Evaluation Of Physical And Mechanical Properties Of Glass Fiber Reinforced Polyester Resin

Dr.P.Suresh, R.Naveen Nayaka, M.V.Manivannan

Abstract: The work reveals the effect of variation in glass fiber percentage and reinforced polyester resin percentage on mechanical properties of resulting composites. The composite was prepared using hand layup method using Mat330GSM Glass fiber mat and Isophthalic resin as reinforcement and using 1.2% Methyl Ethyl Ketone Peroxide(MEK) as a hardener. The main purpose of this project is to study the effect of different fibre composition on mechanical properties of a fibre matrix and develop a lightweight, high strength, high impact resistance for automotive design and manufacturing applications. The developed composite specimens were subjected to bending test, tensile test and impact test as per ASTM standard for evaluating their physical and mechanical properties. It was observed that the increasing fiber percentage from 40% to 50% by weight, the tensile strength increases by 41.54%, impact energy absorption increases by 75% but the bending strength decrease by 25% showcasing enhanced properties.

Index Terms: Bending strength, Composites, Glass fiber, Impact strength, Polyester resin, Polymer matrix, Tensile strength.

1 INTRODUCTION

A composite material is a hybrid material formed by combining two or more physically distinct phases resulting in some new properties which is not found in either of the parent material taken alone. The structure of composites is more complex than metal, ceramics or polymers. From technological aspects and commercial aspect composites are widely used not just that they possess distinct properties from parent material, but because of the fact that the new properties are far more superior than the properties possessed by the parent materials. Composites possess greater strength and stiffness and on the same time it can be light weight resulting in enhanced strength to weight ratios and stiffness to weight ratio which is even higher than generally used metals such as aluminum or magnesium. Composites mainly possess two phases, a matrix phase which surrounds and supports and a fiber or reinforcement phase which gives strength to composite. Composites can have better chances against corrosion than normal metals which are highly prone to one. Other engineering properties like creep, hardness, toughness, fatigue, control over surface finish and quality of look can be improved than the normal metals. With variety of composites like metal matrix composites, polymer matrix composites, ceramic matrix composites we are focused on polymer matrix composites in our studies. Polymer matrix composites are one in which metal or polymer fibers are covered with polymer matrix to form a composite [1, 8]. The composites cover large application areas starting from house hold accessories, automobiles, buildings, ships, bridges, aircrafts and even space crafts.

With such wide scope of application one starts to look out for features like interactions with water, moisture and chemicals, long life span, enhanced mechanical and physical properties, low cost of manufacturing. Experiments on water absorption effects showcases that with increase in moisture absorption the tensile and flexure properties of the material starts to decrease [4]. Composites usually might be subjected to working in harsh environments, exposure of 15 year old storage aged fiber glass polyester composite to concentrated HCL showcased, 48% decrease in tensile strength, 10% decrease in flexural strength, 16% decrease in modulus of elasticity, 10.5% decrease in elongation strength [3]. Addition of materials like TiO2 [5], CaCO3 nano particle [9], Granite powder [10] have showcased good improvements in mechanical properties. The chosen glass fiber material is preferred for reasons such as being stronger, lighter and less expensive when compared to traditional materials. Glass fibers are the most frequently used in structural construction because they have good mechanical characteristics such as high strength & Low density. It is less expensive and easily degradable.

2 EXPERIMENTAL PROCEDURE

2.1 Fabrication Process

Mat 330GSM is chosen as the fiber to be reinforced in an Isophthalic resin. With selecting the fiber and matrix next the hand layup process was used to manufacture the composite. With lot of possible modes of manufacturing like Vacuum Assisted Resin Transfer Molding (VARTM) process, Vacuum Assisted Resin Infusion (VARI) process, hand layup process was selected because of low manufacturing cost [5, 6]. The test specimens were prepared with two combinations of compositions as detailed in table 1 using hand layup technique.

Table 1: Test specimen composition

<table>
<thead>
<tr>
<th>SPECIMENS</th>
<th>GLASS FIBER (wt%)</th>
<th>ISO-RESIN (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

The flow chart of fabrication process involved is depicted in fig 1. A wooden board with clean smooth surface is used as a die for molding as shown in fig 5. In order to avoid contact with
surface and cause unnecessary damages a thin non reactive plastic sheet is covered on the mold.

The glass fibers as shown in fig 2 are weighted as per required composition, after which the glass fibers are spread across to form a matt structure as shown in fig 3. Selected Isophthalic resin has high strength, toughness and corrosion resistance. Methyl Ethyl Ketone Peroxide (MEKP) in the range of 1-2% is used as a hardener. In a clean bowl Isophthalic resin and MEKP hardener are mixed with the help of glass rod taking care of any bubble formation depicted in fig 4. With the glass fibers in mould the Isophthalic resin and MEKP hardener mixture is poured and the allowed to dry. The fabricated specimen is depicted in fig 6.

2.2 Experimental Setup
The Tensile test and Bending test were conducted using ASTM standard Universal Testing Machine (UTM) and Impact test (Charpy) were conducted using Avery type 6703, serial E65422/2 charpy impact tester in the present work[3-6]. For Tensile test with ASTM D-3039 standard specimen of 250x25x4 mm where prepared with 40% wt glass fiber in 60% wt iso resin combination and 50% wt glass fiber in 50% wt Iso
resin combinations and tested under standard loading conditions and the results were recorded. For Bending test with ASTM D-790 standard specimen of 110x25x6 mm where prepared with 40% wt glass fiber in 60% wt iso resin combination and 50% wt glass fiber in 50% wt iso resin combinations and tested under standard loading conditions and the results were recorded. For Impact test with ASTM D-256 standard specimen of 55x10x10 mm where prepared with 40% wt glass fiber in 60% wt iso resin combination and 50% wt glass fiber in 50% wt iso resin combinations and tested under standard loading conditions and the results were recorded. The dimensions of test specimens for tensile, bending and impact tests are detailed in table 2 below.

### Table 2: Test specimen detail

<table>
<thead>
<tr>
<th>Test Specimen</th>
<th>ASTM</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile test</td>
<td>D-3039</td>
<td>250x25x4 mm</td>
</tr>
<tr>
<td>Bending test</td>
<td>D-790</td>
<td>110x25x6 mm</td>
</tr>
<tr>
<td>Impact test</td>
<td>D-256</td>
<td>55x10x10 mm</td>
</tr>
</tbody>
</table>

### 3 RESULT AND DISCUSSION

#### 3.1 Tensile Test

In engineering, tension test is widely used to provide basic design information on the strength of the materials. In the tension test a specimen is subjected to a continually increasing uniaxial tensile force while simultaneous observations are made of the elongation of the specimen. Dimension of specimen are measured and recorded. One end of the specimen is fixed inside intermediate cross head and the other end in lower cross head. Dial gauge is connected to measure the elongation. The load is applied on specimen using UTM machines and the load, elongation are recorded. Once the specimen crosses yield point rapid movement of dial gauge indicator can be shown and once the maximum load is reached the indicator starts to return back and the indicator stops at fracture point. The specimen with 40% wt fiber and 60% wt resin composition resulted with maximum tensile load of 8.52KN and tensile strength of 65MPa. The specimen with 50% wt fiber and 50% wt resin composition resulted with maximum tensile load of 9.88KN and tensile strength of 92MPa.

#### 3.2 Bending Test

The specimen is placed in position with the help of fixtures and supports on UTM after taking down the dimensions. Dial indicators are set to zero and load is applied. The load at which, specimen break is recorded. The specimen with 40% wt fiber and 60% wt resin composition resulted with maximum bending load of 1.48KN and bending strength of 8MPa. The specimen with 50% wt fiber and 50% wt resin composition resulted with maximum bending load of 1.09KN and bending strength of 6MPa.

#### 3.3 Impact Test

Toughness is the ability of a material to absorb energy without breaking. Toughness is tested using impact tests. The notched specimen is supported at both ends and is placed as a beam and struck by hammer in center. The pendulum is notched and pointer is set at 300J and when lever is pulled the hammer is released, without specimen the pointer should stop at 0J, or else the machine should be calibrated. After calibration the specimen is notched and specimen is placed in position the lever is released. Hammer strikes the specimen and it consumes some energy to break the specimen. The pointer points to the energy consumed. The specimen with 40% wt fiber and 60% wt resin composition resulted with impact energy absorption of 8J and the specimen with 50% wt fiber and 50% wt resin composition resulted with impact energy absorption of 14J. The results are tabulated in table 3 and the comparisons are shown in fig 7. It can be absorbed that maximum tensile load and ultimate tensile strength of specimen 2 will be higher than the specimen 1. So increase of fiber content will increase the Tensile strength.

### Table 3: Comparison of Test results

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Fiber (%)</th>
<th>Resin (%)</th>
<th>Max Load (Kn)</th>
<th>Tensile Strength (Mpa)</th>
<th>Max Load (Kn)</th>
<th>Bending Strength (Mpa)</th>
<th>Temperature (K)</th>
<th>Absorbed Energy (Joules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>60</td>
<td>8.52</td>
<td>65</td>
<td>1.48</td>
<td>8</td>
<td>297</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>50</td>
<td>9.88</td>
<td>92</td>
<td>1.09</td>
<td>6</td>
<td>297</td>
<td>14</td>
</tr>
</tbody>
</table>

**Fig 7: Comparison of test results**

In this work, the tensile test, bending test and impact test are carried out to test the various properties of the glass fiber reinforced polyester composites material. Moreover, for better understanding the mechanical properties like microstructure, tensile strength; X-ray diffraction analysis (XRD), Energy dispersive x-ray analysis (EDAX), and scanning electron microscopy analysis (SEM) are the very important analysis to improve the study.

### 4 CONCLUSION

Glass fiber reinforced polyester composites are fabricated...
here with varying fiber wt% from 40% wt to 50% wt. Glass fiber and isophthalic resin share a good Bonding capability and results in high specific strength, low density and high toughness. The resulting composites can used for application in car body rim, chassis and other parts resulting in reducing weight and overall increase in fuel efficiency. The effects of variation in fiber percentage on mechanical properties like Tensile strength, Bending strength and Impact load were investigated. With increase in glass fiber from 40% wt to 50% wt the maximum tensile load increased by 15%, tensile strength increased by 41.54% and the impact energy absorbed by 75%. On the other hand the bending load and bending strength increased by 26.35% and 25% with increase in Iso-Resin from 40% wt to 50% wt. Increase in glass fiber percentage has reversal effect on moisture absorption, ruling it out. In future research can be carried out in finding the additives like TiO₂, CaCO₃ nano particles, granite powder to enhance the mechanical properties of a composite.

REFERENCES
[6]. Qihui Chen, Ting Linghu, Yingju Gao, Zhi Wang, Yaqing Liu, Ruikui Du, Guizhe Zhao. (2017). Mechanical properties in glass fiber PVC-foam sandwich structures from different chopped fiber interfacial reinforcement through vacuum-assisted resin transfer molding (VARTM) processing, Composites Science and Technology.


