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Impact Strength Prediction of Natural Fiber Reinforced Polyester Composites

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ABSTRACT

A composite material occupies amajor part of modern era due to its light weight, good specific strength. Natural fibers are the other alternative to synthetic fibers due to its distinct characteristics like low cost, biodegradability, good strength etc. In thepresent study, an attempt is made to prepare two different composite materials using cotton and bamboo fibersas reinforcement and polyester resin as the matrix material respectively. Composites were fabricated by increasing the weight fraction of fibers in the range of 20%, 25%, 30% and 35% for cotton/polyester composite and 30% and 35% for bamboo/polyester composite respectively. Impact testing of the material was carried asper ASTM D256 standard on an IZOD Impact Tester. The testing samples were prepared to measure the behavior of material along the longitudinal and transverse position of the fiber.The paper signifies outcome as: impact strength of composites gradually increases with increase in the weight fraction of the fiber. The impact strength of the composite material increases forboth longitudinal placed fiber reinforced composites andtransverse placed fiber reinforced composites.Transverse placed fiber reinforced composite has more impact strength compared to longitudinal placed fiber reinforced composites.

Keywords

Natural Fiber Composites,Fabrication, Impact testing, Longitudinal and Transverse impact strength.

INTRODUCTION

The main advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. A composite material is made by combining two or more materials often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite, you can easily tell the different materials apart as they do not dissolve or blend into each other.

Over the last year’s composite materials, plastics, and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have been grown steadily, penetrating and conqueringnew markets relentlessly. Now a day, natural fibers are used over synthetic fibers because of fully or partially biodegradability as well as low cost with good strength. New environmental rules and legislation are forcing industries to find new environment-friendly material. So, natural fibers composite is one of the good ways to overcome this problem.

Natural Fiber type is commonly categorized based on its origin: plant, animal or mineral. All plant fibers contain cellulose as their major structural component, whereas animal fibers mainly consist of protein. Although mineral-based natural fibers exist within the asbestos group of minerals and were once used extensively in composites, these are now avoided due to associated health issues (carcinogenic through inhalation/ingestion) and are banned in many countries. Generally, much higher strengths and stiffness are obtainable with the higher performance plant fibers than the readily available animal fibers [1]. The biodegradability of the natural plant fibers may present a healthy ecosystem while the low costs and good performance of these fibers are able to fulfill the economic interest of theindustry. But still the mechanical strength of natural fibers reinforced polymer composite (NFRPCs) could not match that of SFRPCs and the natural fibers would not replace synthetic fibers in all applications.The ongoing research in Natural fiber reinforced polymer composites has resulted in thereplacement of Synthetic fiber reinforced polymer composites in many automotive, constructional and household applications. Natural fibers are cheap, lighter in weight, biodegradable and are easily available as compared to Synthetic fibers. Chemical modification of natural fibers is necessary for increased adhesion between the hydrophilicfibers and hydrophobic matrix. Mechanical properties of natural fibers are much lower than those of glass fibers but their specific properties, especially stiffness, is comparable to the glass fibers [2]. Bamboo belongs to the grass family Bambusoideae, which consists of cellulose fiber embedded in a lignin matrix. Bamboo has several advantages over other plant fibers such as its low density, low cost, high mechanical strength, stiffness, high growth rate and its ability to fix atmospheric carbon dioxide. Bamboo has traditionally been used in construction and as a material for the manufacture of tools for daily living due to its high strength to weight ratio [3]. Approximately 45,000 tons of domestic cotton fibers were used in the German automotive industry for interior applications, which results in 79,000 tons of composite parts and about 8 kg of cotton-fiber composites in a German car. Reclaimed cotton is mainly used as low-cost fiber in composites used as interior parts for automotive devices [4].The application of natural fibers such as bamboo, jute, banana, coir, linen and the like in Fiber Reinforced Polymeric (FRP) composites have become so vital due to their high effective stiffness and strength, availability, low cost, specific strength, better dimensional stability and mechanical properties, eco-friendly and biodegradable as compared to synthetic fibers [5].

NFCs have growing interest in engineering, building and furniture applications that require impact resistance. Hence, a comparison of available impact test methods can help in choosing single or combination of correct test methods to obtain reliable and accurate impact properties. Izod and Charpy impact tests are easy and fast methods that allow to generating large amounts of datawere studied by NamasivayamNavaranjan, Thomas Neitzert [6]. Impact resistance is the ability of a material to resist breaking under a shock loading or the ability to resist the fracture under stress applied at high speed. Impact behavior is one of the most widely specified mechanical properties of the engineering materials. It is also worth noticing that the Impact strength of natural fibers composites like areca fiber composites increases with increase in volume fraction of fiber in the composite was studied by C.V. Srinivasa, K.N. Bharath [7].There is a significant increase in energy absorbed in Izod impact tests with the incorporation of natural fibers like buried fibers in a polyester matrix composite was studied by Sergio Neves Monteiro, FredericoMuylaertMargem, Michel Picanço Oliveira, Giulio Rodrigues Altoé. [8]. The material is cut into specimens with dimensions 63.5mm x 12.7mm x 6mm and a notch was made at the center of the specimen at 45 degrees angle for impact testing as per ASTMD 256 specifications. The impact strength of the specimen is determined using IZOD impact tester. The impact strengths of the natural fibers composite like Rose Madder and Burmese Silk Orchid composites show that as the fiber weight increases within a composite those composites have better impact strengths. Care should be taken to avoid theformation of cavities within the composite while performing hand lay-up technique was studied by K M D Mazharuddin, B Madhusudhan Reddy, H. Raghavendra Rao [9].The variation of impact strength of the untreated coir polyester composite materials with their fiber volume fractions. Fiber volume fraction of both treated and untreated coir polyester composites increases, impact strength also increases was studied by Easwara Prasad G L, Keerthi Gowda B S, Velmurugan R. [10].Mechanical properties of banana, sisal, coconut, hemp and E-glass fiber reinforced laminates were evaluated to assess the possibility of using it as new material in engineering applications. Mechanical propertieslike tensile, bending and impact strength of composites were improved by the modification of fibers was studied by Olusegun David Samuel et al. (2012) [11]. Specific impact energy of natural fibercomposites like jute and banana is sufficient to partly replacing currently used glass fibers composite reinforcement was studied by P. B. Lokareet al. (2016) [12].In most cases, the specificproperties of the natural fibers composites like impact strength and tensile strength were found to compare favorably with those of glass was studied by Paul Wambua et al.(2003) [13].

MATERIALS AND METHODS

The properties of acomposite material depend on the properties of theindividual material: fiber and matrix used for making acomposite material. In present work, the fabrication of composite is carried out on natural fiber composites by using cotton and bamboo fibers. The fibers are main load carrying member in composites. Polymer generally act as good blinder for fibers as observed from several references. Their load transfer capability and lower cost have prompted the selection of polymers as abinder for the fibers. The matrix material used for the investigation is commercially available. In present work, the general purpose unsaturated polyester resin is selected because of this availability, low cost, low weight, low viscosity and have good mechanical, electrical and chemical resistance properties.The polyester resin can offer at a reasonable cost and should provide a network structure with reasonable physical properties in reasonable time. To accelerate the curing process at a room temperature, MEKP (Methyl Ethyl Ketone Peroxide) as catalyst and cobalt are used with polyester resin which initiates the polymerization process of polyester resin used in thecomposite material.The amount of fiber and resin are used while fabricating the composite material which is based on weight fraction calculation. In this work, weight fraction is taken as 20%, 25%, 30%, 35% for cotton fiber and 30%, 35% for bamboo fiber with polyester resin during fabrication of composites. The fabrication of composite was carried out by using hand lay-up technique. The die and punch setup is shown in figure 1. The fiber layers are arranged unidirectionally to achieve a good strength in a single direction in thedie. Then, the resin is poured into the die. The die and punch setup is pressed by anvils as shown in figure 2. The pressure is applied on the die to maintain the thickness of the plate as 4 mm as per the ASTM D256 standard. The curing or resin was carried out for 24 hours.

Fig 1: (a)

Fig 1: (b)

Fig 1: punch and die setup

Fig 2: Anvil setup

Fig 3: Cotton fiber polyestercomposite plate with 20%cotton fibers

Fig 4: Cotton fiber polyestercomposite plate with 25%cotton fibers

Fig 5: Cotton fiber polyestercomposite plate with 30%cotton fibers

Fig 6: Cotton fiber polyestercomposite plate with 35%cotton fibers

Fig 7: Bamboo fiber polyestercomposite plate with 30%

bamboo fibers

Fig 8: Bamboo fiber polyestercomposite plate with 35%

bamboo fibers

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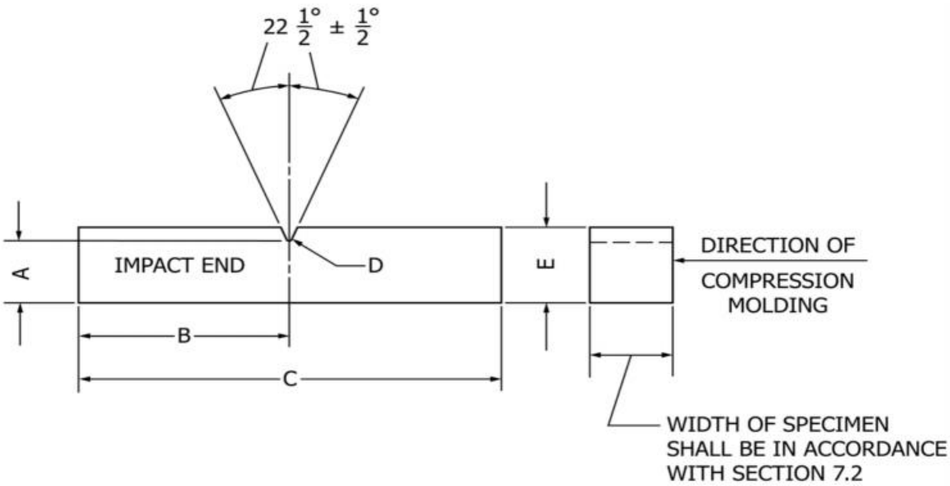
IMPACT TEST

The toughness of natural fiber polyester composites is measured by IZOD impact tester as shown in figure9. Specimen cuts in dimension as per the ASTM D256in size of 63.5mm x 12.7mm x 6mm on vertical milling machine as shown in figure 10. The IZOD Impact tester consists of a pendulum of known mass and length that is dropped from a known height to impact a notched specimen of the composite material. The samples were prepared for longitudinal placed fiber and transverse placed fiber. The cutting of samples was carried out by using CNC vertical machining centers. In longitudinally placed fiber specimen preparation, the cutting was carried out as fibers were arranged perpendicular to theline of direction of v notch as per the figure 10. In transversally placed fiber specimen preparation, the cutting was carried out as fibers are arranged parallel to theline of direction of v notch as per the figure 10.

Fig 9: Impact Tester



	Mm	in.
A	10.16 ± 0.05	0.400 ± 0.002
B	31.8 ± 1.0	1.25 ± 0.04
C	63.5 ± 2.0	2.50 ± 0.08
D	0.25R ± 0.05	0.010R ± 0.002
E	12.70 ± 0.20	0.500 ± 0.008

Fig 10: Dimensions of IZOD Impact Test Specimen

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RESULT AND DISCUSSION

Impact testing of thedifferent volume fraction of cotton and bamboo fibers polyester composite materials (20%, 25%, 30%, 35% of cotton fiber polyester composite materials and 30%, 35% of bamboo polyester composite materials) carried out on IZOD impact tester. For testing, two samples each volume fraction fibers reinforcement polyester composite were carried out for two different positions of fibers in composite material i.e. Longitudinal and Transverse. Specimens before and after testing are shown in figure 11and figure 12. The result shows that as theweight fraction of fibers increases in composite increases the impact strength of thecomposite material as shown in table 1 and table 2 stands for longitudinal and transverse cotton fibers composite materials respectively and table 3 and table 4 stands for longitudinal and transverse bamboo fibers composite materials respectively. AS well as these all results are shown in graphs form in figures from13 to 16. Figure 17 and Figure18 shows the graph of acomparison of longitudinal and transverse cotton fibers composite material and comparison of longitudinal and transverse bamboo fibers composite material respectively, which show that transverse fibers composite material have more strength than longitudinally positioned fibers composite material. Maximum impact strength for both longitudinal as well transverse cotton fibers polyester composite are 1.5615and 11.995 respectively for 35% of cotton fibers. Same for bamboo maximum impact strength for both longitudinal as well transverse positioned fibers polyester composite material are 1.371 and 9.2415 respectively for 35% of bamboo fibers.

Fig 11: Specimens before testing

Fig 12: Specimens after testing

Table 1. Impact strength oflongitudinal cotton fibers polyester composite material

Sr. no.	Weight of Fibers in Composite Material	Joule	Avg.
1a.	20% cotton(Longitudinal Fibers)	1.317	1.265
1b.	20% cotton(Longitudinal Fibers)	1.213	
2a.	25% cotton(Longitudinal Fibers)	1.319	1.3125
2b.	25% cotton(Longitudinal Fibers)	1.306	
3a.	30% cotton(Longitudinal Fibers)	1.540	1.5125
3b.	30% cotton(Longitudinal Fibers)	1.485	
4a.	35% cotton(Longitudinal Fibers)	1.600	1.5615
4b.	35% cotton(Longitudinal Fibers)	1.523	

Table 2. Impact strength of transverse cotton fibers polyester composite material

Sr. no.	Weight of Fibers in Composite Material	Joule	Avg.
1a.	20% cotton(Transverse Fibers)	8.486	8.345
1b.	20% cotton(Transverse Fibers)	8.204	
2a.	25% cotton(Transverse Fibers)	8.498	8.666
2b.	25% cotton(Transverse Fibers)	8.834	
3a.	30% cotton(Transverse Fibers)	8.884	8.692
3b.	30% cotton(Transverse Fibers)	8.500	
4a.	35% cotton(Transverse Fibers)	12.630	11.995
4b.	35% cotton(Transverse Fibers)	11.360	

Table 3. Impact strength of longitudinal bamboo fibers polyester composite material

Sr. no.	Weight of Fibers in Composite Material	Joule	Avg.
1a.	30%bamboo(Longitudinal Fibers)	1.016	1.0645
1b.	30% bamboo(Longitudinal Fibers)	1.113	
2a.	35% bamboo(Longitudinal Fibers)	1.317	1.371
2b.	35% bamboo(Longitudinal Fibers)	1.425	

Table 4. Impact strength of transverse bamboo fibers polyester composite material

Sr. no.	Weight of Fibers in Composite Material	Joule	Avg.
1a.	30% bamboo(Transverse Fibers)	8.884	9.0485
1b.	30% bamboo(Transverse Fibers)	9.213	
2a.	35% bamboo(Transverse Fibers)	9.362	9.2415
2b.	35% bamboo(Transverse Fibers)	9.121	

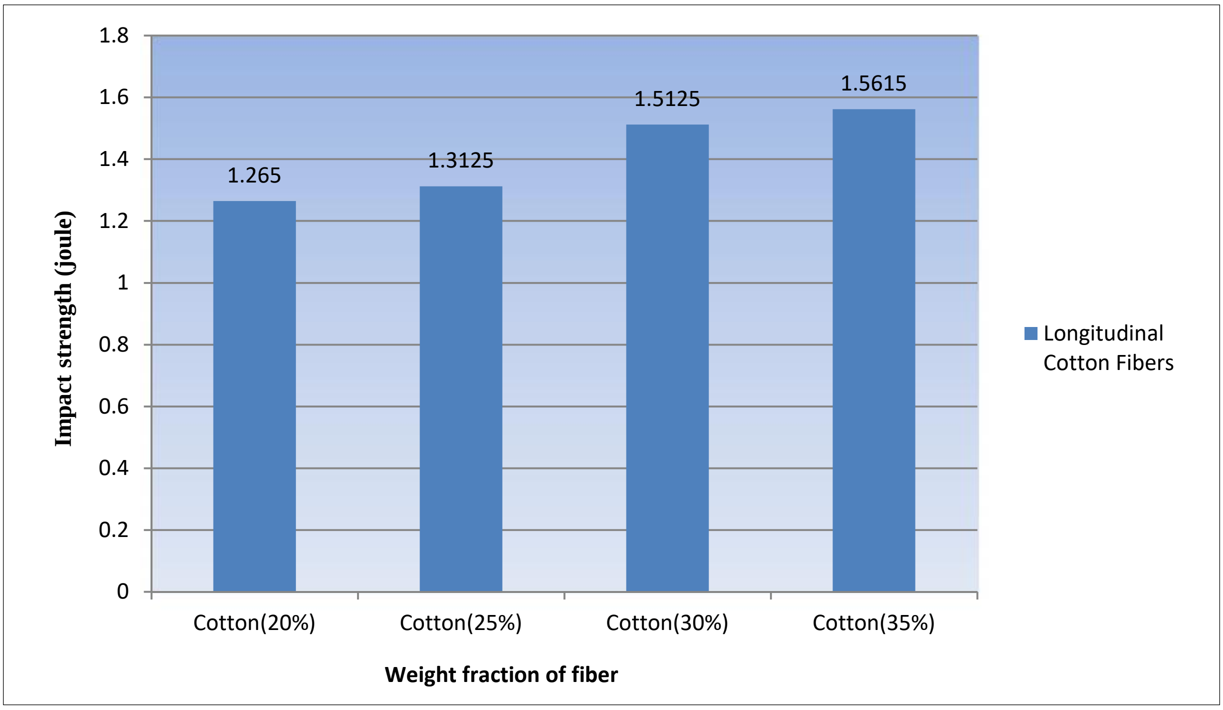

Figure 13: Impact strength of longitudinal cotton fibers polyester composite material

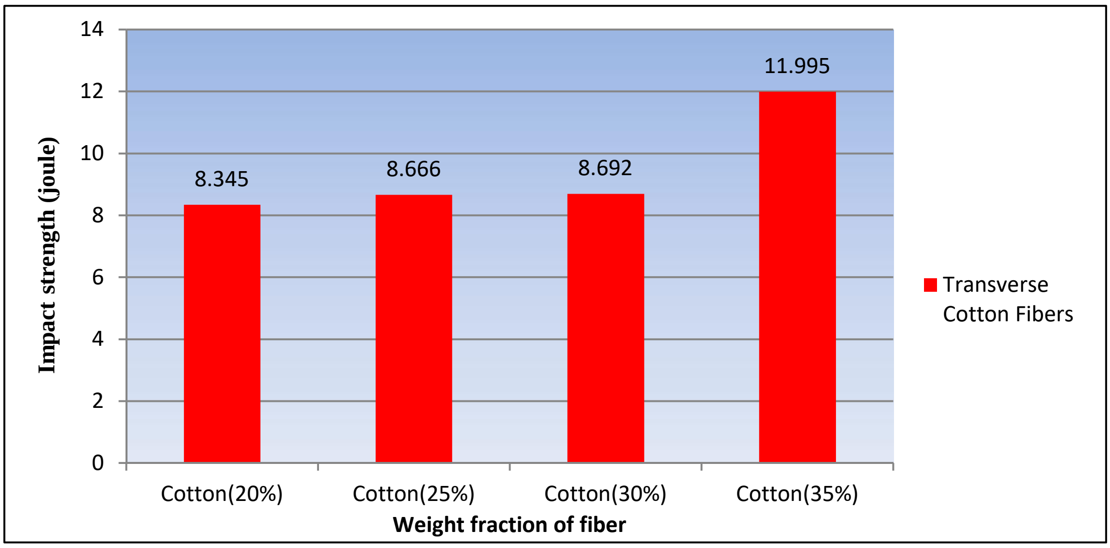

Figure 14:Impact strength of transverse cotton fibers polyester composite material

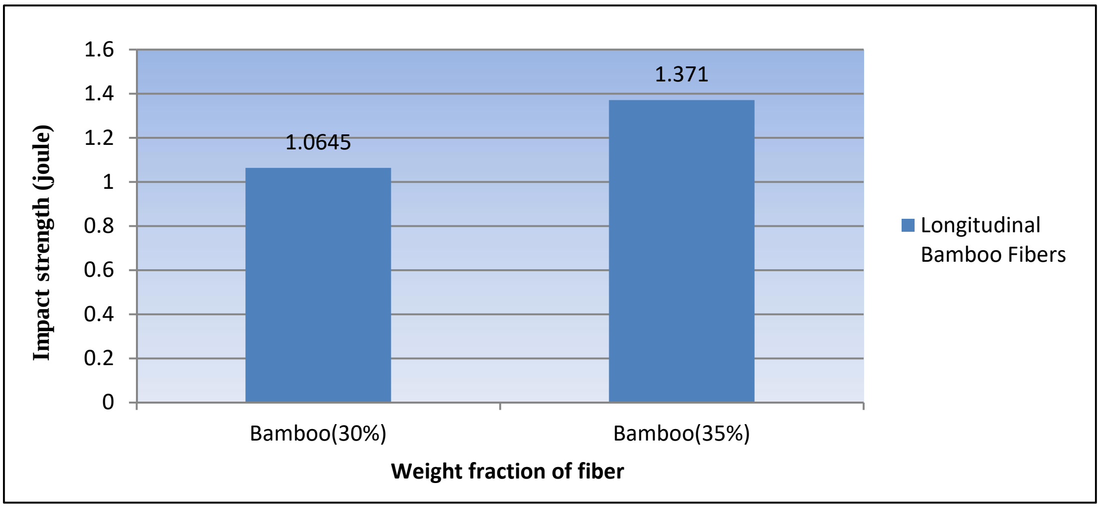

Figure 15:Impact strength of longitudinal bamboo fibers polyester composite material

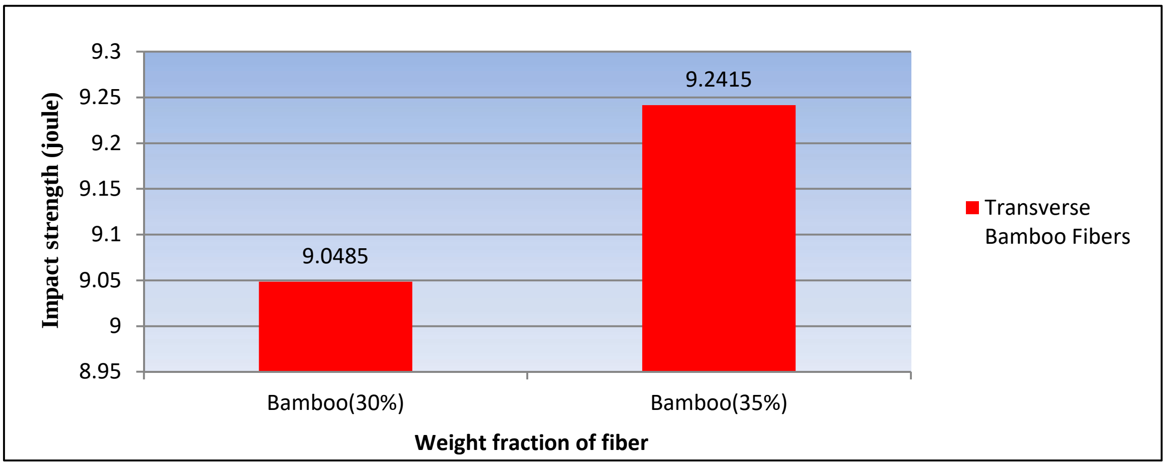

Figure 16:Impact strength of transverse bamboo fibers polyester composite material

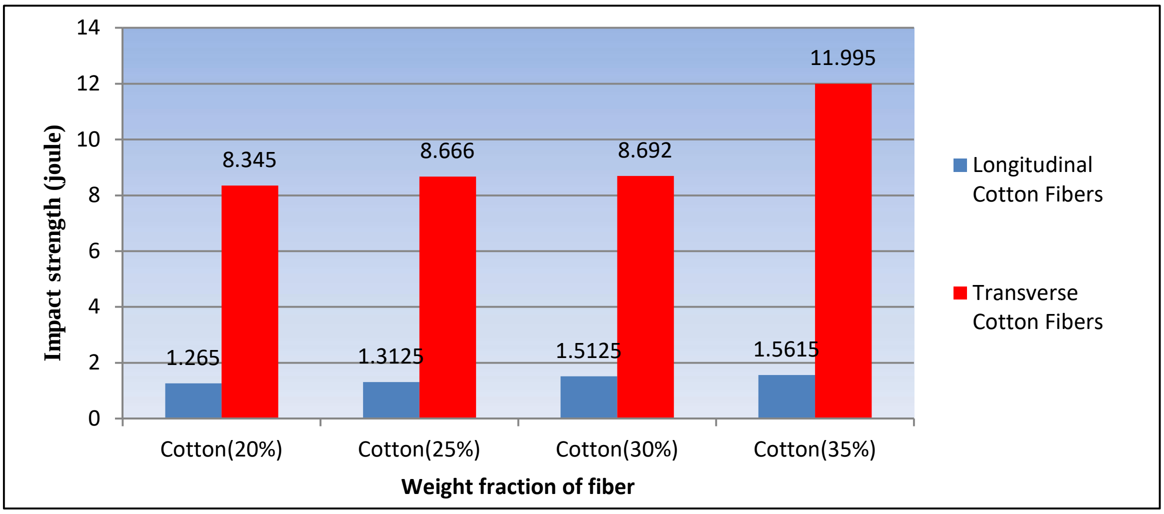

Figure 17: Comparison of impact strength forlongitudinal cotton fibers and transverse cotton fibers polyester composite material

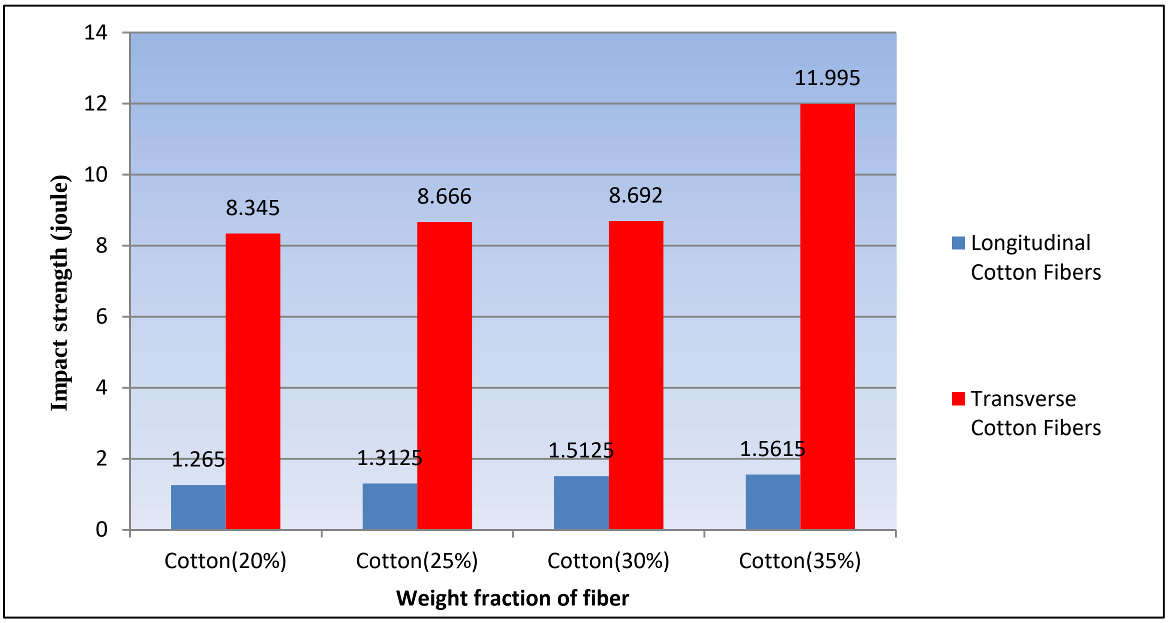

Figure 18:Comparison of impact strength forlongitudinal bamboo fibers and transverse bamboo fibers polyester composite material

CONCLUSION

The following significance outcomeswere found from the present study.

1. The impact strength of thecompositegradually increases with increase in the weight fraction of the fiber.
2. The impact strength of the composite material increases for both longitudinal placed fiber reinforced composites and transverse placed fiber reinforced composites.
3. Transverse placed fiber reinforced composite has more impact strength compared to longitudinal placed fiber reinforced composites.

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