International Journal on Applications in Engineering and Technology
Volume 1 : Issue 11 : November 2015, pp 1 – 6 www.aetsjournal.com ISSN (Online) : 2455 - 0523

EFFECT OF WASTE TYRE PARTICLES REINFORCEMENT ON THE MECHANICAL PROPERTIES OF JUTE AND ABACA FIBER-EPOXY HYBRID COMPOSITES WITH PRE-TREATMENTS

M. LOGANATHAN , N. VADIVEL

Abstract— The aim of this study is to reveal the impacts of tyre particles reinforcement on mechanical properties of natural fiber epoxy hybrid composites. In this connection, the natural fibers jute, abaca and tyre particles were fabricated using conventional hand lay-up process followed by light compression moulding technique and tested for the different weight ratios of (80:0:20, 50:30:20, 40:40:20, 30:50:20, 0:80:20) without any pretreatment and were taken as the base line reference. Subsequently the tests have conducted on the above fibers with alkali treatment and tyre particles with H2SO4 treatment to enhance the mechanical properties. Reused tyres particle was also used as reinforcement in epoxy matrix and this particle was treated with to improve ability of rubber to interact with epoxy, increasing stiffness and tensile strength. The jute fiber, abaca fiber and tyre particle were prepared with various weight ratio and then incorporated into the epoxy matrix. The results indicated that this composite used as alternate material for synthetic fiber polymer composites.

I. INTRODUCTION

The composites are materials comprising of two or more chemically distinct constituents, on a macro scale, having a distinct interface separating them. The reinforcement is called as discontinuous phase which is stronger and harder than the continuous phase. The continuous phase is called as matrix. When the matrix material is polymer, the composite is termed as polymer matrix composite [1-3].

Fiber reinforced polymer composites possesses interesting properties like high specific strength, good fatigue performance, non-magnetic properties, corrosion resistance and low energy consumption during fabrication [4,5]. The hybrid composite is combining two are more different types of reinforcement in a matrix. So in this form both reinforcement and matrix retain their physical and chemical properties. The reinforcements are the principal load carrying members, when the matrix keeps them at the desired location and orientation and also acts as a load transfer medium between them [6, 7]. Venkatasubramanian H et al [8]. Conducted experiment on evaluation of mechanical properties of abaca-glass-banana fiber reinforced hybrid composites. They observed mechanical properties slightly higher for the abaca fiber.

The fibers are derived from plants or some other living species, which are called natural fiber. The natural fibers are renewable, recyclable, low density, high disposability and biodegradable. The natural fibers (Jute and Abaca fiber) have high stiffness and high strength as compared to synthetic fibers [9, 10]. The abaca fiber composite is superior to hybrid composite in tensile strength, flexural strength and impact strength [11-13]. Sakthivel M et al [14] They have investigated mechanical properties of natural fiber polymer composites. They have found use of natural fibers lowers energy needed for production by 80% while the cost of the component is 5% lower than the comparable fiber glass reinforced component. The use of natural fiber like jute not only help us in ecological balance but can also provide employment to the rural people in countries like India and Bangladesh where jute is abundantly available [15]. The alkali treatment of fiber removes lignin and hemicellulose which

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affects tensile properties and molecular orientation of the fibers [16-23].

Colom X et al [24] have conducted Structural and mechanical studies on modified reused tyres composites and showed that the pretreatment of tyre particles with Trichloroisocynauric acid (TCI) reinforced in HDPE composites have worst properties than Sulphuric acid or Silane coupling agent while using 20% weight ratio of waste tyre particles. The treatment of tyre particles with H2SO4 and HNO3 has most effective mechanical properties [25]. Now a days disposal of waste tyres is a hectic problem, increases the pollution and serious ecological threat. The computed more than 5000 million tyres to be rejected in a regular basis by 2030 year [26,27]. Hernandez-Olivares F et al [28] have investigated the fatigue behaviour of recycled tyre rubber filled concrete and its implications in the design of rigid pavements and proposed durability of this rigid pavements is high under high load while influence of tyre particles.

Besides, so far investigate the mechanical properties of using this scrap tyre particle, jute fiber and abaca fiber reinforced epoxy hybrid composites.

II. EXPERIMENTAL WORK

1) Materials

In this experiment, for fabricating the composite specimens Jute fiber, Abaca fiber and waste tyre particle were used. The jute and abaca fiber were purchased from Sakthi fibers Ltd. Chennai, India. The scrap tyre particles were purchased from Eshwar and Balaji Rubber Product Ltd. Namakkal, India. Epoxy resin and curing agent were purchased from CovaiSeenu Fiber Glass Ltd, Coimbatore, India.

2) Alkali treatment of fiber

The fibers have a cellulose rich core, whereas outside is covered by cementing layer which includes waxes, fats, lignin and hemi cellulose (as per Table 1). The cementing layer affects the tensile strength, flexural strength and molecular orientation of the fiber. So the fibers were soaked in aqueous NaOH solution for 5 hours at room temperature to remove the cementing layer. Then the fiber were further washed with distilled water to remove remaining alcohol, rinsed with water and dried in sun light.

TABLE 1 PHYSICAL PROPERTIES OF FIBER

Physical property	Jute fiber	Abaca Fiber
Density [g/cm^3]	1.48	1.35
Tensile strength [kN/mm^2]	410-780	400-980
Stiffness [kN/mm]	10-30	8-27
Young’s modulus [GPa]	26.5	31.1-33.6
Cellulose [%]	50-57	63-68
Hemi cellulose [%]	12-20	19-20
Lignin [%]	12-13	5-6

3) H2SO4 treatment of waste tyre particle

The rubber particles were treated with 96% H2SO4 acid by means of immersion in acid for 1 minute, then removal from this acid. Subsequently tyre particles were dried in air for 1 minute formerly washed with distilled water, rinsed with water and again dried in sun light to increase the ability of rubber to interact with epoxy resin, stiffness and tensile strength.

4) Preparation of Epoxy matrix

The matrix that is used to fabricate the composite is epoxy resin (Araldite LY556) of density 1.15-1.20 g/cm3 and corresponding hardener HY951 of density 1.13 g/cm3. The weight ratio of mixing epoxy and hardener is 10:1.

5) Composite fabrication

A wood mould having dimensions of 235×85×7 mm was used. Before the epoxy is laid up on the mould should be cleaned and dry. The releasing agent (polyvinyl acetate) is applied uniformly on lower mould surface. The epoxy resin and hardener were mixed in a ratio of 10:1 by weight as recommended. Using a brush, the matrix is laid up uniformly for the first layer on the mould surface. Then the fibers were added into the mould. The resin and reinforcement were applied alternatively

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to get the final hybrid composite products. The mould is closed and the composite material was pressed uniformly for 24 hours for curing. After these composites are fully dry, then it is separated from the mould. The edges of the specimen are neatly cut to the required dimensions.

6)Mechanical tests

A. Tensile test

The ability of the material to withstand applied load until breaking is known as tensile strength. The test performed on the Universal Testing Machine (UTM - Model no TUE-CN-1000). There were ten different kind of specimen were prepared according to weight ratio of reinforcement. The tensile test specimens were prepared according to the ASTM D638 standard [29, 30]. The dimension of specimen is 160×12.5×7 mm and the experiment was conducted. The specimen to be tested is fastened to the two end jaws of the UTM machine. The load was applied gradually on the specimen by means of the movable cross head, till the specimen fractures. The magnitude of the load was measured by the load measuring unit. The strain was measured using an extensometer.

B. Flexural test

A material's ability to resist deformation under load is termed as flexural strength. The flexural test was carried on the UTM. The flexural specimens were prepared as per the ASTM D790 standard [31]. The dimension of specimen is 127×12.7×7 mm. Flexural testing commonly known as three - point bending testing.

C. Impact test

The impact strength of the composite specimens was determined using an Izod impact tester as per ASTM D256 standard [30, 32]. The dimension of specimen is 63.5×12.7×7 mm.

In each case, the experiments were repeated for three times and the average values are used for presentation.

III. RESULTS AND DISCUSSION

1)Tensile properties

The ultimate tensile strength of the ten different composite samples (treatment and without treatment specimens) were tested in Universal Testing Machine. A sample graph showing tensile strength of different composites is shown in Fig.1. The tensile strength of the fabricated composite was furnished in the table 2 and 3 for better comparison. The results indicated that the pre-treatment composites have higher tensile strength than untreated composites.

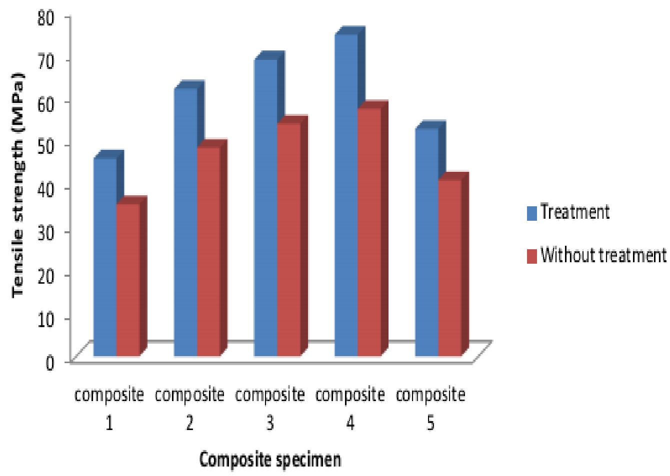

Figure 1

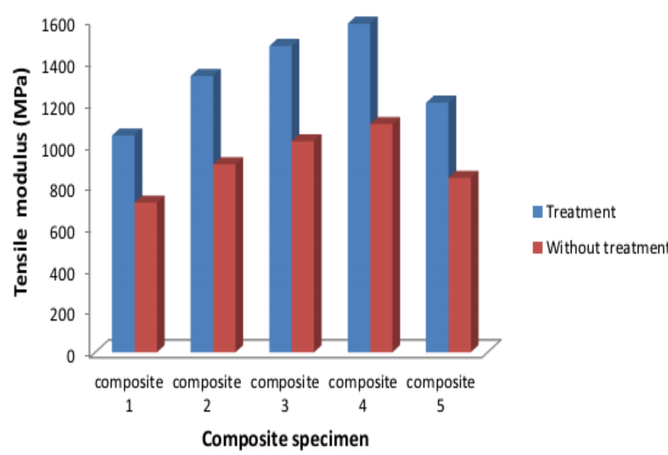

Figure 2

The treatment of tyre particles with H2SO4 improves the ability of tyre particles to interact with epoxy matrix, tensile properties and stiffness. The alkali treatment of fiber reduces cementing layer of fiber which affect tensile properties. So the alkali treatment tends to provide the materials a higher tensile strength than untreated composites. The ultimate tensile strength was found to be maximum for 30:50:20 weight ratio of jute fiber, abaca fiber and waste tyre particles with pre-treatment and reinforced with epoxy hybrid composites. The abaca and tyre particles composite have superior tensile strength compared to jute and tyre particles composite as the abaca fiber has the greater properties than the jute fiber. The sample graph showing tensile modulus of different composite specimens is shown in Fig.2. The tensile modulus of pre-treatment composites increased 144% of untreated composites.

2)Flexural properties

The flexural strength of the ten different composite samples were tested and presented in Fig.3. The flexural strength of the fabricated composite were summarized in the table 2 and 3 for better comparison. The results indicated that the H2SO4 and alkali treatments tend to provide the materials a higher flexural strength than untreated composites. As the alkali treatment improves the surface adhesive properties and stiffness by removing impurities and non-cellulosic materials of fiber. The flexural strength was found to be maximum for 30:50:20 weight ratio of jute fiber, abaca fiber and tyre particles with pre-treatment and reinforced with epoxy hybrid composite. The flexural strength of pre-treatment composites increased 132% of untreated composites.

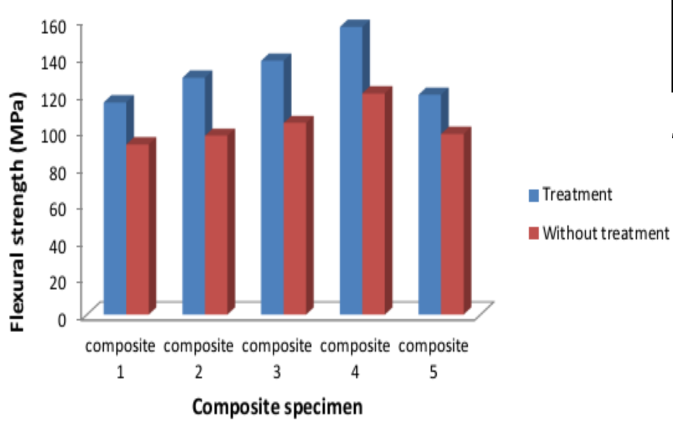

Figure 3

TABLE 2 MECHANICAL PROPERTIES OF PRE-TREATMENT COMPOSITE MATERIALS

Composite	Weight ratio	Tensile strength (MPa)	Tensile modulus (MPa)	Flexural strength (MPa)	Impact strength (Joule)
composite 1	80/0/20	45.71	1044.8	115.23	12
composite 2	50/30/20	61.71	1330.6	128.57	13
composite 3	40/40/20	68.57	1474.6	137.76	15
composite 4	30/50/20	74.29	1582.7	156.12	16.5
composite 5	0/80/20	52.57	1201.	119.38	12

TABLE 3 MECHANICAL PROPERTIES OF WITHOUT PRE-TREATMENT COMPOSITE MATERIALS

Composite	Weight ratio	Tensile strength (MPa)	Tensile modulus (MPa)	Flexural strength (MPa)	Impact strength (Joule)
composite 1	80/0/20	35.16	720.55	92.35	11
composite 2	50/30/20	48.21	905.21	97.06	13
composite 3	40/40/20	53.78	1016.97	103.97	14
composite 4	30/50/20	57.15	1099.12	120.10	16
composite 5	0/80/20	40.75	840.28	98.02	12

3) Impact properties

The impact strength of the different composite samples were tested and presented in Fig.4. The impact load of the different hybrid composites was furnished in the table 2&3 for healthier comparison.

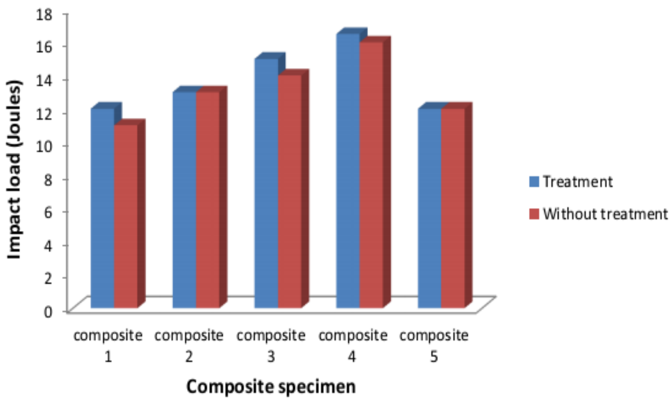

Figure 4

The results indicated that no significant difference between pre-treatment and without treatment composites. The impact load was found to be maximum for 30:50:20 weight ratio of jute fiber, abaca fiber and tyre particles with pre-treatment and reinforced with epoxy hybrid composite.

IV. CONCLUSION

The ten different hybrid composites (pre-treatment and without treatment) were prepared in different weight ratio (80:0:20, 50:30:20, 40:40:20, 30:50:20, 0:80:20) of jute fiber, abaca fiber and waste tyre particle by conventional hand layup technique. The specimens were subjected to tensile, flexural and impact test. From the experiment, the following conclusions were derived.

By the alkali treatment of natural fiber and pre-treatment of waste tyre particle with H2SO4, the mechanical properties such as tensile strength (74.29 MPa), tensile modulus (1582.74 MPa), flexural strength (156.12 MPa) and impact load (16.5 J) were found to be maximum for 30:50:20 weight ratio of jute fiber, abaca fiber and tyre particle reinforced epoxy hybrid composites.

The tensile strength, tensile modulus and flexural strength of pre-treatment composites increased 128%, 144% and 132% respectively of untreated composites.

The abaca and jute fiber are richly available and cheaper than conventional natural fiber, since as discussed above this composite materials have great strength compared to conventional material. This work can be further extended to real time replacement of automotive components such as automotive seat shells and roof panel.

V. ACKNOWLEDGMENT

The authors sincerely acknowledge the support of Strength of Material Laboratory of Civil Engineering Department and Chemistry Department, Government College of Technology, Coimbatore, India.

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