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Study the Material Characterisation of Natural and Synthetic Fiber Reinforced Polymer

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Abstract

During the last few years fibers like glass fiber, carbon fibers have received much more attention than ever before from the research community all over the world. The fiber reinforced polymer (FRP) consisting of glass, carbon or aramid fibers embedded in a resin such as vinyl ester, epoxy or polyester are emerged as one of the most promising and affordable solutions to the corrosion problem of steel reinforcement. The Glass Fiber(GF) reinforcement is used with Polypropylene based composites for the better properties and less cost. The FRP is used in many fields like aerospace, automotive and marine industries for their unique characteristics like high strength, light weight, design flexibility and corrosion resistance. In this study the natural and synthetic fibers are fabricated by fiber reinforced plastics and compare with their mechanical properties. The better mechanical properties of fiber reinforced polymer is obtained and analyse the properties of natural and synthetic fibers.

Keywords: Fiber Reinforced Polymer, Glass Fiber, Polypropylene

Introduction

The industrial application of natural fibers as an alternative for synthetic fibers in polymer matrix composites(PMCs) has already occurred in marketable products. A relevant case oflignocellulosic fiber substitution is in vehicles. The automobile industry is successfully applying composites reinforced with a variety of this type of natural fiber to replace components such as interior panels and seat cushions originally made of glass mat PMC or polymeric foams. The different components made of natural fiber reinforced PMCs in a Mercedes Benz. Important technical reasons exist for this preference. A natural fiber PMC presents less damage to tools and molding equipment, as well as relatively better finishing. Furthermore, a high degree of flexibility, which makes a natural fiber bend rather than fracture, in association with low density and non-abrasive surface, offer practical advantages for reinforcement of PMC components in comparison to glass fibers. The relatively greater toughness of a natural fiber PMC component is able to absorb the high impact energy occurring in an automobile crash.

R. Zah et al. an even stronger argument based on legislation now exists for the use of natural-fiber PMCs in automobiles. A European Community directive requires that the member countries reuse and recover at least 95% of the material from all end-of-life vehicles. Components containing glass fibers cannot easily be separated and, therefore, are difficult to recycle. In contrast to glass fiber, natural-fiber PMCs can be completely burnt to recover energy, which is a practice accepted by the directive. Consequently, the use of natural-fiber PMCs is rapidly increaing in the automobile industry at ansnual growth rates above 20%.

Zah et al. predicted that the future trend of extreme lightweight car design will further enhance the application potential of natural fiber composites eventually leading to the ultimate vision of cars that grow on trees. In addition to technical and environmental advantages, low cost is the main industrial motivation for natural rather than synthetic fibers as PMC reinforcement. The most economical of all synthetics, the glass fiber has a commercial price that varie

Abilash and SivaPragash (2013) studied about environmental benefits of ecofriendly natural fiber

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reinforced polymeric composite material and they proposed that the secondary phase embedded in the matrix is a discontinuous phase. It is usually harder and stronger than the continuous phase. It servers to strengthen the composites and improves the overall mechanical properties of the matrix. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Composites are hybrid materials made of a polymer resin reinforced by fibers, combining the high mechanical and physical performance of the fibers and the appearance, bonding together and enriching the physical properties of polymers. The manufacturing processes, each resulting in their own characteristic products, the design possibilities are numerous. Consequently, a composite product and its manufacturing process can be chosen to best fit the environment in which the products will be made and used. Besides the technical feasibility, manufacturing of composites becomes also financially feasible when using domestically grown natural fibers in combination with simple manufacturing processes.

Begum and Islam (2013) studied about Natural fiber as a substitute to synthetic fiber in polymer composites and they proposed that work presents a brief overview of the improvement of the mechanical properties (tensile and flexural strength and the corresponding modulus of elasticity) of natural fiber reinforced polymer materials. The mechanical strength of the natural fiber reinforced polymer composites (NFRPCs) has been compared with that of glass fiber reinforced polymer composites and it is found that for achieving equivalent mechanical strength of the material, the volume fraction of the natural fiber should be much higher than that of the glass fiber. The eco-friendly nature (emission, economy of energy) of the production of components of NFRPCs has also been briefly discussed. It is concluded that NFRPCs have already been proven alternative to SFRPCs in many applications in automotive, transportation, construction and packaging industries, and the production of natural fiber being labor-intensive, the NFRPC industry will create new employment and will contribute to the poverty alleviation program in developing countries.

Shrikant M Harle(2014) studied about the performance of natural fiber reinforced polymer composites during the latest decades fiber reinforced polymer composites and he proposed that FRPC proved as very valuable material and suitable to be a new construction material. While nowadays, natural fibers have received much more attention from the structural engineers all over the world and utilization of natural fibers as reinforcement in polymer composite for making low cost construction materials has been growing very wide interest. Natural fibers have served many useful purposes but the demand for utilization of it as reinforcement in polymer matrix is growing in recent years. These natural fibers offer a number of advantages over traditional synthetic fibers because of their superior corrosion resistance, excellent thermo-mechanical properties and high strength to weight ratio.

Navdeep Malhotra et al.(2012) proposed that natural fibers have been used to reinforcing materials for over 2,000 years. The necessity for renewable fiber reinforced composites has not been as prevalent as it currently is. Natural fibers are emerging as cost effective and apparently ecologically superior substitutes to glass fibers in composites. In this review a comparative life cycle valuation of Natural fiber reinforced polymer matrix composite materials has been accounted. The methodology and findings of mechanical and fracture surface characterization of various natural fiber composites has been summarized.

Sakthivel and Ramesh (2010) studied that natural fibres was used to reinforce materials they have been employed in combination with plastics. Many types of natural fibres have been investigated for use in plastics including flax, hemp, jute, sisal and banana. Natural fibres have the advantage that they are renewable resources and have marketing appeal. These agricultural wastes used to prepare fibre reinforced polymer composites for commercial use.

During the application of composite materials to structures has presented the need for the engineering analysis the present work focuses on the fabrication of polymer matrix composites by using natural fibres and synthetic fibers and calculating its material characteristics (flexural modulus, flexural rigidity, hardness number, percentage gain of water) by conducting tests like flexural test, hardness test, water absorption test, impact test, density test and

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their results are measured on sections of the material and make use of the natural fibre reinforced polymer.

Materials and methods

The hand lay-up process uses a single-sided mold where the fiber reinforcement, such as fiberglass, carbon fiber or Kevlar, in roll-stock form, is manually placed in the mold. The fiber reinforcement is then saturated with a liquid thermoset polymer, most commonly polyester, vinyl ester, or epoxy resins. In the process of saturating the fiber the laminate is manually formed into the shape of the mold surface using specialized laminating tools. The designation of hand lay-up is derived from the method of manually placing the fiber reinforcement on the mold surface. The liquid resin can be applied either manually from a container, or by a spray gun that dispenses the resin and curing agent mixture. Then "roll-out" the laminate to form the materials into the mold contours, tightly consolidate the laminate, and produce the appropriate proportions of resin and fiber reinforcement. Hand lay-up is a simple method for composite production. A mold must be used for hand lay-up parts unless the composite is to be joined directly to another structure. The mold can be as simple as a flat sheet or have infinite curves and edges. For some shapes, molds must be joined in sections so they can be taken apart for part removal after curing. Before lay-up, the mold is prepared with a release agent to insure that the part will not adhere to the mold.

Table.1 Matetial Compositions

S.No	Materials	Quantity (Grams)
1	Isophthalic polyester resin	100
2	Styrene	20
3	Cobalt octoate(accelerator)	1
4	MEKP (catalyst)	1

Reinforcement fibers can be cut and laid in the mold. It is up to the designer to organize the type, amount and direction of the fibers being used. Resin must then be catalyzed and added to the fibers. A brush, roller or squeegee can be used to impregnate the fibers with the resin. shapes, molds must be joined in sections so they can be taken apart for part removal after curing. Before lay-up, the mold is prepared with a release agent to insure that the part will not adhere to the mold. Reinforcement fibers can be cut and laid in the mold. It is up to the designer to organize the type, amount and direction of the fibers being used. Resin must then be catalyzed and added to the fibers. A brush, roller or squeegee can be used to impregnate the fibers The lay-up technician is responsible for controlling the amount of resin and the quality of saturation. Figure.1 shows the fiber reinforce polymer.

Other fabrication processes such as vacuum bagging, vacuum resin transfer molding and compression molding can be used with hand lay-up to improve the quality of the finished part or save time. If a finished cosmetic surface is required the first step in the process is to apply gel coat to the mold surface. The part is then fabricated from the outside to the inside, beginning with the gel coat finish and then progressing through various layers of the structural laminate. Depending on the requirements many layers of laminate can be built-up to produce a specified thickness that meets the structural requirements of the application. Hand lay-up, while one of the most basic composites/fiberglass molding processes(FRP), is widely used to produce a variety of transportation, marine and commercial products.

Fig.1. Fiber reinforced polymers

Results and discussion

In the fiber reinforcement composites fabricated using through synthetic fiber and natural fiber. The flexural test conducted on the composite specimen.

Table.2 Flexural test

	Synthetic Fiber			Natural Fiber		
	S1	S2	S3	S1	S2	-
Cross Section area (mm^2)	78	78	78	78	78	-
Peak load (N)	1485.9	987.9	877.3	92.0	192.8	-
Fluctural Peak load (Mpa)	300.1	199.5	177.1	18.6	38.9	-

Fluctural Modulus (Gpa)	301.6	414.6	380.5	551.3	451.8	-

Table.2 is showed the peak load, fluctural peak load and fluctural modulus of synthetic fiber and natural fiber composites. The peak load is higher in synthetic fiber reinforcement compare with natural fiber. The very low peak load is obtained in the natural fiber. The more fluctural peak load is obtained in the synthetic fiber composite. But the natural fiber is attained high fluctural modulus.

Table.3 Tensile test

	Synthetic Fiber			Natural Fiber		
	S1	S2	S3	S1	S2	-
Cross Section area (mm^2)	150	150	150	150	150	-
Peak load (N)	24671	16829	26946	3323	1903	-
% of Elongation	9.9	7.9	13.3	2	5.3	-
Break load (N)	6889	7675	7676	662	663	-
UTS (N/mm^2)	164	112	115	22.1	12.7	-

The tensile test conducted on the specimen at size of $150mm^2$ cross section area. Peak load, percentage of Elongation, break load and UTS are observed in this test (Table.3). The peak load is very highest in synthetic fiber. The percentage of Elongation, break load and UTS are more than that natural fiber. So the synthetic fiber reinforcement is stronger than natural fiber.

Table.4 Impact test

	Synthetic Fiber			Natural Fiber		
	S1	S2	S3	S1	S2	-
Impact value (J)	6.5	6.4	6.2	0.75	0.7	-

Table.5 Water absorption test

PMC material	Synthetic Fiber	Natural Fiber
Mass (Before test) g	7.531	7.141
Mass (After test) g	7.532	7.150
Percentage gain of water	0.01	0.09

The impact value (Table 4) is higher in synthetic fiber compare with the natural fiber reinforced composite. From the water absorption test a mass of synthetic fiber before and after the test is more. So the density of synthetic fiber is more than natural fiber reinforcement. Percentage gain of water for synthetic fiber is lesser (Table 5).

Conclusion

The various properties of synthetic and natural fibre reinforced polymer composite are obtained and the specimens are made using hand layup method. The mechanical characteristics tests like tensile test, flexural test, water absorption test and impact test are conducted on the FRP, which is made of synthetic fibers are good in strength, high hardness and less water absorption capacity compare with natural fibers. These synthetic reinforced polymer fibers can use aerospace, automobile, boats, because they are better than the commonly used metals on basics of mass in the mean time the FRP. The natural fibers are ecofriendly and the cost of production is lesser compared to the synthetic fibers. As for the use of natural fibres for reinforcement of polymers the density was expected to be lower than that of synthetic fibre reinforced polymer and mechanical properties was expected to be lower than of synthetic fibre reinforced polymer. Also the cost and health hazards will be minimized.

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