Composite laminates from jute caddies - an industrial waste

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This paper describes design and fabrication process of composite laminates from jute caddies as fibrous reinforcement to unsaturated polyester resin (UPR). Tested composite laminates are found suitable in furniture making, construction and automobile industries, and railway coach building.

Keywords: Adhesive-bonded non-woven, Composite, Jute caddies

Introduction

Jute industry processes about 1.6 million tonnes of jute reed per annum, and produces 30000-40000 tonnes of short unspinnable fibres (jute caddies, JCs) contaminated mainly with oil, grease, remnants of bark, jute stick and clay. JCs contain (oven dry wt): fibre [av. length 2.4 cm, (range 0.5-10.0 cm)], 86.0; oil & grease, 3.8; bark, root, jute stick remnants and very short fibres, 7.0; and clay & dirt, 3.2%. JCs have been tried for making hand-made papers. Jute based polyester resin composite has attracted attention of various studies, wherein jute fabric, either woven or needled, has been used as reinforcing material. Cost of such fabrics is higher (Rs 40-50/kg) in comparison to JCs (Re 1/kg). Jute fabrics, due to lack of compatibility for resin, require pretreatment to make them suitable as reinforcement for unsaturated polyester resin (UPR). Thus JCs, after some pretreatments and processing, appears suitable and cost effective as reinforcement.

This study evaluates JCs for making jute based polyester resin composites and reports development of a technology for utilizing JCs as a fibrous reinforcement for UPR composites.

Processing of JCs to Composite Laminates (CLs)

JCs were converted to CLs under following steps:

i) Scouring of Caddies

Scouring process involved treatment of JCs with a solution of a commercial detergent (2.5% on wt of JCs) containing n-hexane (0.5% on wt of JCs) at 50°C for 2 h at caddies to liquor ratio of 1:15. This was followed by washing with hot and cold water. Different degrees of scouring were achieved by varying duration of scouring. Scoured caddies were dried in air.

ii) Opening and Cleaning of Scoured Caddies

Scoured caddies were opened and cleaned in a Midhurst opener, wherein tufts of caddies were broken down by a pair of fast-rotating saw-toothed rollers having different surface speeds. Individual fibres were then blown into a collecting bag by pneumatic action. In the process, fibres became virtually free from pieces of barks, roots, jute stick remnants and very short fibres.

iii) Preparation of Adhesive-bonded Non-woven Fabric

Opened and cleaned scoured caddies consisting of short and unspinnable jute fibres were converted to fibrous webs by air-laying technique in a Birfield-Callaghan air-laying unit, which consists of a hopper-feeder, a pre-opener and a randomizing unit to convert fibres into randomized fibrous webs (area density, 250-300 g m⁻²) by mechanical and pneumatic (suction) actions. Webs were then impregnated with an aqueous dispersion of polyvinyl acetate (PVAc)(2-3%), squeezed and dried at 60°C. Three levels of application of PVAc (6, 9 and 12% on web wt) were
achieved by varying pressure during squeezing. PVAc, being compatible with UPR, were chosen as adhesive.

### iv) Fabrication of Composite Laminates (CLs)

CLs (thickness, 5 mm; size, 30 cm x 30 cm) were prepared using non-woven fabrics so prepared as the reinforcement and commercial unsaturated polyester resin (USPR), having a styrene content (35%), as matrix by standard hand lay-up technique. USPR was catalyzed with methyl ethyl ketone peroxide (1.5%) and cobalt naphthenate solution (1.5%; cobalt metal, 6%). Multiple layers of non-woven fabrics, reinforced into USPR by brush dabbing, were hydraulically pressed between steel plates (pressure, 5 kgcm⁻² at room temp. 30°C) for 45 min. In order to avoid contact between laminates and steel plates, cellophane papers were used to cover stack of resin impregnated fibrous material. Steel plates and cellophane paper were removed while taking out stack from hydraulic press. Laminates so formed were post-cured for 24 h in an oven at 80°C to get final product. CLs were also prepared using fibrous webs of scoured caddies with different oil content as reinforcements. Webs were held between polyethylene nets during impregnation with USPR to study the effect of oil content of caddies on CLs properties. USPR sheets (without fibre) were also cast using rectangular stainless steel mould under comparable conditions.

### v) Testing of Composite Laminates (CLs)

Mechanical properties of CLs and cast resin were determined in an Instron universal testing machine using rectangular test specimens (100 mm x 12 mm) cut out from laminates and cast resin sheet at random. Tensile strength and Young’s modulus under tensile stress were determined using a test length of 50 mm and a crosshead speed of 1 mm per min according to ASTM standard D-638-82. Flexural strength and Young’s modulus under flexural stress were determined using a crosshead speed of 2 mm per min as per ASTM standard D790-81. Tests (10) were conducted for each specimen and average value calculated. Resistance of CLs to water was determined by immersing flexural test specimens in water for 72 h at 35°C before subjecting them to flexural testing.

### Results

#### Effect of Oil Content of JC and fibre Content of CLs on Properties of CLs

CLs were prepared using fibrous webs of scoured caddies having three levels of oil content (0.54, 0.71 and 1.0 %). Lowering of oil content of JC (Table 1) improves mechanical and water-resistance properties of CLs. Effect of reinforcement is evident only at fibre content level of 26% and above, when strength and modulus values of CLs are higher than that of un-

### Table 1—Properties of composite laminates prepared using webs of scoured caddies having different oil content

<table>
<thead>
<tr>
<th>Fibre Content of composite % by wt</th>
<th>Density g/cc</th>
<th>Flexural strength MPa</th>
<th>Flexural Young’s Modulus GPa</th>
<th>Tensile strength MPa</th>
<th>Tensile Young’s Modulus GPa</th>
<th>Wet flexural strength MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast resin</td>
<td>0</td>
<td>1.18</td>
<td>46.20</td>
<td>2.17</td>
<td>36.06</td>
<td>2.01</td>
</tr>
<tr>
<td>Composites based on caddies having 15% oil</td>
<td>15</td>
<td>1.20</td>
<td>40.62</td>
<td>2.16</td>
<td>26.57</td>
<td>2.00</td>
</tr>
<tr>
<td>Composites based on caddies having 26% oil</td>
<td>26</td>
<td>1.20</td>
<td>47.73</td>
<td>4.28</td>
<td>30.55</td>
<td>2.56</td>
</tr>
<tr>
<td>Composites based on caddies having 35% oil</td>
<td>35</td>
<td>1.20</td>
<td>52.17</td>
<td>5.63</td>
<td>33.38</td>
<td>3.12</td>
</tr>
<tr>
<td>Composites based on caddies having 0.54% oil</td>
<td>15</td>
<td>1.20</td>
<td>41.07</td>
<td>2.19</td>
<td>27.03</td>
<td>2.02</td>
</tr>
<tr>
<td>Composites based on caddies having 0.71% oil</td>
<td>26</td>
<td>1.21</td>
<td>52.31</td>
<td>4.49</td>
<td>38.47</td>
<td>2.68</td>
</tr>
<tr>
<td>Composites based on caddies having 1.0% oil</td>
<td>35</td>
<td>1.22</td>
<td>61.71</td>
<td>5.98</td>
<td>40.11</td>
<td>3.40</td>
</tr>
</tbody>
</table>
reinforced resin sheet. However, with increasing reinforcement (jute) content in CLs, water-resistance is slightly impaired. Lowering of oil content of JCs tends to improve water-resistance of CLs.

Properties of CLs Fabricated Using Adhesive-Bonded Non-woven Fabrics Prepared from Scoured Caddies

Adhesive-bonded non-woven fabrics were prepared using scoured caddies containing oil (0.71%). CLs prepared using adhesive (polyvinyl acetate) – bonded non-woven fabrics as reinforcing substrate (Table 2) exhibit superior strength properties as compared to those based on webs of scoured caddies of similar oil content. Increase in adhesive content of non-woven fabrics (6-9%) results in increase in strength of CLs. However, a further increase in adhesive content (12%) results in only marginal improvement in strength. Hence, polyvinyl acetate adhesive content (9%) may be used to prepare such non-woven fabrics intended for fabricating CLs based on UPR.

Conclusions

Technology for designing and making CLs from JCs is presented. CLs were found suitable in furniture-making, housing, railway coach building and automobile. Machinery required for production may well be fabricated locally.

References