E: ISSN No. 2349-9443 RNI No.UPENG/2012/42622 VOL.-8, ISSUE-1,January (Part-1) 2019
Asian Resonance

Experimental Investigation on Corrosive Wear of Hand Laid Composite Laminate for Direction Control Rod of Boat

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Abstract

The experimental study used a hand laying technique for fabricating a composite material, which has been tested further for replacing the material used for direction control rod of a boat. The aim of the experiment is to minimize the corrosion by using fibre materials. The materials used for preparing the composite material are glass, nylon and jute based on their properties along with epoxy (LY556). The hardener used was HY651matrix. The hand laying technique has been used to prepare the composite The prepare composite material were laminated over the galvanized iron rod, which was similar in shape of a direction control rod. The salt spray test has been conducted for 120 hours and immersion test was conducted for a period of 48 hours. The sodium chloride solution has been used for both the tests. The results obtained were compared with fibre laminates.

Keywords: Fibre Composite Laminates, Hand Lay-Up Technique, Corrosion, Salt Spray Test, Immersion.

Introduction

A direction control rod is a mechanism used to steer the boat which moves through the fluid medium. A direction control rod is a flat plane or sheet of a material used for turning the boat, which is almost immersed in sea water or river. Direction control rod is a part of steering mechanism of a boat or ship. The boat direction control rods are further classified into in-board and out-board direction control rods. Since direction control rod is immersed in water during sailing, the corrosive test is very essential in choosing the material for it. In general fibre materials are better corrosive resistant than metals. A composite laminate is assembly of layers of various fibre materials which are bound together to provide to properties required for a specific application. The three major components of a fibre composite are fibres, matrix, and interface. The purpose of developing fibre composite is to make the component environment friendly and corrosion resistant.

The fibres under research are jute, sisal, banana, palmyra in epoxy matrix. In all the studies the mechanical properties were studied before using it in real time applications. *Muthukar et al* [1] conducted experiments to study the mechanical properties various fibre laminates such as sisal, banana, palmyra and submitted their results.

Priyadharshi et al [2] conducted experiments to study the abrasive wear characteristics of jute reinforced composites with various weight percentages. The research concluded that the wear rate decreased with increased sliding distance. *Elanchezhian* [3] compiled a review paper on jute, sisal and abaca. All these are natural fibres and the author concluded that jute had a better flexural property when compared with other two test fires. *Baharin et al* [4] used banana fibre composites to fabricate a liminated boards. The authors have conducted various tests to determine tensile strength, elongation and flexural modulus. The researchers have reported that there was remarkable increase in all these properties with the increase of fibre layers. *Amal et al* [5] studied the behavior of glass fibre reinforced polymer in their research work. They conducted Izod test to and found that the impact behavior found to be increased with the increase in the volume of fibre material. *Murat Ates* [6] compiled a review article, and mentioned that the major problem with the materials used is corrosion. He suggested a solution that polymer coating would be a solution for that. He has discussed about few protection methodologies using nano-composites, nano-material and carbon based fibres.

J M Duell [7] wrapped the pipelines using fibre reinforced polymers and conducted tests and submitted his recommendations in his research paper. Carbon fibre epoxy composite was used to repair the affected parts of pipe line and tested for the performance.

This experimental investigation aimed to arrive at an composite material which should be corrosive and wear resistant as the material is immersed in salt water. The material should not lack in the performance characteristic as that of the conventional one. The composite laminate is being developed by using the fibres of glass, jute and nylon with epoxy matrix. The tests have been conducted with the composite material and concluding remarks.

PROPERTIES OF THE FIBRE MATERIAL

The table 1 details the properties of the fibre material before it is being used for real time application.

Table 1 Properties of Fibre Material

Material	Tensile Strength, MPa	Hardness	Density, g/cm^3
Jute	773	85.5	1.5
Glass	3445	47	2.55
Nylon	870	115	1.15

Characteristics Of Fibre Material

The table 2 gives an overall view about the materials to be used in this experimental work.

Table 2 Characteristics of Fibre Material

Material	Function	Characteristics
Glass Fibre	Reinforcing agent	Good thermal resistance Good corrosion resistance Less strength compared to carbon fibre
Nylon	Thermoplastic	Good weathering properties Good specific strength
Jute fibre	Natural fibre	Easily available Has high tenacity and heat resistant characteristic
Epoxy resin	Adhesive	Good mechanical and electrical characteristic. Has high resistance to atmospheric and chemical attack

Methodology

Hand lay-up Technique

The hand lay-up technique is the oldest methods of preparing a composite material, which is being preferred for the basic level of a research work [8]. The epoxy resin was prepared 556 with 10 parts of hardener and 1 part of softener. The figure 1 shows the galvanized iron rod without fibre coating.

Figure 1 Galvanized iron without coating

Figure 2 Fibre Composite coated Galvanized iron

The hardener used was HY951 and the softener used was LY556. The rollers was used for removal the air entrapped during the process. The prepared fibre was coated over the galvanized iron and drying process was carried out.

The whole process has been done at room temperature and it doesn't require any specialized tools and machineries. After fabrication has been completed the specimen materials have been tested for the mechanical properties. However, *Faizal et al* [9] mentioned that hand lay- up process is less effective because of non uniform pressure and force applied for laminating. Further, *Abdurohman et al* [10] suggested that vacuum infusion has composites had the higher strength and young modulus when compared to hand laid composites.

Result and Discussion

The direction control rod of the boat will be used in salt water, and hence in the experimental study it is planned to include salt spray test and immersion test. The results of these two tests have been furnished below.

Salt Spray Test

Robert et al [11] submitted a technical report mentioning that for marine applications salt fog test is useful. They have mentioned that degradation experienced by the specimens were not allowing for long term evaluation, but they have suggested for short-term behavior is sufficient to submit the report and suggest for future research. The following are the test conditions maintained during salt spray test of this experimental study.

Table 3 Test Parameters for Salt Spray Test

Description	Range
Concentration of NaCl	5.2 –5.3%
Chamber Temperature	35.1^o C – 33.8^o C
Ph value of salt solution	6.7 – 6.9
Pressure of air	15 Psi
Quantity of solution collected	1.2 – 1.4 ml per hour
Exposure period	120 hours

After the salt spraying test the specimen is washed thoroughly in clean running water to remove the salt deposits and dried immediately.

Immersion Test

Royale (2006) [12] submitted a report that biofouling is the mechanism which causes the degradation. He also mentioned that due the complex biological system, it is highly difficult to identify the biofouling. Hence he concluded that real time immersion study showed that biofouling degration can be mitigated by periodic cleaning the surface of composite material. During the immersion test, the specimens were dipped in hydrochloric acid and sodium chloride solutions for a period of 8, 12, 24 etc upto 120 hours and results were compiled. The fibre composites may or may not react with the solution.

Figure 3 Photographs of Immersion test for 48 Hoursand Samples

The figure 3 shows the photographic image of the samples, which have undergone the immersion test. The table 4 shows the weight (in gms) taken for various composites before and after the immersion test in NaCl solution (0.5%).

Table 4 Weight of fibre composite specimen (in gm)

Fibre laminates	Before testing	After testing
Jute Fibre	22g	22g
Glass Fibre	21g	21g
Nylon	19g	19g

Above table is the evidence for no weight loss percentage after the immersion test for 48 hours. The test has been continued upto 120 hours and found that there was no weight loss percentage in all three fibres.

Conclusion

In this experimental study the fibre laminated composite material for marine applications. The corrosion tests such as salt spray test and immersion tests have been conducted and the results are summarized below.

1. It is found that fibre laminates prepared using nylon, glass and jute fibres has excellent corrosion resistant characteristics.
2. It also has been proved that hand lay-up method is sufficient to prepare this laminate.
3. Jute is a natural fibre, and hence it has the water absorbing characteristics and there was a slight increase in weight during immersion test with NaCl, with 1% concentration.
4. Since the experiments used synthetic nylon, it is found that weight of nylon also increased.
5. Hence it can be concluded that the boat direction control rod can be laminated using these fibre composite material.

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