wjert, 2017, Vol. 3, Issue 5, 207-216. *Review Article* ISSN 2454-695X

World Journal of Engineering Research and Technology

WJERT

www.wjert.org SJIF Impact Factor: 4.326

MECHANICAL PROPERTIES AND CHARACTERISTICS OF NATURAL FIBER-A REVIEW PAPER

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Article Received on 07/07/2017 Article Revised on 27/07/2017 Article Accepted on 17/08/2017

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ABSTRACT

The need of friendly environmental materials has been enforced highly in the engineering field, the very good alternative materials for synthetic fibers for automotive and aircraft fields without much compromising the mechanical and chemical properties. This review paper provides the clear view on mechanical properties like tensile strength, flexural strength and vibration characteristics as per ASTM standards. This review paper reveals the properties of hybrid materials with different modulus of elasticity which will be a viable beneficial solution for structural applications.

KEYWORD: Hybrid, Flexural strength, Modulus of Elasticity, Mechanical properties, Tensile strength.

INTRODUCTION

Recent developments of new materials are rapid in replacement of synthetic materials natural fiber composite is one among them which has high specific light weight and biodegradability. Natural fibers like Flax, hemp, sisal, Kenaf, jute, bamboo etc. are ofenly used as inforcement in polymer matrices. As this natural fibers is abundantly available and in expensive when it is compare to other man made synthetic fibers.

The Mechanical Properties of a natural fiber reinforced composite depends on many parameters such as size, shape, stiffness, mass, durability cost etc. since a variety of glass fibers are available it is used as reinforcement for a large range of parts. Since the automobile industries is replete with models, options and changes in trends the material selection and combinations offered by the materials is also wide ranging, along with a measure of conservation, the choice is also dictated by the demands of the competitive market for new and alternate materials.

The fabrication costs of reinforced plastics is controlled by the devices and tooling used for producing them. In Turn, it is dependent on the basis of the quantity of components needed. Materials used in automotive body parts show high tensile and flexural moduli. The material is not ductile and hence will not yield and the failure is accounted only in terms of fracture. These properties and thickness, determine the maximum bending moment which is several times higher than the point of fracture for steel sheets.

Reinforced plastics can be given the metal finish although the cost of achieving this continues to be prohibitive. They are restricted in their use in car components. While the defects in painted sheet metal parts are easily parts are easily overloaded, the fiber pattern textured is oblivious, though the surface roughness measurements report that it is smoother.

To present a good unique look this study shows that the composite panels may be used as the complete outer skin of the automotive sheet moulding compounds of resins are most suited for this purpose. Inner and outer reinforce is done by panel assembled by adhesive bonding and riveting.

Good stability against corrosion or impact makes the composite widely used in vulnerable valance panel below the front and rear bumpers. The most crucial parameter is weight reduction as it directly affects efficiency, payload and the economy [38]. Durability is the chief factor as these vehicles are normally realizations of capital investments [39].

Merits of Composites

Composite meets the design requirements with significance weight savings as strength-weight-ratio. The followings are merits of composites,

- Tensile strength of composite materials is more the 4 time greater than that of steel or aluminium (depending on the reinforcements).

- It improves the torsional stiffness and properties of impact.
- It has very high fatigue endurance limit up to 55-60% ultimate tensile strength.
- When compared with aluminium it is light weighted.
- While machine is operated the vibration is very lesser.
- Composite produce less noise while machine are operated.
- With an excellent impact and fatigue strength its life span is maximum.
- It has high resistance against corrosion and fire.
- It eliminates the joins and fasteners and appears smooth.

Classification

Natural fibers are classified by two bases mainly they are.

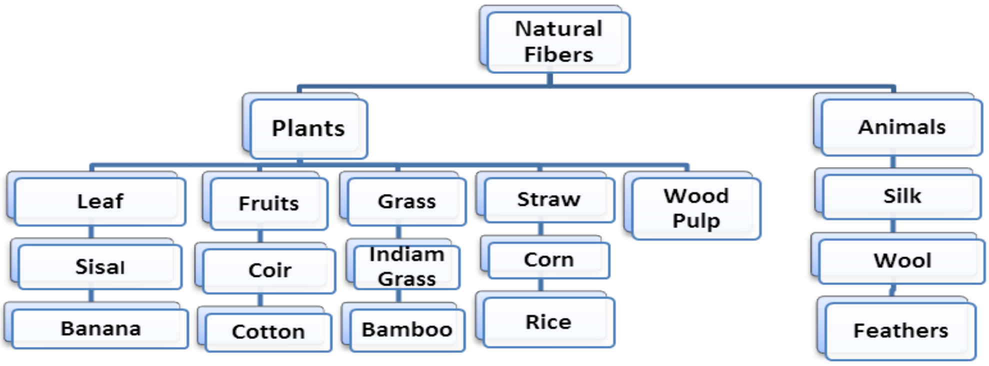

Table 1: Chemical and Mechanical Composition of Natural Fibers.

Fiber	Cellulose (Wt%)	Hemi Cellulose (Wt%)	Lignin (Wt)	Pectin (Wt%)	Moisture (Wt%)	Waxes	Micro fibrilar Angle Wt%)	Density (g/cm^2)	Tensile Strength (MPa)	Failure Strain (%)	Young's Modulus (Gpa)
Flax	71	19.6	2.2	2.3	10	1.7	5.1	1.45	500-900	50-70	1.5-4.0
Hemp	72	20.1	4.7	0.9	9	0.8	2.6	1.48	350-800	30-60	1.6-4.0
Jute	66	17	12.5	0.2	13	0.5	8	1.33	300-700	20-50	1.2-3.0
Sisal	73	12	12	10	16	2	16	1.5	300-500	10-30	2-5

Natural Fiber Reinforced Composites

The reinforced natural fibers are rapidly growing in the industrial and research as they are renewable, cheap, recycled partially or completely 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, and price as well as satisfactory mechanical properties make them 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.

LITERATURE SURVEY

Recent advances in the use of natural fibers (e.g., .ax, cellulose, jute, hemp, straw, switch grass, kenaf, coir and bamboo) in composites have been reviewed by several authors.[6–25] Harish et al.[2] developed coir composite and mechanical properties were evaluated. Scanning electron micrographs obtained from fracture surfaces were used for a qualitative evaluation of the interfacial properties of coir /epoxy and compared with glass fibers. Wang and Huang[1] had taken a coir fiber stack, characters of the fibers were analyzed. Length of the fibers was in the range between 8 and 337 mm. The fibers amount with the length range of 15~145 mm was 81.95% of all measured fibers. Weight of fibers with the length range of 35~225 mm accounted for 88.34% of all measurement. The average fineness of the coir fibers was 27.94 Tex. Longer fibers usually had higher diameters. Composite boards were fabricated by using a heat press machine with the coir fiber as the reinforcement and the rubber as matrix. Tensile strength of the composites was investigated. Nilza et al.[3] use three Jamaican natural cellulosic fibers for the design and manufacture of composite material. They took bagasse from sugar cane, banana trunk from banana plant and coconut coir from the coconut husk. Samples were subjected to standardized tests such as ash and carbon content, water absorption, moisture content, tensile strength, elemental analysis and chemical analysis. Bilba et al.[4] examined four fibers from banana-trees (leaf, trunk) and coconut-tree (husk, fabric) before their incorporation in cementitious matrices, in order to prepare insulating material for construction. Thermal degradation of these fibers was studied between 200 and 700 °C under nitrogen gas flow. Temperature of pyrolysis was the experimental parameter investigated. The solid residues obtained were analyzed by classical elemental analysis, Fourier Transform Infra-Red (FTIR) spectroscopy and were observed by Scanning Electron Microscopy (SEM).

Another prior art of Patent[41] Application No JP2004269333 titled “Carbon Fiber Reinforced Composite Material molding Containing Calcium phosphate Based Material, Method Of Manufacturing The Same And Artificial Bone Using The Same”, To provide a composite material molding suitable for an artificial bone for curing the disease of bone, and having high biocompatibility and excellent mechanical strength. ; SOLUTION: The composite material molding constituted so as to contain at least a calcium phosphate-based material, a carbon fiber material or a carbon fiber-reinforced carbon composite material or further to add an organic natural high polymer or organic synthetic high polymer material. The composite material molding is manufactured by mixing the calcium phosphate-based material with a carbon fiber material or the like or molding and firing the mixture of the materials.

Another prior art of Patent[42] Application No EP0442256 titled "BONE IMPLANT", A bone implant design is proposed in which the implant consists of a main body, in particular of a core and unidirectional fibres which is surrounded by a fibre latticework .The fibre latticework consists of a raised fibre portion in order to maintain the structuring of the latticework on the surface of the fibre netting. The adhesion of the bone material to the implant is promoted by the structured surface. The fibre latticework serves at the same time as a torsion casing.

Another prior art of Patent[43] Application No DE4004475 titled "BONE IMPLANTS WITH FIBRE MESH ON BASE BODY", The bone implant consists of a core with its surface covered by a layer of unidirectional fibres extruding in the longitudinal direction. The fibres are covered with a layer of woven fibres, for a textured surface .The fibre mesh is pref. of twisted fibres, retaining their round cross section. It forms up to 70% fibre portion. The core may be of a composite fibre material with a jocket.

Another prior art of Patent[46] Application No WO8600533 titled "BONE IMPLANT", An implant article for treatment in reconstructive surgery of damage caused to bony material, said article comprising a composite of fibre material which may or may not be bio-degradable and is incorporated in a porous matrix of a bio-degradable organic polymer material

Table 2: Properties of Natural Fibers.

Fibre Type	**Density Kg/m^3**	**Water absorption (%)**	**Modulus of elasticity E (GPa)**	**Tensile strength (MPa)**
Sisal	800-700	56	15	268
Roselle	800-750	40-50	17	170-350
Banana	950-750	60	23	180-430
Date palm	463	60-65	70	125-200
Coconut	145-380	130-180	19-26	120-200
Reed	490	100	37	70-140

Table 3: Physico- Mechanical Properties.

S. No.	Properties	Wool	Silk	Reference
1	Type	Natural	Natural	Quazi et al,(2010)
2	Melting Temperature (C^{O})	570-570	-	Mathase,(2010) Home Page
3	Service Tempertatute (C^{O})	100-400	-	Mathase,(2010) Home Page
4	Density (kg/m^3)	1.3	1.3-1.38	Mathase,(2010) Home Page
5	Tensile strength (MPa)	125-200	650-750	Mathase,(2010) Home Page
6	Elongation (%)	20-40	-	Mathase,(2010) Home Page
7	Polarity	-	Hygroscopic	Quazi et al (2010)
8	Young's Modulus (Mpa)	-	16	Quazi et al (2010)
9	Elongation at failure (%)	-	18-20	Quazi et al (2010)
10	Crystalinity (%)	-	65-70	Quazi et al (2010)

Composite Fabrication

Plant Fibre Composite

The natural fibre are fabricated by several methods, Most of the techniques commonly used for making glass fibre composites are applicable for making natural fibre composites. However, the well-known method for composites making are as followings: Hand Lay-up/Spray up is one of the cheapest and most common processes for making fibre composite products. In this process, the mold is waxed and sprayed with gel coat and cured in a heated oven. In the spray up process, catalyzed resin is sprayed into the mold, with chopped fibre where secondary spray up layer imbeds the core between the laminates resulting a composite. In hand layup processing, both continuous fibre strand mat and fabrics are manually placed in the mold. Each ply is sprayed with catalyzed resin and with required pressure compact laminate is made. Resin transfer molding (RTM) provides high quality finished surface on both the sides of composites with a relatively low energy makes perfect shapes. The fabricator generally gel coats the mold halves, then lays continuous or chopped strand mat and closes the mold. Resin transfers into mold through injection pressure, vacuum pressure, or both. Cure temperature depends on the resin system.

Compression molding is a molding technique for making composite materials with low unit cost with faster cycle times. Sheet molding compounds (SMC) is a sheet that sandwiches fibre between two layers of resin paste. Fibre/Fabric drop onto the paste and a second film carrier faces with another layer of resin. When the SMC is ready for molding, the mold is closed, clamped, and between 500 and 1,200 psi pressure is applied. After curing, mold is opened and the sheets were removed manually or through an injector system and ready for use.

Animal fibre composite

As a composite, wool fibres have been combined with polyester fibres and spun into multistrand yarn as threads, again for use in garments. Traditionally, wool fibres have been spun into multilayer fibres in the form of threads, which are then knitted into cloth and utilized for the manufacture of garments. The composite matrix was prepared from polyester resin with 1% hardener (methyl ethyl ketone peroxide). Samples of composite sheets were prepared in the laboratory from skeins of wool laid alternatively with layers of resin mixture, and placed in a rectangular mould. The top of the mould was sealed and hydraulic pressure of 1.2 MPa was applied for a period of 24 h. The pressure was then reduced to 0.6 MPa, the sample sheet was removed and excess solid resin trimmed. The composite so obtained was cured in air. This process was repeated for sample sheets containing wool by mass of 40, 30, 20 and a control sheet of polyester resin. Fabrication of different types of silk fibre composites, human hair composites and feather fibre composites can be made with hand lay-up technique and compression molding which has been already described in fabrication of plant fibre.

Opportunities and Challenges

Natural fibres have gained much interest among technologists and scientist for applications in civil, military, industrial, space craft and biomedical sectors (Saheb & jog, 1999). In the past two decades, growing interest for natural fibres composites has resulted in extensive research. The driving forces are (i) cost reduction, (ii) weight reduction and (iii) marketing (application of renewable materials). Technical requirements were of less importance; hence application remained limited to non-structural parts for a long time. The reason for this is the traditional shortcomings of NF composites, the low impact resistance and moist degradation. Recent research however showed that significant improvements of these properties are possible. The scope of different natural fiber composites and feature challenges and discussed with following section.

CONCLUSION

This review paper explains the clear study on the need and replacement of natural fibre composite materials for an alternative of synthetic materials which has been applied in automotive and aircraft engineering. The Mechanical and Chemical properties have been compared as per ASTM standards. The present study has been discussed to enhance the properties of natural fibres to create the challenges for better replacement of materials in improvement of its life. In future composite material is going to be implemented in challenging fields like Medical, where human organs were to be replaced.

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