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Influence of Water Absorption, Impact and Damping on CURAUA/Glass Fibers Polyester Composites

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Abstract

Curaua fiber is one of the strongest natural fibers rich in cellulosic content and is being currently considered as reinforcement for any polymer based matrix composites. The current work investigates the dynamic and mechanical properties of polymer matrix composites reinforced with continuous curaua fiber and E glass fiber. The fabricated polymer matrix composites by hand layup technique will be tested for water absorption, Izod, Charpy, damping test and SEM analysis.

Keywords*: Curaua fiber, glass fiber, polyester, hand layup technique, Izod, damping test .*

1. INTRODUCTION

Curaua fiber extracted from the leaves of pineapple much grown in the region of Amazon. Importance of these composites in the field of engineering is that when combines with other natural fibers gives some superior properties different from other [1]. These curaua fibers got some superior strength compared to other fibers. Since these curaua fibers got high impact resistance gained wide application in the field of automobiles [2]. Vegetable fibers got some advantageous properties such as low density, low toxicity and low cost compared to synthetic fibers. Furthermost natural fibers like coir are cellulosic in nature but crystalinity index for coir fiber is 53% and for that of curaua fiber is 81% [7]. The increase in crystalinity index makes the bonding between fibers and resin stronger. Curaua fiber exhibit some increasing mechanical properties when combines with glass fiber, explained in this present work.

2. MATERIALS AND METHODS

2.1 Polyester

High grade polyester of density 1.09g/cm^3, heat distortion temperature 85^{0}C,viscosity 250 micro centi poise, modulus of elasticity 3.3 Gpa, was supplied by Zenith industries (Bangalore, India).Received polyester is mixed with methyl ethyl ketone catalyst and hardener and used for the fabrication of PMC.

Figure1.1: Polyester resin

2.2Curaua fibers

Curaua fiber of density 1.3g/cm^3,lignin content 19%,and cellulose content 64%, was supplied by chalapathy fiber dealer(Andhra Pradesh, India). The longer length fiber is chopped to required length with the help of knife rotary mill. These dimensions of the curaua fibers are similar to that observed in any other lignocellulosic fiber [3] with heterogeneity and significant dispersion in values Fromthese, average values for length (L) and diameter (d) were found as 846 mm and 0.07 mm, respectively, with this lengthbeing more than 15 times its critical length of 10.2 mm[4].The received curaua fibers were cleaned with water and dried in an oven at 60 °C for 24 hours.

Figure1. 2:Curaua fiber

2.3 Glass fiber

Glass fiber of density 2.5g/cm^3, tensile modulus 72.45 Gpa,tensile strength 1380Mpa was supplied by zenith industries (Bangalore, India).

Figure 1. 3. Glass fiber

2.4 Methods

PMC's were developed for 94% polyester + 3% curaua + 3% glass fiber(hybrid) and 96% polyester + 4% curaua fibers(base)combinations using hand layup technique. Composites were molded by mixing long aligned continuous curaua fiber with mixture of resin, hardener, and catalyst. To ensure that the desired amount of curaua fibers were placed throughout the length and width of the mold, additional amount of polyester resin mixed with the catalyst and hardener was added with the fibers. A pressure is applied on the mold during the curing time of 24 hours to facilitate the impregnation of resin through the fibers. After curing, the laminateswere prepared in the direction of fibers aligned.

3. EXPERIMENTS AND RESULTS

3.1 Water absorption test

Water absorption test determines the relative amount of water absorbed when immersed in distilled water. Specimens of dimension 25*25*3mm were fabricated and conditioned before immersing in distilled water. The glass fiber based composites reaches saturation much faster than curaua fiber based composites [5].Conditioned specimens were immersed in container containing distilled water for 24 hour. Weigh the specimens to determine its water absorbing percentage with the help of below equation.1.1. And reconditioned of the specimen is done to determine its soluble percentage and it is calculated with the help of equation.1.2.

$$\text{Soluble matter lost, \%} = \frac{\text{conditioned weight} - \text{reconditioned weight}}{\text{conditioned weight}} \times 100 \qquad 1.1$$

$$\text{Increase in Weight, \%} = \frac{\text{wet weight} - \text{conditioned weight}}{\text{conditioned}} \times 100 \qquad 1.2$$

Table 1.1 Water absorption chart for composites

Composition	Conditioned Weight [gm]	Wet Weight [gm]	Re-conditioned Weight [gm]	Increase in Weight [%]
96% polyester + 4% curaua.	3.28	3.30	3.28	.6097
94% polyester + 3% curaua + 3% glass	3.90	3.91	3.90	.2564

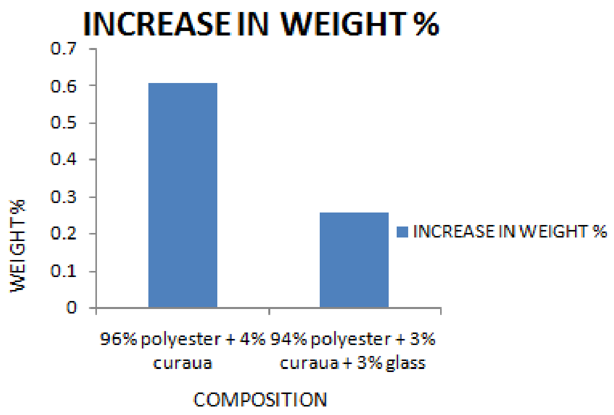

Figure 1.4: Comparison graph for water absorption test

From the water absorption test it can be concluded that the water absorbing percentage of composite with 94% polyester+3% curaua+3% glass has reduced by 18.44% compared to 96% polyester + 4% curaua hence hybridization was effective in reducing water absorbing percentage.

3.2 Impact tests

The Izod and Charpy test is done in an impact setup as per ASTMD256 standard (sample dimension is 63×12.7×10 mm). Initially the specimen must be loaded in the testing machine and a low velocity impact testing process is carried out with a pendulum type impact tester until the specimen breaks.Composites having curaua fiber percentage above 10% results in incomplete rupture of a specimen owing to bend flexibility [6]. The net amount of energy lost during impact tests is equal to the net amount of energy absorbed by the specimen during impact tests. Toughness increase was mainly attributed to the low interface shear stress between a hydrophilic lignocellulosic fiber and a hydrophobic polymeric matrix [8]. The energy absorbed for base and hybrid specimens for Izod and Charpy tests are tabulated in the table 1.2 and table 1. 3 below.

Table 1. 2 Izod chart for composites

Composition	Energy absorbed J	Impact strength KJ/m^2
96% polyester + 4% curaua.	1.4	36.74
94% polyester + 3% curaua + 3% glass	2.5	65.60

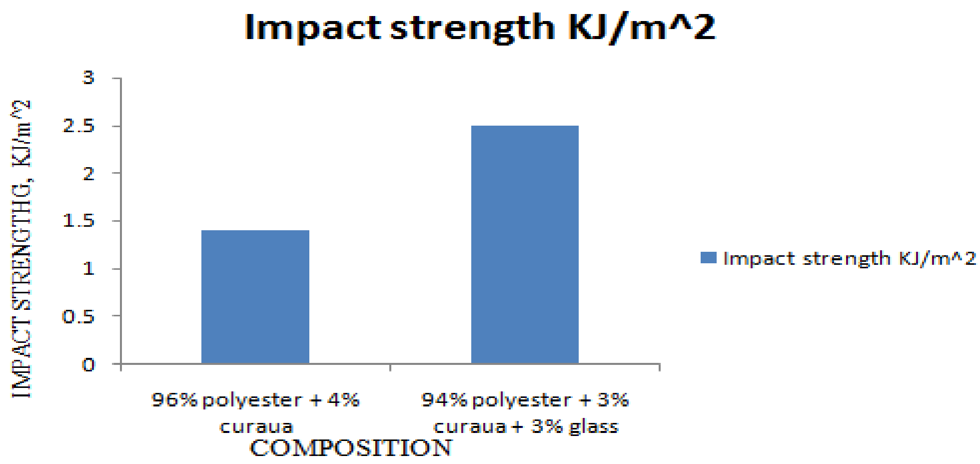

Figure 1.7: Comparison graph for Izod test

From the observation of Izod impact test experiment it can be concluded that, impact strength of composite with 94% polyester+3% curaua+3% glass fiber increases by 78.55%as compared to 96% polyester + 4% curaua fiber hence hybridization was effective in increasing impact strength for Izod specimens.

Table 1.3 Charpy chart for composites

Composition	Energy absorbed J	Impact strength KJ/m^2
96% polyester + 4% curaua.	0.8	20.99
94% polyester + 3% curaua + 3% glass	1.1	28.87

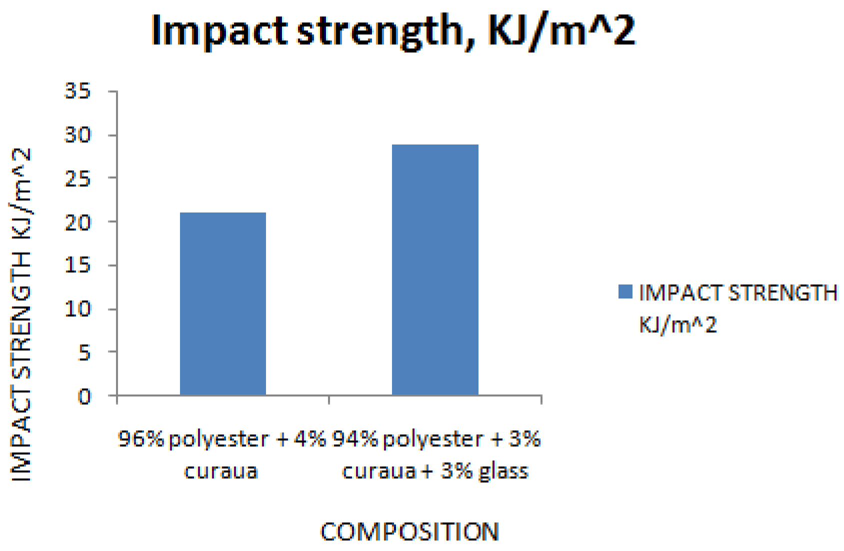

Figure 1.10: Comparison graph for Charpy test

From the observation of Charpy impact test experiment it can be concluded that, impact strength of composite with 94% polyester+3% curaua+3% glass fiber increases by 37.54% as compared to 96% polyester + 4% curaua fiber hence hybridization was effective in increasing impact strength for Charpy specimens.

3.3 Damping Test

Damping test is carried out for both normal and hybrid composition to determine its natural frequency, damping ratio, and mode shapes. Specimens of dimension 150*150*3 mm is developed by hand layup technique and subjected to damping test .Table 1 below describes the natural frequency and damping ratios for normal specimen. The vibrations of any structures and automobiles can be reduced by using composites for their fabrication as the composites are viscoelastic in nature [9].Damping setup consists of impact hammer, accelerometer, dynamic signal analyzer and external computer. Accelerometer and impact hammer is connected to dynamic signal analyzerwhich in turn is connected to external computer. The composites which need to be subjected for damping test is divided into 36 node and the specimen will be hanged like simply supported beam, forced vibrations are induced by using impact hammer on each node of a composite material. Accelerometer is attached to 36^{th} node of a specimen. Once the vibrations are induced on a specimen the amplitude, natural frequency and damping ratios are obtained by using DEWE and ME'scope software for node 1 and it is repeated for all 36 nodes.

Table 1.4 Natural frequency and damping ratio chart for base damping specimen.

Mode shapes	Natural Frequency (Hz)	Damping %
Bending	319	2.7
Twisting	496	2.32
Combination of bending and twisting	643	2.05
Complex	821	2.33

Fig 1.12,1.13,1.14,1.15 shows the bending mode, twisting mode, combination of bending and twisting mode and complex mode for their respective natural frequencies of the base damping specimen.

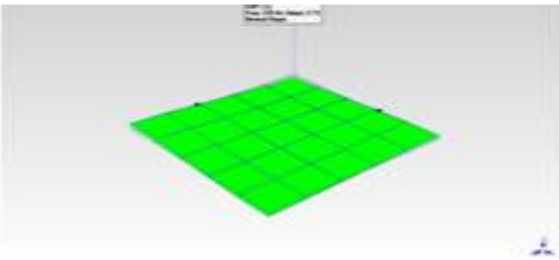

Fig 12: bending mode

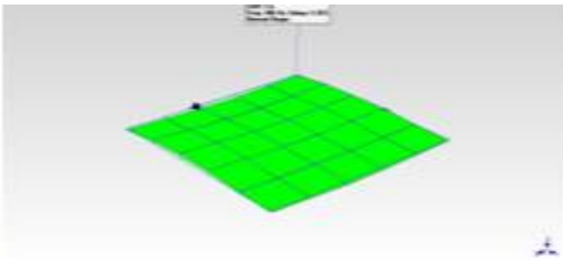

Fig 13:twisting mode

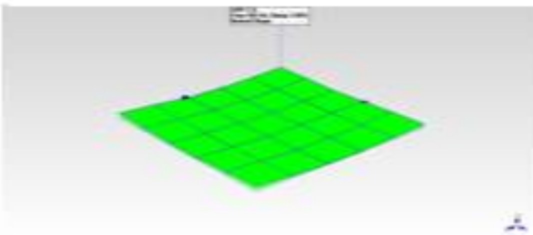

Fig 14:combination of bending,twisting mode

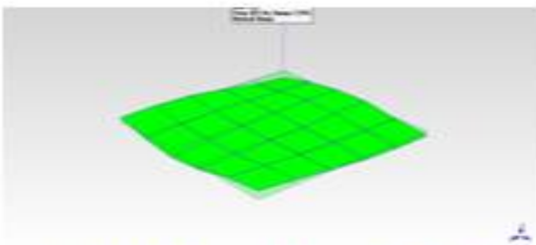

Fig 15 : complex mode

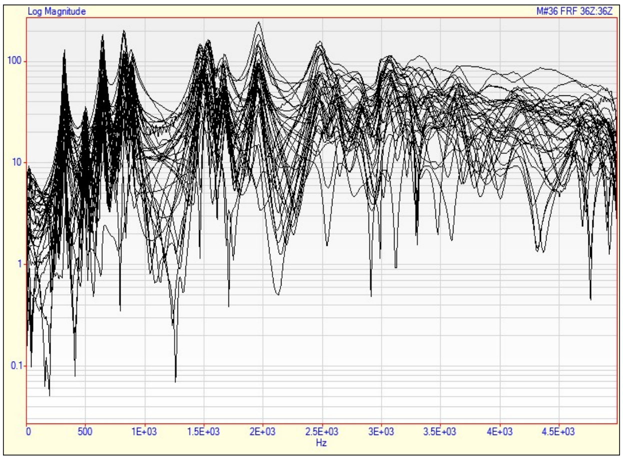

Figure 1.16: Magnitude vs frequency chart for base soecimen.

Table 1.5below describes natural frequency and damping ratios for hybrid specimen.

Mode shapes	Natural Frequency (Hz)	Damping %
Bending	232	3.21
Twisting	458	2.58
Combination of bending and twisting	599	2.4
Complex	1.02e+03	2.49

Figure 1. 17,1.18,1.19,1.20 shows the bending mode, twisting mode, combination of bending and twisting mode and complex mode for their respective natural frequencies of the hybrid damping specimen.

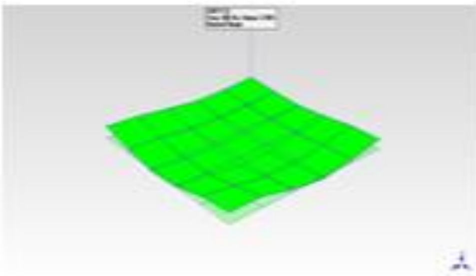

Fig 17:Bending mode

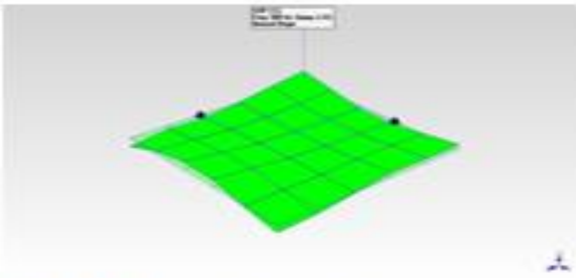

Fig 18:Twisting mode

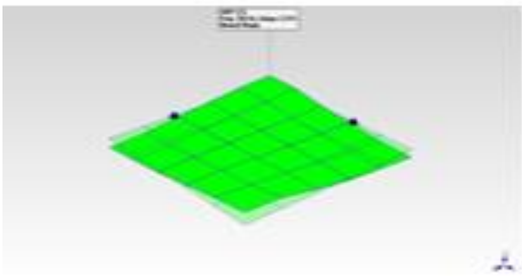

Fig 19:Combination of bending,twisting

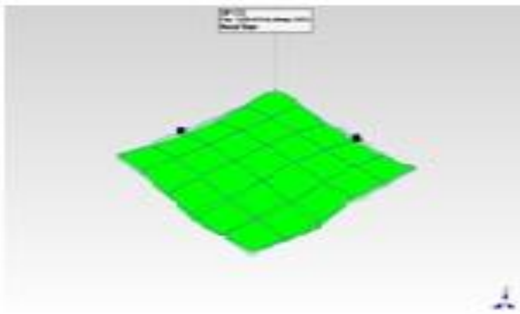

Fig 20: Complex mode

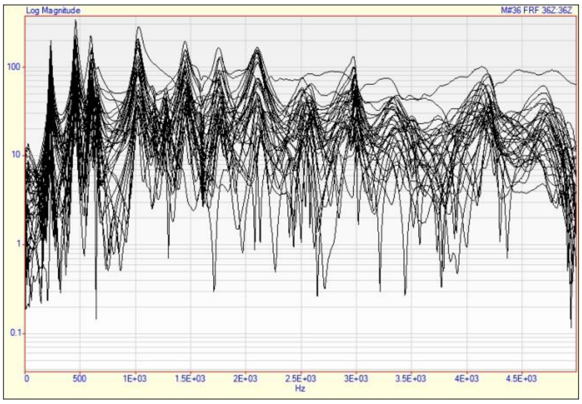

Figure 1.21: Magnitudevs frequency graph for hybrid specimen

From the observation of damping test it can be concluded that the natural frequency of composite material with 94% polyester+3% curaua+3% glass fiber combination is reduced by 13.11% as compared to that of 96% polyester + 4% curaua fiber.

4. CONCLUSION

- Polyester composites reinforced with continuous and aligned curaua fibers displays a linear increase in the Energy absorbed and impact strength, for hybrid composite. Apparently due to the weak fiber/polyester interfacial shear stress which in turn generates larger rupture areas.
- The hybridization (association of curaua and glass fibers) was effective in the sense of reducing the water absorption percentage of that normal composition due to the accumulation of glass fibers which got less water absorbing capacity.
- The damping ratios and natural frequencies is found less for hybrid composites in comparable with normal composite.

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