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Fabrication and Testing of Industrial safety Helmets using Banana and Coir Fiber Polymer Composites

Ajith S[1], Sivaprakash M[2], Ajai L K[3], Efrin raj M[4], Jebi winislin P[5], Bovas S[6]
[2]Professor, [1,3]Assistant Professor, [4,5,6]UG Students
[1, 2,3,4,5,6]Department of Mechanical Engineering
Stella Mary's College of Engineering
Aruthenganvilai, Azhikal Post, Kanya kumari district, Tamil Nadu, India

Abstract: Industrial Safety Helmets, commonly known as hard hats, play a vital role in safeguarding workers from head injuries in various industrial settings. These helmets are designed to provide protection against falling objects, impact from protruding objects, electric shock and other occupational hazards. This project explores the key features, standards and benefits associated with industrial safety helmets. This project made an attempt to investigate the strength and rigidity of safety helmets fabricated using Banana Fiber, Coir Fiber and Polyester Resin. Composite Materials are widely used because of their high strength to wear ratio, high performance at elevated temperature. Natural Fibers have the following advantages: high density, low cost, biodegradability, acceptable particular characteristics, and less wear during extraction and composite production. A Polymer Matrix Composite (PMC) is made with Banana Fiber and Coir Fiber loaded with Polyester resins. Three proportions of safety hare fabricated and various tests are conducted on the product namely Shock Absorption Test, Penetration Resistance test, Flammability Resistance Test, Electrical Resistance test and Water Absorption Test. As per IS: 2925 – 1984 the results are satisfied.
Keywords: Industrial Safety Helmets, Composite Materials, Natural Fibers, Polyester Resin

I. Introduction

1.1 SAFETY HELMETS:

Safety helmet is a form of protective headgear worn to shield the Head from impacts such as falling objects, collision and protecting head against certain dangerous environmental conditions. Safety Helmet is crucial Personal Protective Equipment to protect the body's most important part which is vulnerable for injuries. Their primary purpose is to prevent head injuries caused by falling objects, impacts, electrical shocks, and other workplace hazards. The field of uses for safety helmets is diverse, and they are commonly used in the Construction Industry, Industrial and Manufacturing, Electrical Work, Mining Industries, Oil and Gas, Firefighting etc.[1]

Figure 1. Safety Helmet

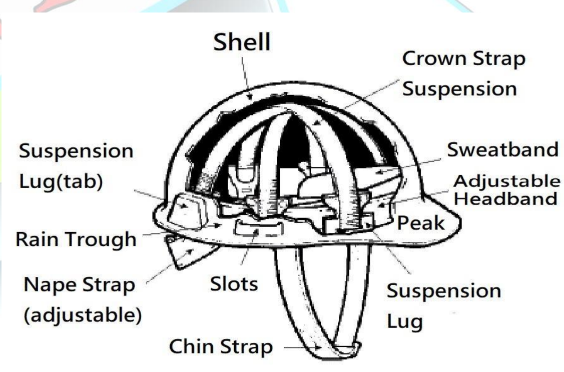

Figure 2. Parts of Safety Helmet

II. Materials And Methods

2.1. NATURAL FIBER

2.1.1 Natural fiber composites in India

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Natural fiber-based composites are becoming increasingly essential in the domains of construction and civil engineering due to their light weight, high strength-to-weight ratio, corrosion resistance, and other advantages. Despite their effectiveness in service, synthetic fiber-based composites are difficult to recycle after their intended service life. The environmental benefits of natural fiber-based composites, on the other hand, are substantial.

2.1.2 Background: national scenario of natural fiber composite

Composite matrices (such cement and polymer) that include natural fiber reinforcement are becoming more popular for low-cost building goods. Because they are made from renewable resources, natural fibers are readily available close to home. More than 400 million tons of natural fibers are produced in India today. Table 1 shows the approximate output of several natural fibers.

estimated production is about 16 million cubic meters only. Apart from wood, natural fiber composites are emerging with an increasing role in building industry to replace timber, steel, aluminum, concrete etc. Composites are being used for prefabricated, portable and modular buildings as well as for exterior cladding panels.

Table 2 shows the celluloses and some other properties of a few fibers available in India. So far, the utilization of **banana**, sisal, jute, coir and bagasse fibers has found many successful applications.

The present requirement of wood in India is about 29 million cubic meters, whereas, the

2.2 NATURAL FIBER HELMET:

In this project work Banana fibers and Coir Fiber are used to manufacture the Safety Helmets with the help of the Polyester resins, As the Banana fibers and Coir has the Strength and durability hence it is chosen as a natural fibers, the fabrication and the testing are done on the banana fiber and coir fiber helmets, the Test Results satisfied the Indian Standards of Safety Helmets. This research work focuses on improving the strength and rigidity of the banana fiber and coir fiber helmet and utilise the waste fibers of the banana trees to a useful product in Safety Field.

2.2.1 MATERIALS USED IN THE SAFETY HELMETS:

Banana Fiber.
Coir Fiber.
Polyester Resins.

Figure:3. Banana Fiber

Figure 4. Coir Fiber

Figure 5. Polyester Resin

2.2.2 BANANA FIBER:

Banana fiber is a ,m strongest natural fibers, and its use dates back thousands of years. The process of extracting banana fiber involves first cutting down the banana plant and then stripping away the outer layers to reach the long fibers within the stalk. These fibers are then cleaned, processed, and spun into yarn or thread for various applications.Banana fiber is known for its durability, flexibility, and
eco-friendliness.

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The history of banana fibre is old more than 700 years. People were aware of the use of banana fibres for the last 700 years. Japanese extracted banana fibres from a banana tree in the 13th century. The people extracted banana fibres manually. Now these days, banana fibres are being extracted with the help of machines. In the traditional fibres extraction process, banana fibres are extracted manually completely. Nepalese process of fibre extraction is more similar to that of silk fibres.

Preparation of Banana Fiber:

The processing of banana fibers involves several steps to extract, clean, and prepare the fibers for use in various applications. Here's an overview of the typical process:

1. **Harvesting:** The first step in obtaining banana fiber is harvesting the banana plants. Once the bananas have been harvested for consumption, the remaining stalks or pseudostems are cut down. These pseudostems are the source of the fibers.

Figure 6. Harvesting of Banana Fibers

2. **Stripping**: After the pseudostems are harvested, they are stripped of their outer layers to expose the fibers within. This is often done manually using knives or machetes to remove the outer sheaths and leaf stalks.

Figure 7. Stripping of Banana Fibers

Extraction: Once the outer layers are removed, the long fibers within the pseudostem are extracted. This can be done using mechanical methods or manual scraping to separate the fibers from the inner core of the pseudostem.

Figure 8. Extraction of Banana Fibers

Washing: The extracted fibers are then washed to remove any remaining impurities, such as sap, dirt, or debris. This helps to clean the fibers and prepare them for further processing.

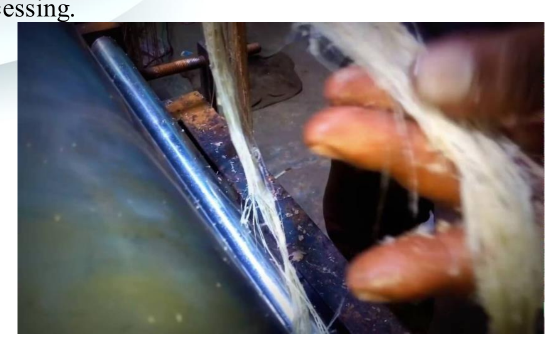

Figure 9. Washing of Banana Fibers

5. **Drying:** After washing, the fibers are dried either

naturally in the sun or using mechanical drying methods. Drying the fibers helps to remove excess moisture and prevent mold or mildew growth.

Figure 10. Washing of Banana Fibers

6. **Softening:** In some cases, the dried fibers may undergo a softening process to improve their texture and flexibility. This can involve soaking the fibers in water or a softening solution to make them more pliable.

Figure 11 Softening of Banana Fibers

7. **Spinning:** Once the fibers are clean and dry, they can be spun into yarn or thread using spinning machines or traditional spinning techniques. This yarn can then be used to weave fabrics or make various products.

Figure 12. Spinning

2.2.2.3 Chemical Composition of banana fiber: Table 3: Chemical Composition of Banana Fibers.

2.2.3 COIR FIBER:

Coir fiber, extracted from the husk of coconuts, is a versatile natural material renowned for its eco-friendly properties and diverse applications. With its robustness and durability, coir fiber is commonly used in the production of mats, ropes, and brushes, offering excellent resistance to moisture and decay. Its sustainable sourcing aligns with the growing demand for environmentally conscious alternatives in various industries

2..2.3.1 Prepration of Coir Fiber:

1.Harvesting: The fruits are harvested when still green to obtain the best quality coir. Husk usually forms 35.45 percent of the weight of the whole nut, when ripe. Husks from ten to eleven month old nuts have been found to give superior quality fiber possessing a golden yellow color. The fiber from the husk is extracted on a commercial scale, either by natural retting process or by mechanical decortications.

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Figure 13. Husking of coconut by Machine

2.Retting: Retting is a curing process during which the husks are kept in an environment that encourages the action of naturally occurring microbes.This action partially decomposes the husk's pulp, allowing it to be separated into coir fibers and a residue called coir pith. Freshwater retting is used for fully ripe coconut husks, and saltwater retting is used for green husks. [13] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences. Elements and speed vectors were thought to be inaccessible, along these lines a NN eyewitness was intended to recoup the limitless states.

Figure 14 Retting of coconut or coir fiber

Figure 15. Extraction of coconut fiber

4.Spinning: Spinning of coir yarn is mainly a cottage industry in India and abroad. It is produced either by wheel spinning or hand spinning or mechanized spinning. Handspun yarn is soft and the twist and thickness are even. Wheel spun yarn has a hard twist; it is stronger and more uniform in size and twist than handspun yarn. The classification of coir yarn is based on variations of color, twist, pitch, scorage etc. and also area of production like; Anjengo, Aratony, Alapat, Beach, Rope yarn, Parur, Muppiri etc.

5.Weaving: Coir yarn is treated with dilute solution of sulphuric acid, which improves its color and gives a certain amount of brightness for the production of mats, Coir mats, fiber mats, especially mats, Mattings, rugs, mourzouks, carpets etc.

6.Dyeing and Printing: Color and design play an important

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part in the marketing of coir products. Dyed yarn is exported to Australia for the manufacture of matting. The following dye stuffs are employed in coir dyeing. Chrysodin YS, Bismarck Brown, Methyl Violet, Malachite Green, Magenta, Naphthalene orange, Naphthalene Red, Naphthalene Green etc. [4] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

2.2.3.2 GENERAL PROPERTIES OF COIR FIBERS:

Strength and Durability: Coir fiber, derived

2.2.3.3 Chemical Composition of Coir fiber: Table 1: Chemical Composition of Coir Fibers.

S.I. No	Substance Name	Percentage
1.	Cellulose	36-43
2.	Hemicellulose	10-20
3.	Liginin	41-45
4.	Pectin	3-4
5.	Water soluable contents	-
6.	Fat and wax contents	-
7	Ash contents	-

2.2.4.2 PHYSICAL PROPERTIES OF POLYESTER RESINS:

Table 2: Physical Properties of Polyster Resin

SI. NO	PHYSICAL PROPERTIES	METRIC UNITS
01	Melt Temperature	260^0 C
02	Tensile strength	152 MPa
03	Flexural Strength	110 MPa
04	Specific Gravity	1.56

2.3 FABRICATION PROCESS:

The entire Fabrication Process and Testing are done in CONCORD HELMET AND SAFETY PRODUCTS PVT LTD, Trichy . The Safety helmet is fabricated under IS2925 Indian Standard of Safety Helmets. The Process involved to produce the Natural fiber Helmet is "**Compression molding**". Before the molding Process the Banana Fiber and Coir Fiber is chopped into small pieces for better absorption of the Resin. These chopped small Banana Fiber materials and Coir Fiber are pre-fabricated as a helmet like structure before the molding process for getting better spreading of the polyester resin thus it increases the strength.

Figure 16. Preparation of Banan Fiber

Figure 17. Preparation of Coir Fiber

2.3.1 COMPRESSION MOULDING:

Compression molding is a method of molding in which the molding material, generally preheated, is first placed in an open, heated mold cavity. The mold is closed with a top force or plug member, pressure is applied to force the material into contact with all mold areas, while heat and

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pressure are maintained until the molding material has cured; this process is known as compression molding method.

Figure 18 Compression moulding machine

The Mold is coated with releasing agent, This releasing agent helps the component to get detached from the mold easily. After that Banana Fiber and coir fiber is placed in the Mold and the compression process is carried out at **150 degree** Fahrenheit and the Mold is cured for 3 to 4 minutes and the helmet is taken out from the Mold and further shaping and straps are attached to the Helmet.

Figure 19. Pre-Fabrication

After the fabrication process is completed the fabricated Helmet is taken out and execess Fiber materials are cut off from the the helmet and additional shapping of the helmet is done in order to improve the asthetics of the Safety Helmet and also improving better surface finish of the Helmet. The manufactured helmets are further tested acoording to the Indian Standard Specification for Industrial Safety Helmet IS 2925

III. Result And Discussion

3.1 Manufactured Helmets:

Figure 20. Manufactured Helmets

3.2 FABRICATION RESULTS:

1. Shell 1:

Shell 1 is fabricated with 50% of Banana Fiber and 50% of Coir Fiber. Shell 1 is failed in electrical resistance test because of poor surface finish due to improper bonding of resin and natural fiber.

2. Shell 2:

Shell 2 is fabricated with 40% of Banana Fiber and 60% of Coir Fiber. It is passed in eletrical resistance test and other tests in **IS: 2925 -1984.**

3. Shell 3:

Shell 3 is fabricated with 60% of Banana Fiber and 40% of Coir Fiber. It is passed in all tests to be done in **IS: 2925 -1984.**

3.3 Test Performed:

Five major test are done on the Natural Fiber Helmet as per the IS2925 Indian Standards.

1. Shock Absorption Test.
2. Penetration Resistance Test.
3. Flammability Resistance Test.
4. Electrical Resistance Test.
5. Water Absorption Test.

IV. Conclusion

The Natural Fiber based Safety Helmet, reinforced with Polyester resins and fabricated through Compression Moulding, stands as a testament to modern engineering ingenuity. With its remarkable strength to weight ratio, this helmet not only meets but exceeds the stringent standards set by the Indian Standards of Safety Helmets IS 2925. Its robust construction ensures reliable protection in industrial facilities, construction sites, and various other applications where safety is paramount. The innovative use of natural fibers not only enhances the helmet's strength but also underscores a commitment to sustainability and eco-friendliness. By harnessing the power of Polyester resins, this helmet achieves a fine balance between durability and lightweight comfort. The Compression Moulding method employed in its fabrication ensures consistent quality and precise engineering, resulting in a product that inspires confidence in its users

In Shell 1, composed of a balanced blend of 50% banana fiber and 50% coir fiber, demonstrates promising characteristics. With a weight of 540gms, it maintains a respectable penetration depth of 6mm, indicating durability and resistance. Moreover, its shock absorption capability, measured at 144kgf, suggests efficient protection against impacts, potentially making it suitable for various applications requiring impact resistance. Furthermore, its successful passage in both electrical and water absorption tests underscores its versatility and reliability, ensuring its suitability across different environments and scenarios. Overall, Shell 1 exhibits a commendable combination of strength, resilience, and versatility, making it a promising material for diverse applications.

In Shell 2, comprising 40% banana fiber and 60% coir fiber, presents notable attributes indicative of its potential utility. Weighing in at 550gms, it maintains a consistent penetration depth of 6mm, suggesting comparable durability to its counterparts. However, its shock absorption capacity, measured at 108kgf, though respectable, falls slightly below that of Shell 1. Nevertheless, its successful clearance of both electrical and water absorption tests underscores its reliability and suitability for various environments. Despite a slightly lower shock absorption capability, Shell 2 demonstrates promising characteristics overall, showcasing a blend of strength, resilience, and versatility that positions it as a viable option for a range of applications.

In conclusion, Shell 3 emerges as a robust contender within the fiber composite realm. With a composition of 60% banana fiber and 40% coir fiber, it strikes a balance that promotes notable performance characteristics. Weighing 550gms, it exhibits consistent penetration depth of 6mm, reflecting durability akin to its counterparts. Notably, its shock absorption capacity of 144kgf stands out as a highlight, surpassing both Shell 1 and Shell 2. Additionally, its successful clearance of electrical and water absorption tests further solidifies its reliability and adaptability across various settings. Shell 3's impressive shock absorption capability, combined with its overall resilience and versatility, positions it as a promising material for applications requiring robust impact resistance.

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