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EXPERIMENTAL ANALYSIS OF MECHANICAL PROPERTIES OF COCONUT COIR FIBER & WHEAT STRAW COMPOSITE MATERIAL

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ABSTRACT

The abundant availability and accessibility of natural fibers are the major reasons for an emerging new interest in sustainable technology. Natural fibers, as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. With low cost, high specific mechanical properties, natural fiber signifies a worthy renewable and biodegradable substitute to the most common synthetic reinforcement i.e. glass fiber. There are numerous potential natural resources in India. Most grows from the forest and agriculture. The presented work in this thesis includes an experimental analysis of mechanical properties of Hybrid composite. Starting with a study and followed by their properties, production process and refinement, finalized with experimental measurements of mechanical properties of the final compositions. Hybrid composites were prepared using coconut & wheat straw fibers of different weight ratios, works led to interesting results – created composites outrun pure coconut & wheat straw fibers. Mechanical properties i.e. tensile strength, Impact energy & bending strength. The test result shows, the composite made by 50%-50% weight fraction of coconut coir & wheat straw fiber has been shown best impact strength 47.27 N/mm^2 as compare to other constitutes of coconut coir & wheat straw fibers. The constitute 70% coconut-30% wheat straw have good tensile strength 108.7 MPa & bending strength 19.80MPa & their density is also less than coconut fibers. These composites can be used in various purposes.

KEYWORDS: Composite, Coconut Coir, Wheat straw, Tensile Strength, Bending Strength, Impact Energy.

1. INTRODUCTION

In the current quest for improved performance, which may be specified by Numerous criteria comprising less weight, more strength and lower cost, currently used materials frequently reach the limit of their utility. Thus material researchers, engineers and scientists are always determined to produce either improved traditional materials or completely novel materials. Composites are an example of the second category. Over the last thirty years composite materials, plastics and ceramics have been the prevailing emerging materials. The volume and numbers of applications of composite materials have developed steadily, penetrating and conquering new markets persistently. Modern composite materials establish a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications.

Composites have already proven their worth as weight-saving materials; the current challenge is to make them cost effective. The hard work to produce economically attractive composite components has resulted in several innovative manufacturing techniques currently being used in the composites industry. The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry.

The most widely used meaning is the following one, which has been stated by Jartiz [1] "Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form". Accordingly one may well classify among the composite materials nearly all substances such as wood, bones, shell etc., and also some man-made materials such as certain powder metallurgy products, electrical insulators, resin bonded magnetic materials, powder charged plastics, paper

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laminates etc.. The weakness of this definition resided in the fact that it allows one to classify among the composites any mixture of materials without indicating either its specificity or the laws which should give it which distinguishes it from other very banal, meaningless mixtures.

Kelly [2] very clearly stresses that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them.

Berghezan [3] defines as “The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings”, in order to obtain improved materials.

VanSuchetclan [4] explains composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

India endowed with an ample availability of natural fiber such as Bamboo, Ramie, Jute, Sisal, Pineapple, Coir, Banana etc. has focused on the improvement of natural fiber composites mainly to explore value-added application avenues. Such natural fiber composites are well matched as wood substitutes in the housing and building sector. The development of natural fiber composites in India is based on two cleft strategy of preventing depletion of forest resources as well as ensuring good economic returns for the cultivation of natural fibers.

The developments in composite material after meeting the challenges of aerospace industry have poured down for catering to domestic and industrial applications. Composites, the spectacle material with light-weight; high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like wood, metals etc. The material experts all over the world focused their attention on natural composites to cut down the cost of raw materials.

Hybrid composites are further developed composites when contrasted with traditional FRP composites. Half and halves can have in excess of one strengthening stage and a solitary lattice stage or single fortifying stage with various grid stages or different fortifying and numerous network stages. They have better adaptability when contrasted with other fiber fortified composites. Ordinarily it contains a high modulus fiber with low modulus fiber. The high-modulus fiber gives the solidness and load bearing characteristics, though the low-modulus fiber makes the composite more harm tolerant and keeps the material cost low. The mechanical properties of a half breed composite can be shifted by changing volume proportion and stacking arrangement of various employs.

Materials in fiber form are stronger and stiffer than that use in bulk form. There is a likely presence of flaws in bulk material which affects its strength while internal flaws are mostly absent in the case of fibers. Further, fibers have strong molecular or crystallographic alignment and are in the shape of very small crystals. Fibers have also a low density which is advantageous. Fiber is the most important constituent of a fiber reinforced composite material. They also occupy the largest volume fraction of the composite. Reinforcing fibers as such can take up only its tensile load. But when they are used in fiber reinforced composites, the surrounding matrix enables the fiber to contribute to the major part of the tensile, compressive, and flexural or shear strength and stiffness of FRP composites.

2. MATERIALS AND METHODS

2.1 Materials

Two fibers were investigated: Coconut & Wheat straw. For the matrix phase epoxy resin (Lapox LY 951) and Hardener (Lapox HY 556) is used for bonding the fibers. A mould of rectangular tube shape has been made, in

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which width & thickness of composite is constant & length can be varied. The sample piece obtained by this mould has constant 10 mm width and its thickness can be varied according to volume of fibers.

2.1.1 Coconut Fiber

Coir fibres are found between the hard, internal shell and the outer coat of a coconut. The individual fibre cells are narrow and hollow, with thick walls made of cellulose. They are pale when immature, but later become hardened and yellowed as a layer of lignin is deposited on their walls. Each cell is about 1 mm (0.04 in) long and 10 to 20 μm (0.0004 to 0.0008 in) in diameter.[5] Fibres are typically 5 to 30 centimeters (4 to 12 in) long.[6] The two varieties of coir are brown and white. Brown coir harvested from fully ripened coconuts is thick, strong and has high abrasion resistance. It is typically used in mats, brushes and sacking. Mature brown coir fibres contain more lignin and less cellulose than fibres such as flax and cotton, so are stronger but less flexible. White coir fibres harvested from coconuts before they are ripe are white or light brown in color and are smoother and finer, but also weaker. They are generally spun to make yarn used in mats or rope.

The coir fiber is relatively waterproof, and is one of the few natural fibres resistant to damage by saltwater. Fresh water is used to process brown coir, while seawater and fresh water are both used in the production of white coir. It must not be confused with coir pith, or formerly cocpeat, which is the powdery material resulting from the processing of the coir fibre. Coir fibre is locally named 'coprah' in some countries. It is a biodegradable and eco-friendly crop. Moreover, It is a strong, stable and versatile material and it has been recognized as an important natural fiber for composite

2.1.2 Wheat straw

Wheat straw is the stalk left over after wheat grains are harvested. Traditionally, it has been treated as a waste. In some countries, farmers burn it, contributing to air pollution and creating a public health hazard. However, these stalks still have value. We reclaim this material and use it to make our wheat straw products. Straw is an agricultural byproduct consisting of the dry stalks of cereal plants after the grain and chaff have been removed. It makes up about half of the yield of cereal crops such as barley, oats, rice, rye and wheat.

Wheat straw is abundantly available resources in current agricultural systems (Jiang et al., 2012-[7]). These harvesting residues contain lignin, hemicelluloses, and cellulose (Hubbe et al., 2010). Cellulose fibrils and lignin impart mechanical strength properties (Panthapulakkal and Sain, 2015)- [8]. Wheat straw contains surface carboxyl, hydroxyl, ether, amino, and phosphate, which enhance its reactivity and physicochemical properties, useful in the preparation of adsorbent materials for the treatment of wastewater (Wang et al., 2016a,b) and slow-release fertilizers (Liu et al., 2013; Xie et al., 2011). Moreover, some researchers have found that wheat straw can be used as reinforcements and/or fillers for nonstructural and structural composites (Panthapulakkal and Sain, 2015[8]).

Figure 2.1 Coconut coir & Wheat straw Fibers

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2.1.3 Polymer: Epoxy Resin

Epoxy resins are made of tightly linked adhesive polymer structure that are often used in the surface adhesives and coating. It is a thermosetting resin, used in strong adhesives and coatings and laminates. Epoxy resins are capable of forming tight cross-linked polymer structure characterized by toughness. Epoxy adhesives are nearly unmatched in heat and chemical resistance. The term epoxy has been widely adapted for many uses beyond fiber reinforced polymer composite. For the fiber reinforced polymers epoxy is used as the resin matrix to efficiently hold the fiber in place. It is compatible with all common reinforcing fibers including glass, agamid and natural fibers.

The reasons of using epoxy resin are: -

1. Low shrinkage during cure
2. Excellent moisture resistance
3. Excellent chemical resistance
4. Good mechanical properties
5. Good insulation properties
6. Excellent adhesion to different materials

In the present work Epoxy resin (Lapox LY 556) is used with the hardener (Lapox HY 951) is used. This has a viscosity of 10-20 poise at 25°C. This combination of resin and hardener takes time to solidification around 12 hours. It is proper cure time for fabrication of composite; its curing time is neither high nor small.

Figure 2.2 Epoxy resin

2.2 Methods

2.2.1 Sample Preparation

The testing samples made by hand layup method. For sample preparation both coconut and wheat straw fiber were cut into small length of 28mm-30mm. These fibers were equally weighted into three groups of 20 gram of fiber i.e. 100% coconut fibers (Sample-S_1),coconut fiber 70% with wheat straw 30% (Sample-S_2), coconut fiber 50% with wheat straw 50% (Sample-S_3), coconut fiber 30% with wheat straw 70% (Sample-S_4) & Wheat Straw 100% (Sample-S_5). Then mould is cleaned by brush and covered the mould by thin plastic film to avoid bonding between mould and sample pieces. Resin and hardener both mixed together in 4:5 respectively by using glass rod in a bowl. Care was taken to avoid formation of bubbles. Because the air bubbles were trapped in matrix may result failure in the material. After making the fiber straight resin and hardener mixture applied over the fibers layer to make the bunch of fibers. Fibers bunch is transfer to the mould and press that bunch with 20 kg load. The castings were allowed to cure for 24hrs at room temperature. The composite is released from mould and these composites are ready for testing. Then after it the samples are again weighted and taking dimensions (fig 2.3) of the composite before testing.

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Figure 2.3 Open mould system used for making composites & Sample Preparation

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2.2.2 Mechanical Testing

In this study, Work has been carried out to investigate tensile, bending and impact properties of hybrid composite of material constitutes coconut fiber & wheat straw. These composites are adhered using epoxy resin consists LY951 resin and HY551 hardener suitably mixed in appropriate volume. Hybrid composites were prepared using coconut & wheat straw fibers of 100% coconut fibers – Sample1,70%-30% - Sample2, 50%-50% - Sample3 and 30%-70% Sample4 & 100% Wheat straw fibers Sample5 Weight fraction ratios, while overall fiber weight fraction was fixed as 20gram.There are three kinds of coconut and wheat straw composites has been prepared. Here for preparing samples Hand layup method is used, specimens are prepared, fibers are arranged in unidirectional manner and tests are carried out, which shows tensile test, Impact test &bending strength test of coconut and wheat straw fibers hybrid composites. The tensile and compressive test was applied on Specimens of 10×10 and length varying from 50mm in dimensions but in different proportions of by weight. The impact test (Charpy test) of specimen also performed on Izod/Charpy test machine.

2.2.2.1 Tensile test

The mechanical properties of composite are depending on numerous variables like fiber loading and fiber length. The tensile test is generally performed on flat specimens. The most commonly used specimen geometries are dog-bone and the straight side type with end tabs. According to ASTM D3039-76 test models the tensile test of composites is carried out utilizing Universal Testing Machine Instron 1195. A load was connected to the both sides of composite samples for the testing. The experimental set up and specimen for tensile test is shown in Figure 3.11 the span length of the specimen was 42 mm. the tests were performed with constant strain rate of 2 mm/min.

2.2.2.2 Impact Test

These loads are applied suddenly. The stresses induced in these components are many times more than the stress produced by gradual loading. Therefore, impact tests are performed to asses shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed as (i) Rupture energy (ii) Modulus of rupture and (iii) Notch impact strength.

Two types of notch impact tests are commonly-
a. Charpy test
b. Izod test

in charpy test, the specimen is placed as 'cantilever beam'. The specimens have V-shaped notch of 45°. U-shaped notch is also common. The notch is located on tension side of specimen during impact loading. Depth of notch is generally taken as t.5 to t/3 where't' is thickness of the specimen.

2.2.2.3 Flexural Test (Bending Test)

Three point bend tests were performed in accordance with ASTM D 790 test method I, procedure to measure flexural properties. The samples were 100 mm long by 10 mm wide by 10 mm thick. In three point bend test, the outer rollers are 64 mm apart. A three point bend test is chosen because it requires less material for each test and eliminates the need to accurately determine center-point deflections with test equipment. The flexural modulus and the maximum composite stress were calculated using the relationships given in our earlier paper [9]. Three identical samples were prepared for each volume fraction of fibre and all the specimens were tested at a strain rate of 0.5 mm/min using an electronic tensometer. The density of the fibre and its composites were measured using picnometric procedure. The flexural strength of composites was found out using the following equation

$$\tau = \frac{3fl}{2bt^2}$$

Where τ is the flexural strength, f *is* the load, l is the gauge length, *b* is the width and *t* is the thickness of the specimen under test.

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Figure 2.4 Composite Sample weighing & Mechanical Testing

3. RESULTS AND DISCUSSION

The mechanical properties like impact strength, bending strength and tensile strength has been tested different samples of Coconut & wheat straw with epoxy mix fiber composite.

Tensile test was carried out on UTM machine in accordance with ASTM D 3039-76 standard. All the specimens were of straight side type with end tabs dimension (150x10x10) mm.

Impact test was carried out on (Izod & Charpy) Impact test machine in accordance with ASTM D 3039-76 standard. All the specimens were of straight side type with end tabs dimension (50x10x10) mm & (55x10x10) mm.

Three point bend tests were performed in accordance with ASTM D 790 M-86 test method I, procedure to measure flexural properties. The samples were 100 mm long by 10 mm wide by 10 mm thick.

Table3.1 Comparative Analysis of mechanical properties of composite

S no.	Sample	Tensile Strength in (MPa)	Impact Energy in (Kj/m2)	Bending Strength in (MPa)
1	S_1	131	45.20	20.20
2	S_2	108.7	46.80	19.80
3	S_3	97.65	47.27	18.00

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4	S_4	77.20	46.75	16.20
5	S_5	52.50	46.25	15.80

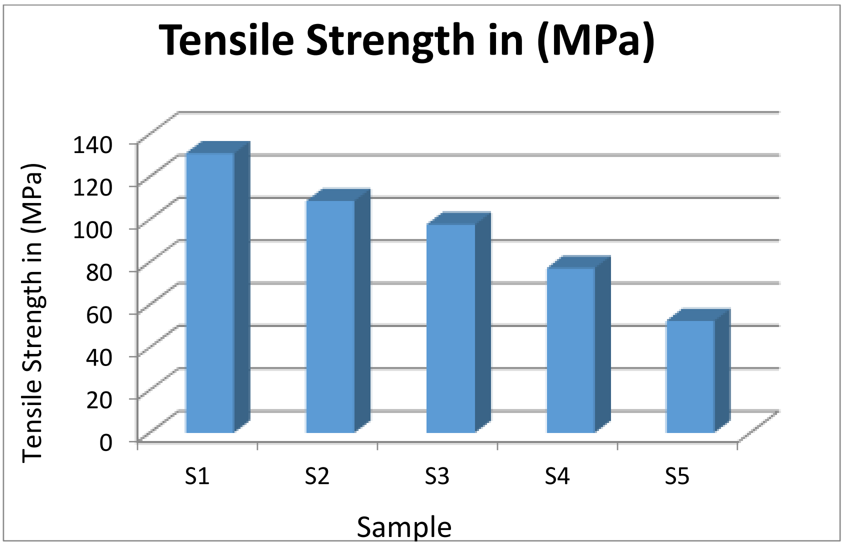

Figure 3.1 Tensile strength of a tested Composite Sample

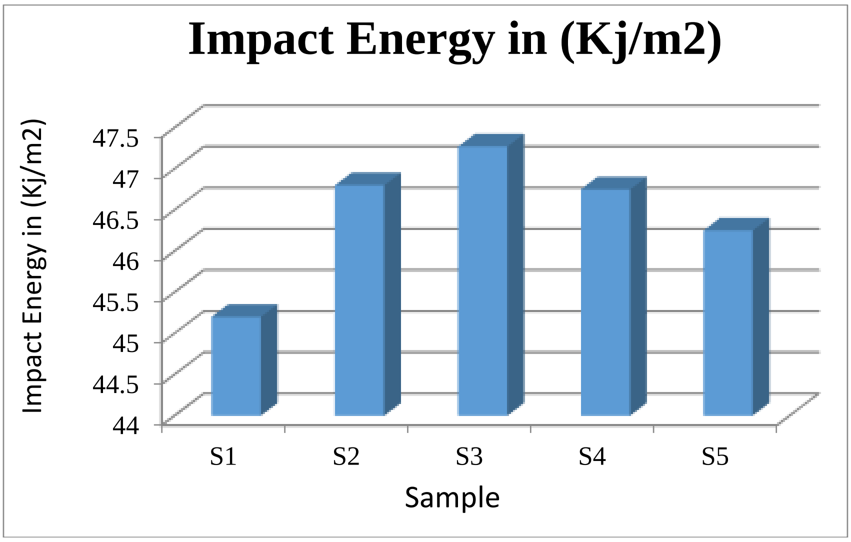

Figure 3.2 Impact Energy of a tested Composite Sample

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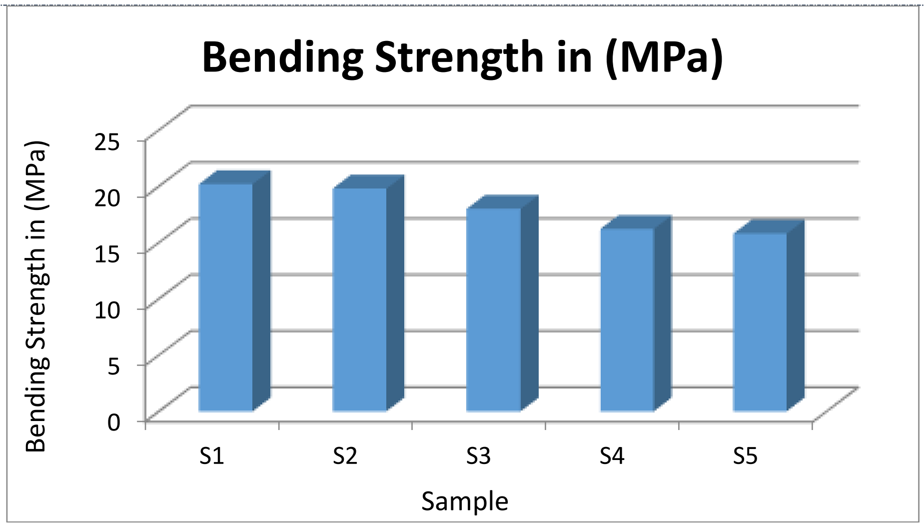

Figure 3.3 Bending Strength of Tested Composite Sample

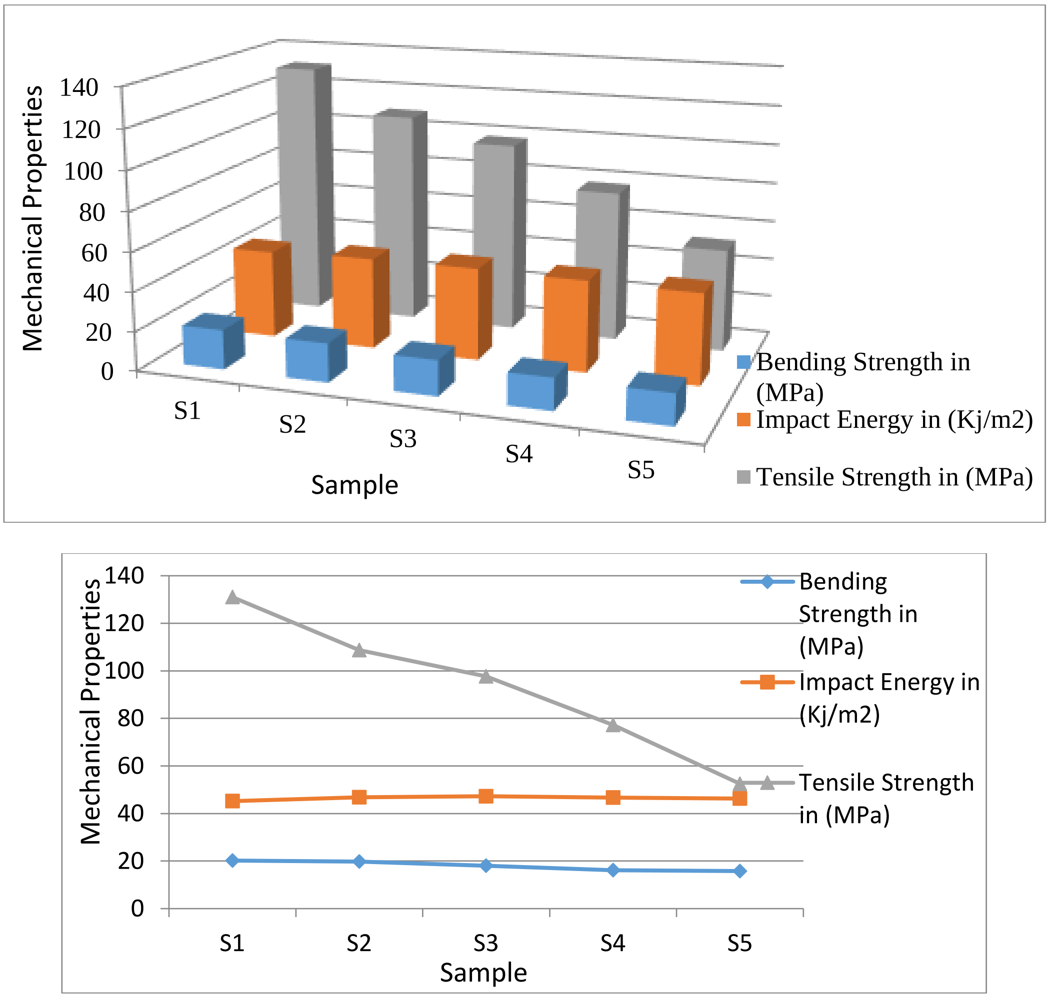

Figure 3.4 Comparative Analysis of mechanical properties of composite

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4. CONCLUSION

Polymer matrix composite contains the Coconut coir and Wheat straw fibers as the reinforcement phase by different proportions of weight of fibers. The material properties of fabricated coconut and wheat straw fibers reinforced composites were observed. It is found that

1. It is found that tensile and bending strength of coconut-wheat straw fibers composite decreases on decreases of the percentage of coconut fibers.
2. It is found that increase of the percentage of coconut fiber help to reduce the density of the composite and by the addition of coconut fiber the impact strength of the composites also improved significantly.
3. The hybrid composite made by coconut and wheat straw by using different weight ratio are showing the good strength to weight ratio as compare to their individual constituents composite.
4. The hybrid Composite made by 50% coconut with 50% wheat straw has maximum impact energy and it is also shows significant tensile and bending strength.
5. These different hybrid composites can become good replacement of traditionally using synthetic fibers.

Coconut is the largest producing fruit of the world, that's by the production of coconut, is high. From the testing the observations have been found that individually Wheat straw is not having good strength as compare to coconut fiber. But the coconut-wheat straw fibers composites are showing good strength to weight ratio. The presence of wheat straw fibers in the coconut-wheat straw fibers hybrid composite helps to improve impact strength of the composite.

5. FUTURE WORK

1. In these present work fibers composites were made by arranging the fibers in longitudinal direction. For the future work directionality of fibers providing big scope for further study.
2. Economics of the composite material is very important for the feasibility of material development.

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