Fabrication of Industrial Safety Helmet by using Hybrid Composite Materials

B.Murali, D.Chandramohan, S.K.Nagoor Vali and B.Mohan
Department of Mechanical Engineering, Veltech, Avadi, Chennai, India

Abstract—Composite materials with thermoplastic matrices and a reinforcement of natural fibers are increasingly regarded as an alternative to material replacement for various applications. The substitution of the traditionally used composite of natural fibers such as sisal, banana and jute can lead to a reduction of the component's weight and furthermore to a significant improvement of specific properties like impact strength, compression strength. One of the major fields of application for such materials can be found in structural components manufacturing of industrial safety helmets.

In this project work natural fiber particle reinforced materials such as Sisal, Banana and jute reinforced polymer composite material with epoxy resin has been used for fabrication of industrial safety helmet. Impact strength and compression strength values are identified. The helmet manufacturing aspects are reviewed. Both the thermoplastic and the natural fiber composite shell manufacturing techniques are presented with specific mentioning of the advantages and disadvantages to each type from the manufacturing point of view.

Key Words- Hybrid, Mechanical properties, Natural fiber.

I. INTRODUCTION

A. Overview of Composite material

Composites are combinations of two or more materials in which one of the materials, is reinforcing phase (fibres, sheets or particles) and the other is matrix phase (polymer, metal or ceramic). Composite materials are usually classified by type of reinforcement such as polymer composites, cement and metal- matrix composites (Chemical and Materials Engineering). Polymer matrix composites are mostly commercially produced composites in which resin is used as matrix with different reinforcing materials. The different type of fibre is natural (plant, animal, mineral) and man-made fibre for different application. In metal matrix composites, metal is one of important part of element and other part may be metal, ceramic or organic compounds. Cement matrix composites are made up of cement and with aggregate and basically used in building applications. Natural fibres have many remarkable advantages over synthetic fibres. Nowadays, various types of natural fibres have been investigated for use in composites including flax, hemp, jute straw, wood, rice husk, wheat, barley, oats, rye, cane (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm, sisal, coir, water hyacinth, pennywort, kapok, paper mulberry, banana fibre, pineapple leaf fibre and papyrus. Natural fibres are largely divided into three categories depending on their origin: Mineral based, Plant based, and Animal based. Natural fibre composites posses the advantages such as easy availability, renewability of raw materials, low cost, light weight and high specific strength, and stiffness. It is expected that in the near future biodegradable polymers will replace synthetic polymers, at least in some specific applications where a short life of the product will be more desirable. Natural polymers are considered suitable to replace synthetic ones in some specific applications where a long span life is not required. Natural fibre thermoplastic composites are relatively new family of composite materials.

B. Merits of composite

Advantages of composites over their conventional counterparts are the ability to meet diverse design requirements with significant weight savings as well as strength-to-weight ratio. Some advantages of composite materials over conventional ones are as follows:

- Tensile strength of composites is four to six times greater than that of steel or aluminium (depending on the reinforcements).
- Improved torsional stiffness and impact properties.
- Higher fatigue endurance limit (up to 60% of ultimate tensile strength).
• 30% - 40% lighter for example any particular aluminium structures designed to the same functional requirements.
• Lower embedded energy compared to other structural metallic materials like steel, aluminium etc.
• Composites are less noisy while in operation and provide lower vibration transmission than metals.
• Composites are more versatile than metals and can be tailored to meet performance needs and complex design requirements.
• Long life offer excellent fatigue, impact, environmental resistance and reduce maintenance.
• Composites enjoy reduced life cycle cost compared to metals.
• Composites exhibit excellent corrosion resistance and fire retardancy.
• Improved appearance with smooth surfaces and readily incorporable integral decorative melamine are other characteristics of composites.

Composite parts can eliminate joints / fasteners, providing part simplification and integrated design compared to conventional metallic parts.

C. Natural Fiber Reinforced Composites

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, Roselle, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and manmade fibers used for the manufacturing of composites. Fiber reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. The manufacture, use and removal of traditional fiber-reinforced plastic, usually made of glass, carbon or aramid fibers–reinforced thermoplastic and thermo set resins are considered critically because of environmental problems. By natural fiber composites we mean a composite material that is reinforced with fibers, particles or platelets from natural or renewable resources, in contrast to for example carbon or aramide fibers that have to be synthesized.

D. Helmet

A helmet is a form of protective gear worn on the head to protect it from injuries. Most helmets are made from resin or plastic, which may be reinforced with fibers such as aramids. All helmets attempt to protect the user's head by absorbing mechanical energy and protecting against penetration. Their structure and protective capacity are altered in high-energy impacts. Beside their energy-absorption capability, their volume and weight are also important issues, since higher volume and weight increase the injury risk for the user's head and neck. Anatomical helmets adapted to the inner head structure were invented by neurosurgeons at the end of the 20th century.

E. Materials

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II. MATERIAL AND METHODS

The matrix material used in this investigation was bio epoxy resin Grade 3554A and Hardner 3554B. Supplied by Lab chemicals, Chennai. jute, banana and sisal fibers have been used traditionally in high strength ropes in India especially in South India regions.

A. Manufacturing process

1) Chemical Treatment

The fibers are powdered. Then the fibers are cleaned normally in clean running water and dried. A glass beaker is taken and 6% NaOH is added and 80% of distilled water is added and a solution is made. After adequate drying of the fibers in normal shading for 2 to 3 hours, the fibers are taken and soaked in the prepared NaOH solution. Soaking is carried out for different time intervals depending upon the strength of fiber required. In this study, the fibers are soaked in the solution for three hours.

2) Advantages of chemical treatment

Chemical treatment with NaOH removes moisture content from the fibers thereby increasing its strength. Also, chemical treatment enhances the flexural rigidity of the fibers. Last, this treatment clears all the impurities that are adjoining the fiber material and also stabilizes the molecular orientation.

3) Procasting Process

A wooden mold of rectangular shape is taken with a size of 210x45x10 mm width, length, and depth. The fiber powder that has been prepared using chemical treatment is taken with equal ration of three mixtures (hybrid fibers) and steer finely. The matrix of epoxy resin is poured in to the ingredient with 1:1 ratio of hardner and resin and mix up gradually to get as free of air gaps. The fine mixture of fiber and matrix is filled in the rectangular wooden mold and dry it under room temperature. The process of procasting is to be done under the room temperature since the hardener and the resin loses the adhesiveness over the rise of temperature.

4) Hand Lay Up Method
Hand lay-up is a simple method for composite production. A mold must be used for hand lay-up parts unless the composite is to be joined directly to another structure. The mold can be as simple as a flat sheet or have infinite curves and edges. For some shapes, molds must be joined in sections so they can be taken apart for part removal after curing. Before lay-up, the mold is prepared with a release agent to insure that the part will not adhere to the mold. Reinforcement fibers can be cut and laid in the mold. It is up to the designer to organize the type, amount and direction of the fibers being used. Resin must then be catalyzed and added to the fibers. A brush, roller or squeegee can be used to impregnate the fibers with the resin. The lay-up technician is responsible for controlling the amount of resin and the quality of saturation.

5) Fabrication of Industrial safety helmet

Fabrication of industrial safety helmet is done with hand lay-up method that is engraved to the shape of the industrial safety helmet. The length of fiber used in the mould was limited to 25 cms. The epoxy resin with hardener was thoroughly mixed with required fibers in the ratio of 60:40. The fiber resin was allowed to spread uniformly up to required thickness. The moulds are meticulously clamped together. The mould was placed in room temperature for 24 hours. Then the helmet was carefully removed by uncoupling the male and female moulds. Final product of industrial safety helmet is depicted in fig 5.1.

![Fabricated Hybrid Industrial safety helmet](image)

**Figure 5.1 Fabricated Hybrid Industrial safety helmet**

III. MECHANICAL TESTING

A. Impact Test

The impact test, the strength of the samples was measured using an Izod impact test machine. All test samples were notched. The procedure used for impact testing was ISO 180. The test specimen was supported as a vertical cantilever beam and broken by a single swing of a pendulum. The compressive strength of hybrid composite was determined in accordance with ASTM D 695-96. The specimens were cut to 200x30x11 plate thickness regular prisms. The test was performed at 1.3 mm/s strain rate in a universal testing machine.

B. Flexural test

Flexural test is also known as bending test. Applying a point load at centre of composite material does it. The specimen size for the flexure test is 90mm X 3mm. It is also done in Universal Testing Machine. When the beam is bent in clear that the fibres of the upper half are compressed and those of the lower half are stretched. Between these region of compression and stretching, there is a layer which is neither compressed nor stretched. This surface is called the neutral surface of the beam and the cure of any particular fibre on this surface is known as an elastic curve or deflection curve of the beam. The line in which any plane section of beam cuts the neutral surface is called the axis of the section.

IV. RESULT AND DISCUSSION

<table>
<thead>
<tr>
<th>Properties</th>
<th>ABS plastics</th>
<th>Hybrid composite Helmet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>370 gram</td>
<td>252 gram</td>
</tr>
<tr>
<td>Impact strength</td>
<td>50J/m</td>
<td>53.06J/m</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>0.10KN</td>
<td>0.12KN</td>
</tr>
<tr>
<td>Cost</td>
<td>450</td>
<td>200</td>
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The Table 4.1 shows that the hybrid composite industrial safety helmet has better properties than the Acrylonitrile – Butadiene –Styrene (ABS) plastics.

V. CONCLUSION

After determining the material properties of natural fiber reinforced composite using compressive test and impact test, the hybrid composites showed comparatively better performance. It has shown that Natural fiber reinforced composite material of Sisal jute and Banana Hybrid material has a sustainable strength for the application of industrial safety helmets.

Then from the experimental method the three fibers such as Banana, jute and Sisal makes a hybrid composite, which
posses better strength and reduces half of the original weight. Hence it is better to replace, the As4 polyphenylene sulphide Plastic in industrial safety helmets as, hybrid composite materials.

REFERENCES


