

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 12, December 2019

Fabrication of Helmet Shell Using Bamboo and VakkaFiber

Somasundaram A^{1*}, Anish Kumar M^{2#}, Ashok R^{3#}, Bhoopathi D^{4#}

Associate Professor, Department of Mechanical Engineering, Kongu Engineering College, Erode, Tamilnadu, India^{*}

U.G. Student, Department of Mechanical Engineering, Kongu Engineering College, Erode, Tamilnadu, India[#]

ABSTRACT: Hybrid natural composite material are synthesized using combination of two or more natural fibres as reinforcement together with matrix, which have attracted the attention of researchers due to their low density with high specific mechanical strength. The present work attempts to make an improvement in the current existing helmet manufacturing methodology and materials used to have better mechanical properties as well as to enhance the compatibility between fibre and matrix. The hybrid composites are prepared with the epoxy resin matrix and fibres such as Bamboo and Vakka by hand lay-up method with appropriate proportions resulted in helmet shell structure. The fabricated hybrid composite are evaluated for mechanical properties such as tensile strength, hardness and impact strength. The result showed that hybrid composite could be a potential application for helmet with further optimisation of volume fraction natural fibres.

KEYWORDS: Hybrid, Bamboo Fiber, VakkaFiber, Epoxy Resin, Hand lay-up Method, Mechanical Properties.

I. INTRODUCTION

A helmet is a type of protective gear worn on the head to guard against injury. Most helmets are made out of plastic or resin that can be lined with fibers like aramids. Most helmets seek to protect the head of the user by absorbing mechanical energy and defending from penetration. For high-energy impacts, their structure and protective capability are altered. In addition to their ability to absorb heat, size and weight are also important issues because higher volume and weight increase the risk of injury to the head and neck of the individual. At the later part of the 20th century, neurosurgeons invented anatomical helmets adjusted to the internal head structure.

Although fiber-reinforced polymers (FRP) have been largely applied to various engineering fields to, these materials have been used for many technical applications, especially where high strength and hardness are required, but with low component weight. The good specific properties (i.e. weight-related) are due to the low density of the matrix systems employed (unsaturated polyesters, polyurethanes, phenol or epoxy resins) and the embedded fibers which provide high strength and rigidity (bamboo, aramid and carbon fibres). In addition, the fact that composite parts can be tailored specifically during manufacturing by orienting the reinforcing fibers in the directions of the load applied makes great use. Therefore, the compound material itself is a direct result of structural manufacturing and many different technologies have been developed to achieve the property needed. Currently, composite materials based on polymer are used for many life applications, such as automobile, sporting goods, marine, electrical, industrial, building, household appliances, etc. due to their unique properties with high strength and rigidity, light weight, economic and corrosion resistance. The research work on composite materials based on polymer has been focused in the past decade as the need for these materials has been greatly increased in many applications. Recently, natural fibers (such as bamboo, jute, cotton, vakka etc.) have been used to strengthen the mechanical properties of the basic polymer in a polymer-based matrix.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 12, December 2019

II. LITERATURE SURVEY

The use of natural fibers for the reinforcement of the composites has received increasing attention both by the academic sector and the industries. Natural fibers have many significant advantages over synthetic fibers currently, many types of natural fibers have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, wheat, barley, sisal, vakka, coir, bamboo etc.

The mechanical characteristics of epoxy resin reinforced with 30% coconut fiber, 10% glass fiber, 60% epoxy resin were studied by Marimuthu, K.P et al. [1] He discussed about the mechanical properties like micro-hardness, density, tensile strength and of the composites are affected by the addition of coconut fiber. The hardness of the composite increased. There is a negative effect on ultimate tensile strength when coconut fibers got added. The impact strength increased with addition of coconut fiber in Epoxy Glass fiber composite. Kalaprasad, G et al. [2] had done theoretical modeling of tensile properties of Vakka fibre reinforced low density polyethylene composites. The experimentally observed tensile properties (tensile strength and modulus) of short Vakka fibre-reinforced LDPE with different fibre loading have been compared with the existing theories of reinforcement.

The variation of tensile strength of unsaturated polyester based Vakka–bamboo hybrid composites with fibre loading has been studied. The tensile strength of these hybrid composites has been found to be higher than that of the matrix at John, K et al. [3] The variations of impact strength and Tensile strength of unsaturated polyester based Vakka/bamboo hybrid composites with fibre loading have been studied. The impact strength of these hybrid composites has been found to be higher than that of the matrix, the effects of NaOH treatment and trimethoxysilane treatment on the impact and Tensile properties of these Vakka/bamboo hybrid composites have also been observed by John, K et al. [3]

Rao, K.M.M et al. [6] studied the tensile, flexural and dielectric properties of composites made by reinforcing vakka as a new natural fibre into a polyester resin matrix. The fibres extracted by manual processes have been used to fabricate the composites. These composites are tested for tensile, flexural and dielectric properties and compared with those of established composites like bamboo and vakka made under same conditions. The composites are fabricated up to a maximum volume fraction of fiber of 0.37 in the case of tensile testing and 0.39 for flexural and dielectric testing. It has been observed that the tensile properties increase with respect to volume fraction of fiber for vakkafiber composite and are also more than those of sisal and banana composites and comparable to those of bamboo composites. The flexural strength of vakkafiber composite is more than that of banana composite and is closer to sisal fiber composite with respect to the volume fraction of fiber, whereas the flexural modulus is much higher than those of banana and sisal fiber composites and also very much closer to bamboo fiber composites.

Rao, K.M.M et al. [5] studied with an aim of introducing new natural fibres used as fillers in a polymeric matrix enabling production of economical and lightweight composites for load carrying structures. An investigation of the extraction procedures of vakka (*Roystonea regia*), date and bamboo fibres has been undertaken. The cross-sectional shape, the density and tensile properties of these fibres, along with established fibres like Vakka, vakka, natural and vakka, are determined experimentally under similar conditions and compared. The fibres introduced in the present study could be used as an effective reinforcement for making composites, which have an added advantage of being lightweight.

Zhang, K et al. [7] explained the reason for treating fibers in NaOH Solution. The NaOH concentration (6wt.%) treated Bamboo fibers have improved in tensile properties and showed strong bonding with epoxy matrix.

Bharath, B et al. [4] synthesised the bio composite helmet using sisal, coconut, areca and banana fiber using hand lay-up method with appropriate weight proportions and find out its mechanical behaviour (tensile strength, impact strength etc.). The mechanical testing results of fabricated bio composite helmet indicate that, concept of using multiple natural fibers is viable for helmet application. However, there is a scope to optimize the volume fraction of natural fibers as reinforcements to achieve enhanced mechanical properties of helmet. So, it is clearly indicates that reinforcement of natural fibers have good and comparable mechanical properties as conventional composite materials.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 12, December 2019

III. METHODOLOGY

A. Materials Selected

- I. Polymer matrix: Epoxy resin (LY-556) was provided by CovaiSeenu& Company, Coimabatore. It has viscosity of 9-12 Nm/s² and Density of 1.1-1.4 g/cm³ at room temperature. Along with Hardener (HY-951) has viscosity of 0.5-1 Nm/s² and Density of 0.946 g/cm³.
- II. Reinforcement: Extracted Natural fibers such as Bamboo and Vakkafiber are used whose have tensile strength of 150-800 Mpa and 300-530 Mpa respectively.
- III. NaOH Solution: 5% Sodium Hydroxide (NaOH) an alkaline solution used to enhance the surface morphology of natural fibers.

B. Methodology

The materials used for the matrix in the present work are epoxy resin grade (LY-556) and Hardner (HY-951) Natural fibers such as bamboo and vakkafibers were used in the make of hybrid composites as reinforcement. Using 5 % of NaOH and 95 % of distilled water, natural fibers are given chemical treatment to remove moisture content from the fibers, which greatly contributes to their strength. Chemical treatment also increases the fibers' rigidity. In addition, chemical treatment helps to remove all the impurities present in the fiber material and also helps in proper molecular orientation, resulting in better inter-facial bonding between the matrices. The fibers were initially washed in running water before chemical treatment and dried in the absence of sunlight. The dried fibers are then allowed chemical treatment by soaking for 4 hours with the 5% NaOH and 95% of the distilled water solution found in glass beaker. In contrast, fibers that are chemically treated are dried. Two composite samples were produced through the hand lay-up process as shown in Fig.1 with different volume fraction of fiber and epoxy resin. Specification of sample 1 is 10% bamboo fiber, 10% vakkafiber, 80% of epoxy resin and sample 2 is 15% bamboo fiber, 15% vakkafiber, 70% epoxy resin. Then the samples were cut into required dimension as mentioned in ASTM standards for testing (Hardness, Impact and Tensile).

Evaluating the mechanical properties of the fabricated composite samples by various testing like hardness, impact and tensile test to identify the best volume fraction of matrix and reinforcement for fabrication of helmet shell. Fabrication of helmet shell was carried out by adopting the following hand lay-up technique. Initially, the layer of release gel was applied on the outer surface of prepared pattern as shown in Fig.2. Then, epoxy resin was applied sequentially chopped bamboo and vakkafiber was placed in a randomly oriented manner and once again epoxy resin is applied over the layer of fiber for better surface finish. Subsequently, allowed for curing time of about 6-8 hours, then the mould was released. After removing well cured and dried helmet shell from the mould, the extra projections were cut, filed and smoothed with help of sand paper to achieve the desired shape as shown in Fig.3.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 12, December 2019



Fig.1 (a): Applying release gel



Fig.1 (b): Sample preparation



Fig.1 (c): Surface finishing of sample



Fig.2: Prepared pattern



Fig.3: Fabricated Helmet shell

IV. TESTING AND RESULTS

A. Hardness Test

Abrasive wear or erosion and thermal deformation are caused by reduced hardness of the material therefore it is important to identify the sample with greater hardness. The two samples as per in ASTM standard (ASTM D2240) as shown in Fig.4 are subjected to Hardness test using Shore D Micro hardness tester. Each samples was tested at three locations with the specimen being subjected to a load of 0.5 kg for a dwell time of 10 seconds for each location. Table 1 shows the hardness values of two sample specimens with different fiber volume fraction.



Fig.4: Hardness test specimen

Table 1: Hardness test values

Sample I.D	Shore "D"			Average
	Iteration 1	Iteration 2	Iteration 3	
Sample 1	70.2	68.5	66.5	68.4
Sample 2	56.8	61.2	59.7	59.23

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 12, December 2019

B. Impact Test

Izod impact test specimen were prepared in accordance with ASTM D256-97, to measure the impact strength. The specimens are prepared to dimensions of 64 x 12 x 9 mm width. A V-notch is provided having an included angle of 45° at the centre of the specimen and 90° to the sample axis. The depth of the notch is 2mm. the samples were fractured in plastic impact testing machine and the impact strength of the sample specimen have been evaluated. The sample specimens after impact testing is shown in Fig.5. Table 2 shows the impact values of two sample specimen with different fiber volume fraction.



Fig.4: Impact test specimen

Table 2: Impact test value

Sample I.D	Joules
Sample 1	9.2
Sample 2	7.8

C. Tensile Test

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the flat type. During the test a uniaxial load is applied through both the ends of the specimen. Dogbone shaped tensile test specimens were made in accordance with ASTM-D 638M to measure the tensile properties as shown in Fig.5. Typical points of interest when testing a material include: ultimate tensile strength (UTS) or peak stress; offset yield strength (OYS) which represents a point just beyond the onset of permanent deformation; and the rupture (R) or fracture point where the specimen separates into pieces. The tensile test is performed in the universal testing machine (UTM) Instron 1195 and results are analysed to calculate the tensile strength of composite samples. Table 3 shows the tensile value of two sample specimen with different fiber volume fraction.



Fig.5: Tensile test specimen

Table 3: Tensile test value

Sample I.D	Mpa
Sample 1	6.96
Sample 2	7.35

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 12, December 2019

V. CONCLUSION

- ✓ The natural fibers have been successfully reinforced with the epoxy resin by simple wet hand lay-up technique. The aim of this project is to find the tensile, impact strength of natural fibers reinforced hybrid-composites.
- ✓ The fibers like bamboo and vakka were successfully used to fabricate hybrid composites with varying the fiber percentage.
- ✓ The new hybrid composite produced with natural fibers as reinforcements gives good mechanical properties as compared with pure matrix material as shown in Table 4. These hybrid-composite can be used in Aerospace and automobile applications.
- ✓ Concept of using hybrid natural fibers is viable for helmet application as shown in Fig 6. However, there is a scope to optimize the volume fraction of natural fibers as reinforcements to achieve enhanced mechanical properties of helmet. So, clearly indicates that reinforcement of hybrid natural fibers have good and comparable mechanical properties as conventional composite materials.

Table 4: Result comparison of ABS and Fabricated composite

Material	Weight (g)	Tensile Strength (MPa)	Impact Strength (J)	Hardness (Shore D scale)
ABS	460	8.78	8.4	63.7
Sample 1 Hybrid Fiber Composite	420	6.96	9.2	68.4



Fig.6: Fabricated helmet shell

REFERENCES

- [1] Marimuthu, K.P., Kumar, S.M., Kumar, V.R. and Govindaraju, H.K., 2019. Characterization of Mechanical Properties of Epoxy Reinforced with Glass Fiber and Coconut Fiber. *Materials Today: Proceedings*, 16, pp.661-667.
- [2] Kalaprasad, G., Joseph, K., Thomas, S. and Pavithran, C., 1997. Theoretical modelling of tensile properties of short sisal fibre-reinforced low-density polyethylene composites. *Journal of Materials Science*, 32(16), pp.4261-4267.
- [3] John, K. and Naidu, S.V., 2004. Tensile properties of unsaturated polyester-based sisal fiber-glass fiber hybrid composites. *Journal of Reinforced Plastics and Composites*, 23(17), pp.1815-1819.
- [4] Bharath, B., Kumar, G.C., Shivanna, G., Hussain, S.S., Chandrashekar, B., Raj, B.S., Kumar, S.A. and Girisha, C., 2018. Fabrication and Mechanical Characterization of Bio-Composite Helmet. *Materials Today: Proceedings*, 5(1), pp.2716-2720.
- [5] Rao, K.M.M., Rao, K.M. and Prasad, A.R., 2010. Fabrication and testing of natural fibre composites: Vakka, sisal, bamboo and banana. *Materials & Design*, 31(1), pp.508-513.
- [6] Rao, K.M.M. and Rao, K.M., 2007. Extraction and tensile properties of natural fibers: Vakka, date and bamboo. *Composite structures*, 77(3), pp.288-295.
- [7] Zhang, K., Wang, F., Liang, W., Wang, Z., Duan, Z. and Yang, B., 2018. Thermal and mechanical properties of bamboo fiber reinforced epoxy composites. *Polymers*, 10(6), p.608.
- [8] Sinha, A.K., Narang, H.K. and Bhattacharya, S., 2017. Mechanical properties of natural fibre polymer composites. *Journal of Polymer Engineering*, 37(9), pp.879-895.
- [9] Karmarkar, A., Chauhan, S.S., Modak, J.M. and Chanda, M., 2007. Mechanical properties of wood-fiber reinforced polypropylene composites: Effect of a novel compatibilizer with isocyanate functional group. *Composites Part A: Applied Science and Manufacturing*, 38(2), pp.227-233.
- [10] Zuhudi, N.Z.M., Jayaraman, K., Lin, R.J.T. and Nur, N.M., 2018, May. Impact Resistance of Bamboo Fabric Reinforced Polypropylene Composites and Their Hybrids. In *IOP Conference Series: Materials Science and Engineering* (Vol. 370, No. 1, p. 012047). IOP Publishing.