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A review on the tensile properties of natural fiber reinforced polymer laminated composites

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Abstract: Natural fibers have recently become attractive to researchers, engineers and scientists as an alternative reinforcement for fiber reinforcement polymer(FRP),due to their low cost ,fairly good mechanical properties, high specific strength, non abrasiveeco friendly and bio degradability characteristics .Natural fibers widely used in aerospace and automotive industry for their desired characteristics. In this project, Natural fibers such as banana stem, Hemp, coir and kenaf are used. By arranging these fibers with specific angular arrangement with laminated coating of polymers, Many properties like Machinability, Toughness, hardness, Tensile properties can be improved and can be tested using finite element analysis. This project mainly concerned with the tensile properties of natural fiber composites. Finite element analysis is used perform to determine the tensile properties of the composite material.

Keywords Natural fibers, Polymers, Properties, Lamination

Introduction

Two or more chemically distinct materials which when combined have improved properties over the individual materials. Composites could be natural or synthetic. Composites are a combination of two materials in which one of the material is called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other material called the matrix phase. Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material. The essence of the concept of composites is that the load is applied over a large surface area of the matrix. Matrix then transfers the load to the reinforcement, which being stiffer, increases the strength of the composite. It is important to note that there are many matrix materials and even more fiber types, which can be combined in countless ways to produce just the desired properties.

In the United States, composites manufacturing is a 25 billion dollar a year industry. There are about 6000 composites related manufacturing plants and materials distributors across the U.S. The industry employs more than 235,000 people. An additional 250,000 people are employed in businesses that support the composites industry, including materials suppliers, equipment vendors, and other support personnel.

About 90% of all composites produced are comprised of glass fiber and either polyester or vinyl ester resin. Composites are broadly known as reinforced plastics.

Table 1 Review Literature

Study	Authors
Tensile strength is greater for parallel arrangement than perpendicular.	H. Ku, H. Wang, N. Pattarachaiyakoop& M. Trada
Chemical treatements help in developing	M.M. Kabir , H. Wang, K.T. Lau

bonding properties of fibers.	and F. Cardona
Possibility of replacing glass fibers with natural fibers is efficient one.	Paul Wambua, Jan Ivens and IgnaasVerpoest
Natural fibers have greater environmental benefits.	F.P. La Mantiaand M.Morreale
Increase in particle size improves tensile properties of fiber composites.	D.J. Bray, S.G. Gilmour, F.J. Guild and A.C. Taylor
Green composites mixed with glass fibers improves properties of fibers.	M. Ramesh, K.Palanikumar and K. Hemachandra Reddy
Development of automotive field increases the demand of usage of natural fibers due to their high strength to weight ratio.	Georgios Koronis, Arlindo Silva and MihailFontul

Bonding Characteristics of Composites

Natural fibers are being used as the reinforcement in the Thermoset polymer matrix composites. The adhesion between the polymer matrix and the fibers affects the properties of the composites. A strong fiber-matrix interface bond is needed for high mechanical properties composites. The chemical surface treatment of fibers improves the fiber matrix adhesion andtensile properties of the composites. The natural fibers are hydrophilic while polymer resins are hydrophobic in nature. This is reason for poor adhesion between them.Flax fibers and viscose fibers are used this experimental investigation. Bio-based epoxy and basic epoxy are used as polymer resin. Fibers are separated from the bundle manually. Single fiber tensile testing is done for non-treated flax fiber, glass fiber and viscose fiber. The characterization of the interfacial shear strength between fiber and matrix is tested by the micro-bond test. Single fiber pull-out test, the fiber bundle pull out test and the single fiber fragmentation test are also common micromechanical adhesion testing methods for the composites. Spectroscopic techniques are suitable for the surface characterization of the fiber before and after a surface modification or a micro mechanical testing.

Properties of bonding polymers

Unsaturated polyesters (UP) and epoxy are the most used Thermoset resins in natural fiber composites. Their chemical structures are shown in **Figure:**1 and 2. UP resins are made from different unsaturated and saturated acids, glycols and styrene, which acts as a cross-linking monomer. These resins are easy to use and low cost material. The molecular weight of the uncross-linked polyester is 1200 to 3000 g/mol. UP resins have only medium level mechanical properties and high cure shrinkage, but they are low viscosity which makes the processing easy. Polyesters are viscous liquid or brittle solid. They have a lowdegree of polymerization. The major problem with thisresin is their high shrinkage during curing reaction.

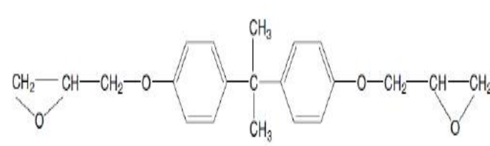

Figure: 1 the chemical structure of epoxy resins

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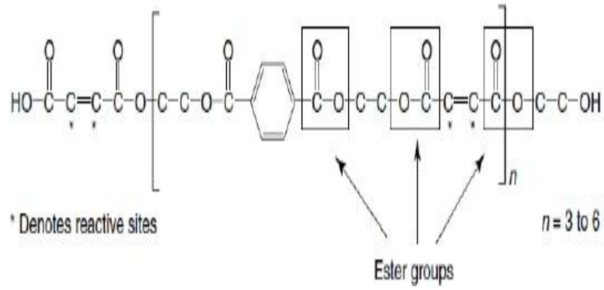

Figure: 2 The chemical structure of a unsaturated polyester resin

The interface between the natural fiber and Thermoset

Mechanical interlocking, attractive forces and chemical bonds between the natural fiber and the resin are the main factors that affect the bonding interfacial adhesion between the Thermoset matrix and the natural fiber. Hydrogen bonds and Vander Waals force are physical attractive forces which are importance in the interface. Natural fibers have hydroxyl groups and hydrogen bonds can therefore be formed to the surface of the natural fiber. The unsaturated polyester resin does not have hydroxy group in its backbone, and this is a reason for the weak bonds between natural fiber and the polyester.

The bond strength in natural fiber - reinforced composites is decreased by the absorption of moisture. The hydrophilic fibers absorb the moisture from the environment, and hydrogen bonds are formed between the hydroxyl groups of the cellulose molecules and the absorbed water, as shown in **Figure:**3.3. The first water molecules are absorbed directly onto the hydrophilic groups of the fibers. The later absorbed water molecules are attracted to other hydrophilic groups on the cellulose back-bone. Moisture absorption affects also the dimensional stability of natural fibers. This results to poor adhesion between the resin and the matrix which causes debonding. Drying the fibers before the processing is very important, because it increases the mechanical properties of the composites.

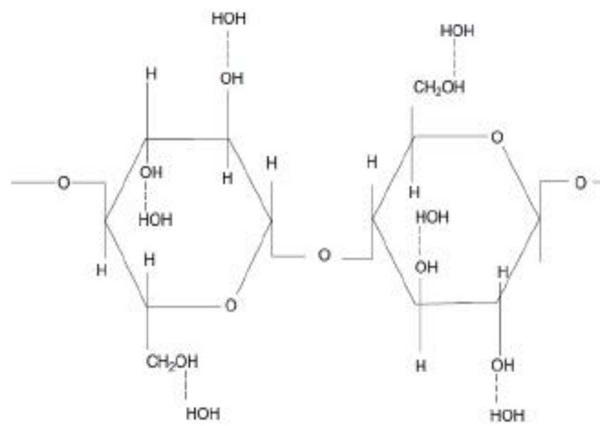

Figure: 3 Absorption of moisture by natural fibers occurs because the hydroxyl groups of the cellulose molecules and the water forms hydrogen bond

Tensile Properties On Natural Fibers

Various natural fibers had been chosen to prepare laminated composite to utilize their advantages of low density, less abrasion to equipments, bio degradability, high strength tolow weight ratio, low cost, less health risk and low energy consumption over manmade fibers like glass, carbon and metal fibers. The **Figure:**4 shows the tensile strength of various natural fibers.

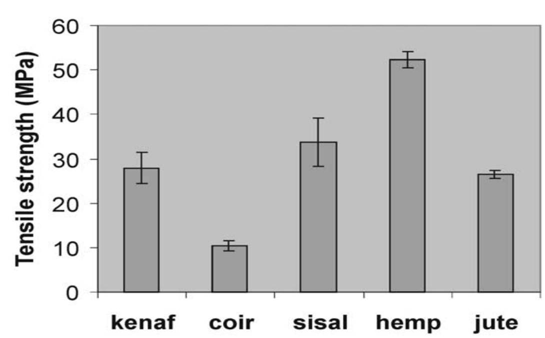

Figure: 4 Tensile strength of Natural fibers.

Table 2: Properties of Thermoset polymers

Properties	Polyester	Epoxy
Density (g/cm³)	1.2 - 1.5	1.1 - 1.4
Young's modulus (GPa)	2 - 4.5	3.0 - 6.0
Tensile Modulus (MPa)	40 - 90	35 - 100
Compressive strength (MPa)	90 - 250	100 - 200
Tensile elongation to break (%)	2	1.0 - 6.0
Cure shrinkage (%)	4.0 - 8.0	1.0 - 2.0
Water absorption 24h at 20 °C	0.1 - 0.3	0.1 - 0.4

Arrangement of fiber determines the strength of composites. The **Figure:**5 shows that perpendicular arrangement of fiber decreases the tensile strength and parallel arrangement increases the tensile strength. Which yield maximum tensile strength will be determined.

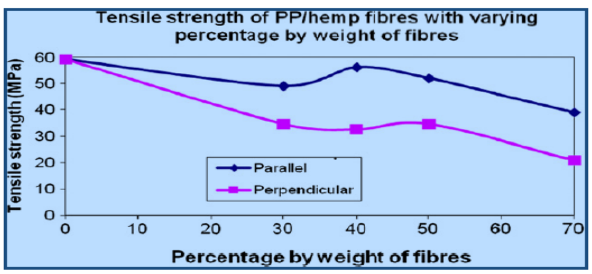

Figure:5 Tensile strength of polypropylene/hemp fibres with varying percentage by weight of fibres.

Conclusion

High strength to weight ratio of Natural fibers increases the utilization of these fibers in automotive industries.Laminated composites improve the properties of natural fibers than randomly reinforced fibers. Angular arrangement of fibers and volume fraction of fibers plays a vital role in properties of fibers. Research work on various angular arrangements will yield better results on properties of composites.

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