Experimental Investigation of different orientation of Glass fiber Composite Laminates with moisture content

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Abstract: Composites are the combinations of different resources mixed together to attain certain structural characteristics and properties. In composites the component materials in-fact do not dissolve totally, but they behave as one with similar evenness in the properties. However, these components interface with one another are distinguished physically. The basic lead of these materials is that the behavior and performance of the constituent composite material is much better to those of the individual materials from which it is made. In additional, the advanced composite materials are prepared with inbuilt resin matrix substances, usually the matrix phase with fiber phase with differently oriented based on the requirement are discontinuous in phase which provides to improve the material strength as well as stiffness. However, the prime problems anxious with the structural applications for the fiber reinforced plastic (FRP) components are their resistance to environment and complex loading cyclic stress. The present work focuses on studying effect of water absorption was observed on material properties of glass/epoxy samples.

Keywords: Glass fiber, polymer composites, epoxy matrix, capillary action, Moister absorption, plasticization.

1.INTRODUCTION

Composite materials are recognized as a promising class of engineering materials demonstrating new prospects for structural, automobile, aviation and many more engineering applications from the recent past. The existence of composite materials seems to be from the ages, they are naturally formed from the various natural materials and minerals present on the earth crust by the result of ongoing prolonged evolution processes. In this connection, the metal age has witnessed the pure metals, alloys, solid solutions, mixtures and compounds also, often studied under the subject called metallurgy. But in the modern age, the advancement or developmental efforts that are taking place in composites have erased the boundaries of this subject, as it is neither a pure metal or a compound, nor a mixture, but more than any of these.

Basically, the characteristics, behavior or properties of any composite material are seem to be much superior to those of the individual component materials from which it is made up of. However, the non linear behaviour of composite material is complex to understand and also very complicated with the true nature of fatigue.

The composites are chosen for certain applications such that they possess high toughness, high tensile strength, high strength to weight ratio, good rating for fatigue and high creep resistance. The above advantages paved a way to increase the utilization of the composites which are significantly influenced the production firms. It is expected to use the huge volumes of advanced composite materials such as Polymer Matrix Composites (PMC). Polymer composites filled with various metals are of interest for many fields of Engineering. The great advantage of employing PMC is the weight reduction for better fuel efficiency fatigue results and good corrosion resistance. Polymer composites are showing promising advent of the next generation material s Many factors affect the performance of engineering composite and polymer materials. This section will portray the effects of moisture and temperature on the mechanical properties of the materials used in a composite system including polymers, fibre reinforced polymer composites and adhesive joints. Not only water but moisture could also affect interface and even fibre itself significantly . Carbon fibres known for impermeable nature still absorb 0.02 wt% water .In many situations, delamination is often recognized as the most common critical and early detected defect mechanism associated for composite materials. In addition, the interface region in the filled system is susceptible to water attack and also water invades the interface due to progressive interface degradation

The factors such as moisture and temperature had very minimal effects on longitudinal properties of such unidirectional polymer composites. However, firstly it was also observed that the shear modulus and strength were not reduced by the moisture absorption, but non-linearity was increased. Secondly, the reduction of the strength in composite (transverse tensile strength) was reported to be higher than that of the neat resin. Both these phenomena come into picture due to interface degradation and residual stress induced by swelling. Most importantly, these two effects were supposed to be more rampant when test specimens were tested at room temperature or below, where the matrix behavior was more brittle. Hence, it is more important to investigate the variation in the mechanical properties of unidirectional polymer composites under environmental conditions (both humid and elevated temperatures).

2. EXPERIMENTAL MATERIALS AND METHODS

a.Specimen Fabrication

The material was taken as a woven glass fiber epoxy matrix composite laminates .The Fiber reinforcement was kept constant for each layer of glass fabric were used to fabricate composite laminates. The Identical woven glass fiber layers were selected depending on the thickness of the composite laminates and Specimen fabricated by hand lay-up process An epoxy matrix is LapoxL-12 resin and K-5 hardener was selected for making composite laminates. The volume fraction of glass fibers is approximately 60%.. The composite laminates were first cured at room temperature for 24 hrs under a pressure of 0.5MPa using a hydraulic press. The post-curing were carried out at 1100C for 5 hrs and then cooled to room temperature.

Fig-1 Specimen fabrication by hand lay-up

Figure-2 Composite laminates

Figure-3 Specimens

b. Experimental Procedure

Experimental setup is made to determine the effects of moisture content on the glass fiber composite laminates. The Specimens of different orientations 30°,45°, 60°, 0°/90^0 are immersion in water. The properties of the composite samples taken before immersion in aqueous environments such as distilled water or saline water. Now, the Specimens are placed in water tub for a certain duration to determine the properties after immersion in the water

Figure-4(a) The Specimens of 30° Orientation are immersion in the water

Figure-4(b) The Specimens of 45° Orientation are immersion in the water

Figure-4(c) The Specimens of 60° Orientation are immersion in the water

Figure-4(d) The Specimens of 0°/90^0 Orientation are immersion in the water

3.RESULTS AND DISCUSSIONS

a. Moisture Testing Result

Table 1

Fiber Orientation	Weight of specimen before immersion in water (kg) W1	Weight of specimen after immersion in water (kg) W2	% of water absorption
30°	6.1	6.1	0%
45°	6.7	6.7	0%
60°	6.7	6.7	0%
0°/90^0	9.0	9.1	1.11%

b.Corrosion Testing Result

Table 2

Fiber Orientation	Weight of specimen before immersion in water (kg) W1	Weight of specimen after immersion in water (kg) W2	% of water absorption
30°	5.7	5.7	0%
45°	6.4	6.5	1.56%
60°	5.6	5.7	1.78%
0°/90^0	8.2	8.3	1.21%

c.SEM analysis

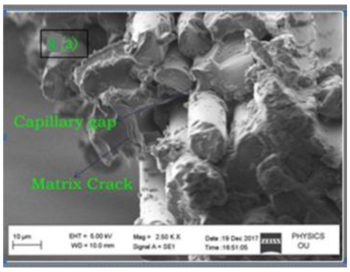

Figure5(a):SEM graph of the micro capillary tubes and matrix crack

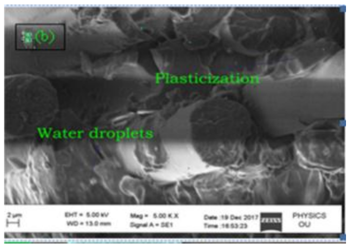

Figure-5(b) SEM graph of the water droplet sand plasticization

The failed samples are exposed to scan using SEM graphs. In the fig 5(a) the formations of micro capillary tubes in the form of gaps are observed along with a matrix crack. In the fig 5(b) water droplets are identified which caused the plasticization to occur in the matrix

4. CONCLUSIONS:

Based on the results of the moisture testing of glass fibre reinforced with epoxy resin and hardener in pure water, it can be concluded that the water absorption for 0°/90^0 is 1.11 percentage, while for 60^0, 45^0, and 30^0, the water absorption is 0 percentage. This suggests that the glass fibre reinforced with epoxy resin and hardener has a high resistance to moisture absorption, especially when the fibres are oriented at angles other than 90^0 degrees. These results can be useful in designing and manufacturing composite materials that require high moisture resistance.

Based on the corrosion testing results in the salt water, it can be concluded that the glass fiber reinforced with epoxy resin and hardener has relatively low water absorption rates. The water absorption percentage varies with the angle at which the fibre is placed, with the highest absorption rate observed at a 60^0 angle and the lowest at a 30^0 angle. Overall, the results indicate that the material is resistant to corrosion in salt water and can be considered suitable for applications in marine environments. However, further testing may be required to evaluate its long-term durability and performance under various conditions.

Efforts were also made to study the effect of preform and number of reinforcement layers on water seepage in the laminate. The results appreciated that the preform and the fiber content also plays an important role in the interfacial behaviour of the material under aging. Plasticization of the matrix causes the degradation in the matrix strength causing a change in the interfacial properties of the fiber and matrix. Due to which fiber pull out phenomena was observed in the SEM analysis of the failed samples. Micro capillary tubes were also visible which cause the water drift in the interface of the sample. The fiber – matrix interface strength reduces due to the plasticization that occurs in the matrix phase due to the presence of moister. Thus when structure is designed for the environment which is moist an optimal required layer has to be used else the performance of the structure would be affected under service.

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