

Mechanical Properties of E-Glass/ Vinylester/Powder Rubber Hybrid Composites

Sudheer K V ¹, Pramod Kumar N ², Avinash N V ³ and Umashankar K S ⁴

Abstract:

The present work is to determine the mechanical properties of a polymer composite which consist of a vinyl ester as matrix and woven glass fiber (E-glass) filled with milled recycled rubber as reinforcement. The influences of different volume (0%, 3%, 6%, and 9%) of the filler on the mechanical properties of the composites were studied. The composite materials are analyzed with the consideration of recycled rubber and without recycled rubber. The mechanical characteristics of these composite materials are compared in terms of young's modulus using tensile test and flexural strength using flexural test as per the ASTM standards. The hybrid composite filled with 6% reinforcement shows better properties in terms of flexural strength and elasticity is increased with increase in filler addition.

Keywords:

Glass fibre, Recycled rubber, Flexural test, Tensile test, Vinylester

^{1,2,3} PG Students., Dept. of Mechanical Engineering, KVGCE, SULLIA, DK – 574327

VTU, Belgaum. Karnataka, India, ¹[E-mail:sudheerkv21@gmail.com](mailto:sudheerkv21@gmail.com)

⁴Professor., Dept. of Mechanical Engineering

KVGCE, SULLIA, DK – 574327, VTU, Belgaum, Karnataka, India, ⁴[E-mail:ukskvqce@gmail.com](mailto:ukskvqce@gmail.com)

²[E-mail:pramodnk90@gmail.com](mailto:pramodnk90@gmail.com) , ³[E-mail:nvavinash50@gmail.com](mailto:nvavinash50@gmail.com)

Introduction

Industrial applications including the textile technologies such as weaving, stitching, braiding are being employed to fabricate advanced composites with conformability, quality and integrated mechanical properties. One of the objectives of using textile reinforcement is to take advantage of through-the-thickness arrangement of fibers to enhance mechanical strength and toughness [1].

Composites materials are among the oldest and newest of structural materials. The older concept of composites is simply the mixing of two or more materials to rectify some shortcomings of a particular useful component. The concept of combining two dissimilar materials has acquired a broader significance. The combination has its own distinctive properties in terms of strength or resistance to heat [2]. The principle attraction of modern composites materials is that they are lighter, stiffer and stronger than any material produced ever before. Plastics do not prove themselves to be sufficiently strong, stiff and dimensionally stable for their use in high performance load bearing applications. On the other hand, glass fibers possess very high strength, sufficient stiffness and durability. By combining these two materials in specific weight ratio to produce glass reinforced plastics (GRP) with excellent mechanical and temperature resistance properties can be achieved. Proper composition and orientation of continuous fibers makes it possible to design a GRP of desired properties and functional characteristics. Such GRP can be several times stronger than steel, almost as stiff as Aluminum, with a specific gravity of only one quarter that of steel.

In recent times, E-glass fiber and vinyl ester resin based composites have found extensive use in naval structures. Composites results in the potential for a limitless number of new material systems having unique properties that cannot be obtained with any single monolithic material. There are mainly three different types of reinforcements in a composite material like fibrous and particulate reinforced composite materials. Fiber-reinforced materials have been found to produce durable, reliable structural components in wide applications. The excellent mechanical properties of composites were the main reason for their wide use and applications. The recent developments in composite preparation shown that, adding filler to the composite material along with glass fiber will enhance the mechanical properties of the composites.

As per the reusable material is considered, the tyre will become unusable after its continuous usage for several years in the automobile field. So the disposal of this tire became a huge problem [3]. The researchers think about the reuse of these tires in various other fields and as a result today it is in the area of composite materials. Recovered rubber has some properties that are better than those of virgin rubber.

The present work proposes the incorporation of the milled recycled rubber at the interface area between layers made of glass woven fabric. To evaluate the performances of this new composite material from the mechanical behaviour point of view, some mechanical tests were carried out: flexural test, tensile test of a rectangular plate. Moreover, some

mechanical characteristics are compared with the ones obtained in case of the composite reinforced only with glass woven fabric.

Materials and Methods Used

The following materials are collected to prepare the composites.

- Bidirectional (BD) glass fiber woven fabric cloth.
- Vinyl ester resin.
- PVA mold releasing agent.
- Recycled rubber filler Material

Glass fibers having density of 360 g/m² as the reinforcing material, milled recycled rubber as a filler and vinyl ester resin, a Bakelite Hylame product of grade HPR 8171 having density of 1.052 g/cm³ were used as the matrix material [4]. MEKP, cobalt octoate and N-N dimethyl aniline were used as catalyst, accelerator and promoter, respectively. A Bakelite Hylame product of grade HPR 8171 having density of 1.052 g/cm³ got good corrosion resistance and outstanding mechanical properties, especially resiliency and elongation also low viscosity and excellent bonding strength make us to choose it as a matrix material.

Samples with fiber roving were prepared by taking 16 layer of roving of E-glass and soaked in vinyl ester resin with the catalyst, accelerator and promoter in 1: 1: 1 ratio to the weight of the resin designated as GFRP

16. First, the glass fiber is cut into 250x250 mm size of 16 layers. Then the sample is prepared by hand layup technique. The vinyl ester resin is used as matrix materials. One sample with only glass fiber/vinyl ester is prepared then the samples is prepared with glass/recycled rubber/vinyl ester [5]. The sizes of the filler material selected as 600 microns. Also the percentage of filler is varied as: 0%, 3%, 6%, 9% then, the specimens were cut from the plates for the flexural test (three-point method) and tensile test according to the ASTM standards. The speed of loading was 1.5 mm/min during both the bending (flexural test) and tensile test. Before each test of a specimen, the dimensions of its cross-section were accurately measured.

Table 1. Specimen Types

Type	1	2	3	4
Fiber	60%	60%	60%	60%
Matrix	40%	37%	34%	31`%
Filler	0%	3%	6%	9%

Fig. 1 and Fig. 2 represent the unused tyre rubber milled to 600 micron size used as filler material and die arrangement for compaction using hydraulic press arrangement respectively are as shown.



Figure 1. Milled recycled rubber filler.



Figure 2. Die arrangement

The testing machine recorded pairs of values during the tensile tests: tensile force F and elongation of the tensile specimen [6]. It may note that to obtain more data about mechanical behaviour in tensile test, an extensometer is initially mounted on each tensile specimen tested. The extensometer is a strain-measuring device used to record data concerning to the changing of the normal strain ϵ during testing [7]. The software of the testing

machine allows calculating the elastic modulus E (Young's modulus).

Fig.3 and Fig.4 represents the samples prepared after the curing and the specimen is prepared as per the ASTM standard for test respectively as shown.



Figure 3. Cured sample



Figure 4. Test specimen



Figure 5. specimen after flexural test

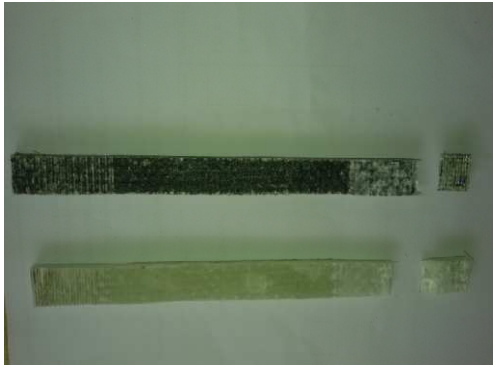


Figure 6. Specimen after tensile test

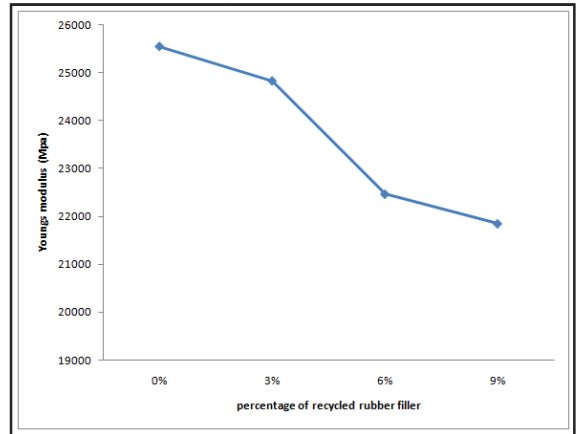


Figure 8. Values of young's modulus obtained in tensile test



Figure 7. Tensile test arrangement

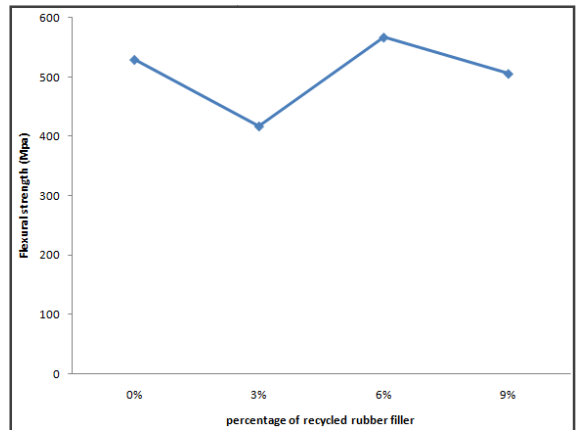


Figure 9. Vales of flexural strength obtained in FT

Result And Discussions

Fig. 8 and Fig. 9 represent the variations in young's modulus and flexural strength respectively for the varying percentage of filler addition, obtained after the experimentation.

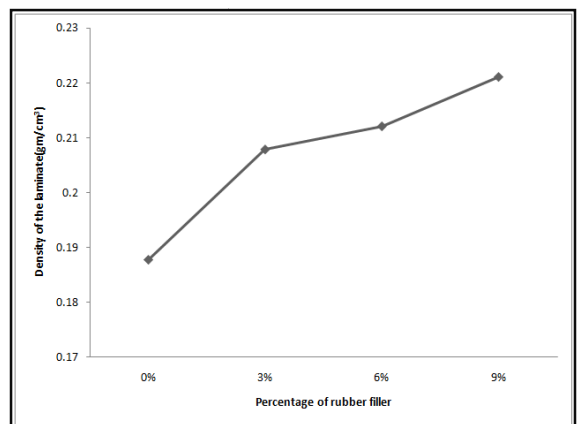


Figure 10. Density of the laminate

From Fig. 9 it is observed that flexural strength increases with the increase in the percentage of filler. Flexural strength describes the stress carrying capacity of a material and reflects both toughness and inherent flaw size. Flexural strength was found in this work to increase as recycled rubber content in the composites increased and it is found optimum at 6% of the filler. Any mechanism capable of delaying crack propagation and increasing toughness, such as toughening resulting from rubber inclusions, would be expected to result in an increase in flexural strength [8]. But, Fig.8 it is observed that the Young's Modulus 'E' goes on decreasing with the increase in the percentage of filler. The young's modulus signifies the stiffness of the material indicating that the stiffness decreases on addition of recycled rubber filler. This decrease is attributed to the lowering of the cross- linking density and plasticization effect. In Fig.10 it is observed that the density of the laminate increases with increasing the filler percentage. The reason for this is, the rubber has got higher density than the matrix material.

The microscopic views of the composite material without recycled rubber and with recycled rubber are as shown in the figure.



Figure 11. The microscopic views of the composite material without recycled rubber and with recycled rubber are as shown in the figure.

From the microscopic observation it is predicted that the bond between the rubber particles and the matrix makes little or no difference except to disperse the rubber particle in the matrix. The cross-section of the specimen made of Recycled rubber filler composite shows that two layers reinforced with glass woven fabric are separated with a layer made of recycled rubber and epoxy.

Conclusions

It is an attempt to use unused rubber from the tyre used in automobiles for the structural applications. The composite material of vinyl ester reinforced with glass fiber and recycled rubber with varying percentage of rubber contents are prepared by hand layup techniques. From the experimental observation it is convinced that elastic property increased with increase in filler addition and stress carrying capacity also increased. As the tyre material which is available abundantly and the use of this as filler material in composites will

definitely help to create an eco-friendly environment.

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