STATE-OF-THE-ART LIGHT WEIGHT BIOCOMPOSITE HELMETS FOR CHILDREN

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ABSTRACT

Children start crawling normally at the age of 7-8 months and they learn walking stably by 2-3 years. However during this course of time many times they fall down and get head injuries. For the parents it is serious matter of concern and worries. Many varieties of head covers or helmets for children have been developed and sold commercially. However they are costly, heavy and cause irritation and head itch. Therefore in the present work an attempt is made to design and develop a novel light weight biocomposite helmets for children. Simple hand-layup moulding technique is used for the composite fabrication. Natural coir fiber and synthetic fevicol adhesive are used as reinforcement and matrix phase materials respectively. Initially the tensile and impact strength of the coir fiber biocomposite laminate is determined and then a helmet is fabricated to protect the head of the children from injuries as a product of biocomposite.

Keywords— Children; head injury; helmet; biocomposites.

INTRODUCTION

Head is a very important part of the human body. Head injuries in children are common and are very serious case of concern. Therefore the covers or helmets to protect the children from head injuries are very essential. However these helmets have to be very light in weight, soft, well ventilated and irritation free, so that a child can wear for long time comfortably. Composite materials are used for the fabrication of helmets. Composites are the advance materials which have higher strength to weight ratio. Basically composite is the combination of reinforcement and matrix phase materials. Reinforcement phase decides the strength of the composites whereas matrix phase binds all the fibers of the reinforcement phase fibers or particles [1]. Mostly synthetic fibers and resins are used for composite fabrication. Helmets made from synthetic composites leads to head itch and skin irritations. However, recently various researchers have used bio-fibers such as coconut (coir), sisal, jute [2], banana [3], pineapple leaf [4] etc for the composites fabrication. Advantages of natural fibers over traditional reinforcing glass and carbon fibers are: low cost, low density, high toughness, acceptable specific strength properties, ease of separation, and biodegradability [5]. Among the natural fibers, the coir fiber has remarkable application in the automotive industry owing to its hard-wearing quality and high hardness (not fragile like glass fiber), good acoustic resistance, moth-proof, not toxic, resistant to microbial and fungi degradation, and not easily combustible [6]. The coir fibers are also more resistant to moisture than other natural fibers and withstand heat and salt water. Therefore European car manufacturers and suppliers have used coir fiber reinforced polymer composites for door panels, seat backs, headliners, package trays, dashboards, and interior parts to reduce the weight and cost of the cars [5]. Coir fiber reinforced polypropylene composite panels were used for automotive interior applications [6]. Coir fibers were also user for the fabrication of sound-absorbing and thermal-insulating nonwoven composite board [7]. Further the biocomposites made form bio-fibers and resin systems are very adequate to the human body. Therefore in the present work biocomosite is used to fabricate helmets for the children. Coir fiber with synthetic fevicol adhesive is used for the composite fabrication.

BIOCOMPOSITE FABRICATION

In the present work biocomposite panels are fabricated by hand-layup room temperature natural curing technique illustrated in Fig. 1. The coir fibers natural cloth obtained from the coconut tree is dried in sun bath to reduce the moisture content. Then the cloth is cut to the required dimensions such that the longer fibers oriented along the length of the strip and short fine fibers oriented perpendicular to the length of the strip. Cloth thickness varies from about 0.5 to 1.5 mm. Cut strips are dipped in fevicol SH synthetic adhesive bath and stacked one over the other to get the required thickness. Excess amount of adhesive is squeezed out with a roller. Adhesive tape is used to avoid edges delamination before curing. The laminate is kept for curing at room temperature for 12 hrs. Fig. 2 shows the fabricated coir fiber biocomposite panel specimens. Each specimen is 10 mm thick, 200 mm in length and 40 mm in width. These specimens are now subjected to tensile test to determine the mechanical strength properties. The average density of the panels is 580 kg/m^3.

TESTING

A. Tensile Test

The tensile tests are conducted on the specimens to determine the tensile strength and modulus of elasticity. The samples are tested on Universal Testing Machine (UTM) with a load capacity of 10 tones as shown in Fig. 3. Load is applied gradually until the specimen fails and the corresponding load for every 0.5 mm deformation is recorded. Stress-strain curve is plotted as shown in Fig. 4. Slope of the curve gives the value of elastic modulus. Average tensile strength of the composite strips is 11.05 N/mm^2. Average modulus of elasticity of the coir composite is found to be 1498 (N/mm^2).

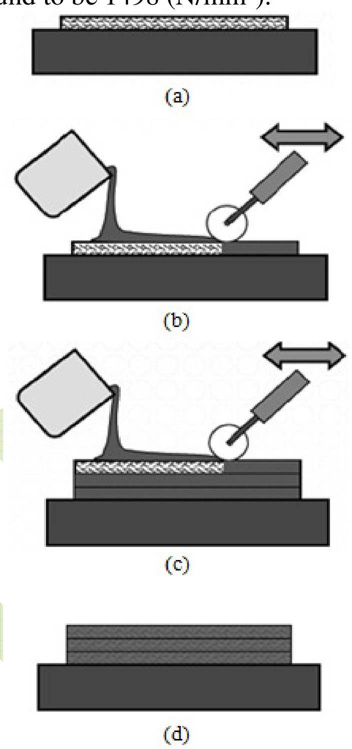

Fig. 1 *Hand Lay-up process of composite fabrication (a) Reinforcement lay-up (b) Wetting by matrix (c) Repeated lay-up of reinforcement layers (d) Matrix curing*

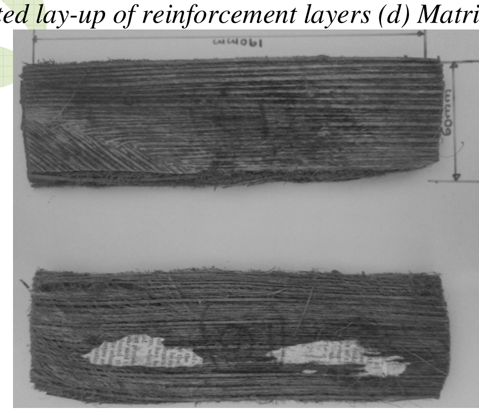

Fig. 2 *Biocomposite specimens for tensile test*

Fig. 3 Biocomposite specimen tested on UTM

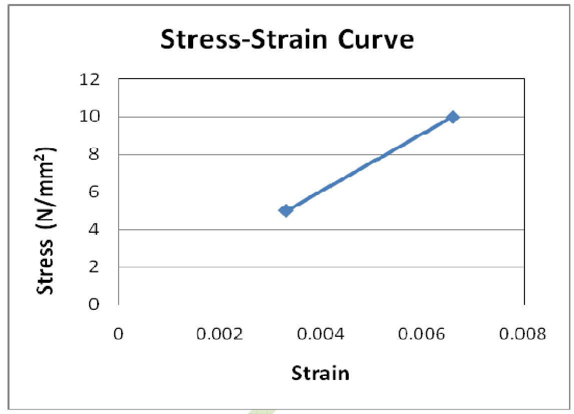

Fig. 4 *Stress-strain curve to determine elastic modulus*

Sample	Applied load	Tensile strength	Elastic Modulus
1	4320	10.8	1473
2	4520	11.3	1523

Table 1 *Tensile strength properties of coir fiber reinforced biocomposites panel*

B. *Impact Test*

Two coir composite samples with V- notch are prepared for the test as shown in Fig. 5. Thickness of the specimen below the notch is 10 mm and effective width is 15 mm. Impact test is conducted on Charpy impact testing machine to cut the specimen across the fiber orientation as shown in Fig. 6. Energy absorbed by the specimen is noted and the impact strength is calculated using the relation given by Eq. (1) and tabulated in Table 2. Average impact strength is found to be 0.0385 J/mm^2.

$$\text{Impact strength} = \frac{\text{Energy absorber}}{\text{Area below notch}} \qquad (1)$$

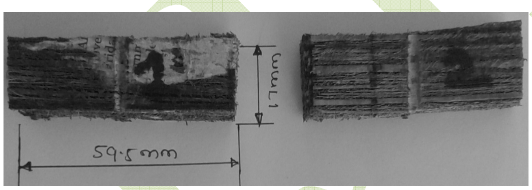

Fig. 5 *Biocomposite specimens for impact test*

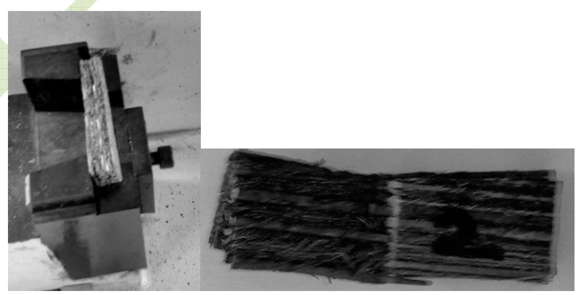

Fig. 6 *Charpy impact test of Biocomposite*

Table 2 *Impact strength of coir fiber reinforced biocomposite panel*

Sample	Energy absorbed (J)	Impact strength (J/mm^2)
1	5.6	0.037
2	6.1	0.040

FABRICATION OF HELMET

Coir fiber biocomposites were used for various applications to take the advantages of light weight, high strength and low cost as discussed in the introduction section. However in the present work coir fiber fevicol adhesive biocomposite is used for the fabrication of a state-of-the-art light weight helmet for child. This is a very unique and specific application. This kind of helmet is to be very light in weight, adequate to body skin, comfortable for long time wearing and should protect the child from head injuries. A metallic container is made as a mould and coir fiber cloth strips wetted with fevicol adhesive are placed one over the other to cover the circular area of the mould and to get uniform thickness of about 6 mm. After the hand-layup it is kept for room temperature curing. Cured helmet is removed from the mould and it is cut to the required shape and painted to get the finished product. Fig. 7 shows the fabricated helmet. Weight of the helmet is 152 grams.

Fig. 7 *Coir Fiber Biocomposite Helmet for Child*

CONCLUSION

In the present work coir fiber biocomposite is fabricated and tested. Its tensile strength, modulus of elasticity and impact strength are determined. Tensile strength is found to be 11.05 N/mm^2, modulus of elasticity is 1498 N/mm^2 and impact strength is 0.0385 J/mm^2. Further a state-of-the-art novel helmet for protecting the head of kids from injuries is fabricated as a product of biocomposite.

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