A Review on Natural Fiber Reinforced Polymer Matrix Composites

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ABSTRACT: Now a days pollution is increased day by day due to plastic. So, analyst are demanding to minimize the percentage of plastic and to take advantage in polymer composites because of their ecofriendly nature. A natural fiber reinforced polymer matrix composite is briskly developing in essential analysis and industrial applications.Natural fibers are cheap, recyclable, biodegradable and recyclable. Natural fiber has advantage as compared to synthetic fiber such as carbon and glass fiber and advantage is low density, low cost, high specific strength,good mechanical properties, non-abrasive, bio-degradability characteristics and eco-friendly.So conventional fiber such as glass, aramid and carbon are replaced with natural fiber. Further, it presents arbitrary of different surface treatments applied to natural fibers and their effect on natural fiber reinforced polymer composite's properties. In composites, different fibers are used as reinforcement. In the improvement of science and technology, the new system of evaluation andcharacterization of composite's properties(chemico-thermo-mechanical-physico)have been used that have analyzed the new scope of utilizing them for automobile, aerospace, building, construction industry. This paper is focused on a review of natural fiber reinforced polymer matrix composite.

Keywords: **Natural fiber; natural fiber reinforced polymer (FRP) composites**

I. INTRODUCTION

Fiber is a hair-alike material which is in distinct stretched pieces, relatedthread pieces.There are two types of fibers: natural fiber and man-made fiber. A substance formed by animals or mineral source and plants which can be spun into thread, filament and more be bound, knitted and woven is called natural fiber.Man-made fiberconsists of regenerated fibers and synthetic fibers.There are many natural fibers such as banana, jute, sisal, coir, bagasse, hemp, wool, cotton, etc. These fibers have a chemical composition such as lignin, cellulose and hemicellulose. To remove this impurity, chemical treatment is necessary. Fiber reinforced polymer (FRP)composites are made of two or more materials which have different properties and when combined, composites have different properties from the individual component. FRP has two phases. One is reinforcement phase and other is matrix phase. As reinforcement, natural fiber and glass fibers are used. In matrix phase, thermoplastic and thermosetting resin are used. In thermoplastic resin, polyphenylene sulfide, polycarbonate, polypropylene and polyphenylene oxide are used where in a thermosetting resin, epoxy, polyester and phenolic resin is used. Tolerable mechanical properties in particular strength and stiffness are given by thermosetting resin. Genetic engineering is new advances in natural fiber improvement[1]. Natural fiber has an advantage over conventionalcomposites such as ecological and low density so natural fibers are pleasing to industry. The applications of Natural fiber composites are inautomobile, packaging, building and construction, paper industry and railway coach interiors. Replacement of high-cost glass fiber for low load-bearing applications is possible in natural fiber composites[2].

II. LITERATURE SURVEY

U.S.Bongarde[12] studied the classification and properties of the natural fiber. Fig. 1 shows the classification of natural fiber.

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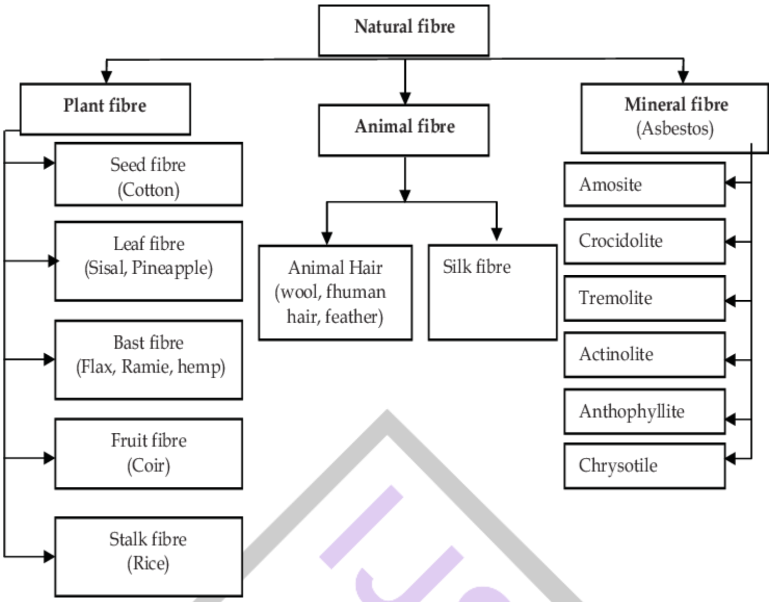

Figure 1. Classification of natural fiber

From animal, mineral sources and plant, Natural fibers are made.Natural fibers can be classified according to their origin as:

1) Plant fiber: There are many plant fibers such as banana, jute, flax, bamboo, cotton and hemp and. The sub category of plant fiber as below:

a) Seed fiber: From the seed, Fibers are collected. Kapok and cotton are the examples of seed fiber.
b) Leaf fiber: From the leaves, fibers are collected. Agave and sisal are the examples of leaf fiber.
c) Bast/skin fiber: From the bast or skin, Fibers are collected. The Tensile strength of this fiber is high compared to other fibers. Application of this fiber is in paper, packaging, and fabric. Jute, banana, flax and soybean are the example of bast fiber.
d) Fruit fiber: From the fruit of the plant, Fibers are collected. Coir fiber is the example of fruit fiber.
e) Stalk fiber: From the stalks of the plants, Fibers are collected. Bamboo, grass, barley and rice are the example of stalk fiber.
2)Animal fiber: These fibers contains silk fiber and animal hair. It includes wool, human hair, and feather fiber.
3) Mineral fiber: Mineral fibers are naturally occurring fiber procured from minerals. Mineral fiber is sub-divided into a metal fiber, amosite, tremolite, ceramic and asbestos.
The properties(mechanical and physical) of composites depend on the chemical composition (lignin, Cellulose, waxes, water content, pectin, hemicelluloses) of fiber according to processing methods and grooving (aging conditions, climate, and soil features). Table 1 shows the chemical composition of natural fiber.

Table 1. Chemical composition of natural fiber

Fiber	Lignin(Wt%)	Cellulose(Wt%)	Pectin(Wt%)	waxes	Hemicellulose(Wt%)
Bamboo	32	60.8	-	-	0.5
Hemp	3.7-5.7	70-74	0.9	0.8	17.9-20.4
Jute	12-13	61.1-71.5	0.2	0.5	13.6-20.4
Kenaf	8-13	45-47	3-5	-	21.5
Sisal	10-14	66-78	10	2	10-14
Coir	40-45	32-43	3-4	-	0.15-0.25
Banana	5	63-64	-	-	19

Mechanical properties of natural fibers are most important. In most cases, conditions of experiments are different. Natural fiber's mechanical properties depend on diameter and length of particular fibers. Table 2 shows the tensile properties and density of natural fiber.

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Table 2. Mechanical properties of natural fiber

Fiber	Density(g/cm^3)	Tensile strength(Mpa)	Tensile modulus(Gpa)	Elongation(%)
Bamboo	1.4	500-900	30-50	2
Jute	1.3	350-800	20-50	1.2-3.0
Hemp	1.48	300-700	30-60	1.6-4.0
Flax	1.45	500-740	50-70	1.5-4.0
Coir	1.2	150-180	4-6	20-40
Sisal	1.5	300-500	10-30	2-5
Banana	1.35	529-914	15-20	3

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Xue Li and Lope G. Tabil[3] studied the different chemical treatment used for to improve mechanical properties, to remove impurities such as lignin, cellulose, and hemicellulose, to decrease water absorption of water and to improve the bond between fiber and matrix. They studiedare different chemical treatment such as alkali or mercerization, acetylation, silane,acrylation, benzoylation, isocyanates andrelated coupling agents.

S.M. Sapuan[4] studied Mechanical properties of woven banana fiber reinforced epoxy composites. They made three samples of composite(woven banana fiber and epoxy resin) with different geometry. Then carried out the tensile test and flexural test(three point bending test). From the result, they found that in x-direction maximal value of stress is 14.14 MN/m^2 and in Y-direction maximal value of stress is 3.398 MN/m^2. For Young's modulus, the value in the x-direction is 0.976 GN/m^2 and in Y-direction is 0.863 GN/m^2. In the flexural test, the maximal load 36.25 N is applied to get the deflection of 0.5 mm(specimen beam of woven banana fiber). The maximal Young’s modulus and stress in x-direction were recorded to be 2.685 GN/m^2 and 26.181 MN/m^2, respectively. They also worked on Statistical analysis using ANOVA(analysis of variance).

N. Venkateshwaran[5] studied that tensile properties(tensile strength and modulus of elasticity) of natural fiber hybrid composite material(banana/sisal fiber) with 0:40, 20:20, 10:30, 30:10 and 40:0 ratios, although volume fraction of fiber was immovable as 0.4V$_f$. Then, he studied comparison between Rohm(rule of hybrid mixture)and experimental showed that they are in better understanding.Fig. 2 and 3 shows the experimental and theoretical (Rohm)tensile strength and modulus of the hybridcomposite.

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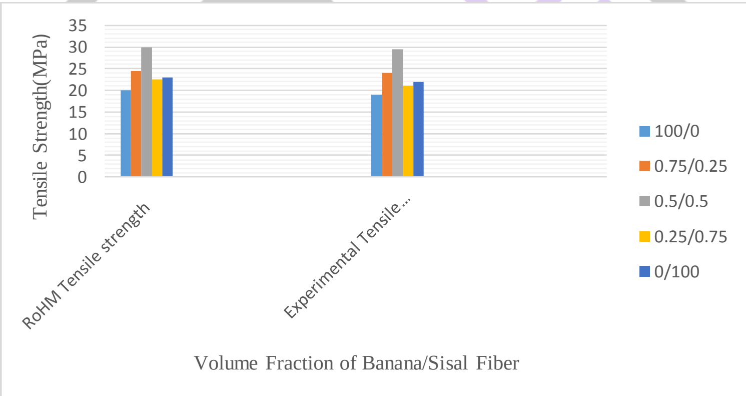

Figure 2. Comparision of experimental and Rohm tensile strength of composite

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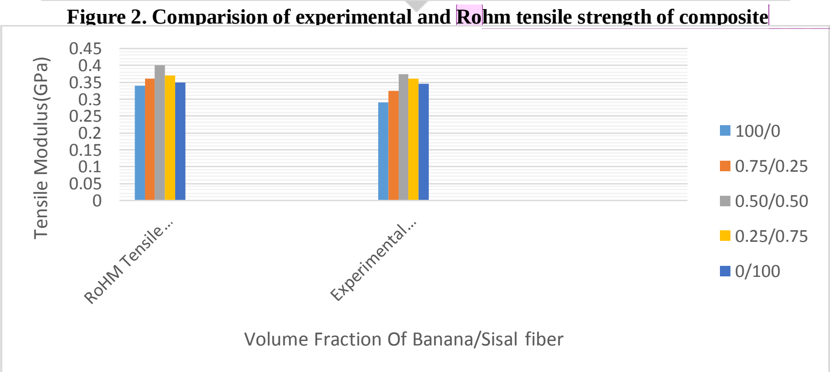

Figure 3. Comparison of experimental and Rohm tensile modulus of composite

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From fig. 2 and 3, it was observed that the experimental values are little lower than theoretical values(Rohm value).

M. Boopalan[6] studied the thermal properties and mechanical properties of banana and jute fiber reinforced epoxy hybrid composites. He made a composite plate from banana and jute fibers with different weight ratios such as 100/0, 50/50, 75/25, 25/75 and 0/100 and integrated into the epoxy matrix by a mouldingtechnique. The impact, flexural, tensile, water absorption test and thermal were implemented using a sample of hybrid composite. Results show that the thermal, flexural and mechanical properties are maximum in sample of 50/50 weight ratio and moisture absorption properties increase with increasing with weight ratio. Morphological analysis was executed to inspect fiber take off of the sample and behavior of fracture behavior by SEM(scanning electron microscope).

Laly A. Pothan[7] studied DMA(dynamic mechanical analysis) of banana fiber reinforced polyester compositewith special reference to the effect of temperature, fiber loading, and frequency. The morphology of the system, the nature of the interface between the phases and intrinsic properties of the components,determine the composite's dynamic mechanical properties. At lower temperatures (in the glassy region), the values of E' are maximal for the neat polyester whereas at temperatures above glass transition temperature(Tg), the value of E' are found to be maximal for composites with 40% fiber loading, indicating that the incorporation of banana fiber in polyester matrix induces reinforcing effects appreciably at higher temperatures. The damping peaks and loss modulus were found to be reduced by the fiber's incorporation. The damping peaks height depended on the content of fiber. The Tgrelated with the damping peak was reduced up to a content of fiber of 30%. The value ofglass transition temperature(Tg) was raised with higher content of fiber. He also studied that SEM(scanning electron microscope) of a composite with 10%, 20% and 40% fiber loading. He observed that adhesion between fiber and matrix is good in 40% fiber loading.

Mansour Rokbi[8] studied the effect of chemical treatment on flexural strength and a flexural modulus of alfa fiber reinforced polyester composite.Before making of the composite plate, pretreatment of fiber is necessary. Alkali treatment is best for alfa fiber. He made five composite plates with different manufacturing method and there are Untreated Alfa fibers, 01% NaOH at 24h, 05% NaOH at 24h, 05% NaOH at 48h and 10% NaOH at 24h. Heobserved that behavior of bending of composite made from alkali treatment is better compared to untreated fiber composite.He also observed that flexural properties(flexural strength and flexural modulus) of composites are better in 10% NaOH at 24h and poor in 5% NaOH at 48h.

A. Baharin[9] studied the effect of banana leaves lamination on the mechanical properties(tensile properties and flexural properties) of particle board panel. He madeLaminated composites by laminating the binderless banana stem particle boards with banana leaf tapes using adhesive in the form of a double-sided tape. He observed that flexural strength is high in four layers of Particle board. When a number of layer of banana leaf tapes are raised, the flexural modulus increased and tensile strength also improved. Tensile strength is highest with four layers of banana leaf tapes. But, the number of layers increasing, tensile modulus decreased. The fiber orientation is the most important factor to affect mechanical properties of the particle board. When fiber orientation is parallel to test direction, it gives highest tensile strength but fiber orientation is not affect the flexural strength.

Sherely Annie Paul[10] Effect of chemical treatments and fiber loading on specific heat, thermal diffusivity and thermal conductivity of banana fiber/polypropylene matrix composite materials at a temperature of the room. These specific heat, thermal diffusivity and thermal conductivity (thermophysical properties) of the composites were examined as a function for various chemical treatments and of the fiber loading given to the banana fiber. He observed that thethermal diffusivity and thermal conductivityof the composites reduce with the loading of fiber. But doesn't change in the specific heat of the fiber composites. The chemical treatment is used for to improve thermophysical properties of the composite. He studied some chemical treatment and observed that Benzoyl chloride treatment gives the highest value of thermal diffusivity and thermal conductivity. He was also observed that banana fiber composites made from 10% NaOH treatmentgivesuperior thermophysical properties compared to 2% NaOH treated banana fiber composites.

Vishnu Prasad[11] studied the FEA of banana and jute fiber reinforced polymer matrix composite and development of design specification using analysis of variance(ANOVA) approach.He made hybrid polymer composite with jute fiber as reinforcement and general purpose resin as matrix material by hand lay-up method. The tensile strength is studied using experimental and numerical analysis. The nature of hybrid matrix at different composition is also studied. The commercial Finite Element Analysis software ANSYS is used for a numerical study.

N.V. Rachchh[13] examined the mechanical properties such as density, tensile strength, hardness and flexural strengthof NFCs(natural fiber reinforced composite). He made a composite plate from rattan fiber as reinforcement and unsaturated polyester resin GP-7150 as matrix material by hand lay-up method. Composite plate were made with different proportions such as 5%, 7.5%, 10%, 12.5%, 15% and 17.5% of rattan fiber.Tensile and flexural tests were performed in UTM(universal testing machine) and hardness test carried out in barcol impresser. From results, he observed that up to 12.5% mechanical properties were increased and then reduced because of resin are not tolerable to transfer load between fibers.

M. Jawaid, H.P.S. Abdul Khalil[14] studied the Effect of fiber loading of jute on dynamic mechanical properties and tensile properties of oil palm epoxy matrix composites. Hybrid composites madeby jute and oil palm fiber with epoxy matrix by hand lay-up method. From the result, they observed that tensile properties of hybrid composites were raised with rising fiber loading of jute as compared to oil palm–epoxy composite. The behavior of matrix/fiber interface was inspected through SEM(scanning

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electron microscope) of tensile fracture samples. The Addition of jute fiber to oil palm composite increases the storagemodulus while damping factor shifts towards higher temperature region. To recognize the phase behavior of the samples of composite, cole–cole analysis was performed. The hybrid composite with jute:oil palm (4:1) showed highest tensile properties and maximal damping behavior. The hybrid composite system used for raising dynamic and tensile mechanical properties of the oil palm–epoxy composite possibly due to the bond between matrix and fiber.

James Holbery[15] studied the use of natural fiber reinforced polymer composites in the automotive industry.Natural fibers such as hemp, jute, banana, kenaf, sisal and flax offer such advantages as devaluation in cost, weight, recyclability and less dependence on foreign oil sources.He studied about properties of thermoset and thermoplastic polymer used in natural fiber composites& properties of the natural fiber. He also studied automotive parts produced from natural fiber such as wood/cotton fibers are used in a glove box, Cotton with PP/PETFibers are used in the trunk floor, Flax mat with polypropylene used in floor panels, Leather/wool backing used in the seat covering, etc.

M Rajesh[16] studied the vibration characteristics of sisal/banana hybrid composite beam. He made three composite beams. One is banana composite, second is sisal composite and third is hybrid composite with Methyl Ethyl Ketone Peroxide (MEKP) hardener and unsaturated polyester resin. From results, he observed that flexural properties and frequency are raised with raising a percentage of fiber up to 50% and after adding material, the flexural properties and frequency should be decreased. It indicates higher the content of fiber in composite decrease the material's stiffness. Because the higher content of fiber builds a poor bond between matrix and fiber.

III. CONCLUSION

The current report focuses on the growth of natural fiber reinforced matrix composites. Industries are in constant search of new materials to profit margins and lower costs. To reduce pollution, need to find renewable resources. Natural fibers have an advantage such as low cost and energy compared tosynthetic fiber such as glass fiber and carbon fiber. So natural fibers are replaced with a synthetic fiber to develop bio-composites.Physical and mechanical properties of different natural fibers are better because of a combination of fiber.

Some disadvantages must be overcome duringaccomplishment the entire probable of natural fibers. First is, Surface treatment of fiber should be developed and achieved. Second, Composite's properties are highly depended on the volume percentages of resin and fibers. Composite's properties are anisotropic- the propertiesvary from point to point.The creation to crop economically pleasant components of the composite has a conclusion in a few new techniques of manufacturing presently being used in the composites industry.

IV. ACKNOWLEDGEMENT

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