Review of Banana Fiber Composite and its Applications

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Abstract— Today engineering industries are finding alternate ways to produce their products using eco-friendly materials. Natural fiber is used as an alternative resource to synthetic fibres. They can be as well reinforced for making polymer composite materials and their manufacturing is inexpensive, renewable and environment friendly. Natural fibers have low cost, low density and low durability as compare to synthetic fibers but with the help of fiber treatments, mechanical properties of natural fibers are improved. Natural fibers have distinct properties than synthetic fibers like high strength, low weight, low cost processing and bio degradability. 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, 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, price and their satisfactory mechanical properties offers an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products etc. Banana farming generates more quantity of biomass which goes as waste. The parts of banana tree above ground such as pseudo-stem and peduncle are the major source of fibre. Banana fibers used as a raw material in industry for production of papers, tea bags, currency and reinforced as a polymer composite. The present paper discussed the properties of banana fiber and its application in various industries.

Key words: Banana, Hand Lay-Up, Composite, Fiber, Textile, Paper

I. INTRODUCTION

Banana fiber is a lingo-cellulosic fiber which is obtained from the pseudo-stem of banana plant (Musa sepientum). Banana fiber has good specific strength properties comparable to those of conventional material, like glass fiber. This material has a lower density then glass fibers. The pseudo-stem is a cylindrical, clustered aggregation of leaf stalk bases. Banana fiber is a waste product of banana cultivation and either not properly utilized or partially done so. Useful applications of such fibers would regularize the demand which would be reflected in a fall of the prices. Banana fibers have highly strength, light weight, smaller elongation, fire resistance quality, strong moisture absorption quality, great potentialities and biodegradability. Banana fiber has been recognized for apparels and home furnishings. Banana fiber has great potentialities for paper making and special demand of handmade paper. Banana fiber is used in making products like filter paper, paper bags, greeting cards, lamp stands, pen stands, decorative papers, rope, mats and composite material etc. Banana fiber has been used in making currency notes in Germany and trial run is in process in India also. Polypropylene reinforced with banana fiber is used by automobile companies for making under floor protection panels in luxurious cars like Mercedes. Banana fibers mostly used in making handicrafts and home decorative. Composite material of banana fiber is also used in building boards and fire resistance boards.

Fig. 1: Banana fiber

Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. There has been lot of research on use of natural fibers in reinforcements. Banana plant is a large perennial herb with leaf sheaths that form pseudo stem. Its height can be 10-40 feet (3.0-12.2 meters) surrounding with 8-12 large leaves. The leaves are up to 9 feet long and 2 feet wide (2.7 meters and 0.61 meter). Banana plant is available throughout Thailand and Southeast Asian, India, Bangladesh, Indonesia, Malaysia, Philippines, Hawaii, and some Pacific islands.

A. Banana Fiber Extraction Processing, Yarn Spinning & Weaving:

Fig. 2: Extraction of Banana Fiber from Banana plant.

The extraction of the natural fiber from the plant requires certain care to avoid damage. In the recent experiments and study, initially the banana plant sections were cut from the main stem of the plant and then rolled lightly to remove the excess moisture. Impurities such as pigments, broken fibers, coating of cellulose etc. in the rolled fibers were then

removed manually by means of comb. The fibers are then cleaned and dried. This mechanical and manual extraction of banana fibers is tedious, time consuming, and may cause damage to the fibres. Therefore this type of technique is not recommended for industrial application. A special machine was designed and developed for the extraction of banana fibers in a mechanically automated manner. It consists mainly of two horizontal beams whereby a carriage with an attached and specially designed comb, could move back and forth. The fiber extraction using this technique could be performed simply by placing a cleaned part of the banana stem on the fixed platform of the machine, and clamped at the ends by jaws. This eliminated relative movement of the stem and avoided premature breakage of the fibers. This was followed by cleaning and drying of the fibers in a chamber at 200° C for three hours. These fibers were then labelled and ready for lamination process. After fiber is collected, the process goes to yarn spinning. The researcher investigated the traditional process, which use the filament yarns in weaving banana fabric. The finding showed that the convention process was very time-consuming, thus not appropriate for today's use. Therefore, this research explored open-ended spinning process for yarn development. The fiber ware cut in to 3-centimeter length for spinning process. After yarn spinning, weaving is done in the looms as per normal process like any other material.

B. Characteristics of Banana Fibers:

Banana fiber has its own physical and chemical characteristics and many other properties that make it a fine quality fiber are listed below.

1) Appearance of banana fiber is similar to that of bamboo fiber and ramie fiber, but its fineness and spin ability is better than the two.
2) The chemical composition of banana fiber is cellulose, hemicellulose, and lignin.
3) It is highly strong fiber with average fineness of 2400Nm
4) It has smaller elongation.
5) It has somewhat shiny appearance depending upon the extraction & spinning process.
6) It is light weight.
7) It has strong moisture absorption quality. It absorbs and releases moisture very fast.
8) It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber.
9) It can be spun through almost all the methods of spinning including ring spinning, open-end spinning and semi-worsted spinning.

C. Properties of Banana Fibers

PROPERTY	VALUE
Tenacity	29.98 g/denier
Fineness	17.15
Moisture Regain	13.00%
Elongation	6.54
Alco-ben Extractives	1.70%
Total Cellulose	81.80%
Alpha Cellulose	61.50%
Residual Gum	41.90%
Lignin	15.00%

Table 1: Properties of banana fiber

D. Chemical Treatments on Banana Fibers

Processing techniques that are used to increase strength of banana fibers remove impurities on fibers and improve wettability called chemical treatments. This is because natural fibers are affected by environment concerns like repeated seasons and pollution. There are so many chemical treatments method available to increase the strength and remove impurities of the natural fibers. Among these treatment alkali treatment provides better results. In this treatment fiber were rinsed in NaoH solution for 1hr and soaked in HCL solution for another 1hr. The pH value of solution describes acid levels of raw and alkali treated fibers.

II. APPLICATIONS OF BANANA COMPOSITES

1) Lina Herrera-Estrada et. al. [8] reported that banana fiber composites can be used for automotive and transportation applications. Fiber surface chemical modifications and treatments were studied along with processing conditions for epoxy and eco-polyester banana fiber composites. Flexural tests show that banana fiber/eco-polyester composites have a higher flexural strength and modulus, due to improved fiber/matrix interaction. Environmental tests were conducted and the compressive properties of the composites were evaluated before and after moisture absorption.
2) Furqan Ahmad et. al. [1] discussed the properties and application of natural fiber composites in automobile industries due to their lightweight, low-cost, and environmental aspects. Comparisons of material indices for beam and panel structures were made to investigate the possibility of using natural fiber composites instead of conventional and non-conventional materials.

Fig. 3: Application of Banana fibre in automobile sector

3) Vigneshwaran et. al. [15] reported the use of banana fiber in textile and packaging industries. He indicated that many more value added products can be made from banana fiber which includes transportation boxes of fruits & other materials, files, covers and packaging materials etc. With this we can minimize the deforestation due to various wood/ cellulose processing industries, thus protesting our ecology and environment.

Fig. 4: Yarn made from Banana fibre

Fig. 5: Banana fibre in textile industry

4) Lamis R. Darwish et. al [6] show that the starch matrix-banana fiber composites satisfy the maxillofacial bone fixation requirements. Extensive experiments had been conducted in order to investigate the morphological, thermal and mechanical properties for the proposed composite. The optimum mechanical properties were obtained at 50 wt. % BFs. Furthermore, Incorporating BFs into the TPS matrix improved the thermal properties of the composite. Thus the mechanical and thermal properties of this composite nominate it to be used in the fabrication of maxillofacial bone plates.
5) W. H. Zhu et. al. [16] shows that Pulped banana fibre (Cavendish) is a satisfactory fibre for incorporation into a cement matrix. He indicated that the mechanical properties like high flexural strength and fracture toughness coupled with a density of 1.45 g/cm^3 and a water absorption of <25% by mass make such materials suitable for use as building materials.
6) Marwan Mostafa et. al. [12] reported the use of banana fibres in construction industry. He indicated that Building with Compressed Earthen Blocks (CEBs) is becoming more popular due to their low cost and relative abundance of materials. Such enhancements will raise the number of storeys of a building that can be built with CEBs. His experimental work studies on the classic CEB(Compressed Earth Block) with no fibers and B-CEB(Banana-Compressed Earth Block) including an axial compression test and flexural test (three-point bending test) by using testing methods according to American Society for Testing and Materials (ASTM) standards (ASTM C-67). Also, in order to obtain the load-deflection curve and bending modulus (E) from the flexural test, the Linear Variable Differential Transformer (LVDT) sensor was placed under the mid-span of the block for vertical displacement measurements. The results of his study highlighted general trends in the strength properties of different design mixes by adding different lengths of banana fibers in the CEBs. These efforts are necessary to ensure that B-CEB technology becomes a more widely accepted building material that will verify the earth building technology for offering affordable houses. From his experimental work, it is concluded that the blocks constructed by adding banana fibers (B-CEB) throughout the mix performed better than the block with no fibers (CEB) in both compressive and flexural strength.
7) Uraiwan Pitimaneeyakul et. al. [13] indicated the use of banana fiber in uses in textile and paper industry. The yarn spinning and knitting were experimented for fabric making.
8) Singh V. K et.al studied the mechanical behavior of banana fiber based hybrid bio composites. In this research, author prepared the banana fiber and silica powder reinforced composite material. Scanning electron microscopy shows that banana fibers are well dispersed in the resin matrix. Addition of fiber increases the modulus of elasticity and decreases the ultimate tensile strength of the epoxy. And further addition of silica also increases the modulus of elasticity and reduces the ultimate tensile strength. Addition of banana highly reduces yield strength and addition of silica gives better results than banana reinforced composites but still having yield strength highly reduced. Banana reinforced improve the impact strength of epoxy materials. Addition of fibers increases the capacity of water absorption. This test is necessary where the composites are used in moisture affected areas. Addition of banana fiber reduces bending strength and addition of silica with banana has not given better bending strength than banana fiber reinforced composites.
9) Hoi-yan Cheung et.al [5] explained the comprehensive review on different kinds of natural fibre composites and their potential in future development of different kinds of engineering and domestic products. The author discussed that the use of natural fibre mixed with biodegradable and bioresorbable polymers can produce joints and bone fixtures in the biomedical and bioengineered field to alleviate pain for patients.
10) S.M. Sapuan et. al. [14] discussed the Design and fabrication of multipurpose table using a composite of epoxy and banana pseudostem fibres. The aesthetic value coupled with strength and mechanical properties make banana trunk fibre-woven fabric-reinforced composites a suitable material for furniture making. Design and fabrication details using hand lay-up process are described.

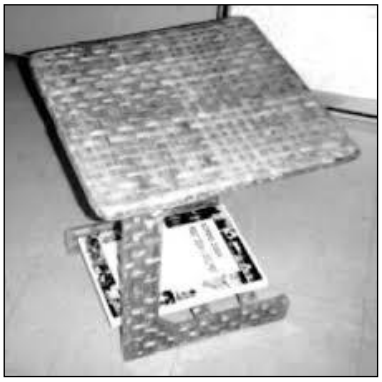

Fig. 6: Multipurpose table made from Banana fibre

11) Kuldeep B. et al. showed that composites can be successfully used in fabrication of automobile components and that helps in reduction of weight, increase in stiffness and also life of the components. And hence contributes in improving efficiency and thereby reducing emissions. As the weight of the rotating components of an engine decreases, more RPMs can be achieved for same working conditions.

III. CONCLUSION

The present review explores the potentiality of banana fiber composites, emphasizes both its mechanical and chemical properties. Properties of banana fibers are superior as compared to natural fibers. The utilization and application of the cheaper goods with high performance is possible using this composite technology. This review concludes that waste part of banana tree i.e. Banana fiber can be used for making various valuable goods as:

1) Banana fiber extraction process is low cost effective process.
2) Chemical treatment improves strength and removes impurities on fibers.
3) Chemically treated fibers composite have more tensile properties than untreated fiber composite.
4) Chemical composition on banana fiber and BFR composite can be predicted through FT-IR spectrum.
5) Scanning electron microscopy reveals surface morphology and factor for failure of composites. BFR composite effectively can be produce by hand layup process.

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