EXPERIMENTAL INVESTIGATION OF CORROSIVE WEAR OF BOAT DIRECTIONAL CONTROL ROD COATED WITH FIBRE COMPOSITES USING HAND LAY-UP TECHNIQUE

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Abstract—
In this present work fibre composite laminates were developed in order to minimize the corrosion of boats directional control rod. The directional control rod of fishing boat remains in the saline water during the travel and hence gets easily corroded. Our aim is to minimize the corrosion using fibre laminates. The fibres such as glass, nylon and jute fibre were chosen based on their impressive properties along with epoxy (LY556) and hardener (HY951) matrix. Hand lay-up technique was used to prepare the laminates. The prepared fibre composites were laminated over the galvanized iron rod similar to that of boats directional control rod. The corrosive wear tests such as salt spray and immersion test were conducted. The salt spray test was done for a period of 120 hours and immersion test was done for a period of 48 hours with 0.5\% and 1\% of Nacl solution. The results obtained were compared among the fibre laminates.

Keywords— Fibre composite laminates, Hand lay-up technique, Corrosion, Salt Spray Test, Immersion Test

1. INTRODUCTION

Composite laminate is an assembly of layers of fibrous materials which are joined together to provide required engineering properties. Fibre Composites are composite building materials that consist of three components (i) fibres (ii) matrix and (iii) interface. Fibre composites were developed in order to satisfy the need of eco-friendly products. The natural fibres laminates were developed using fibres as a jute, sisal, banana and Palmyra in epoxy matrix. The mechanical properties of the fibre laminates were studied [1]. Priyadarshi Tapas investigated on the abrasive wear behaviour of jute reinforced composites (chemically treated) with different weight percentages and found that the wear rate decreases with increasing sliding distance [2]. The mechanical behaviour of natural fibre composites such as jute, sisal and abaca was studied by C.Elanchezhian. He observed that jute had good flexural property compared to the other two fibres [3]. Various laminated boards were prepared using banana fibre composites by changing the number of fibre layers. The tensile strength, elongation, flexural modulus were found to be increased as the number of fibre layers increased [4]. Amal A.M Badawy experimented on the impact behaviour of glass fibre reinforced
polymer (GFRP) using Izod test. The increase in fibre volume fraction increases the impact strength [5]. The major problem in industries is the corrosion of metals. Many methods have been developed to prevent the corrosion of metals such as polymer coatings. The various techniques such as protection using polymers, nano-materials, nano composites and carbon based fibres were discussed [6]. J.M Duell developed a new method to stop external corrosion by wrapping the pipelines using fibre reinforced polymers (FRP) [7]. The damaged piping and pressure vessels were repaired using carbon-fibre/epoxy composite. This provided as a solution for the damaged parts and the tests conducted provided satisfactory results [8]. In order to replace carbon-reinforced composites Cristiano Fragassa did a case study where he laminated a yacht deck hatch using natural fibre composites [9]. Md. Shamsuddoha presented his review on fibre reinforced polymer composites for the usage in under- ground, under water and in-air applications.

Taking all this into consideration the present work is based on developing fibre composite laminates using jute, glass and nylon fibres with epoxy matrix in order to prevent corrosion and to study its corrosive wear behaviour.

2. MATERIALS AND METHODS

2.1 MATERIALS

<table>
<thead>
<tr>
<th>Fibre Material</th>
<th>Tensile Strength (Mpa)</th>
<th>Density (g/cm³)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute Fibre</td>
<td>85.5</td>
<td>1.5</td>
<td>[3]</td>
</tr>
<tr>
<td>Glass Fibre</td>
<td>47</td>
<td>2.55</td>
<td>[12]</td>
</tr>
<tr>
<td>Nylon</td>
<td>115</td>
<td>870</td>
<td>1.15</td>
</tr>
</tbody>
</table>

The materials are selected based on their unique properties. The fibres are selected from both natural and synthetic fibres. Synthetic fibres are known to be corrosion resistant while natural fibres major disadvantage is that they absorb water. Since research has been already done on jute we tried to use the fibre for lamination. The synthetic fibres chosen were glass fibre and nylon along with matrix material epoxy (LY556) and hardener (HY951).

2.1.1 GLASS FIBRE

Glass fibre consists of numerous extremely fine fibres of glass. They are known to have good thermal insulation and corrosion resistance. It is used as a reinforcing agent. It may have less strength compared to carbon fibre but is cheaper and is less brittle when used in composites.

2.1.2 NYLON

Nylon is known to be a thermoplastic silky material with better weathering properties and good specific strength. It finds its use in commercial applications.

2.1.3 JUTE FIBRE

Jute fibre is a natural fibre which is easily affordable. It is made up of cellulose and lignin. It has high tenacity and heat insulation properties.

2.1.4 EPOXY RESIN (LY556)

Epoxy resin has excellent adhesion properties along with good mechanical and electrical characteristics. It is highly resistant to chemical and atmospheric attack.

2.1.5 HARDENER (HY951)

Hardeners are not catalyst but they react with epoxy resins contributing great properties to the resins. These hardeners are responsible for the physical properties of the resins.

2.2 HAND LAY-UP TECHNIQUE
Hand lay-up technique is the oldest and simplest method for fabrication of composites. The epoxy resin is prepared with hardner and softner in the ratio of 10:1. The softner used is LY556 and the hardner used is HY951. The fibres are brushed with epoxy resin and entrapped air is removed with the help of rollers. The fibres are then coated over the galvanized iron rod and let to dry.

The hand lay-up technique is the simplest technique for processing fibre-resins into final products. It does not require specialised equipments and takes place at room temperature. After the preparation of fibre composite laminates the specimens were taken for testing. The figure 1 shows the galvanized iron rod before laminating it with fibre composites and figure 2 shows the image of the galvanized iron rod after lamination with fibre composites.

Figure 1- Photographic image of Galvanized iron rod before Lamination

Figure 2- Photographic image of Galvanized iron rod after Lamination

3. METHODOLOGY

The literature survey has been conducted to determine the research works on this field and the lack of fibre composite laminates over cylindrical rods using different fibres other than carbon fibre led to our work. The fibre composite laminates were prepared and tested for corrosive wear as depicted in our methodology. Based on the results the conclusions were drawn. The methodology as shown in fig 3 has been taken to complete the investigation.

Figure 3- Methodology

4. RESULTS AND DISCUSSION
4.1 CORROSION TESTS

The two corrosion test processes performed to determine the corrosive wear of fibre composites are as follows

1. Salt spray test
2. Immersion test

4.1.1 SALT SPRAY TEST

Salt spray test is a standard corrosion test used to determine the corrosion resistance of materials and surface coatings. It is an accelerated corrosion test which produces a corrosive attack on the material in order to determine its resistance. We have performed the salt spray test for a time period of 120 hours at ASTM B 117-16 in order to determine the corrosion resistance of fibre laminates. The testing parameters are as follows.

**TEST PARAMETERS**

- Concentration of Sodium Chloride: 5.2-5.3%
- Chamber Temperature: 33.8-35.1°C
- PH of salt solution: 6.7-6.9
- Air Pressure: 15psi
- Collection of solution per hour: 1.2-1.4 ml
- Exposure period: 120 hours

The method of cleaning the specimen before loading and after completing testing:

- a) Specimen is cleaned gently prior to loading.
- b) Specimen washed gently in clean running water to remove salt deposits from their surfaces and then dried immediately.

The figure 4 shows the image of the salt spray testing machine at which the corrosion test was performed.
The table shows the results of the salt spray test performed to determine the corrosion wear of laminates. None of the fibre laminates showed corrosion during the test.

4.1.2 IMMERSION TEST

The immersion test involves the dipping of the specimens in the Hcl or Nacl solutions for a period of 8, 12, 24 hours etc and then taken out. There may or may not be a reaction. The condition can be increased by boosting corrosion rates by increasing the pressure, salt concentration or temperature.

In our work we have performed the immersion test in two different compositions of 0.5% and 1% of Nacl solution for a time period of 48 hours. The specimens were weighed before dipping and then weighed after dipping (after 48 hours). The results obtained are as follows:

<table>
<thead>
<tr>
<th>Fibre Laminates</th>
<th>Time Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute Fibre</td>
<td></td>
</tr>
<tr>
<td>At 24 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 48 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 72 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 96 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 120 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>Glass Fibre</td>
<td></td>
</tr>
<tr>
<td>At 24 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 48 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 72 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 96 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 120 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>Nylon</td>
<td></td>
</tr>
<tr>
<td>At 24 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 48 hours</td>
<td>No Corrosion</td>
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</tr>
<tr>
<td>At 96 hours</td>
<td>No Corrosion</td>
</tr>
<tr>
<td>At 120 hours</td>
<td>No Corrosion</td>
</tr>
</tbody>
</table>

From the table it is clear that there was no change in weight of fibre laminates when dipped in 0.5% Nacl solution. But when dipped in 1% Nacl solution jute and nylon fibre laminates weight increased.

Table 3-Weight loss percentage at 0.5% NaCl composition

<table>
<thead>
<tr>
<th>Fibre laminates</th>
<th>Before testing</th>
<th>After testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute Fibre</td>
<td>22g</td>
<td>22g</td>
</tr>
<tr>
<td>Glass Fibre</td>
<td>21g</td>
<td>21g</td>
</tr>
<tr>
<td>Nylon</td>
<td>19g</td>
<td>19g</td>
</tr>
</tbody>
</table>

Table 4-Weight loss percentage at 1% NaCl composition
4.2 CONCLUSION

In this study the fibre laminated composites are prepared and checked for corrosive wear since they are to be coated for marine related application.

1. Based on this investigation we have found that the fibre laminates prepared using nylon, glass and jute fibres have good corrosion resistant characteristics.
2. Hand lay-up technique proved successful in developing the fibre laminates.
3. Jute being a neutral fibre has water absorption properties and hence absorbed water and increased in weight during the 1% NaCl immersion test.
4. Whereas nylon on the other hand was synthetic nylon and not a pure one. Hence the weight of nylon also increased after the immersion test.
5. The corrosion of the boat direction control rod can be minimized using these fibre composite laminates.

REFERENCES