Fabrication & Characterization of Hybrid composite with Waste Natural Fiber & Synthetic Fiber

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Abstract. The series of development in the field of hybrid composites are exist. Which gave idea to develop new material which is fabricate with residue of natural product and synthetic fiber. The present work is focused to utilize waste of natural fiber and synthetic fiber to development of Hybrid composite. There are variety of natural fiber available cheaply also become waste after their primary objectives like sugarcane bagasse, sisal coconut coir, banana fiber obtained from nature directly and some of synthetic fiber like rubber etc. The present work is a progress in this regards by using waste synthetic fiber that is wheel tyre with residue of Sugarcane that is bagasse taken into consideration their tensile strength and elastic property of wheel tyre. Both the fibers got waste in millions of tones across the world by every year and their decomposition is very hazarded for environment. So this work is aiming on the two objectives one is to develop new material and characterized their property other is mitigate waste material by converting it in some use full material which is many goods of day today life human kind also in automobile sector medical equipement and aviation sector. Hand ley up technique is used for developing new material, extraction process of natural fiber, clinging and cleaning, extraction of synthetic rubber. Epoxy resin is used as a bonding agent and characterized their mechanical properties like tensile strength compressive strength impact strength hardness and moisture containing capacity.

1. INTRODUCTION

1.1 Composite

The advanced technologies requires new kind of materials with different syntheses of characteristics that may not be fulfil by traditional metals, alloy, ceramic and polymeric material. This is especially true for materials that are needed for aerospace, underwater, and transportation applications. For example, aircraft engineers are increasingly searching for structural materials that have low densities, are hardness, toughness, and abrasion and impact resistant, and are not react with moisture so easily. This is a rather formidable combination of properties. [1] A composite comprises of two major elements in which one of the elements, known as the reinforcing phase, in the shape of sheets, fibres or particles is embedded into the other element called the matrix phase. Composites normally consist of fibre or particulate form that is flexible and tough as compare to the continuous matrix phase.

The properties of resultant material i.e. composite are better than the properties of the individual materials that make the composite. The matrix works as a medium of load transfer between fibres.
whereas reinforcement provides strength and stiffness to the matrix. The matrix even protects the fibres from environmental damage during and after processing of composite. [2]

A composite is material having multiphase which is made manually for the desired characteristics, in present context, spontaneously these properties are inherent in the materials. Along with that, the ingredients phases must not be chemically similar and isolate by a distinct interface. Thus, most metallic alloys and many ceramics do not fit this definition because their multiple phases are formed as a consequence of natural phenomena excellent materials. Many of the composites have been fabricated to enhance combinations of mechanical properties like that tensile strength, Hardness, and ambient and high-temperature strength. [3]

1.2 CLASSIFICATION OF COMPOSITES

1.2.1 Based on Matrix:
   1.2.1.1 Polymer Matrix Composite (PMC)
   1.2.1.2 Metal Matrix Composite (MMC)
   1.2.1.3 Ceramic Matrix Composite (CMC)

1.2.2 Based on reinforcement
   1.2.2.1 Short-fibre reinforced composite
   1.2.2.2 Continuous fibre reinforced composite

1.2.3 Polymeric Matrices
   1.2.3.1 Thermosetting and
   1.2.3.2 Thermoplastic polymer composites.

![Figure 1. Classification of polymeric matrices for natural fibre composites](image-url)
1.3 HYBRID COMPOSITES

The composites that involve the reinforcement of two or more fibres in a common matrix are called hybrid composites. Hybrid composites are specifically employed in those conditions which require a combination of different set of properties of different fibres or when both lateral and longitudinal mechanical performance of composite is required. Hybrid Composites provide us with the advantage of using the properties of one fibre to compliment that is deficient in the other. The properties of the hybrid composites depends upon many factors which are- fibre density, fibre length, fibre quality, fibre orientation, nature of interface between fibres, fibre to matrix bonding capacity etc. There are many application of natural fibre hybrid composites seen in various Electrical Industries, manufacture of storage devices, Packaging Industries, Railways Coaches etc.

2.0 MATERIAL REQUIREMENT SHEET PREPARATION

The materials required for fabrication of composites are:

2.1 Fibres (Reinforcement)

2.1.1 Bagasse fibre
2.1.2 Wheel Tyre
2.1.3 Epoxy Resin

Fibre reinforcing is very useful technique to enhance the characterization of Composite material. During fabrication mixing of fibre with the matrix and their bendability with agent is very concerning parameter of fabrication. Mechanical stirrer is used for proper mixing of fibre with bonding agent. Another concerning point during fabrication i.e. Orientation of fibre because orientation become the key factor to decided their mechanical strength. Fibre reinforcement in the composite is very easy and cheap in Hand lay-up technique.

In this experiment Hand Lay-Up Technique is used for fabricating the composite material:

![Figure 2. Technique flow chart of FRP by hand lay-up](image)

The hand lay-up is one of the ancient and most popular production process for composites. This fabrication technique included manual layering of fibre, or in particulate form kept in mould and conjugating advantages of resin matrix to form a sandwich stack. The mixture of resin and the fibre is then rolled, brushed, or squeezed using hand rollers to distribute the resin uniform thickness, release trapped air with help of pines and consolidate the composite layers to certain good bendability between the reinforcement fibre and the epoxy resin system and to get a prescribed dimension of sheet. Mainly,
the hand layup production method may be classified into four essential stages: mould formation, mixture coating, layup, and curing. That method is worker oriented where the laminate quality, resin mixing, and laminate resin contents are mainly dependents upon the workers skill, as in this method not much fibre loading is possible. However, longer fibres can be used in this process and its versatility and low tooling cost has made it attractive for applications in shipping and aviation components. Many Bullet proof components are manufactured by the hand layup process from ramie fibre–reinforced composites with epoxy as a matrix. The figure 3 (a) clearly shows the hand lay-up technique.

2.1.1 Sugarcane Bagasse
The Bagasse fibers utilized in this work were obtained from local market. Sugarcane bagasse is a plentiful lingo cellulosic waste excretion mostly grows in countries that harvest sugarcane like India, china and many other tropical countries.
Bagasse which is extracted by the raw sugarcane shown in figure 3 (b), is left after the juice has been extracted from the sugar cane biodegrades in 25-65 days. Each 10 tons of sugarcanees processed in a sugar factory produces approximately 3 tons of wet bagasse. Bagasse is primarily employed as a burning raw material in the sugar cane mill furnaces. Approximately 9% of bagasse is employed in alcohol (ethanol) production. [4]

2.1.1.1 Treatment of fiber
When sugarcane was crushed their juice extracted properly after that it will cleaned in fresh water then it willed with boiled water and finally it will dried in sun light, the figure 5 (a) & (b) treated bagasse which is converted into clean bagasse fibre for the fabrication.
2.1.2 Wheel Tyre

A wheel tyre rubber is stated that “continuous pneumatic covering made of natural rubber or synthetic rubber or a combination of natural and synthetic rubber encircling a wheel, whether new, used or retreaded”. Wheel Tyres are generally divided as per its requirement, like wheel tyre for light vehicles (Passenger), wheel tyre for heavy duty vehicles (Truck) and the tyre off-the-road (OTR). The percentage of constituent which is added in wheel tyres are given below. The percentage of rubber in each segments of the wheel tyre is good enough to compare but the truck wheel tyre have basically natural rubber. The table 1 shows comparative study of their ingredient. The wheel of Truck have rubber in which 65% natural and 35% synthetic; while reversal is exist in other wheel tyres. [5]

| Ingredient | Percentage composition |
|------------|------------------------|
|            | Passenger | Truck | OTR |
| Rubber     | 47        | 45    | 47  |
| Carbon black | 21.5     | 22    | 22  |
| Metal      | 16.5      | 25    | 12  |
| Textile    | 5.5       | -     | 10  |
| Zinc Oxide | 1         | 2     | 2   |
| Sulphur    | 1         | 1     | 1   |
| Additives  | 7.5       | 5     | 6   |

Table 1. Material Composition of Tyres [7]

The biggest dissimilarity in the integration amongst the wheel tyre types are not present in of garment fibres and the presence of greater metallic component in Carbon black is a sharp, tiny and soft amorphous produced at the time created when crude oil or natural gas is combusted by a required content of oxygen, that causes improper burning and creating a large amount of fine soot. So much carbon black is required for producing tyre. Sulphur and similar other elements are found in wheel tyres. Prescribed elements, when added with rubber and then increased temperature, to manufacture special tyre properties such as large resistance for a racing tyre or great mileage (but less friction) for light motor vehicle wheel tyre. Some elements provides the property elasticity for the wheel into its structure into a tyre. Other elements secure the tyre rubber from the harmful radiation of sun light. The trend towards use of recycled materials has increased the demand for crumb rubber. The producer of asphalt tyre rubber is one of the biggest application of crumb rubber, consuming approximate 22 crore pounds, or approximately 1.3 crore tyres per year. Crumb rubber may be crushed with asphalt to enhance the characteristics which is utilised in expressway construction. Crumb rubber has other applications, including ground cover under playground accessories, treadmills material, and likewise particles ingredient in athletics and sports ground. Several different applications for wheel tyre rubber include moulded goods.

2.1.2.1 Treatment of Tyre Rubber

Wheel tyre rubber is made by minimizing the size of complete tyres along with extra granulators. The decrement of size minimizing procedure combined next for minimizing additives approaches description to finish good. Finally the wheel tyre is processed at normal temperature, frozen at very low temperature before the surface finishing, manufacturing neat and clean, tiny particles with dissimilar mechanical features than ambient crumb rubber. Crumb rubber is used in rubberized asphalt...
concrete, paving applications & many other products which are derived with tyre rubber including synthetic turf infill and moulded rubber products. Too small crumb tyre rubber of 80-200 mesh are ready to use in a wider range of development & advanced goods, and ensure about the new methods of crushing wheel tyre rubber plateformholds. [6] The figure 4 (a) shows waste wheel tyre and the crushing into the runner for making of particulate synthetic fibre and also figure 4 (b) represent the treated crushed rubber in refine granular particles for the fabrication.

![Figure 5. (a) Crushed rubber from Wheel tyre & (b) Treated Wheel Tyre [6]](image)

2.1.3 Epoxy Resin
Epoxy resin is favorable by researchers because of their super bond strength. Another season for using Epoxy system is their easy availability and low cost. This is an alternate of welding process for the fabrication, this epoxy system, which is thermoset have a superior resistance to other chemicals. Another advantage of this resin system is that it never react with other chemical after mixing and fabrication of sheet It has good resistance towards heat. And once resin got set there is a less possibility of any chemical reaction. These resistance property of resin system is very feasible for the electronic and electrical equipment. [7]

Researchers are opted due to the focused to method of heat flows outward, non-conductor to electrical, cohesive similarity substance, less weight, sound absorption, oscillation, and less reactive with moisture. Presence is to be mentioned and their fabrication cost. This resin is cohesive amalgamation that fulfill all the desired needs. Its thermal, mechanical and electrical characterizations, strength, and durability are what epoxy is noted for. These characterizations as well as the resistance to immersion and hostile chemical vapour are the reason behind the epoxy resin mostly become the first choice of researchers. [8]

2.1.3.1 Specification of Epoxy Resin

2.1.3.1.1 Superior adhesion to different materials.
2.1.3.1.2 Exceptional strength and toughness.
2.1.3.1.3 Good chemical and moisture resistance.
2.1.3.1.4 Tasteless, Odourless and non-toxic.

Epoxy resin has surprising cavity occupy capacity. This resin presents it’s resistance towards low temperature as well as high radiation.
Epoxy resin system is popularly adopted for composite manufacturing. Epoxy resins manufactured by the reaction of epichlorhydrin with materials such as biphenyl A or aromatic amines as it has been noted below. The figure 6 show the bondtite matrix comprising AY-105 epoxy resin which is part -A and HY-951 hardener which is part-B and the part-A & part –B are mixed with the ratio of 10:8 as per catalogue of company.
2.2 Mould
Mould is an important component for the fabrication of composite. In this experiment, a mould of dimension 650 mm length, 450 mm width, and 10 mm thick is used. Two wooden frames of dimension 450 mm length, 300 mm width, and 50 mm thick are made for the fabrication of bagasse fibre and wheel tyre reinforcing epoxy hybrid composite. In the present composite, bagasse is taken 14% by weight, 4% by weight of wheel tyre, and 82% of epoxy resin. After 48 hrs at NTP, the fabricated sheet is moulded under some load so that a proper shaped desired dimension sheet is prepared.

3.0 TESTING AND RESULT

3.1 Tensile test
To examine the value of Young’s Modulus, percentage of deformation or elongation, and maximum tensile stress of the bagasse and Wheel tyre composite material. The tensile test is done on Universal testing machine (Model No-AST 40) and the following result is obtained.
Tensile Test Specimen (ASTM D638) – The specimen’s dimensions are 150 x 15 x 6 mm³.  
Young’s Modulus = 0.148 KN/mm²  
Percentage of Elongation = 2.69%  
Maximum tensile stress = 0.028 KN/mm²

3.2 Impact Test
For obtaining toughness of bagasse fibre and wheel tyre hybrid composite Impact Test performed. The size of specimen is as ASTM D256 with dimension 63 x 13 x 6 mm³. There are three test would be done and the average value would be calculated which 36.5J/s. So we find improve impact strength as compared neat matrix sheet.

3.3 Hardness Test
This test is done on digital Rockwell Hardness testing Machine of Model RHT, M-scale, 100 kgf force carrying capacity, 1/4” ball intender. Hardness test is performed to find out the resistance against penetration on Digital machine of hardness testing with model RBHT, M scale, 100 kgf force capacity [1], Rockwell Hardness Test Specimen (ASTM D785) – The specimen’s dimensions are 50 x 50 x 6 mm³. The hardness of bagasse fibre & wheel Tire composite 60.52 HRM which get greater as compared to neat epoxy hardness value.

It is clearly shown that the hardness of the particulate form of Bagasse fibre and Tyre Rubber hybrid composite 60.52 (mean value) is greater than the neat Epoxy sheet hardness.

3.4 Moisture Containing Capacity
Moisture containing capacity can be tested on specimen. The specimen dimensions (50 x 50 x 6 mm³) were according to ASTM D570 standard. The specimen is dipped in water tub and its weight.

![Figure 9](image)

**Figure 9.** (a) Specimen dipped in tub & (b) Moisture Containing Capacity

Noted every 24 hrs. Epoxy resin never react with water i.e. why there is least possibility of absorbing moisture content. Since natural fibre contains small content of moisture during first 8-16 hrs but after sometimes it showed in the above figure 10 (b) small change of about 0.5grams in mass. Initial mass of work piece is 20gms and after 48hrs it gain to a mass of 20.70gms. Further there is no change in the mass of work piece.

4.0 Conclusion
The tensile test is performed on bagasse fibre and wheel tyre composite and it is found that the Modulus of Elasticity and Maximum tensile stress of bagasse Fibre & Tire rubber composite is slightly increases than the form of composite neat epoxy and Hardener and Elongation percentage are also increases in composite.
The following result have been seen which are as follows:

- The tensile strength of bagasse and wheel tyre composite is 0.028 KN/mm².
- The value of hardness of this composite 60.52 HRM which is less than neat epoxy sheet. Which is due to fibrous heterogeneity.
- Bagasse fibre and wheel tyre composite having Impact strength 36.5 J/s which is almost three times of impact strength of neat epoxy sheet i.e.12.3 J/s.
- The fabricated sheet piece contain only 0.70 gm of water in three days and then it failed to absorb any moisture.(in line)

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