A Review of Analysis of Reinforced Natural Fiber Composite Material

Anooj Joseph[1], Shadab Imam[2]

[12]*Department of Mechanical Engineering, Christian College of Engineering and Technology, Bhilai*

ABSTRACT

Natural fiber composites (NFC) because the name implies is formed of natural resources therefore possesses environmentally useful properties like biodegradability. With its natural characteristics, NFC is getting additional attention in recent years in varied application as well as automotive, merchandise, structural and infrastructure. many studies have shown that NFC may be developed into a supporting support for applications in structural and infrastructure application. As associate designed material, similar with fiber composites, the properties of NFC may be tailored to fulfil sure needs. The challenge in operating with NFC is that the giant variation in properties and characteristics. The properties of NFC to an oversized extent influenced by the sort of fibers, condition wherever the plant fibers are sourced and therefore the sort of fiber treatments. However, with their distinctive and big selection of variability, fiber composites may emerge as a replacement various engineering material which may substitute the utilization of fiber composites.

Keywords: Natural Fibers, Composite Materials, Mechanical Properties etc.

I. INTRODUCTION

Processing of plastic composites using natural fibres as reinforcement has increased dramatically in recent years. The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural designs to be more versatile. By definition these composite materials are engineered or naturally occurring materials made from two or more constituents materials with significantly different physical or chemical properties which remain separate and distinct at macroscopic and microscopic scale within the finished structure. These are materials that comprise strong load carrying material known as reinforcement imbedded in weaker material known as matrix. Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. The reinforcement may be particles, platelets or fibres and are usually added to improve mechanical property such as stiffness, strength and toughness of the matrix material. Long fibres that are oriented in the direction of loading offer the most efficient

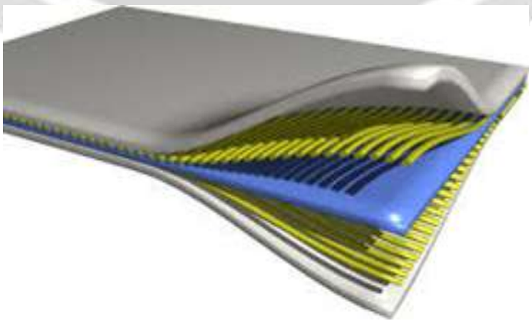

Fig 1. Composite Material

1.1 Types of Composites

In some broad way composite materials can be classified into three groups in the basis of matrix materials. They are:
(a) Metal matrix composites (MMc)

(b) Ceramic matrix composites (CMc)
(c) Polymer matrix composites (PMc).

II. LITERATURE REVIEW

In this chapter, some of the literature on mechanical behaviour of natural fibre-based polymer composites with special emphasis on coir fibre reinforced polymer composites.
Ticoalu et. al. [3] (2010), Natural fiber composites (NFC) as the name implies is made of natural resources thus possesses environmentally beneficial properties such as biodegradability. With its natural characteristics, NFC is obtaining more attention in recent years in various application including automotive, merchandise, structural and infrastructure. Several studies have shown that NFC can be developed into a load-bearing structural member for applications in structural and infrastructure application. As an engineered material, similar with synthetic fiber composites, the properties of NFC can be tailored to meet certain requirements. The challenge in working with NFC is the large variation in properties and characteristics. The properties of NFC to a large extent influenced by the type of fibers, environmental condition where the plant fibers are sourced and the type of fiber treatments. However, with their unique and wide range of variability, natural fiber composites could emerge as a new alternative engineering material which can substitute the use of synthetic fiber composites.

Faruk et. al. [4] (2012), Due to environment and sustainability issues, this century has witnessed remarkable achievements in green technology in the field of materials science through the development of biocomposites. The development of high-performance materials made from natural resources is increasing worldwide. The greatest challenge in working with natural fiber reinforced plastic composites is their large variation in properties and characteristics. A biocomposites properties are influenced by a number of variables, including the fiber type, environmental conditions (where the plant fibers are sourced), processing methods, and any modification of the fiber. It is also known that recently there has been a surge of interest in the industrial applications of composites containing biofibers reinforced with biopolymers. Biopolymers have seen a tremendous increase in use as a matrix for biofiber reinforced composites. A comprehensive review of literature (from 2000 to 2010) on the mostly readily utilized natural fibers and biopolymers is presented in this paper. The overall characteristics of reinforcing fibers used in biocomposites, including source, type, structure, composition, as well as mechanical properties, will be reviewed. Moreover, the modification methods; physical (corona and plasma treatment) and chemical (silane, alkaline, acetylation, maleated coupling, and enzyme treatment) will be discussed. The most popular matrices in biofiber reinforced composites based on petrochemical and renewable resources will also be addressed. The wide variety of biocomposites processing techniques as well as the factors (moisture content, fiber type and content, coupling agents and their influence on composites properties) affecting these processes will be discussed. Prior to the processing of biocomposites, semi-finished product manufacturing is also vital, which will be illustrated. Processing technologies for biofiber reinforced composites will be discussed based on thermoplastic matrices (compression molding, extrusion, injection molding, LFT-D-method, and thermoforming), and thermosets (resin transfer molding, sheet molding compound). Other implemented processes, i.e., thermoset compression molding and pultrusion and their influence on mechanical performance (tensile, flexural and impact properties) will also be evaluated. Finally, the review will conclude with recent developments and future trends of biocomposites as well as key issues that need to be addressed and resolved.

Shalwan & Yousif [5] (2013), In this article, a comprehensive literature review on the mechanical and tribological behaviour of polymeric composites based on natural fibres is introduced. The effects of volume fraction, orientations, treatments and physical characteristics of different types of natural fibres on the mechanical and tribological properties of several thermoset and thermoplastic polymers are addressed. The effects of the tribological operating parameters (applied load, sliding velocity and sliding distance) on the frictional and wear performance of natural fibre polymer composites are demonstrated. The collected date and analyses revealed that volume fraction, orientations, type of treatment and physical characteristics of the natural fibres significantly influence the mechanical and tribological behaviour of composites. The most influence key in designing natural fibre/polymer composite is the interfacial adhesion of the fibre with the matrix. NaOH chemical treatment found to be the most useful treatment method to enhance the interfacial adhesion of the natural fibres with the matrix, while other techniques exhibited either no effect or deterioration on the fibre strength. Frictional characteristics of the natural fibre composites are poor and solid lubricants are recommended to reduce the friction coefficient of the materials.

Shinoj et. al. [6] (2011), Twenty first century has witnessed remarkable achievements in green technology in material science through the development of biocomposites. Oil palm fiber (OPF) extracted from the empty fruit bunches is proven as a good raw material for biocomposites. The cellulose content of OPF is in the range of 43%–65% and lignin content is in the range of 13%–25%. A compilation of the morphology, chemical constituents and properties of OPF as reported by various researchers are collected and presented in this paper. The suitability of OPF in various polymeric matrices such as natural rubber, polypropylene, polyvinyl chloride, phenol formaldehyde, polyurethane, epoxy, polyester, etc. to form biocomposites as reported by various researchers in the recent past is compiled. The properties of these composites viz., physical, mechanical, water sorption, thermal, degradation, electrical properties, etc. are summarised. Oil palm fiber loading in some polymeric matrices improved the strength of the resulting composites whereas less strength was observed in some cases. The composites became more hydrophilic upon addition of OPF. However, treatments on fiber surface improved the composite properties. Alkali treatment on OPF is preferred for improving the fiber–matrix adhesion compared to other treatments. The effect of various treatments on the properties of OPF and that of resulting composites reported by various researchers is compiled in this paper. The thermal stability, dielectric constant, electrical conductivity, etc. of the composites improved upon incorporation of OPF. The strength properties reduced upon weathering/degradation. Sisal fiber was reported as a good combination with OPF in hybrid composites.

Kabir et. al. [7] (2012), This paper provides a comprehensive overview on different surface treatments applied to natural fibres for advanced composites applications. In practice, the major drawbacks of using natural fibres are their high degree of moisture absorption and poor dimensional stability. The primary objective of surface treatments on natural fibres is to maximize the bonding strength so as the stress transferability in the composites. The overall mechanical properties of natural fibre reinforced polymer composites are highly dependent on the morphology, aspect ratio, hydrophilic tendency and dimensional stability of the fibres used. The effects of different chemical treatments on cellulosic fibres that are used as reinforcements for thermoset and thermoplastics are studied. The chemical sources for the treatments include alkali, silane, acetylation, benzoylation, acrylation and acrylonitrile grafting, maleated coupling agents, permanganate, peroxide, isocyanate, stearic acid, sodium chlorite, triazine, fatty acid derivate (oleoyl chloride) and fungal. The significance of chemically-treated natural fibres is seen through the improvement of mechanical strength and dimensional stability of resultant composites as compared with a pristine sample.

Hu et. al. [8] (2011), The scientific world is facing a serious problem of developing new and advanced technologies and methods to treat solid wastes, particularly non-naturally-reversible polymers. The processes to decompose those wastes are actually not cost-effective and will subsequently produce harmful chemicals. Owing to the above ground, reinforcing polymers with natural fibers is the way to go. In this paper, most of the natural fibers mentioned were plant-based but it should be noted that animal fibers like cocoon silkworm silk, chicken feather and spider silk have also been used and the trend should go on. Those fibers, both animal- and plant-based have provided useful solutions for new materials development, in the field of material science and engineering. Natural fibers are indeed renewable resources that can be grown and made within a short period of time, in which the supply can be unlimited as compared with traditional glass and carbon fibers for making advanced composites. However, for some recyclable polymers, their overall energy consumption during collecting, recycling, refining and remoulding processes have to be considered to ensure the damage of the natural cycle would be kept as minimal.

Bella et. al. [9] (2014), From the present study it is possible to draw out that:

- The use of natural fibres such as kenaf and sisal is functional to the reduction of tensions due to the plastic shrinkage that determine the occurrence of cracks on the surface of the structures exposed to water evaporation;
- The results obtained from flexural and compression tests, carried out on three kinds of reinforced plaster, show low stresses, comparable between them, because they depend on the partial achievement of carbonation process;
- The mechanical performance of the lime plasters subject to freeze/thaw cycles decrease in considerable way, regardless of the type of fibres, because of the degrading action of the water (frozen and thawed) determines a general decay of the manufactured products along the edges (scaling), with consequent loss of material;
- The lime plasters reinforced with natural fibres showed lower weight loss than those reinforced with to polymeric ones. This behaviour is due to hydrophilic nature of natural fibres. Then the sisal and kenaf fibres can be a valid alternative to polymeric ones in the mortar.

Izani et. al. [10] (2013), the objective of this study was to evaluate the effect of fiber treatment on both morphological and single fiber tensile strength of empty fruit bunch (EFB). EFB fiber was treated with boiling water, 2% sodium hydroxide (NaOH) and combination both NaOH and boiling water. Fiber morphology was characterized by scanning electron microscopy (SEM). Thermogravimetric analysis (TGA) was further used to measure the amount and rate of change in the weight (weight loss) of treated fiber as a function of temperature. Based on the results of this work it seems that alkali treatment improved most of the fiber properties. NaOH treatment was found to alter the characteristic of the fiber surface topography as seen by the SEM. The thermal stability of NaOH treated and water boiling treated EFB fiber was found to be significantly higher than untreated fiber. The best results were obtained for alkali treated fiber where the tensile strength and Young's modulus increased compared to untreated fibers. The overall results showed that alkali treatment on EFB fiber enhanced the tensile strength and thermal stability of the fiber samples.

III. CONCLUSION

After study of previous researcher have shown the feasibility of the usage of natural composite in various mechanical engineering application. The all-natural composites which are composites made of natural fibers and biodegradable resins are an important development that shows feasibility not only for non-load bearing construction elements but also for structural elements. Thus, natural fiber composites offer precious environmental benefits.

Currently the growing use of natural fiber composites is based more on the environmental and low-cost benefits rather than on their strength capabilities. Therefore, more research is needed to obtain better strength and modulus properties including optimizing the interfacial bond between the fiber and resin by means of fiber treatment.

REFERENCES

[1] M.E. Tuttle, Structural Analysis of Polymeric Composite Materials, Marcel Dekker, Inc., 2004.

[2] M.C.Y. Niu, Composite Airframe Structures, 2nd ed., Hong Kong Conmilit Press Limited, 2000.

[3] A. Ticoalu, T. Aravinthan, and F. Cardona, "A review of current development in natural fiber composites for structural and infrastructure applications," in Proceedings of the Southern Region Engineering Conference (SREC '10), pp. 113–117, Toowoomba, Australia, November 2010.

[4] O. Faruk, A. K. Bledzki, H.-P.Fink, andM. Sain, "Biocomposites reinforced with natural fibers: 2000–2010," Progress in Polymer Science, vol. 37, no. 11, pp. 1552–1596, 2012.

[5] A. Shalwan and B. F. Yousif, "In state of art: mechanical and tribological behaviour of polymeric composites based on natural fibres", Materials & Design, vol. 48, pp. 14–24, 2013.

[6] S. Shinoj, R.Visvanathan, S. Panigrahi, and M. Kochubabu, "Oil palm fiber (OPF) and its composites: a review," Industrial Crops and Products, vol. 33, no. 1, pp. 7–22, 2011.

[7] M. M. Kabir, H. Wang, K. T. Lau, and F. Cardona, "Chemical treatments on plant-based natural fibre reinforced polymer composites: an overview," Composites Part B: Engineering, vol. 43, no. 7, pp. 2883–2892, 2012.

[8] H. Ku, H. Wang, N. Pattarachaiyakoop, and M. Trada, "A review on the tensile properties of natural fiber reinforced polymer composites," Composites Part B: Engineering, vol. 42, no. 4, pp. 856–873, 2011.

[9] G. Di Bella, V. Fiore, G. Galtieri, C. Borsellino, and A. Valenza, "Effects of natural fibres reinforcement in lime plasters (kenaf and sisal vs. Polypropylene)," Construction and Building Materials, vol. 58, pp. 159–165, 2014.

[10] M. A. Norul Izani, M. T. Paridah, U. M. K. Anwar, M. Y. Mohd Nor, and P. S. H'Ng, "Effects of fiber treatment on morphology, tensile and thermogravimetric analysis of oil palm empty fruit bunches fibers," Composites Part B: Engineering, vol. 45, no. 1, pp. 1251–1257, 2013.