it has smaller elongation with light weight.
- It has somewhat shiny appearance depending upon the extraction & spinning process.
- It has strong moisture absorption quality. It absorbs as well as releases moisture very fast.
- It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber.
- Its average fineness is 2400Nm.
- It can be spun through almost all the methods of spinning including ring spinning, open-end spinning, bast fiber spinning, and semi-worsted spinning. Table 3.1: Properties of Banana Fibers

Tenacity	29.98 g/denier
Fineness	17.15
Moisture Regain	13.00%
Elongation	6.54
Alco-ben Extractives	1.70%
Total Cellulose	81.80%
Alpha Cellulose	61.50%
Residual Gum	41.90%
Lignin	15.00%

SILICON CARBIDE:

Fig 3.2: Silicon Carbide

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics, and numerous high-performance applications. The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components. Structural and wear applications are constantly developing. Silicon carbide is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice. This produces a very hard and strong material. Silicon carbide is not attacked by any acids or alkalis or molten salts up to 800°C Chemical purity, resistance to chemical attack at temperature, and strength retention at high temperatures has made this material very popular as wafer tray supports and paddles in semiconductor furnaces. The electrical conduction of the material has lead to its use in resistance heating elements for electric furnaces, and as a key component in thermistors (temperature variable resistors).

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Silicon Carbide Properties:

- Low density
- High strength
- Low thermal expansion
- High thermal conductivity
- High hardness
- High elastic modulus
- Excellent thermal shock resistance
- Superior chemical inertness

EPOXY RESIN

Fig 3.3: Epoxy Resin

Epoxy resins, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols. These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing. Reaction of polyepoxides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with high mechanical properties, temperature and chemical resistance. Epoxy has a wide range of applications, including metal coatings, use in electronics / electrical components/LED, high tension electrical insulators, paint brushes manufacturing, fiber-reinforced plastic materials and structural adhesives. Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group. A wide range of epoxy resins are produced industrially. The raw materials for epoxy resin production are today largely petroleum derived, although some plant derived sources are now becoming commercially available. Epoxy resins are polymeric or semi-polymeric materials, and as such rarely exist as pure substances, since variable chain length results from the polymerisation reaction used to produce them. High purity grades can be produced for certain applications, e.g. using a distillation purification process. One downside of high purity liquid grades is their tendency to form crystalline solids due to their highly regular structure, which require melting to enable processing. An important criterion for epoxy resins is the epoxide content. The equivalent weight or epoxide number is used to calculate the amount of co-reactant (hardener) to use when curing epoxy resins. As with other classes of thermoset polymer materials, blending different grades of epoxy resin, as well as use of additives, plasticizers or fillers is common to achieve the desired processing and/or final properties, or to reduce cost. Use of blending, additives and fillers is often referred to as formulating.

Applications:

- Paints and coatings and Adhesives
- Industrial tooling and composites
- Consumer and marine applications
- Aerospace applications

3.EQUIPMENTS DETAILS

Apart from the material used for the making of the Project work. The basic equipment used:

- Pressure gauge
- Hydraulic Jack
- Stop watch
- Sieve Analysis screens
- Cuboids of different volume
- Fabricated bottle Jack Briquette machines

3.1PRESSURE GAUGE:

A vacuum gauge is an absolute pressure gauge used to measure the pressures lower than the ambient atmospheric pressure. Other methods of pressure measurement involve sensors which can transmit the pressure reading to a remote indicator or control system

3.2 SIEVE ANALYSIS SCREENS

A sieve analysis (or gradation test) is a practice or procedure used to assess the particle size distribution (also called *gradation*) of a granular material. The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, soil, a wide range of manufactured powders, grain and seeds.

3.3 METHOD DETAILS

In this project we have made three square plates using the banana fibers and different composition of silicon carbide and epoxy resin. In the making of the first plate the banana fibers were used in total weight percentage of 35% along with it silicon carbide percentage is kept as 0% and the binding material which is epoxy resin percentage is 65%. In the making of the second plate the banana fibers were used in total weight percentage of 35% along with it silicon carbide percentage is increased to be kept as 2% and the binding material which is epoxy resin percentage is 63%. In the making of the third plate the banana fibers were used in total weight percentage of 35% along with it silicon carbide percentage is increased to be kept as 4% and the binding material which is epoxy resin percentage is decreased to be 61%.

The making of the project is incomplete without their analyses in computer software to test its physical characteristics. The software used is ANSYS and the details about the software is being discussed.

4 .EXPERIMENTAL ANALYSIS

To test the physical characteristics of the project specimen we have done various physical test on each of the composite materials plate, the tests will show the behavior of the composite material in various physical conditions.

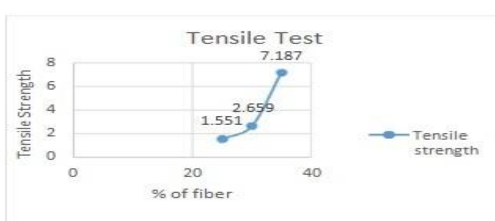
The tests by which we have analyzed our project specimen are,

- Tensile test
- Flexural or Bending test
- Impact test
- Water Absorption test

Raw materials are the starting point for development of new materials and quality of new material itself is dependent upon the raw materials. Then come the role of processing techniques to fabricate the new materials and characterizations techniques to ensure their quality. This Section describes the materials and methods used for the testing of all the composites under this investigation. It presents the details of the testing and characterization techniques in terms of mechanical and chemical properties of the composite samples.

4.1 TENSILE TEST

The tensile properties of the False banana and bamboo fibers filled epoxy resin composite material were determined by 100 kN universal testing machine at fixed strain rate 1 mm/min under displacement control mode. The results are presented in Table 9.3. The tensile strength of the false banana and bamboo fibers epoxy composites decreases at 40wt% fiber loading. This decrease in tensile strength is due to the maximum void contents and weak interfacial adhesion in case of composites i.e. when the material is stressed in tension test it tends to elongate and when the material elongates the bond between False banana and bamboo fibers and epoxy resin weakens and leads to the loosening of False banana and bamboo fibers and leads to fracture of material. Tensile test specimens were made in accordance with ASTM A 370 to measure the tensile properties.



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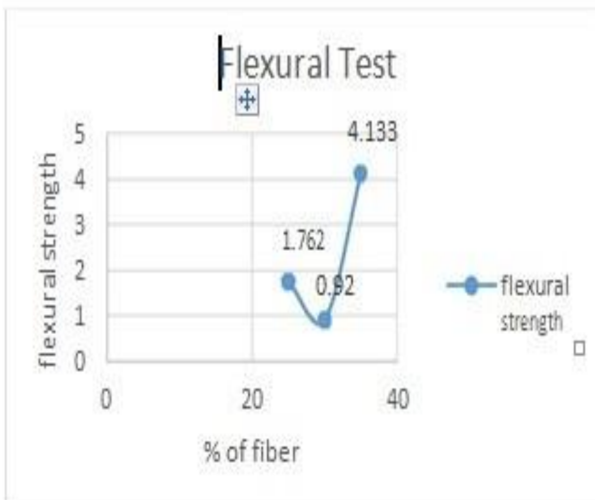
4.1 FLEXURAL OR BENDING TEST

Three-point bend tests were performed in accordance with ASTM A 370 to measure flexural properties. The specimen made according to the ASTM standard. In three-point bending test, the samples were tested at a strain rate of 0.5 mm/min. A three-point bend tested was chosen because it requires less material for each test and eliminates the need to accurately determine center point deflections with test equipment. The flexural properties have a very important role in structural applications. The flexural properties obtained at different weight percentage of false banana and bamboo fibers have been shown in Table 9.1. The effect of weight% of false banana and bamboo fibers on flexural strength is shown in Table 9.1.

It is observed that flexural strength decrease with an increase in false banana and bamboo fibers weight% in epoxy resin. It is observed that flexural strain fist decreases with an increase in bamboo fiber weight% in epoxy resin and then
Increases with an increase in weight %.



4.2 IMPACT TEST

The results obtained by the impact tests are shown in table 4.4. The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strainrate test which determines the amount of energy absorbed by a material during

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fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply.

Sl. No.	Izod Impact value in 3
1	0.35
2	0.20
3	0.30
4	0.30
5	0.45
6	0.35
7	0.35
8	0.30
9	0.35

Table 4.4: IMPACT Test

4.3 WATER ABSORPTION TEST

Water absorption is a very important test for natural particles and fibers reinforced composites to define their potential for outdoor working. The performance of these composites may suffer while they are exposed to environmental conditions for long time. The water absorption test provides information about the adhesion between the particles and the matrix in the interface region, as higher the adhesion between the matrix and the particles fewer will be sites that could store water and will lead to lower water absorption. Moisture buildup in the cell wall could result in fiber swelling and affect the dimensional stability of the product. If necessary, the moisture absorbed in the fiber cell wall can be

reduced through the acetylation of some of the hydroxyl groups present in the fiber. The samples are taken out periodically and weighed immediately after wiping out the water on the surface of the sample, using a precise four digit balance to find out the content of water
absorbed. All the Samples are dried until constant weight with four digit balance, previous to immersing in water. Percentage of water uptake is calculated by the following equation-

$$WA(\%) = \frac{W_2 - W_1}{W_1} * 100$$

W1 = initial weight of specimen g
W2= specimen weight after N hours of water soaking, g

Water absorption behavior of natural fiber thermoplastic composites have been studied by a number of researchers and the effectiveness in reducing the amount and rate of water absorption has been well-documented in the literature It have been investigated the long-term water absorption behavior of various natural fiber (wood flour, kenaf fiber, rice hulls, newsprint etc.) polypropylene composites and have also studied the effect of natural fiber type and fiber content. Authors have found that the Chemical composition of the natural fibers is responsible for the different water uptake behavior.

5.CONCLUSION

A Polymer matrix composite contains the various natural fibres as the reinforcement phase was successfully fabricated .The material properties of fabricated natural fibre reinforced composites were observed. It is found that polymer banana reinforced natural composites is the best natural composites among the various combination. It can be used for manufacturing of automotive seat shells among the other natural fibre combinations.

From the current experiments results, it has been observed that fiber ratio has major effect on the mechanical properties of the composites like as hardness, tensile strength, flexural strength and impact strength.It has been observed that the better mechanical properties found for composites having banana fiber.

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