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Development of Pumpkin Based Polymer Composite and Study of Their Mechanical Properties

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ABSTRACT

The modern dynamic world can't imagine its development without bringing the concept of advancement in material composite. Various researches are going on in this field to achieve the desired standard. Natural fiber reinforced polymer composite has a huge affinity to replace the composite made up of synthetic fiber. This is primarily because of the advantages like light weight, non-toxic, non-abrasive, easy availability, low cost, and biodegradable properties. Various matrices used currently are soft and flexible in comparison to natural fibres their combination leads to composite formation with high strength-to-weight ratios. The rapid advancement of the technology for making industry products contributes consumer the ease of making a suitable choice and own desirable tastes. Researchers have expanded their expertise in the product design by applying the usage of raw materials like bamboo fibre which is stronger as well as can be utilized in generating high end quality sustainable industrial products. The objective of the present study is to investigate the mechanical behaviour of short pumpkin stem fiber reinforced epoxy based composites. Pumpkin stem fibers in powder form are reinforced in epoxy resin to fabricate composite materials. The effect of this content on the mechanical behaviour of composites is studied. Later we are going to test the mechanical properties as per different ASTM standards. From the results of the testing we can observe the properties and use them in different mechanical application.

***Keywords*— Natural fiber reinforced Composite, Epoxy resin, Pumpkin stem, Bamboo fibres.**

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I. INTRODUCTION

Composite material can be defined as the material which is composed of two or more distinct material on macro scale with different properties to form a new material with a property that is entirely different from the individual constituents. The primary phase of a composite material is called a matrix having a continuous character. In other words, matrix is a material which acts as a binder and holds the fibers in the desired position thereby transferring the external load to reinforcement. These matrixes are considered to be less hard and more ductile. The composite material consists of a matrix along with a fiber with some filler material. The reinforced material can be either synthetic or natural fibers. In the demand of increasing environmental security, several natural fibers reinforced polymer composites (NFPCs) are brought into the competitive market. NFPCs provide a wide range of advantages over synthetic fiber based composites. These advantages include high strength to weight ratio, high strength at elevated temperatures, high creep resistances and high toughness. These advantages can also be in the form of their light weight, high durability and design flexibility. In NFPCs, the used matrices are either thermoset or thermoplastic. Polyester, Epoxy and phenolic resin are the commonly used thermoset matrix whereas polypropylenes, polyethylene and elastomers occupy the large scale position in thermoplastic matrix.

Based on the matrix used, composite material can be divided into three types i.e. Metal Matrix Composite (MMC), Polymer Matrix Composite (PMC) and Ceramic Matrix Composite (CMC). The selection of any of the above composite material depends upon the type of application. The most commonly used composites are polymer matrix composite. This is primarily because of their light weight and specific properties compared to ceramics and metals. Besides, the polymer matrix composites can be processed at low temperature and pressure.

In the present study, epoxy is as the matrix material. Generally, epoxy has a glassy appearance with classic advantages like good adhesion to other materials, good mechanical properties, good electrical insulating properties, good environmental and chemical resistances etc. The epoxy when treated with natural fiber to synthesize a fiber reinforced polymer composite, there is an interface formed between the matrix and the fiber. The adhesion between the fibers and the matrix around this interface decides the properties of the composites based on which its further application is decided. There are numerous fibers provided by nature to the human mankind. Based on the source of origin, this natural fiber can be classified into three categories such as animal fiber, vegetable fiber and mineral fibers.

Synthetic fibers reinforced polymer composites (SFPCs) have excellent properties over NFPCs. Mechanical properties of SFPCs such as tensile strength, flexural strength, impact energy and tensile modulus have higher end value. But when the comparison is made in terms of specific properties (property/specific gravity), because of lower densities of natural fibers, NFPCs have comparable specific properties to that of SFPCs. Investigations on plastics and cements when reinforced with natural fibers such as banana, bamboo, coir, jute, pineapple leaf, sisal, sun hemp, straw and wood fibers have been reported. The natural fiber used in the present study is pumpkin fiber due to many reasons. They are easily available and main thing that they the waste from vegetable. They are hard and tough waste which can be utilized for useful application.

In fiber reinforced polymer composite, the fiber used may be of different size. Depending upon the application and the type of property to be imparted to the composite, size of fibers are accordingly determined. In fiber reinforced polymer composite, the reinforcing can be either of fibrous or can be non-fibrous. If the fiber used in the composite is derived from the natural resources like animals or plants, then the fiber is said to be natural fiber and the composite is said to be natural fiber reinforced polymer composite. Many a times, it does happen that the mechanical behaviour of a NFPCs do not gives a convincing result and have shown inconsistent values in many cases. Lack of sufficient data for such fibers and their irregular characteristics are the prime reason behind this. On the other hand, there are several issues related to the natural fiber which wills to bring a full stop to the research going on in this field. But even though researchers have shown their benchmark contribution to this challenge and have become successful at many steps. The biggest challenge with the use of natural fiber is that these fibers are hydrophilic in nature i.e. they are moisture loving while many polymers are hydrophobic (moisture hating). Hence it has always been source of hindrance offered by natural fiber against its proper adherence with the matrix composite. The mechanical behaviour of the NFPCs are mostly influenced by the large number of parameters like volume fraction of fibers, fibers length, fibers aspect ratio, fiber-matrix adhesion, fiber orientation, and stress transfer at the interface. Hence to improve the overall mechanical behaviour of the composites, the properties of matrix and fibers have to be 6 improved first. Several investigations have been made on various natural fibers such as hemp, kenaf, flax, jute and bamboo to study the effect of these fibers on the mechanical and physical strength of composite materials. Better the bonding at the interface between the fibers and the matrices better is the mechanical behaviour of the composite. Since the load can be easily transfer to the fibers by the matrix. It has been reported by few investigators that the mechanical properties of the composites gets improved with increment in interfacial strength. Bamboo finds its application in composite materials in several forms. These forms range from short bamboo fiber to long strips including the whole bamboo. Researchers have expanded their interest in the product development by using the usage of raw materials like bamboo fibre which is stronger as well as can be utilized in generating high end quality sustainable industrial products. The impact strength of a composite when reinforced with a short bamboo fiber has been studied by several investigators for different fiber length and fiber content and optimum property has been reported. Studies on characterised short sisal and coconut fibers composites as well as sisal fabric composites using compact tension specimens have been made. It was found that increasing fiber content increased fracture toughness of the composites. Reinforcement of matrix with these short natural fibers increases the fracture toughness of the composites significantly. Three different types of natural fibers coir, sugarcane bagasse and banana fibers were studied and it was found that all of these composites have their fracture toughness increased. Coir and sugarcane bagasse fibers reinforcement improved the fracture toughness by 15.7%, and 17.8% respectively. Polyester reinforced with short bamboo fibers ranging from 10 to 50, 30 to 50 and 30 to 60 vol% at increments of 10 vol% for bamboo fibers at 4, 7 and 10mm length respectively was studied. The increment in fiber content deteriorates the fracture toughness at 4mm of fiber length. Positive effect of fiber reinforcement was observed for 7 and 10mm fibers length. The optimum fiber content is found to be at 40 vol% for 7mm 7 fiber and 50 vol% for 10mm fiber. The highest fracture toughness was achieved at 10 mm/ 50 vol% fiber reinforced composite, with 340 % of improvement compared to neat polyester. The effect of short fiber on mechanical behaviour of composite has been studied by few investigators. The effect of chemical treatment on mechanical behaviour of banana fiber reinforced polyester composites has been studied and reported that the mechanical properties of different alkali treated banana fiber composites showed improved fiber matrix interactions. Short sisal fiber reinforced with LDPE has been studied and it was shown that the tensile properties of the sisal-LDPE composites was enhanced. Chemically treated natural fiber reinforced thermoplastic composites offered enhanced mechanical and physical properties under extreme conditions. Tensile properties such as tensile strength and tensile modulus of chemically treated short sisal fiber reinforced composites with different fiber loading has been studied. Jute fibers are found to be very good in enhancing the fiber matrix adhesion and thus mechanical properties in jute fiber reinforced PP composites. Impact behaviour of natural fiber reinforced polymer composites has been studied by few investigators. Physical and mechanical properties of sisal fiber reinforced epoxy composites were reported by Bisanda and Ansell. Yang et al.

have studied mechanical properties and morphology of thermoplastic polymer composites filled with rice husk flour.

II. EXPERIMENTATION

2.1 Preparation of pumpkin stem powder

The pumkin stem which is the waste from pumkin vegetable, will be collected from our locality and cleaned manually for two or three times. These were dried for 8 days to free the moisture present in it so that they will totally dry. Then they will be grounded to powder of 100-300 microns.

. Fig. 1 Pumpkin stem

Fig. 2 Pumpkin stem Powder

2.2 Proportion of mixing

Before fabrication different samples are made by taking different weight fraction of matrix and fibre i.e. Epoxy resin and pumpkin stem powder. There is a table given below showing the weight fraction of the sample taken:

TABLE 1**:** Composition and designation of fiber reinforced composites

Composites	Composition
S-1	Epoxy resin (90wt %) + Pumpkin stem powder (10wt %)
S-2	Epoxy resin (85wt %) + Pumpkin stem powder (15wt %)
S-3	Epoxy resin (80wt %) + Pumpkin stem powder (20wt %)

2.3 Fabrication of Composite

Dry stems of pumpkin will be brought from the market. They will be then put in the blender machine for obtaining fibre particles. The weighed epoxy and hardener will be first manually stirred with a glass rod followed with an addition of weighed fiber. The fiber and epoxy resin is thoroughly stirred to make sure there is no air bubble trapped in the mixture. The mixture is then poured in a mould. The mixture should uniformly distributed over the inner surface of the mould and then closed. A constant dead load will be put on the mould for the purpose of curing to enhance the mixture to take the desired shape of mould. The load is then released after some time. The composite thus obtained will then further allowed to be cured in air for some hours

III. TESTING

3.1 Tensile properties:

After the fabrication of pumpkin reinforced epoxy based polymer composite, the sample of appropriate dimension is prepared to carry out various tests like tensile strength test, flexural strength test, micro hardness test and Impact test under ASTM standards. Both tensile strength and flexural strength tests is carried out on flat specimen. A uniaxial load is applied to the specimen in both the direction of the specimen, finally leading to the failure of the specimen after ultimate stress. The ASTM standard test method for tensile properties of composites has the designation D 3039-76.

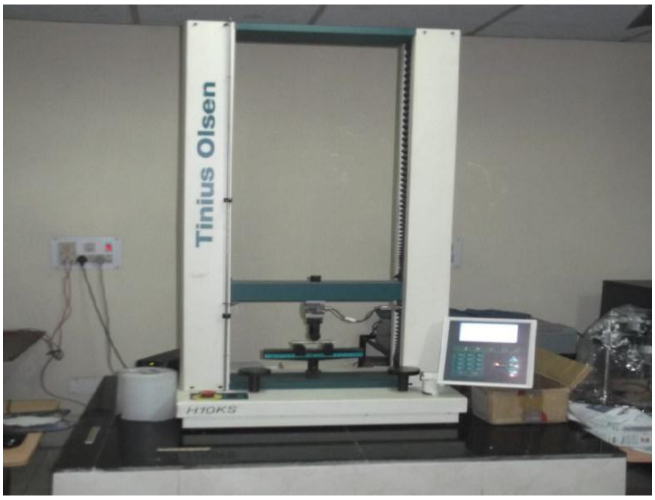

Fig 3 Experimental set up for tensile and flexural test

3.2 Hardness properties:

Micro hardness test is carried out by using the instrument named LECO hardness tester. The test is commonly known as Vickers Micro hardness test. The specimen used in this case is also of flat shape. A diamond indenter of right pyramid shape with a square base and an angle of 136^0 between two opposite faces are forced into the material under a load, F kgf. After indentations (rhombus shape) produced by the indenter on the specimen, both the 12 diagonals are measured and hardness value is thus calculated. The instrument is shown below.

Fig 4 LECO Micro hardness tester

3.3 Impact properties:

Impact strength of a material is defined as the property of a material by virtue of which the material opposes it fracture under stress applied at high speed. Impact strength of a polymer composite material is entirely related to its toughness as a whole. The instrument used for impact test in present study is Izod Impact Tester (ASTM D256) as shown in Fig 5

Fig 5 Izod Impact tester

IV. Applications

The use of composite materials dates from centuries ago, and it all started with natural fibres. In ancient Egypt some 3 000 years ago, clay was reinforced by straw to build walls. Later on, the natural fibre lost much of its interest. Other more durable construction materials like metals were introduced. During the sixties, the rise of composite materials began when glass fibres in combination with tough rigid resins could be produced on large scale. During the last decade there has been a renewed interest in the natural fibre as a substitute for glass, motivated by potential advantages of weight saving, lower raw material price, and 'thermal recycling' or the ecological advantages of using resources which are renewable. On the other hand natural fibres have their shortcomings, and these have to be solved in order to be competitive with glass. Natural fibres have lower durability and lower strength than glass fibres. However, recently developed fibre treatments have improved these properties considerably. To understand how fibres should be treated, a closer look into the fibre is required.

The vegetable world is full of examples where cells or groups of cells are 'designed' for strength and stiffness. A sparing use of resources has resulted in optimisation of the cell functions. Cellulose is a natural polymer with high strength and stiffness per weight, and it is the building material of long fibrous cells. These cells can be found in the stem, the leaves or the seeds of plants

Advantages of natural fibres:

a) Low specific weight, which results in a higher specific strength and stiffness than glass. This is a benefit especially in parts designed for bending stiffness.
b) It is a renewable resource, the production requires little energy, CO_2 is used while oxygen is given back to the environment.
c) Producible with low investment at low cost, which makes the material an interesting product for low-wage countries.
d) Friendly processing, no wear of tooling, no skin irritation
e) Thermal recycling is possible, where glass causes problems in combustion furnaces.
f) Good thermal and acoustic insulating properties

Here are some applications that can be proposed to the current study:

V. Conclusion

As the pumpkin stems become harder when it is dried we can make use of it in a better useful applications. Once we get the properties of pumpkin stem we can implement it in mechanical applications. Also if possible in automobile applications such as roofs and doors.

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