Investigation on Mechanical Properties of Coconut Fiber reinforced Polyester Composites

R.Jeyakumar, R.Ramamoorthi , K.Balasubramanian

Abstract: ***The composite materials reinforced with natural fibers plays a vital role for structural applications. Composites are escalating as sensible preferences in contrast to the metal combinations in numerous applications like automotives, marine and aviation, sports and products applications. Fiber composites offer numerous benefits like, high tensile strength and modulus, minimum specific gravity. In this paper it is viewed as that coconut inflorescence fiber reinforced polyester based polymer composites were manufactured by hand layup strategy and then followed by compression moulding method. The coconut fibers were exposed to alkali treatment to make the fiber free of hydrophobic substance. The mechanical properties for example tensile, flexural and izod impact strength were conducted and Scanning Electron Microscope investigation was carried out to discover the fracture failure. The results demonstrated that there is significant increment in strength of the composites contrasted with neat polymer composites. These natural fiber reinforced composites are mostly used in grain storage silos, bio gas containers, bath tubs , chairs lampshades, boats etc.***

Keywords: Coconut fiber composites, Compression moulding technique, Mechanical properties.

I. INTRODUCTION

A composite is mixture consists of two substances in which one of the substances, called the reinforcing stage, is as continuous and discontinuous fibers, sheets, or particulates, and is surrounded indifferent materials called the matrix stage. The reinforcing material and the matrix material can be polymer, metal, or ceramic. Composites commonly comprise a fiber or particulate stage that is inflexible and stuffer than the constant matrix stage and fill in as the foremost load transmitting members. The matrix behaves about as a load transmit medium between fibers [1]. The matrix stage is more flexible than the fibers and in this way goes about as an origin of composite durability. The matrix additionally provides to protect the reinforcement stage from natural failure, during and after composite manufacturing. Composites are utilized for their basic properties, yet in addition for thermal, electrical, tribological, and usual applications. Due to the following properties the composites are chosen for different applications, there are; Higher strength to weight ratio, Higher creep resistance, Higher tensile strength and modulus at high temperatures and Higher toughness. Innovatively, large amount significant composite materials in which the dispersed stage is as fiber. The objectives of fiber strengthened composites frequently incorporate high strength to stiffness and a weight to strength ratio. Those attributes are communicated as far as specific strength and modulus parameters, which relate, to the proportions of tensile strength to specific gravity and modulus of elasticity to specific gravity respectively. Fiber reinforced composites with especially high specific strength and moduli have been fabricated that utilize low density fiber and matrix materials [2]. The orientation of the fibers with respect to another, the fiber dispersion and concentration all influence the strength and different properties of fiber strengthened composites. The critical fiber length is fundamental for important strengthening and stiffening of the composite material. The behaviour of a composite comprise its orientation of fibers are high anisotropic namely, depends upon the direction in which they are estimated. For continuous fiber reinforcement the strain in the matrix and the strain in the fiber under load are same at the initial level [3]. At low stress level, the matrix may behave plastically while the fiber still will be flexible.

Most realistic composites that are being produced for various applications are discontinuous fibers. Since fibers do not traverse the entire length of the specimen, the bond between the matrix and the fiber is broken at the end of fiber, which is carrying less stress than the center part of the fiber. The stress in the discontinuous fibers is not uniform along its length. Generally the fibers are arranged in discontinuous manner in order to maintain strength uniformly in all directions [4]. The applications of polymer matrix composites are increasing from day to day applications to high technology innovative applications during last four decades of their potential properties. These composites are utilized in the best assorted variety of composite relevances as well as in the biggest capacity in light of their ambient temperature properties effortlessness of manufacture and cost. These composites are demonstrate by high strength and stiffness, and superior dimensional constancy; resistance to corrosion, high impact and fatigue strength. However, the potential properties can be accomplished just by proper design and investigation of composite structures. The structures experience different loading conditions, for example, static, semi static, dynamic, impact during their service life [5]. The reinforcement of composites using natural fiber has customary expanding consideration equally by the research and industrial sectors. The natural fibers have numerous huge preferences over manmade fibers. Recently, numerous varieties of natural fibers were examined for the use in plastics including cotton, flax, jute , sisal, bamboo , hemp, pineapple leaf fiber, rice husk, sugar cane bagasse , bamboo, grass, kenaf, coir, and banana fiber.

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Thermoplastics polymers reinforced with uncommon wood fillers are getting a charge out of fast development because of their numerous advantages; lightweight, applicable strength and stiffness. Some plant proteins are remarkable bio gradable materials, due to their elastic properties. Wheat gluten is remarkable among grain another plant proteins in its capacity to frame a proper bond with visco versatile belongings once plasticized. Due to these causes, wheat gluten has been used to process eatable or eco friendly contributions or pressing materials. Hemp is a best dialect cellulosic fiber used as reinforcement and recyclable composites [6].

Each one of these fibers are developed as farming crops in different regions of the planet and are regularly utilized for manufacturing ropes, cover support, sacks, etc. The constituents of natural fibers are cellulose small scale fibrils scattered in an indistinct resin of lignin and celluloses. The variety of sort of the fiber, the cellulose substance is in the scope of 60– 80 wt% and the lignin substance is in the scope of 5– 20 wt%. Likewise, the moisture content in these fibers may vary up to 20 wt% [7].

The importance of these recyclable fiber reinforced polymer composites is fast developing area in terms of their contemporary applications and major investigation. These composites are sustainable, low cost, completely or in part environmental friendly and green composites.

The natural fibers availability, accessibility, inexhaustibility, low density, low cost and acceptable mechanical performances make them an optional fiber to glass, Kevlar , carbon and other synthetic fibers used for fabrication of composites[8]. These fibers containing composites are all the more biodegradable, and are utilized in vehicles, railroad coaches, aviation, armed forces applications, building and development enterprises, bundling, consumer products etc.

In the present research, the specimens were prepared with different percentage of fiber and matrix composites. There is a still gap may existing between the different length of fiber matrix composite and their mechanical properties compared with pure polyester composite. This gap trigged us to conduct the research in this area.

II. MATERIALS AND METHODS

A. Fiber Extraction Process

Fibers are available in the stack of nut of coconut tree. Coconut inflorescences are kept in water about 10 days and then compacted with a wooden mallet until the lignin and cellulose matters are cleaned off. Then the fibers were placed without contact with sunlight for the fibers to get separated out individually.

Fig. 1 Coconut Inflorescence

B. Alkali treatment of Coconut Inflorescence

The coconut fibers were subjected to 5% sodium hydroxide solution and washed in distilled water until the fibers were alkali free substances. Then the washed fibers were dried in shadow.

Fig. 2 Extracted Coconut Inflorescence Fiber

C. Fiber Preparation

The alkali treated fibers were consistently chopped for different length of 3mm; 5mm, 7mm and 10mm .The fibers and polyester resin were mixed thoroughly with ratio of 30:70 [9].

D. Selection of Matrix

The following resins are used for the polymer matrix composites Resin-Isophthallic unsaturated Polyester resin, Methyl Ethyl Ketone Peroxide as acting as accelerator to speed up the chemical process and Cobalt Naphthalene used as catalyst to increase the rate of chemical reaction.

E. Composite Fabrication

Specimen are prepared with the mixing ratio of polyester resin and coconut inflorescence fibers 70:30.The coconut inflorescence fiber were cleaned dried and exactly chopped with different proportion 3mm,5mm,7mm and 10mm. The ratio of mixing polyester resin, benzyl peroxide catalyst and cobalt Naphthalene accelerator with10:1:1.

The weight fraction of fibers with particular length should be chosen and mixed in the bowl and spread uniformly on the mold of plat size 270*270*3.2 mm and then packed together by providing a load of 20 tons by hydraulic operated compression moulding machine to fabricate the laminate. Resin mixed with accelerator and catalyst is poured over the compressed fiber mat and the pressure is applied till the complete closure of mould. The samples are prepared and cured at ambient temperature [10].

III. RESULTS AND DISCUSSION

A. Tensile property of fiber reinforced polymer composites

The tensile test was carried out as per ASTM D638. It reviews the strength required to fracture a reinforced specimen. It was also used to discover the extension to which the specimen elongates to that breaking point. The tensile modulus of the specimen can determined from the stress and strain curve. The tensile properties of material can vary depending upon the ambient temperature and homogeneity of the specimens was prepared. The ultimate tensile strength of different specimens was plotted in fig.3. The ultimate tensile strength is 18.11N/mm^2 for 10 mm fiber compared to other reinforcement.

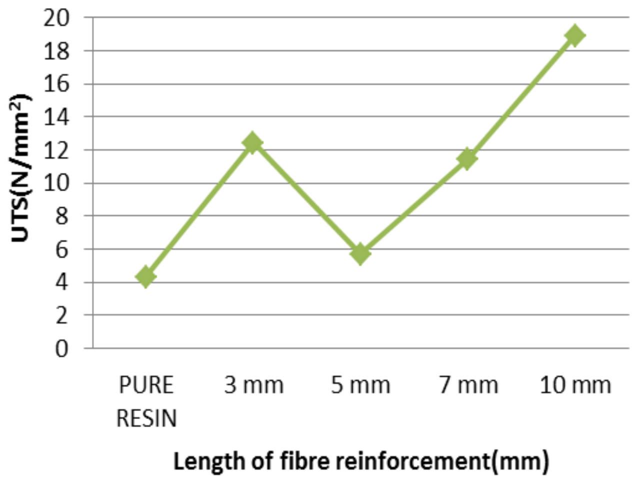

Fig. 3 Ultimate Tensile Strength vs Length of fiber Reinforcement

F. Flexural property of fiber reinforced polymer composites

The flexural examination determines the behavior of materials subjected to loading of simple supported beam. The flexural test was carried out under ASTM D790.The maximum stress and strain are calculated for increments of load. The results are scattered in a stress-strain diagram. The flexural strength is defined as the maximum stress in the outermost fiber and it is calculated at the surface of the specimen on the convex or tension side. Flexural modulus is calculated from the slope of the stress vs. deflection curve. If the curve has no linear region, a secant line is fitted to the curve as shown in fig. 4 to determine slope.

The flexural behaviour of the polymer composites with varying fiber length was investigated. The weight percentage of natural fiber and matrix were used in the ratio of 30:70 and has a flexural strength of 6.34 N/mm^2.

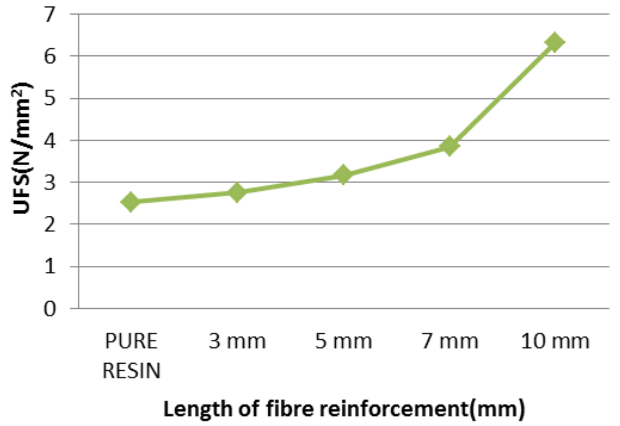

Fig. 4 Ultimate Flexural Strength vs Length of fiber Reinforcement

G. Impact Test of fiber reinforced polymer composites

The impact strength is one of the most important property of a material and the most difficult to measured. The impact resistance in many applications was used to measure a critical service life of the product. More importantly these days, it involves the perplexing problem of product safety.

Izod impact tests were conducted based on ASTM D256. Fig.5 shows the izod impact strength of fibers/PR. The 3mm, 5mm, 7mm and 10mm of chopped fibers were mixed with polyester resin, benzoyl peroxide catalyst &cobalt naphthalene accelerator concentration. Energy absorbed of 30:70 ratio of maximum point 0.60J which is quiet higher compared with the pure polyester.

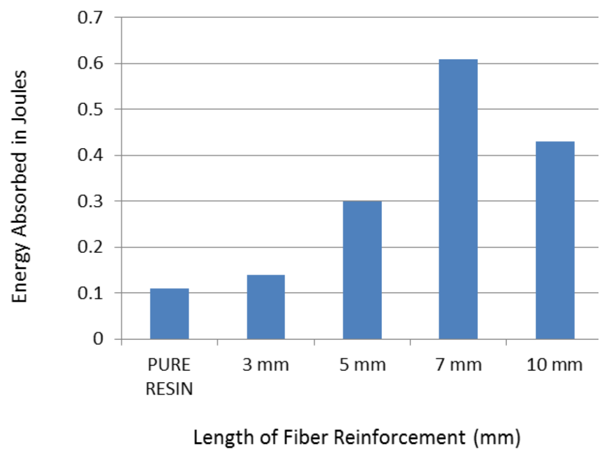

Fig. 5 Energy absorbed vs Length of fiber Reinforcement

H. SEM Analysis of fiber reinforced polymer composites

The specimens subjected to impact test were examined for their surface morphology and the nature of attraction between the fiber and the matrix were also observed. Except 3 mm reinforced fiber there were voids observed for all other specimens and fiber distribution was good for 7 mm reinforced fiber. This result revealed that 7 mm length fiber having more impact strength than the remaining fiber composites.

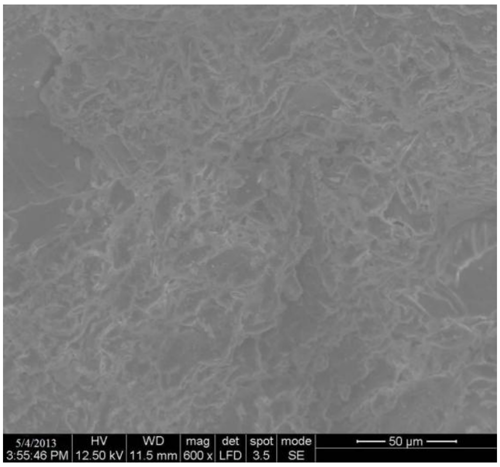

Fig. 6 SEM image of 3mm fiber Reinforced Composite

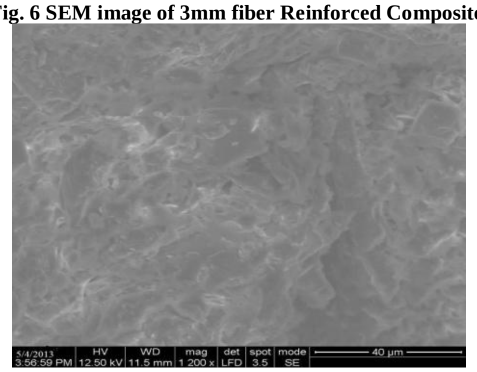

Fig. 7 SEM image of 5mm fiber Reinforced Composite

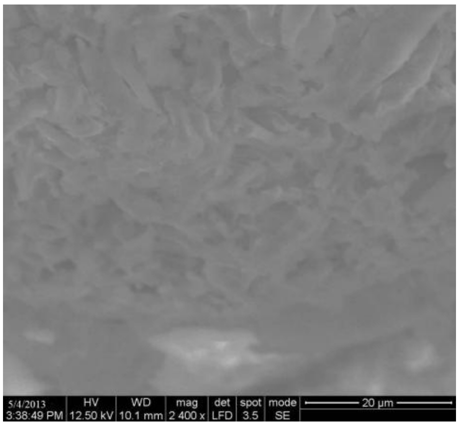

Fig. 8 SEM image of 7 mm fiber Reinforced Composite

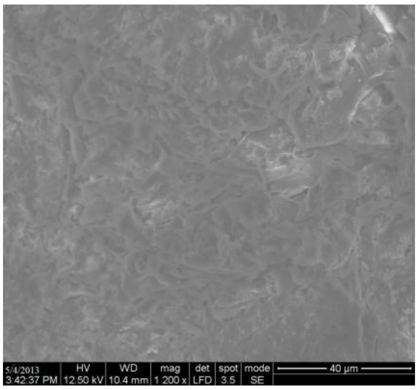

Fig. 9 SEM image of 10mm fiber Reinforced Composite

IV. CONCLUSION

The investigation on the mechanical behaviour of natural fiber reinforced polyester composites leads to the following conclusions: This work shows that manufacturing of coconut inflorescence fibers and polyester resin with reinforced composites with different fiber lengths is possible by hand lay- up technique. The tensile test demonstrated that the ultimate tensile strength of about 18N/mm^2 for 10 mm fiber which is 5 times to that of pure polyester resin. The flexural test showed ultimate flexural strength stress of about 6 N/mm^2 which is 3 times to that of pure polyester resin. The impact stress showed a maximum energy of about 0.6 joules which is 6 times to that of pure polyester resin.

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