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Design and Fabrication of Urban equipment product from Waste Tyre by Powder Metallurgy process

Mohammed Kubaib Ahamed.S, Prabakaran.P, Chinnaraj. R, Sabarees.S, M. Loganathan , M.Senthil

Abstract— The aim of this study is to reveal the impacts of tyre particles reinforcement on mechanical properties of epoxy hybrid composites. In this connection, tyre particles and resin were fabricated using Powder Metallurgy process (conventional hand lay-up process – Sintering process) followed by light compression moulding technique and tested for the different weight ratios of (25:75, 50:50, 75:25). By using ambient process for getting tyre powder in the size of (5 mesh-30 mesh) and Pretreatment of tyre particle with H_2SO_4 to enhance their mechanical properties and molecular orientation. To testing the mechanical properties impact and hardness test is undergone. The ratio of (50:50) seems too good in hardness and Impact strength. The results indicated that this composite used as alternate material for fabrication of Urban Equipments product.

Keywords: Polymer matrix composites; Tyre particles reinforcement; H_2SO_4 treatment; Impact test; Powder Metallurgy process.

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 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 H_2SO_4 and HNO_3 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 waste tyre particles were used. Epoxy resin and curing agent

Mohammed Kubaib Ahamed.S,Prabakaran.P,Chinnaraj.R, Sabarees.S, U.G Student, Department of Mechanical Engineering, Knowledge Institute of Technology,Salem.

M. Loganathan , Asst.Professor of Mechanical Engineering, Knowledge Institute of Technology,Salem. (Email id: loganlogath.6391@gmail.com) cell no: +9178455 44325.

M.Senthil , Asso.Professor of Mechanical Engineering, Knowledge Institute of Technology,Salem.

were purchased from Covai Seenu Fiber Glass Ltd, Coimbatore, India.

2) Selection of reinforcement

Scrap Tyre particles

Tyres contain 47 % of Synthetic rubber
This tyre particles were obtained from Ambient process.
The tyre particles size are 5 mesh to 30 mesh

3) Ambient process

Ambient grinding can be accomplished in two ways: granulation or cracker mills. In an ambient system, the rubber, tires or other feedstock remain at room temperature as they enter the cracker mill or granulator.

Ambient grinding is conducive to any size particle, including whole tires. It can be accomplished in two ways: granulation or cracker mills. In an ambient system, the rubber, tires or other feedstock remain at room temperature as they enter the cracker mill or granulator.

Ambient grinding is a multi-step processing technology that uses a series of machines (usually three) to separate the rubber, metal, and fabric components of the tire. Whether using granulation equipment or cracker mills, the first processing step typically reduces the original feedstock to small chips. The second machine in the series will grind the chips to separate the rubber from the metal and fabric. Then a finishing mill will grind the material to the required product specification. After each processing step, the material is classified by sifting screens that return oversize pieces to the granulator or mill for further processing. Magnets are used throughout the processing stages to remove wire and other metal contaminants. In the final stage, fabric is removed by air separators.

Rubber particles produced in the granulation process generally have a cut surface shape and rough texture, with similar dimensions on the cut edges. Uses for the crumb rubber or granulate produced in this process include safety and cushioning surfaces for playgrounds, horse arenas and walking/jogging paths.

Cracker mills - primary, secondary or finishing mills - are all very similar and operate on basically the same principle: they use two large rotating rollers with serrations cut in one or both of them. The roll configurations are what make them different. These rollers operate face-to-face in close tolerance at different speeds. Product size is controlled by the clearance between the rollers. Cracker mills are low speed machines operating at about 30-50 RPM. The rubber usually passes through two to three mills to achieve various particle size reductions and further liberate the steel and fiber components.

These mills do not have screens built into the mill and as such the mill itself does not control the final particle. A stand-alone screening system will separate “sized” particles from oversize granules following the mill and re-circulate the oversize products. The crumb rubber particles produced by the cracker mill are typically long and narrow in shape and have a high surface area.

4) H_2SO_4 treatment of waste tyre particle

The rubber particles were treated with dilute H_2SO_4 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.

5) 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.

Fig.2.5.1 Matrix

6) Composite fabrication

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 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.

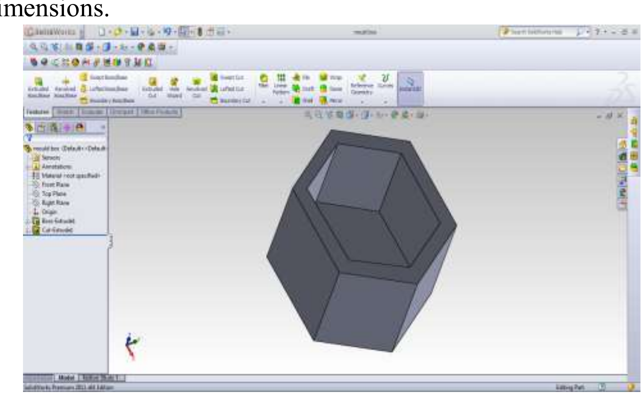

Fig.2.6.1 CAD model of Work piece

Fig.2.6.2 Real model of Work piece

7) Composition of required composites

Table 2.7.1 Composition of composites

Reinforcement / Composite	Matrix (%)	Tyre particles (%)
C1	25	75
C2	50	50
C3	75	25

Fig.2.7.1 Urban equipment product

Fig.2.7.2 Different composites based ob composition

8) Mechanical tests

A. Hardness test

Hardness maybe defined as the ability of a material to resistance against indentation and abrasion. The specimens are prepared as for the ASTM D 140 specification In all hardness tests, a define force is mechanically applied on the test piece for about 15 seconds. The indenter, which transmits the load to the test piece, varies in size and shape for different tests. In Brinell hardness testing, steel balls are used as indenter. Diameter of the indenter (D) and the applied force depend upon the thickness of the test specimen, because for accurate results, depth of indentation (d) should be less than 1/8th of the thickness of the test pieces.

The indentation is measured and hardness calculated as

$$BHN=\frac{2P}{\Pi D(D-\sqrt{(D^2-d^2})}$$

Fig.2.8.1 Hardness test

Load (P) = 187.5 kg

Diameter of Indenter (D) = 3.17 mm

Diameter of load impression (d) = 1.733 mm

BHN $= \frac{2P}{\pi D\left[D-\sqrt{D^2-d^2}\right]}$

$= \frac{2\times 187.5}{\pi\times 3.17\left[3.17-\sqrt{3.17^2-1.733^2}\right]}$

= 73.025

B. Impact test

The impact strength of the composite specimens was determined using an Izod impact tester.

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

Fig.2.8.2 Impact test

III. Results and Discussion

Table.3.1 Results of Mechanical Properties

Reinforcement Composite	Hardness strength	Impact strength (J)
C1	40	9
C2	73	15
C3	52	11

The treatment of tyre particles with H_2SO_4 improves the ability of tyre particles to interact with epoxy matrix, Hardness and Impact strength. The Hardness strength and Impact strength were found to be maximum for 50:50 weight ratio of Matrix and tyre particles.

IV. Conclusion

The hybrid composites were prepared by using scrap tyre particles reinforced Epoxy hybrid composites by Powder Metallurgy (hand-lay-up technique - sintering process). The Hardness strength and Impact strength were found to be maximum for 50:50 weight ratio of Matrix and tyre particles.

The Tyre particles are richly available and cheaper than conventional and synthetic rubber, 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 Urban equipment product and automotive components such as automotive seat shells and roof panel.

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