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Development of E-Glass and Rubber Powder Composite Material

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Abstract

This paper illustrates the fabrication of the composite made up of E-glass and recycled rubber powder. Composites are materials that are produced from two or more constituent materials. Composite materials play a substantial role in our lives. Composites can replace metals due to their high strength and lightweight. The advantages of using these recycled rubber powder and glass fibre are environmental gains, reduced energy consumption, lightweight, insulation, and sound absorption properties. The composite comprises glass fibre as the matrix, and micronized rubber powder (MRP) obtained from old tires as filler. The composite is made using the high-compression hand layup method. The fabricated composites are characterized by flexural, hardness, and tensile testing as per ATSM standards to find the impact of rubber powder as filler material on the mechanical properties of glass-reinforced epoxy composites.

Keywords: Composite materials; Rubber powder; Glass Fiber Sheet; Hand layup Method; Light weight.

1. Introduction

A polymer matrix is used to create composites, commonly referred to as Fiber-Reinforced Polymer (FRP) composites, which are then reinforced with an engineered, synthetic, or natural fibre (such as glass, carbon, or aramid) or other reinforcing material [1]. The matrix transfers the weight between the fibres and shields them from external and environmental harm. In turn, the fibers give the matrix reinforcement and rigidity to prevent cracking and fracture.

Glass fibre-reinforced polymer composites are the most widely used composite materials. In recent years many fibres reinforced composite materials have been widely used in manufacturing various parts in the automotive and aerospace industries [2]. Composite materials are superior to metallic materials in terms of fatigue strength-weight ratio and fatigue damage tolerance of many composite laminates. For these reasons, fibre-reinforced composites have emerged as a significant class of structural material. They are considered a substitution for metals in many weights critical components in the aerospace, automotive, and other industries [3,4].

The used tires are non-biodegradable, cause environmental damage, and can be used in making these composites. Instead of burning these old tires, which cause more damage to nature, they can be micronized and used in making these composites [5,6]. We can reduce rubber waste by using micronized rubber made from old tires. Micronized rubber powder can be used as filler material to fabricate fibre-reinforced composites, improving mechanical and dampening properties [7].

The method used in making the composite made up of E-glass fibre and micronized rubber powder is the high-compression hand layup method [8,9]. The composite made is a conventional unidirectional layer method.

2. Methodology

The methodology is a process for implementing and developing the project. The methodology for the composite fabrication is shown in Figure 1.

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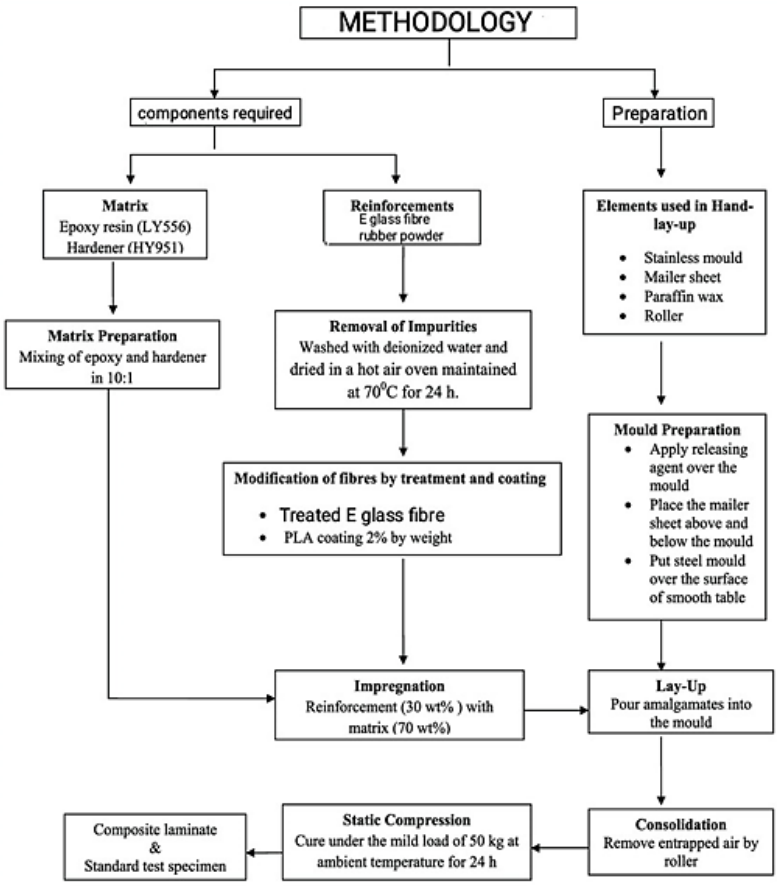

Figure 1: Flow chart of making the composite.

3. Components

The following components are used in the fabrication process of the composite material.

3.1. Epoxy Resin ((LY556)

Epoxy is the family of basic components or cured end products of epoxy resins. The class of reactive prepolymers and polymers known as epoxy resins, commonly referred to as poly epoxides, contains epoxide groups. Epoxy is another name for the functional group made up of epoxides. Oxirane is the epoxide group's IUPAC name. A thermosetting polymer is created when poly epoxides react with one another or with polyfunctional hardeners. This polymer frequently has good mechanical properties and great thermal and chemical resistance. Epoxy is used for a variety of things, such as metal coatings, composites, electrical components (such as chips on board), LEDs, high-tension electrical insulators, the manufacture of paint brushes, fiber-reinforced plastic materials, and structural and other adhesives.

3.2. Hardener (HY951)

Hardener HY951 is a Low viscosity, epoxy resin system that can be cured at room temperature. Key Properties are good mechanical strength and resistance to atmospheric & chemical degradation.

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3.3. Mild Steel plates

Mild steel is a general-purpose steel, in industry it is commonly referred to as “low carbon steel”. I’m not sure on the origin of the name mild steel. It is the easiest type of steel to work with.it is a very common type of steel used in most things from table frames to cargo ships. some of its characteristics include, Easy to weld, needing no special attention or equipment. Easily formed and bent, unlike other grades of carbon and alloyed steels such as railway line and bi alloy plates. These take a large amount of force to bend compared to mild steel due to the higher strengths.

3.4. PVC Covers

Polyvinyl chloride (PVC) is one of the widely produced synthetic polymers of plastic. PVC is available in two basic types: rigid (also known as RPVC) and flexible. PVC in its rigid form is employed in pipe construction as well as in profile applications, such as doors and windows. Plastic bottles, non-food containers, food-covering sheets, and plastic cards are also made with them. (Plasticizers can be added to make it softer and more flexible; phthalates are the most popular choice. It is also used in this form for flooring, signage, phonograph records, inflatable items, plumbing, electrical wire insulation, imitation leather, and many more uses where the rubber is substituted. It is used with cotton or linen to create the canvas.

3.5. E-Glass Fiber

E-glass is more commonly known as electrical glass. It is a lightweight composite material that is used in aerospace, marine, and industrial applications. E-glass fiberglass cloth is an industry standard that provides a balance between performance and cost. Its draping characteristic is excellent and makes it cleaner to work with. E-glass was developed to be used in electrical applications, but it is used in numerous other areas as well. It has led to the production of glass-reinforced plastic combined with thermosetting resins. Sheets and panels made from glass-reinforced plastic are used quite extensively in nearly all industrial areas. It protects the structural integrity against any mechanical impact.

3.6. Micronized Rubber Powder

Micronized rubber powder (MRP) is classified as fine, dry, powdered elastomeric crumb rubber in which a significant proportion of particles are less than 100 µm and free of foreign particulates (metal, fiber, etc.). MRP particle size distributions typically range from 180 µm to 10 µm.

Figure 2: Epoxy Resin

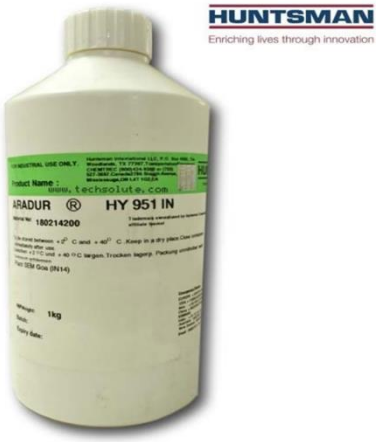

Figure 3: Hardener

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Figure 4: Mild steel plates

Figure 5: PVC Covers

Figure 6: Glass Fibre sheet

Figure 7: Rubber Powder

4. Fabrication of the Composite

Hand layup method

The thermosetting polymer in liquid form is thoroughly mixed in an appropriate proportion with a prescribed Hardener (curing agent) and then poured onto the surface of the mat already placed in the mould. Reinforcement in the form of woven mats or chopped strand mats is cut to the mold size and placed at the top of the mould after. The brush is used to spread the polymer uniformly. The second layer of the mat is then placed on the polymer surface, and any trapped air as well as any excess polymer is removed by lightly rolling the mat-polymer layer, up until the necessary number of layers are stacked, the procedure is repeated for each layer of polymer and mat. The mould is opened after curing, either at room temperature or at a particular temperature, and the produced composite part is removed and processed further.

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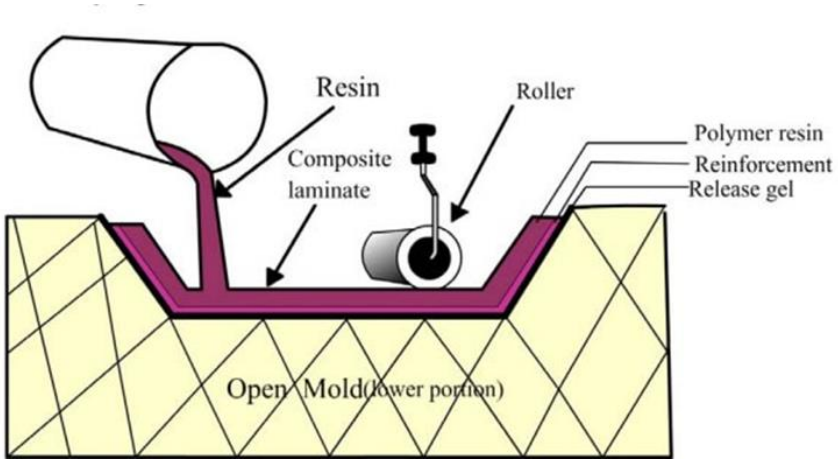

Figure 8: Schematic Diagram of Hand Layup Method

5. Final Product

The composite is made with the E-glass fiber mat as reinforcement and the micronized rubber powder as filler material. The epoxy resin (LY556) and hardener (HY 951) as the matrix in the making of the composite. The composite is made using the high-compression hand layup method. The composite made in the process is lightweight and durable. The composite produced is an insulator and can be used in machines that work on electrical energy.

Figure 9:Final Obtained Composite

5.1. Dimensional parameters

The following are the dimensions of the final obtained product as shown in Table 1.

Table 1: Dimensional Parameters of the Composite

Parameter	Value
Specimen type	Flat Plate
Specimen width	13.04 mm
Specimen thickness	3.57 mm
Cross-sectional area	46.55 sq. mm

6. Experimental Results and Discussions

The section presents the experimental results of the obtained composite. Tensile test, load vs displacement, flexural stress, and hardness test are the conducted tests. The results are discussed in the following sections.

6.1. Tensile Test

The results of the tensile test are shown in Table 2. Here, the sample is tested in a Universal Testing Machine (UTM 2.5-213-0816), and the test method considered is ASTM D 3039. The ultimate tensile load obtained is 11904 N and the ultimate tensile strength is 255.7 N/mm^2. The total elongation observed in the composite sample is 2.8%. The yield load is 31.740 kN and the yield stress is 556.842 MPa.

Table 2: Tensile Test Reports

Parameter	Value
Equipment	UTM 2.5-213-0816
Test Method	ASTM D 3039
Ultimate tensile load (N)	11904
Ultimate tensile strength (N/sq.mm)	255.7
Elongation (%)	2.800
Yield load (kN)	31.740
Yield stress (MPa)	556.842

6.2. Load vs Displacement

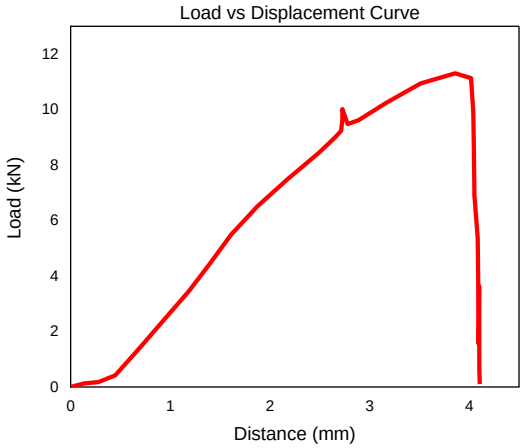

Figure 10: Load vs Displacement graph

The load vs displacement curve, obtained from the UTM machine is shown in Figure 10. Here, it can be observed that the value of the load is varying from zero to a maximum value of 11.9 kN. The curve is varying linearly up to the proportionality limit. At the displacement of 2.75 mm, we can see the load value varying due to varying crystalline structures. The maximum displacement observed is 4.1 mm.

6.3. Flexural Test Reports

The flexural test results are shown in Table 3. The tests are conducted in a universal testing machine (UTM/60T-170-0507) and the test method is ASTM D 790-2003. The flexural load observed is 840 N and the flexural strength is 1920 N/mm^2.

Table 3:Flexural Test Reports

Parameter	Value
Equipment	UTM/60T-170-0507
Test method	ASTM D 790-2003
Thickness (mm)	3.5
Breadth (mm)	25.03
Length of span (mm)	56
Flexural load (N)	840
Flexural strength (N/sq.mm)	1920

6.4. Hardness Test Report

The hardness test has been conducted using the Rockwell hardness testing machine (TESA 17773) and the test method is ASTM D 2240. The test has been conducted for 3 different locations and the average values of 74.3 is obtained.

Table 4: Hardness Values

Location	Impression 1	Impression 2	Impression 3	Average
ON SURFACE	74	74	75	74.3

7. Conclusion and Future Scope

The composite made up of the E-glass fibre and rubber powder is strong and lightweight and gave results better than many metals that are being used. The features of this composite such as being lightweight and cheap to make can be used in many industries. The composite gave extraordinary results when it comes to flexural and tensile strengths. The composite can be used in the principal constructions of planes, ships, and other vehicles. In most categories, it is the most Eco-friendly option, because of its ability to reduce weight. As a result, it can be utilized as a substitute to steal situations where great reliability is required over a long period of time. The composite made is more efficient and cheaper compared to metals used in categories.

The project has a very vast scope in the future. This project can be updated in near future as and when the requirement for the composite arises as the project is very flexible in terms of expansion. The project can be further developed by changing the filler or the fiber used. Efforts are being made to increase the toughness and improve the elongation capabilities of epoxy resin matrices. An important area of study is a reduction in the costs of raw materials and the fabrication of composite materials.

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