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Mechanical Property Evaluation of Sisal and Banana Fiber with Tyre Particles Reinforced Epoxy Hybrid Composites

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***Abstract*—** This work deals with fabrication and investigation of mechanical properties of natural fiber such as Sisal and Banana fiber with waste tyre particles reinforced epoxy hybrid composites. The sisal fiber, banana fiber and tyre particles were prepared with various weight ratios (85:0:15, 65:25:15, 45:45:15, 25:65:15, 0:85:15) and then incorporated into the epoxy matrix by hand lay-up technique. The mechanical properties such as tensile strength, flexural strength and impact values were evaluated. This study shows that addition of banana fiber in sisal/tyre particles composites of up to 45% by weight results in increasing the mechanical properties. The results indicated that this composite used as alternate material for synthetic fiber polymer composites.

KeyWords: Natural fiber, Polymer matrix composites, Mechanical properties, Waste tyre particles, Hybrid.

I. Introduction

Composites are materials consisting of two or more chemically distinct constituents on a macro scale having a distinct interface separating them. The discontinuous phase is harder and stronger than the continuous phase and which is called reinforcement, whereas continuous phase is termed matrix [1, 2]. Now a days natural fiber such as sisal and banana fiber composite materials are replacing the glass and carbon fiber owning to their potential availability and cost [3]. The sisal-jute hybrid composites are environment friendly and user friendly materials and have healthier elastic properties [4, 5]. The disposal method of synthetic fiber reinforced polymer and their recycling have been the serious ecological threat [6, 7]. The natural fiber composites plays important role in the environmental situation and variety of application [8].

The matrix material can be metallic, polymeric or ceramic when the matrix is a polymer, the composite is called polymer matrix composite. In this form both fibers and matrix retain their physical and chemical identities. The reinforcement are the principal load carrying members, while the matrix keeps them at desired location and orientation, acts as a load transfer medium between them and protects from environmental damage [9-12]. The fiber reinforced polymer composites possessing interesting properties like high specific strength and stiffness. Low thermal expansion, non-magnetic properties, corrosion resistance and low energy consumption during fabrication [13]. The sisal fiber is the promising reinforcement because of low density, high specific strength, no health hazards and finding applications in making of ropes, mats, carpets and fancy articles [14]. The adding sisal fiber with glass fiber improves thermal properties and water resistance of hybrid composites [15]. The hybridization of sisal fiber with banana/epoxy composites up to 50% by weight increasing the mechanical properties and decreasing the water absorption properties [16]. The disposal of waste tyres is a hectic problem, increases the pollution and serious ecological threat. An estimated 1000 million tyres reach the end of their useful lives every year and 5000 million more are expected to be discarded in a regular basis by the year 2030 [17, 18]. Hernandez-Olivares F et al [19] have conducted on 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. This prompted us to investigate the mechanical properties of sisal and banana fiber reinforced with waste tyre particles reinforced epoxy hybrid composites.

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II. Experimental

A. Materials

In this present investigation Sisal fiber, Banana fiber and waste tyre particles were used for fabricating the composite specimen. The banana and sisal fibers were obtained from Dharmapuri District, Tamilnadu. Epoxy resin and curing agent were purchased from Covai Seenu Fiber Glass Ltd, Coimbatore, India. The tyre particles were purchased from Balaji rubber product Ltd., Tamilnadu.

B. 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. 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.

C. HNO_3 treatment of waste tyre particle

The rubber particles were treated with 95% HNO_3 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.

D. Preparation of Epoxy matrix

The matrix that is used to fabricate the composite is epoxy resin (3554 A) of density 1.15-1.20 g/cm3 and corresponding hardener 3554 B of density 1.13 g/cm3. The weight ratio of mixing epoxy and hardener is 10:1.

E. Preparation of Composite Specimen

The composite materials used for the present investigation is fabricated by hand lay-up process. First the natural fibers were cleaned in the distilled water then dried in sun light. The epoxy resin and accelerator were mixed potentially and it is laid up uniformly for first layer on mould surface. Then fibers and tyre particles were added into the mould subsequently. The matrix and reinforcement were applied alternatively to form hybrid composite. The air gaps formed between the layers during fabrication are gently squeezed out by using roller. After the composite material get hardened completely, the composite material is taken out from the mould and rough edges are neatly cut and removed as per the required dimensions.

F. Mechanical Testing

1) Tensile test

The tensile test is performed on the Universal Testing Machine (UTM). There are five different kind of specimen were prepared according to the weight ratios used. The fabricated specimen for tensile test is presented in Fig. 1. This tensile test specimen is prepared according to the ASTM D638 standard [20, 21]. The dimensions, gauge length and cross head speeds are chosen according to the ASTM D638 standard. A tensile test involves mounting the specimen in a machine and subjecting it to the tension. The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures. The experiments were prepared for several times and average values were used for healthier discussion.

Fig -1: Tensile and Flexural test specimen

2) Impact test

The impact test specimens were prepared according to the required dimension following the ASTM D256 standard [21, 22]. During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily and can be used to measure the toughness of the material and yield strength.

3) Flexural test

The flexural specimens were prepared as per the ASTM D790 standards [23]. The three-point flexure test is the most common flexural test for composite materials. The testing process involves placing the test specimen in the UTM and applying force to it until it fractures and breaks. The specimen used for conducting the flexural test is presented in Fig. 1. From the testing machine the flexural load was recorded for all the test samples.

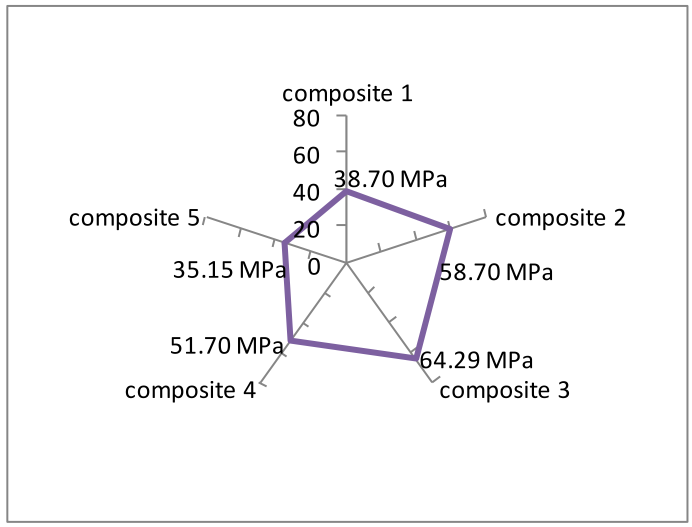

Fig -2: Tensile strength of different composites

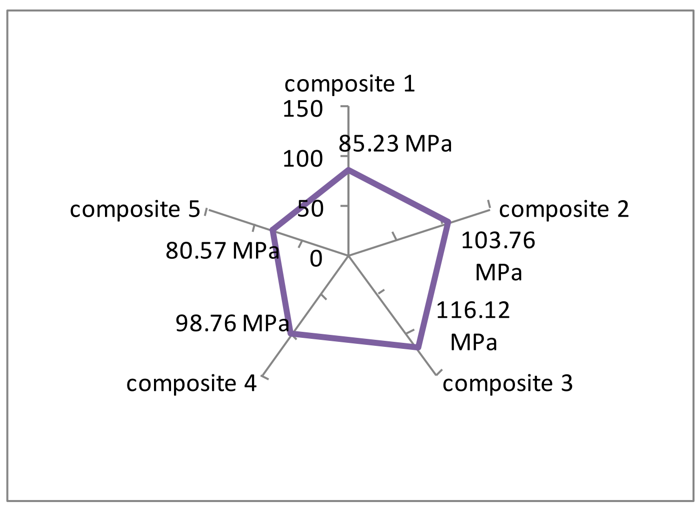

Fig -3: Flexural strength of different composites

III. RESULTS AND DISCUSSION

A. Tensile properties

The ultimate tensile strength of different composite samples were tested and presented in Fig. 2. The result indicated that the tensile strength of sisal fiber/tyre particle composite was slightly higher than the banana fiber/tyre particle composite. The tensile strength was found to be maximum for 45:45:15 weight ratio of sisal fiber, banana fiber and tyre particle reinforced polyester hybrid composites.

B. Flexural properties

The flexural strength of different composite samples were tested and presented in the sample Fig. 3. The flexural strength was found to be maximum for 45:45:15 weight ratio of sisal fiber, banana fiber and tyre particle reinforced polyester hybrid composites.

C. Impact properties

The mechanical properties like tensile strength, flexural strength and impact values of all five composite specimens were compared and tabulated in Table 1. The result indicated that the impact value of sisal fiber/tyre particle composite was slightly better than the banana fiber/tyre particle composite. The impact values of different composite samples were tested and plotted as shown in Fig. 4.

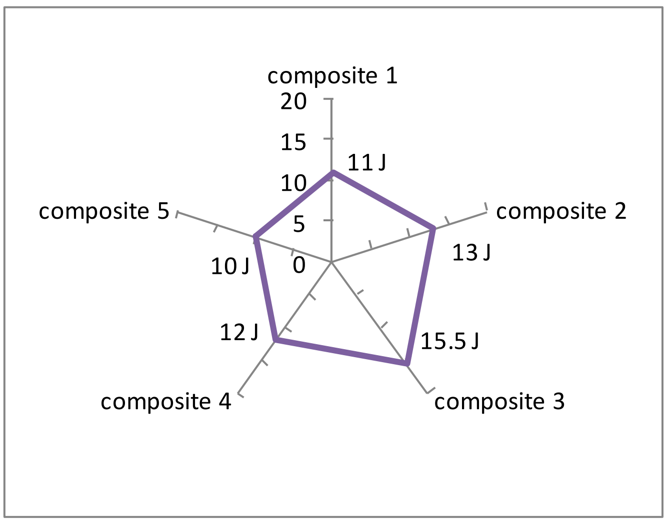

Fig-4: Impact values of different composites

IV. CONCLUSIONS

The different weight ratios of hybrid composite specimens were prepared and subjected to tensile, flexural and impact loading. From the experiment the following conclusions were derived.

The tensile strength, flexural strength and impact values were found to be maximum for 45:45:15 weight ratio of sisal fiber, banana fiber and tyre particle reinforced epoxy hybrid composites. The maximum values obtained for tensile strength, flexural strength and impact values are 64.29 MPa, 116.12 MPa and 15.5 J respectively. The mechanical properties of sisal fiber/tyre particle composite were slightly higher than the banana fiber/tyre particle composites. The hybridization of banana fiber with sisal fiber/tyre particles not only improve the mechanical properties of this hybrid composites but also reduce its cost and make it eco-friendly composite. It has been used in many applications which require medium strength.

Table -1: Mechanical properties of different composites

Composite	Weight ratio (Sisal/ Banana / Tyre particles)	Tensile strength (MPa)	Flexural strength (MPa)	Impact values (J)
Composite 1	85/0/15	38.70	85.23	11
Composite 2	65/25/15	58.41	103.76	13
Composite 3	45/45/15	64.29	116.12	15.5
Composite 4	25/65/15	51.70	98.57	12
Composite 5	0/85/15	35.15	80.57	10

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