A Review on Hybrid Composites: Fabrication, Properties and Applications

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Abstract - The aim of this work is to develop a new class of hybrid composite by combining natural fibers and synthetic fiber. The synthetic fiber reinforced composite possess high specific strength, and excellent mechanical property but their fields of application are very limited because of their inherent higher cost of production they are prefers only for military and aircraft applications and also it is difficult to devise suitable disposal methods for them. Due to many environmental problems, the disposal methods for glass fiber and there recycling have been seriously acknowledged. Instate of this nowadays, natural fiber form is an interesting option for the most widely applied fiber in the composite technology. Natural fibers may play an important role in developing biodegradable composites to resolve the current ecological and environmental problems. Natural fibers also have good mechanical property. For increasing the strength of composite adding the layer of glass fiber in laminate, there for increases the property of composite material and can be used in various fields of engineering application.

1. INTRODUCTION

Natural fiber composites are nowadays widely used instead of synthetic fibers due to their advantages like biodegradability, low weight, low cost and high specific mechanical properties. Synthetic fiber composites have far better mechanical properties than natural fiber composites but since they are highly expensive, they are justified only for aircraft and military applications. After the development of composite it's the challenges for researchers have focused to needs of domestic and industrial applications.

Research and development of natural fibers as reinforcement for automotive sectors is a growing interest to scientists and engineers. Nowadays, natural fibers form is an interesting option for the most widely applied fiber in the composite technology. Many studies on natural studies such as keraf, bagasse, jute, ramie, hemp and oil palm [1]. Fiber reinforced composites with thermoplastic matrices have successfully proven their high qualities in various fields of engineering application. However, Natural fibers generally have poor mechanical properties compared with synthetic fibers but these composites were used as a source of energy to make shelters, clothes, construction of weapons. High cost of synthetic fibers and health hazards of asbestos fibers have really necessitated the exploration of natural fibers [2]. Consequently, natural fibers have always formed wide applications from the time they gained commercial recognition. They possess desirable properties such as biodegradable, renewability, combustibility, lower durability, excellent mechanical properties, low density and low price. Excel- lent price-performance ratio at low weight in combination with the environmentally friendly character is very important for the acceptance of natural fibers in large volume engineering markets, such as the automotive and construction industries.[3]

A composite may be defined as a physical mixture of two or more different materials. The mixture has proper-ties which are generally better than those of any one of the materials. It is necessary to use combinations of materials to solve problems because any one material alone cannot do so at an acceptable cost or performance. These composites were produced in simple shapes and easy design structures by positioning the structural elements on top of each other to create the desired design.

Strength of glass fiber reinforced composites depends not only on the properties of the components but also on the mechanism of composite failure which is a function of how well the composite was formed [4].

In polymeric composite terms, natural fiber reinforcement is a manufactured assembly of long or short bundles of natural fibers to produce a flat sheet or mat of one or more layers of fibers. These layers are held together either by mechanical interlocking of the fibers them-selves or with a binder to hold these materials together giving the assembly sufficient integrity to be handled. The un-reinforced plastics have low density, are relatively easy to process, resistant to weathering and do not require a surface finish [5].

In order to fully utilize the natural fibers, understanding their physical and mechanical properties is vital. A unique characteristic of natural fibers is depended upon the variations in the characteristics and amount of these components, as well as difference in its cellular structure. Therefore, to use natural fibers to its best advantages and most effectively in automotive and industrial application, physical and mechanical properties of natural fibers must be considered. Many studies have investigated the properties of natural fibers. Numerous researchers have studied mechanical properties of varied natural fibers [6].

Traditionally, natural fibers are used and known for rope, twine, and course sacking materials; and they are biodegradable and environmentally friendly crop. All mentioned studies have assisted engineers with the design and efficient usage of the natural fibers. However, the fibers modification is required and needed to improve mechanical properties for composites product. Efficiency of the fiber-reinforced composites also depends on the manufacturing process that the ability to transfer stress from the matrix to fiber.

The properties of natural composites depend on the strength of the fiber and the interfacial adhesion of the matrix with the fiber. The properties of the composite can be improved by using glass fiber. [7] Banana fiber in combination with glass is making excellent and cost effective composite materials. Many researchers [8-9] have reported that the mechanical efficiency of the fiber reinforced polymer composites depends on fiber-matrix and the ability to transfer stress from the matrix to fiber. By combining the synthetic fiber with natural fiber in the same matrix can be obtained best properties.

2.FABRICATION AND MATERIAL CHARACTERIZATION

2.1 Material

2.1.1 Banana Fiber

It is obtained from a banana plant. On an average, the plant grows about (2 meter) tall and the fiber is fond from the stem of the plant. These fibers are generally used to make ropes but nowadays it is gaining importance as excellent reinforcement for composite materials. The buyers for banana fibers are erratic and there is no systematic way to extract the fibers regularly. Useful applications of such fibers would regularize the demand which would be reflected in a fall of the prices.

Fig-1 Banana fiber

2.1.2 Jute fiber

Jute is one of the most affordable natural fibers. It is mainly composed of plant materials like cellulose and it can be spun into coarse or strong threads. Jute takes nearly 3 months, to grow to a height of 12–15 feet. Retting process is used to separate the fiber from the stem of the plant. The major types of retting are mechanical retting, chemical retting, steam retting, and water or microbial retting. The retted fibers are then dried in open air or by using mechanical means.

Fig-2 Jute fiber

2.1.3 Glass fiber reinforced polymer

Glass fiber is a material that contains extremely fine fibers of glass. It is light in weight, extremely strong, and robust. It is formed when thin strands of silica glass are extruded into many fibers with small diameters. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes. The individual filaments are now bundled together in large numbers to provide a roving. They are then woven in a machine to produce woven roving. In general, it is used as a reinforcing agent for composites to form a very strong and light fiber reinforced polymer (FRP) composite material.

Fig-3 Glass fiber

2.1.4 Preparation of epoxy Resin and hardener

Resin Matrices have as main purpose to transfer the stresses imposed on the composite material to the fibers, as well to serve as a support and protection of the fibers. Generally, composite matrices of thermosetting resins are used because they have great mechanical properties and dimensional stability. They are also resistant to chemical attack and have high thermal resistance.

Epoxy resin is used to give great binding properties between the many fiber layers to form the matrix. The epoxy resin used at room temperature is (Grad-257). Hardener (Grad-140) is used to improve the interfacial adhesion and impart strength to the composite. A resin and hardener mixture of (1:2) is used to obtain optimum matrix composition.

Fig-4 Epoxy resin and hardener

2.1.5 Mould Preparation

The fabrication of the various composite materials is carried out through the hand lay-up technique. The mould used for preparing composites is made from two rectangular chromium-plated mild steel sheets having dimensions of 300 mm×100 mm. Four beadings were used to maintain a3 mm thickness all around the mould plates. The functions of these plates are to cover, compress the fiber after the epoxy applied, and also to avoid the debris from entering into the composite parts during the curing time.

Fig-5 Mould plates

2.2 Fabrication procedure for specimen

The composite material is fabricated by using hand layup method. GFRP layers are placed on top and bottom on the specimen and intermediate layers are filled by natural fibers. Resin and hardener mixture (1:2) is spilled for every layer. Initially the fibers are dried in sun light to remove the moisture. The mould surface is cleaned and releasing agent (Poly Vinyl Alcohol) is applied. The woven roving (GFRP) are then completely filled with epoxy resin, rolled to remove the entrapped air and to uniformly spread the mixture. Now the banana fibers and jute fibers are arranged alternatively with horizontal and vertical orientation (Fig. 6).

GFRP(Woven Rovings)
Banana fiber (Vertical Orientation)
Jute fiber (Horizontal Orientation)
Banana fiber (Vertical Orientation)
GFRP(Woven Rovings)

Fig-6 Schematic diagram of banana–jute–GFRP.

For each layer, resin hardener mixture is applied and rolled. Within 15 to 20 min resin is dried. So ,following layers need to be stacked up within the time period of15 min to avoid drying of epoxy resin. Finally the fiber are closed. With woven roving just like the base of the laminate. Now a load is applied for a curing period of 24 hours. After the curing process, test samples were cut to the required sizes prescribed in the ASTM standards. Similarly the banana–GFRP composite is prepared by replacing intermediate layers (Fig. 7).

GFRP(Woven Rovings)
Banana fiber (Vertical Orientation)
Banana fibre (Horizontal Orientation)
Banana fibre (Vertical Orientation)
GFRP(Woven Rovings)

Fig.-7 Schematic diagram of banana–GFRP.

Similarly, the jute–GFRP composite is prepared by replacing intermediate layers (Fig. 8).

GFRP(Woven Rovings)
Jute fiber (Vertical Orientation)
Jute fiber (Horizontal Orientation)
Jute fiber (Vertical Orientation)
GFRP(Woven Rovings)

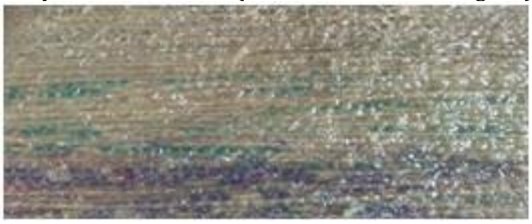
Fig-8 Schematic diagram of jute–GFRP

2.3 Stages in Hand-layup Method

1 Layer of GFRP (Bi- directional)

2 Layer natural fiber (Uni-Directional 0 degree)

3 Layer natural fiber (Uni-Directional 0 degree)

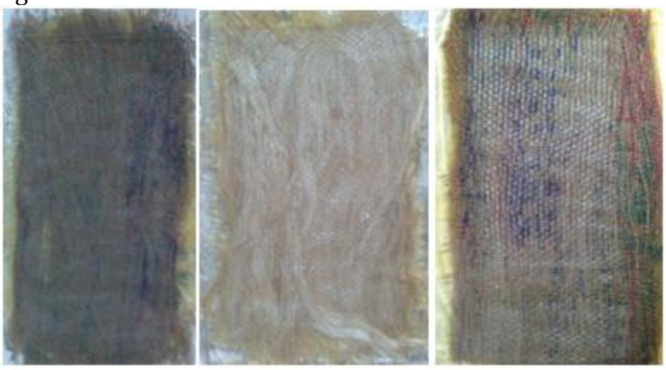


4 Layer natural fiber (Uni-Directional 0 degree)

5 layer GFRP (Bi- directional)

Fig-9 Stages in Hand-layup Method

According to this stages by hand layup process fabricate three different type of composite material shown in below figure 10.



I Types **II Types** **III Types**

Fig.10 Three types of fabricated hybrid composite material

2.4 Properties of different types of natural fiber

The selection of suitable fibers is determined by the required values [13-15] of the stiffness and tensile strength of a composite (Table 1). Further criteria for the choice of suitable reinforcing fibers are, for example, elongation at failure, thermal stability, adhesion of fibers and matrix, dynamic and long-term behavior, price and processing costs. The study and utilization of natural polymers is an ancient science.

Table-1: Material property

Material	Density (g/cm^2)	Tensile Strength (Mpa)	Young's Modulous (Gpa)	Elongation of Break (%)
Flax	1.45	500-90	50-70	1.5-4.0
Hemp	1.48	350-80	30-60	1.6-4.0
Kenaf	1.3	400-700	25-50	1.7-2.1
Jute	1.3	300-700	20-50	1.2-3.0
Bamboo	1.4	500-740	30-50	2
Sisal	1.5	300-500	10-30	2-5
Glass Fiber	2.5	1200-1800	72	2.5

Fibers provide strength and stiffness and act as reinforcement in fiber-reinforced composite materials; ultimately the properties of a composite are governed by the inherent properties of these fibers.

3. Application

Research into composite based products such as natural composites is increasing in the hopes of developing alternatives to petroleum-based plastics and synthetic reinforcing fibers. Natural composites present several environmental advantages, including reduction of fossil fuel use and lower green-house gas emissions. They also present functional benefits, with adequate tensile strength, stiffness as well as competitive costs. These are being explored as alternatives to petroleum-based plastics. Reinforcing natural fibers such as cotton, jute, flax, hemp, sisal, kenaf and more recently corn and soy are increasingly replacing synthetic fibers. Presently, the main markets for hybrid composites are in the construction and automotive sectors.

Present scenario is to develop both thermoset and thermoplastic natural fiber/resin composites with challenging properties. The term —challenging included good chemical resistance, surface finish, complex manufacturing high mechanical properties (stiffness, impact, strength, etc.) and addressed a number of industries including medical devices, industrial, automotive, marine and construction. To verify these composites, several model products and demonstrators were produced and evaluated using modeling and structural tests. The use of fiber-reinforced plastic composites in the automotive industry has grown significantly in recent years because of their low weight, design flexibility, corrosion resistance and cost effectiveness. With further developments and improvements in performance, however, new opportunities and applications will likely arise. For composite materials made from renewable materials, the greatest advantage, environmentally, is to be gained by having natural fibers.

4. Conclusions

The hybrid composite is the best option in automotive for door panels, seat back, head liners, package trays, dash boards and interior parts application. Jute composite can be used where high impact strength is necessary. Banana and jute fibers are normally available from agricultural resources are cheaper than the conventional natural fibers like hemp, sisal, etc.

This work can be real time further extended in automotive components such as bumper and engine cover. The composites mechanical property are characteristics and analyzed under different working conditions and better design may be provide a way for green environment concept.

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