A Review of Mechanical Properties of Hybrid Fiber Polymer Composite for Structural Applications

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***Abstract*: This article represents an overview of the mechanical characteristics of the natural-synthetic fiber-polymer composite. Recently the natural fiber becomes more attractive to the researcher because it is a good alternative of the synthetic fiber reinforced composite because of their low density, eco-friendly nature, low cost, recyclable. Now the natural fiber plays a very important role in developing automobile parts and structural application. This article shows that hybrid fiber polymer composite is more useful in the production of automobile parts and structural application due to their excellent mechanical and thermal characteristics and replace synthetic material from the market and save the environment.**

***Keywords*: Mechanical Properties, Thermal properties, Composite, Hybrid, Natural Fiber**

Introduction

The natural fiber is very useful and easily available from the natural resources like agriculture, animal, plant but synthetic recyclable but mechanical properties are better than natural fiber. So many researchers developed a material called composite material. A composite is an auxiliary material that comprises at least two joined constituents that are consolidated at a perceptible dimension and are not solvent in one another. One constituent is known as the strengthening stage and the one in which it is inserted is known as the grid. The strengthening stage material might be as strands, particles, or pieces. The network stage materials are commonly persistent. Autar K Kaw [1]. Matrix and Reinforcement both are an integral part of composite materials. The reinforcement and matrix are the phase of the composite which are insoluble with each other and differ in physical form and chemical composition. Matrix is used to hold the reinforcement, stopping the crack propagation, protect the reinforcement from the external environment and provide good strength of the composite. The composites are classified on the basis of its matrix and reinforcement. Matrix-based composite is polymer matrix composite, metal matrix composite, and ceramic composites. Reinforcement composites are classified as filler composites, flake composite, fibrous composites, and particulate composites. Fabulous composites are divided into the single and multilayered composite. While laminates and hybrid both are the part of multilayered composites. Rahul Shrivastava et al. [2]. Fiber reinforced polymer composite has much structural application due to its low weight, easy fabrication, low price and good mechanical characteristics as compared to polymer resin. When the increased the natural fiber in composites the thermal conductivity reduced so it is desirable for heat flux dissipation for electronics packaging components. The use of natural fiber reduced the weight of the specimen by 10% and the energy needed for production by 75-80% as compared to fiberglass reinforced material component. M.SAKTHIVEI et al. [3]. Natural fiber such as banana, hemp, jute, sisal, kenaf etc.used as a reinforcement for polymer composites. When they are used as a filler in composite, they provide good mechanical properties as compare to synthetic fiber. When adding the compatibility agents in composite the mechanical characteristics and weathering stability improve because of making covalent interaction between a surface hydroxy group of the natural fiber and compatibilizer. The additive MAH-PP increase the tensile strength, flexural strength, and stiffness of the composites. Marcel Ionel Popa et al. [4]. When looking at information from changed sources, it ought to be viewed as that various factors that are not constantly revealed have an impact on fiber properties. These incorporate testing speed, measure length, dampness substance, and temperature. By and large quality increments with expanding dampness substance and diminishes as temperature builds; Young's modulus diminishes with dampness content. Here and there it is likewise indistinct in the writing concerning whether the tests have been directed on single strands (single cells) or on fiber groups (some of the time alluded to as specialized filaments). Estimation of properties is commonly founded on the all-out cross-segment of a fiber or fiber pack, in any case, single filaments have a focal empty lumen which takes up a noteworthy extent of the cross-sectional territory. The portion of the cross-sectional region taken up by the lumen has been observed to be, for instance, 27.2%, 6.8% and34.0% for sisal, flax, and jute individually thus it could be viewed as that estimations of solidarity and solidness acquired not considering are underestimations to a similar degree. K.L. Pickering et. al [5]. Factors affecting the mechanical and thermal properties of NFC are:

· Selection of fiber

· Selection of matrix

· Manufacturing method used for composite

· Moisture contains

· Chemical and mechanical treatment

· Interfacial molecular bonding

The mechanical characteristics of natural fiber shown in Table 1. In this table, it is showing that the E-glass fiber has good tensile strength as compared to all natural fiber and Young's modulus of the flax is more than all fiber. So natural fiber mixed with synthetic fiber in order to obtain the characteristics of both and reduced weight, cost of the specimen. Sanjay M Ra et al. [6]

Table 1: Physical Properties of Natural Fibers

Fibers	Tensile Strength (MPa)	Young's modulus (GPa)	Elongation at Break (%)	Density (g/cm3)
Abaca	400	12	3-10	1.5
Bagasse	350	22	5.8	0.89
Bamboo	290	17	-	1.25
Banana	529-914	27-32	5.9	1.35
Coir	220	6	15-25	1.25
Cotton	400	12	3-10	1.51
Curaua	500-1150	11.8	3.7-4.3	1.4
Flax	800-1500	60-80	1.2-1.6	1.4
Hemp	550-900	70	1.6	1.48
Jute	410-780	26.5	1.9	1.48
Kenaf	930	53	1.6	-
Pineapple	413-1627	60-82	14.5	1.44
Ramie	500	44	2	1.5
Sisal	610-720	9-24	2-3	1.34
E-glass	2400	73	3	2.55

Natural fiber Reinforced Polymer Composites

Flexural Strength of the jute fiber epoxy based composite is good as compare to other treated or non treated composite the flexural strength of jute fiber epoxy based composite after surface treatment is 89 MPa which is greater than other treated composite. The impact strength of non treated jute /epoxy composite is more than all other non treated composite but after surface treatment of the composite, the impact strength also decreases. The tensile strength of the non treated jute fiber epoxy based composite is better than non treated sisal and banana based composite after the surface treatment of composite by NaOH the tensile strength improve. During the surface treatment by NaOH the surface area interaction increases between fiber and resin which causes tensile strength increase. Jai Inder Preet Singh et al. [7]. Most of the mechanical properties depend on chemical constituent (crystalline cellulose, non-crystalline cellulose, and lignin) of the natural fiber reinforced polymer composite. The flammability of natural fiber restricts its application in many sectors (electronics, automotive, maritime and aircraft industries). Carbon-based polymer composite has good thermal conductivity as compared to the natural fiber reinforced polymer composite. In hemp fiber reinforced polymer composites, the phosphorus is used to reduce the flammability. It is noticed that when we added fire retardant into polymer matrix the mechanical properties changed. Kin-takes Laua et al. [8]. Carbon fiber composite is used in many industries like automobile, sporting goods, aerospace, etc due to its high strength, high modulus, low density, high-temperature resistance. Carbon fibers are unidirectional reinforcement; the carbon fibers are arranged in such a way that composite is stronger in the direction where the load is applied. Saira Taj et al. [9]. Sisal fiber reinforced polymer composite the mechanical properties such as tensile strength, tensile modulus, flexural strength, flexural modulus, and impact strength is maximum when we used epoxy polymer as compare to thermosets used including polyester, vinyl ester, and phenolic resin. K. Senthilkumar et al.[10]Impact strength, density, and hardness of the banana reinforced epoxy polymer composite is good as compare to coir, sisal polymer composite. The water absorption capacity of the banana reinforced polymer composite is about 10% of its mass and the percentage of gain water by coir, sisal polymer composite is 9%,5% of its mass. The energy absorbed by the banana reinforced polymer composite during impact test is 5 joules although the energy absorbed by the coir and sisal reinforced composite during impact test is 4 joules so impact strength is good for banana fiber-polymer composite. M.SAKTHIVEl1 et al. [3]. The Young's modulus and the Tensile strength of bamboo fibers increased by 14% and 38%, respectively of the bamboo fiber reinforced epoxy composite when it is chemical (6%wt. NaOH) treated and flexural modulus of the bamboo reinforced polymer composite is higher when length and content of the bamboo fiber increased**.** Kai Zhang

et al. [11]. The tensile, compressive and bending strength of the jute fiber reinforced polymer (epoxy) composite increase with increase the fiber In composite and the impact strength of the composite is not changed when the amount of fiber increased. The jute fiber reinforced polymer composite is used in construction purposes, automobile industry, window and door frames, roof tiles, etc. Asheesh Kumar et al. [12]. Synthetic fiber mostly reinforced with polypropylene polymer composite because of its good properties, E-glass fiber mixed with polypropylene to provide good mechanical properties at low cost in fiber reinforced plastic industries. S-glass fiber reinforced polypropylene composite used in aircraft components and missile casings because of it the highest tensile strength among all fibers. Arpitha. G. R et al. [13].

Hybrid Fiber Reinforced Polymer Composite

The tensile and flexural strength of the jute, pineapple leaf fiber, and glass reinforced polyester composite is less than the jute, pineapple, and glass reinforced epoxy composite. So in many structural applications epoxy is used as a matrix in order to achieve better tensile flexural strength. When we increase the fiber content in composite the flexural and tensile strength of hybrid fiber reinforced polymer composite increased. M. Indra Reddy et al.

[14]. The glass fiber is notwithstanding with high temperature due to its low melting temperature so carbon fiber is used as a matrix in reinforced polymer composite. Fibre reinforced polymer with a mixture of glass fiber and carbon fiber increased the strength and stability of the material. The small amount of carbon fiber will reduce the weight and cost of the material. The low weight of the material will reduce the 8-10% total weight of the aircraft which Causes the fuel consumption also be reduced. P. M. Bhagwat et al. [15]. The warm properties, for example, warm conductivity, warm diffusivity, and explicit warmth limit of mixture composite are influenced by the synthetic treatment of fiber and filler focus. The warm conduct of cross breed pineapple leaf fiber (PALF) and glass fiber fortified polyester composites has been assessed that the substance treatment of fiber diminishes the composite warm contact opposition. In Banana and Pineapple leaf fiber strengthened polyester composites the warm conductivity of cross breed composite increment with increment the temperature and reduction with increment volume division the fiber in the composite. The particular warmth limit of fiber-fortified polyester composites estimated in the scope of 30◦C — 120◦C and find that the particular warmth of composite reductions with expanding volume portion of filaments characteristic fiber half and half composite is utilized in numerous applications where protection are required, for example, vehicle enterprises, electronic bundles, building development, and game merchandise and so on. P. V. Ch. R. K. Santosha et al. [16]. The natural hybrid fiber polymer composite now used as a biomaterial in medical science for an implant of human body bone replacement. The properties required for bio-material are corrosion resistance, resistance to implant wear, low weight, etc. Amid the wear investigation of 12%, 24% and 36% of Hybrid Fiber (Natural fiber-Sisal, Jute and Hemp) polymer composite material it is discovered that 36 % Hybrid Natural filaments Polymer Composite Material has greatest wear rate, Friction Force and Weight Loss as contrast with 12% and 24% cross breed fiber polymer composite so expanding the level of normal fiber increment the wear rate of example. So as to lessen the heaviness of the example the level of fiber increment in the composite. Henceforth, the heaviness of 36% of Hybrid regular fiber polymer composite is under 12%,24% half and half characteristic fiber polymer composite, so we can utilize this sort of low weighted cross breed common fiber polymer composite as an elective material for Human Orthopedic Implants. Dr. A Thimmana Gouda et al. [17].

APPLICATION

Natural fiber reinforced polymer composite today now used in the automobile industry due to its low weight and good strength. In automobile manufacturing industries the bonnet of the car made from the flax/vinyl ester at the place of the steel panel and reduces the 31.7% weight of the bonnet. Gilsu Park et al. [18]. Volvo used soya based foam in linings in its C70 and V70 models for their seats with natural fibers, and they produced a cellulose-based cargo floor tray for improving the quality of noise reduction. Mercedes, BMW, and Audi start using natural fiber composites for interior and exterior applications. Mercedes-Benz used an epoxy matrix with the addition of jute in the door panel and Toyota developed Eco plastic from sugarcane and used in line and interiors of the vehicle. Hemp and flax is a good source of producing the natural fiber composite which is used in automobile, furniture, paper, packaging, and structural application. N Ramli et al.[19]. In the aerospace structural application the natural fiber plays a very important role, fiber-metal laminates hybrid composite material are used in its structural application. The hybrid fiber-metal composites offer the advantages of both fiber reinforced and metallic material. There are various types of the metal-fiber composite are available such as aramid-reinforced aluminum laminate, carbon-reinforced aluminum laminate, glass reinforced aluminum laminate. Most of the wind turbine blade is made from the carbon/epoxy, wood/epoxy composites. Hai Nguyen et al.[20].

Conclusions

This paper has reviewed the research focusing on natural fiber reinforced polymer composite, hybrid fiber reinforced polymer composite materials including their mechanical and thermal properties and its structural application. The mechanical properties of natural fiber reinforced polymer composite is poorer than synthetic fiber reinforced polymer composite. A possible solution to this problem is the use of Natural/synthetic fiber combination in hybrid polymer composite. Hybrid fiber polymer composite material provides good strength both in tension and compression, good impact strength, low in weight, low cost. The Synthetic-Natural hybrid fiber composite provides low thermal conductivity and specific heat capacity so it can be used in many applications such as automobile, aerospace, etc. where insulation is required. In hybrid reinforced polymer composite the thermal conductivity and Specific heat capacity decrease with increasing the volume fraction of fiber and the thermal conductivity of hybrid composite material increase when the temperature increased. However further research is necessary to evaluate the thermal and mechanical

properties of the hybrid(synthetic-natural) fiber reinforced polymer composite since it also has excellent structural properties and increases the area of application in automobile, packaging, aerospace, naval, electrical component and civil engineering works.

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Conflicts of Interest Statement:-

It is certified that Authors have no affiliations or involvement in any organization with a financial or nonfinancial interest in the subject matter or material discusses in this manuscript.

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