Effect of Metakaolin on Wood Flour Polyester Composite

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Abstract:- The demand for wood products is continuously rising inspite of rapid depletion of forest around the world. Research in the area of green technology is being done to provide wood substitutes which make use of wood materials mixed with a polymer to provide a cost effective, improved performance and termite resistant material. The use of wood flour filled polymer composites has been considerably studied from the scientific and commercial point of view over the last decades. Wood flour is an attractive filler for polymer due to their reduced environmental impact and globally pleasant aesthetical properties. They are also low cost and low density material and high specific, biodegradable and non abrasive during processing. Wood reinforced polyester composite are made by mixing wood flour with polyester matrix. The composite is fabricated using compression molding technique. Prepared samples were characterized for mechanical properties and water absorption.

Key words: wood flour, polymer composites, metakaolin, reinforced

I. INTRODUCTION

The study of filling plastic composites has stimulated immense interest in meeting the future Shortage of plastic materials [1]. In fact, synthetic fibers such as nylon, rayon, aramid, glass, polyester and carbon are extensively used for the reinforcement of plastics [1-2]. Nevertheless, these materials are expensive and are non-renewable resources. Because of the uncertainties prevailing in the supply and price of petroleum based products, there is very needed to use the naturally occurring alternative. In many parts of the world, besides the agricultural purposes, different parts of plants and fruits of many crops have been found to be viable sources of raw material for industrial purpose. Fiber reinforced polymer composites have been broadly used for applications requiring high rigidity and strength [3-5]. Composites made from natural fibers are low cost and light weight and easily available and enhanced mechanical properties and free from health hazards. Despite the attractiveness of natural fiber reinforced polymer matrix composites, they suffer from lower modulus, lower strength, poor moisture, microbial and UV resistance.

Present work reveals the use of wood flour reinforced with metakaolin (filler) polyester composites. This study reports tensile strength, flexural strength and flexural modulus and water absorption study of wood flour filled-polyester composites.

II. MATERIAL AND EXPERIMENTAL PROCEDURE

2.1 Materials

2.1.1. Wood Flour

Wood flour is finely pulverized wood that has a consistency fairly equal to sand or sawdust, but can vary considerably, with particles ranging in size from a fine powder to roughly the size of a grain of rice. Most wood flour manufacturers are able to create batches of wood flour that have the same consistency throughout. All high quality wood flour is made from hardwoods because of its durability and strength. [6] WPCs refers to any composites that contain plant (including wood and non-wood) fibers and thermosets or thermoplastics. Thermosets are plastics that, once cured, cannot be melted by repeating. These include resins such as epoxies and phenolics, plastics with which the forest products industry is most familiar. Thermoplastics are plastics that can be repeatedly melted. This property allows other materials, such as wood fibers, to be mixed with the plastic to form a composite product. Polypropylene (PP), polyethylene (PE) and polyvinyl chloride (PVC) are the widely used thermoplastics for WPCs and currently they are very common in building, construction, furniture and automotive products [7]

2.1.2 Metakaolin

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume.

2.2 Preparation of composite

Compression Moulding technique is used to fabricate the hybrid composite by reinforcing wood flour and metakaolin into polyester matrix. Composite are prepared in different weight fractions (5,10,15,20,30,40). A stainless steel mould having dimensions of Cavity size: 22 x 30 x 1.0 cm is used for casting of composites. Silicon spray is used to facilitate easy removal of the composite from the mould after curing. The cast of composite is used to cured under a load of 200 kg for 24 hours before it is removed from the mould. Dimension of
specimen are cut as per ASTM standard using a diamond cutter for tensile, flexural and impact test. 

Wood flour, metakaolin and polyester resin (with hardener- methyl ethyl ketone peroxide and accelerator- cobalt naphthoate) were mixed manually in a ratio 60:40 respectively. The mixture was transferred into iron molds () and then pressed using a hydraulic press. A sample was taken out after 24 hrs.

III. MECHANICAL TESTING

Mechanical test (tensile test, flexural test and water absorption test) on the specimen of polyester and hybrid wood flour/Metakaolin reinforced polyester composite are carried out. Five separate specimen of each composite are tested and their average value is reported.

3.1 Tensile Strength

Tensile strength of composite samples was determined by following ASTM D 638 using an Instron model 3382 testing machine. Dumbbell shaped samples of composites with dimension 150x12.99x3.5 mm were tested [4]. Samples were tested to failure under tension at a crosshead speed of 1.5 mm/min. An extensometer was attached to the guage section of the sample for strain measurement. Five samples were test to checked the reproducibility of results. Tensile strength, elongation at break were recorded.

3.2 Flexural properties

Three point bending test of composite samples was performed according to ASTM D 790. Flexural test of composite samples was conducted using Instron Machine Model 3382. Rectangular samples with dimensions 80 x 10 x 3.5 mm mm were tested at a crosshead speed of 3 mm/min at room temperature. The support span for the flexural test was 51.00 mm. An average of five specimens of each type of samples was reported as a result.

3.2.1 Flexural strength

FORMULA

\[ \text{flexural strength} = \frac{3P^2}{2bd^2} \]

\( P = \) load
\( b = \) width of specimen; \( d = \) depth of specimen

Elongation = initial length-final length
initial length

\[ \text{Speed} = \frac{Zl^2}{6d} \]

\( Z = \) rate of strain
\( l = \) span length
\( d = \) depth of beam

3.2.2 Flexural Modulus

\[ EB = \frac{L^3 \times m}{4b d^3} \]

\( EB = \) Modulus of elasticity in bending, M Pa
\( L = \) Support span, mm
\( b = \) width of beam tested, mm
\( d = \) depth of beam tested, mm
\( m = \) slope of the tangent to the straight line portion of the load deflection curve, N/mm of deflection.

3.3 Water absorption

Water absorption analysis of wood flour filled composites was performed according to ASTM D 570. Pre-weighed samples were immersed in distilled water at room temperature. After 24 hrs samples were taken out and weighed. Water absorption was determined using the following equation:-

\[ WA = \frac{W_a - W_b}{W_b} \times 100 \]

\( WA = \) water absorption
\( W_a = \) weight of samples before test
\( W_b = \) weight of samples after test.
IV. RESULTS AND DISCUSSION

Graph 1. Shows Tensile strength of wood flour (W.F.) composite.

Graph 2. Shows flexural strength of wood flour (W.F.) composite.

Graph 2. Shows flexural modulus of wood flour (W.F.) composite.

Table 1. Optimization of polyester wood flour polyester composite without metakaolin

<table>
<thead>
<tr>
<th>Composition</th>
<th>Tensile strength</th>
<th>Flexural strength</th>
<th>Flexural modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.E.</td>
<td>W.F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>0</td>
<td>15.43</td>
<td>11.64</td>
</tr>
<tr>
<td>95</td>
<td>5</td>
<td>16.23</td>
<td>12.35</td>
</tr>
<tr>
<td>90</td>
<td>10</td>
<td>18.69</td>
<td>13.23</td>
</tr>
<tr>
<td>85</td>
<td>15</td>
<td>19.65</td>
<td>14.14</td>
</tr>
<tr>
<td>80</td>
<td>20</td>
<td>21.54</td>
<td>15.01</td>
</tr>
<tr>
<td>75</td>
<td>25</td>
<td>23.67</td>
<td>16.85</td>
</tr>
<tr>
<td>70</td>
<td>30</td>
<td>25.52</td>
<td>17.56</td>
</tr>
<tr>
<td>65</td>
<td>35</td>
<td>28.98</td>
<td>18.23</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>30.69</td>
<td>19.06</td>
</tr>
<tr>
<td>55</td>
<td>45</td>
<td>25.52</td>
<td>17.23</td>
</tr>
</tbody>
</table>

After the optimization all the sample were prepared in the ratio 60:40 and found that the addition of metakaolin decrease the mechanical properties.

Table 2. Wood flour polyester filled with metakaolin.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Tensile strength</th>
<th>Flexural strength</th>
<th>Flexural modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester</td>
<td>wood flour metakaolin mpa</td>
<td>mpa</td>
<td>mpa</td>
</tr>
<tr>
<td>60</td>
<td>30</td>
<td>10</td>
<td>23.69</td>
</tr>
<tr>
<td>60</td>
<td>20</td>
<td>20</td>
<td>19.27</td>
</tr>
<tr>
<td>60</td>
<td>10</td>
<td>30</td>
<td>10.9</td>
</tr>
</tbody>
</table>

Wood fiber is hydrophilic in nature due to polar –OH group in its structure. The polar group forms hydrogen bonds by absorbing water molecules and this induces swelling in fibers. Wood flour reinforced polyester samples shows 45% water absorption. Due to the small pore size the durability of metakaolin filled wood flour polyester toward water absorption is greatly increased as compared to wood flour polyester sample without particulate filler. Samples show only 1.8% water absorption after a week.

The mechanical properties are characteristic of materials that are revealed when that material is subjected to mechanical loading. Mechanical properties play a major role in material selection for suitable applications. The performance of composite materials can be evaluated by their mechanical properties. Wood floor reinforced polyester samples without filler shows 30.69 MPa, 3673.63MPa and 19.06 MPa tensile strength, flexural modulus and flexural strength respectively. Addition of metakaolin decrease the mechanical properties. Metakaolin filled wood flour polyester composite
shows 10.9 MPa, 979.89 MPa, 13.67 MPa tensile strength, flexural modulus and flexural strength respectively.

V. CONCLUSION

Now a day a lot of attention is paid to environmentally-friendly materials. This resulted in growing interest in natural lignocellulosic materials and composites based on them. Inclusion of wood flour in polyester improved the load bearing capacity (tensile strength) and the ability to withstand bending (flexural strength and modulus) but with the incorporation of metakaolin in wood flour polyester composite dramatically decrease the tensile, flexural modulus and strength and increases the water absorption.

It is concluded from the result that wood flour polyester composite is used with some reinforcing material so that it would be helpful for the material to increase its tensile and flexural strength and modulus.

REFERENCES

[3]. Agarwal BD and Broutman LJ. Analysis and performance of fiber composites, New York: Wiley and Sons (SPE Monograph); pp 355 1980