Effect of Fiber Content and Post Stress on Moisture Absorption of Jute Polyester Composite

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Abstract. Polymer composites have gained much more attention because of their lightweight, low cost, ease of fabrication, corrosion resistance, wear property etc. In this regard, natural fiber became very popular because of its biodegradability. The moisture absorption of the natural fiber reinforced polymer composites, however, causes many adverse effects on their mechanical properties as well as on long-term performance. This moisture absorbing tendency limits their uses in many engineering applications also. In this research work jute polyester composites containing 5, 10 and 15wt% jute fiber were fabricated in hand lay-up method applying various post-stress conditions and then moisture absorption tests were carried out on prepared samples. It has been found that for unstressed composites, water absorption increased linearly with increasing jute fiber content. Interestingly, with an increase in post-stress, water absorption decreased. In this regard, better results were found for composites containing a higher proportion of jute fibers.

Keyword: Jute fiber composite, Polyester, Fiber content, Post-stress, Moisture absorption.

1. Introduction

Nowadays, natural fiber composites are emerging as an alternative to replace the glass or other man-made fiber reinforced composites in many engineering applications. Natural fibers as an alternative reinforcement in polymer composites have attracted the attention of many researchers and scientists due to their advantages over conventional glass and carbon fibers [1]. Most composites have strong, stiff fibers in a matrix and in this case, the matrix is weaker and less stiff. The objective is usually to make a component which is strong and stiff, often with a low density [2]. The important driving force for such emergence of utilizing natural fibers is that they are abundant, inexpensive and biodegradable and impose no adverse effects on the environment [3].

One of the main drawbacks of using natural fibers as reinforcement is their hydrophilic nature. Polymeric materials are normally hydrophobic, so there lays an incompatibility between fiber and matrix. Due to the hydrophilic nature of natural fibers, they absorb a significant amount of moisture which has a deleterious effect on the mechanical properties of composites [4]. The influence of water uptake on the mechanical properties of jute fiber reinforced polypropylene composites was studied by A C Karmaker and co-workers [5]. They have observed that the swelling of jute fiber in composite material has a positive effect on the mechanical properties. When the fiber absorbs a small amount of water, the fibers tend to swell slightly. This results in the development of a strong mechanical interlocking between the fiber and the matrix. So at very low water absorption, the natural fiber reinforced polymer composites
show a slight increase in their mechanical properties. However, in the case, composites which were immersed in cold water for 48 hours, fibers absorb more water and swell considerably. This excess water absorption and the resultant uncontrolled swelling of the fiber leads to matrix cracking and ultimate debonding of the fiber. It has been reported that the water absorption of cellulose fiber reinforced polymer composites depends on the concentration of the fiber [6].

In order to decrease moisture absorption, fiber surface can be modified by employing chemical modifications to improve the adhesion between fiber and matrix [7]. Effect of fiber loading on moisture absorption was also studied by several researchers [8]. Effect of hybridization with glass fibers and chemical modification of fiber on moisture absorption of banana fiber/polyester composite were also studied [9]. The long-term water absorption behavior of composites with different natural fibers and polypropylene were investigated [10]. Fiber surface modification to reduce the moisture absorption of sisal/polyester was also studied [11].

In this research work effect of different fiber content on moisture absorption of continuously aligned jute fiber reinforced polyester composite was studied. Later post stress induced moisture absorption reduction was also studied.

2. Experimental

2.1 Materials and methods

In this research work, raw jute fiber was collected from local market of Bangladesh and then it was washed for removing any kind of dirt and then was dried in sun to drive away the moisture. To avoid any dissimilarity in properties of the composite, the middle portion of every jute fiber was selected so that they have the same diameter.

The polyester resin was used as the matrix material and Methyl Ethyl Ketone Peroxide was used as hardener. The pure polyester sample was fabricated using resin and hardener. For composite fabrication required amount of continuous and aligned jute fibers (10 & 15 percent by weight) were placed on the lower part of the mold and then the upper part was closed. Resin with 2% hardener was poured in the mold and after 7-10 minutes, when the resin starts to coagulate, various post stresses (0 kPa, 2.5 kPa, 5 kPa and 10 kPa) were applied. Then the whole setup was kept at room temperature for 24 hours.

2.2 Moisture Absorption Test

Three specimens were made from each sample according to ASTM 570-98 standard (76.2mm x 16mm). For moisture absorption test samples were dried in a furnace at 100°C for 3 hours. It took almost 1 hour for the furnace to reach 100°C. Counting of 3 hours of time begins just after the temperature of the furnace reaches 100°C. After heating in the furnace for 3 hours the samples were cooled for 10 minutes and then
they were kept in a container full of tap water for 6 days. After 6 days their percentage of moisture absorption was measured using following formula.

\[
\text{% Water Absorption} = \left(\frac{M_{\text{wet}} - M_{\text{dry}}}{M_{\text{dry}}} \right) \times 100
\]

2.3 Visual Inspection

Visual inspection of the samples was also done to identify any change on the surface of the samples after immersing into the water for 6 days.

3. Results and Discussion

3.1 Moisture Absorption

3.1.1 Pure Polyester Sample

Moisture absorption of pure polyester was conducted. Generally pure polyester absorbs very little amount of moisture. Average moisture absorption by pure polyester was found to be 0.7% at room temperature which matches with the result of other researchers [12].

3.1.2 Jute Polyester Composite

Moisture absorption by 5 wt% jute fiber reinforced polyester composite is found to be 1.8% which is much higher than pure polyester sample. Hydrophilic nature of jute fiber causes this excess moisture absorption. Moisture absorption of sisal and roselle fiber reinforced polyester increases linearly with increasing fiber content [13]. G Rajeshkumar and his co-workers reported the same effect for phoenix sp fiber reinforced epoxy composites [14]. This also happened in this research. Moisture absorption of 10 wt% jute fiber reinforced polyester was found to be 2.6%, 0.8% higher than 5 wt% jute fiber reinforced polyester and moisture absorption of 15 wt% jute fiber polyester was found to be 3.23%, 0.63% higher than 10 wt% jute fiber reinforced polyester. Moisture Absorption vs Fiber Content (figure 4) reveals that moisture absorption of jute fiber reinforced polyester increases almost linearly with increasing fiber content.
3.2 Effect of Post Stress
10 wt% jute fiber reinforced polyester fabricated without any post stress absorbs 2.6% moisture in room temperature. Moisture absorption was observed to decrease gradually with increasing post stress. A Avena and A R Bunsell also reported the same effect of pressure on moisture absorption by polymer composites [15]. Composite fabricated under 2.5 kPa post stress absorbs 2.33% moisture. For 5 kPa and 10 kPa post stress, it becomes 2.17% and 2.14% respectively. That means moisture absorption decreases almost 0.46% for 10 kPa post stress. Change in moisture absorption with increasing post stresses for 10 wt% jute fiber reinforced polyester can be easily visualized from figure 5.

![Figure 4: Moisture absorption vs Fiber Content](image1)

![Figure 5: Change in moisture absorption with increasing post stress for 10 wt% jute-polyester composite](image2)

Moisture absorption by jute-polyester composites with varying post stresses relative to moisture absorption by pure polyester is presented in figure 6. Relative moisture absorbed by composite fabricated under 0 kPa and 10 kPa post stresses are 371% and 306% respectively.
Composite fabricated with 15 wt% jute fiber absorbs a higher amount of moisture as mentioned before. The composite that was fabricated without any post stress absorbs 3.23% (by weight) moisture at room temperature. With increasing post stress moisture absorption decreases like the previous case and for 10 kPa post stress, it becomes 1.98%. That means moisture absorption decreases almost 1.25% for 10 kPa post stress. From figure 7 it can be seen that the decrease in moisture absorption with increasing post stress is gradual. And it decreases rapidly for a larger amount of post-stress.

![Figure 6](image_url)

**Figure 6:** Percentage of moisture absorption by jute-polyester composites fabricated under different post stresses relative to pure polyester (for 10wt% fiber content)

From the above data relative moisture absorption by jute-polyester composites fabricated under different post stresses to pure polyester is drawn and is presented in figure 7. The figure shows that relative moisture absorption decreases from 461% to 282% when post stress is increased from 0 kPa to 10 kPa. It is evident from figure 6 and 8, that the effect of post-stress on moisture absorption is more

![Figure 7](image_url)

**Figure 7:** Change in moisture absorption with increasing post stress for 15 wt% jute-polyester composite
pronounced for higher jute fiber content. It happened because in case of higher fiber content it becomes difficult for the matrix to cover all the fibers. This causes more moisture uptake by the fibers. Applying pressure causes the matrix to cover all the tiny spaces inside the composite hence reducing the moisture absorption.

So it is obvious that moisture absorption decreases with increasing post stress. This is due to the more effective impregnation of the jute fibers by the resin, which certainly occurred as a higher pressure is applied during the matrix setting. This effective impregnation causes better wetting of hydrophilic jute fibers by hydrophobic polyester resin. As a result, their moisture absorption tendency decreases as there is lesser exposed surface to absorb moisture from the atmosphere.

3.3 Visual Inspection
After 6 days when the specimens were taken out of the water it was seen that the fibers at the corners became darker than before. They absorbed water more than the fibers at the middle of the specimen and became darker.

Figure 8: Percentage of moisture absorption by jute-polyester composites fabricated under different post stresses relative to pure polyester (for 15wt% fiber content)

Figure 9: Moisture absorption test sample;
(a) Before and (b) After immersing into water
4. Conclusion

This research project aimed to investigate the change in moisture absorption of jute fiber reinforced polymer matrix composite under different post stresses for 10 wt% and 15 wt% fiber content. The outcomes of this research are as follows:

- Generally pure polyester absorbs a little amount of moisture but jute polyester composites absorb moisture in a significant amount. Moisture absorption increases with increasing fiber content.
- For both 10 wt% and 15 wt% jute fiber reinforced polyester, moisture absorption decreases with increasing post stress.
- Composites containing a higher proportion of jute fiber show better results under higher post stresses than composites with lower jute fiber content.

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