Research Article

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Moisture absorption behavior of stressed and unstressed E-Glass epoxy composites under varying conditions of temperature

Abstract

In order to meet the market demands the practitioners are searching for light weight and higher strength materials at lower cost. In this context, the mechanical and structural properties of fibre reinforced plastic (FRP) satisfy the market demands and has been used worldwide for many industrial applications. But in the due course of time a composite part behaves like a sponge and absorbs moisture which leads to increase in weight and degradation of mechanical properties. This loss in mechanical properties may be due to plasticization of matrix by water and degradation of fiber-matrix interfacial bond. Hence the present study analyses the moisture absorption behavior of E-Glass epoxy Inter Laminar Shear Strength (ILSS) stressed and unstressed specimens of fiber weight fraction 60:40.

Keywords: E-glass fibres, polymer matrix composites, moisture absorption behaviour

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Saravanan R

Department of Mechanical Engineering, University Visvesvaraya College of Engineering, India

Correspondence: Saravanan R, Department of Mechanical Engineering, University Visvesvaraya College of Engineering, India, Email rsaravanan72@yahoo.com

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Introduction

Since the composites are exposed to different types of environment continuously, it is necessary for the designers to know as much as possible, about the properties of materials they use. Though the initial properties of composites are reasonably well, they do not remain constant forever. Deterioration takes place sooner or later depending on the environment they are exposed to. Composites are exposed to different types of environments such as ultraviolet radiation, low/high temperatures, and humidity (dry and wet). All these factors tend to degrade the composites' structural integrity in several ways that ultimately reduce their service life. Of these factors, humidity has been recognized to be the most detrimental factors affecting the composites performance. Moisture can penetrate the composite structure sufficiently to cause degradation effects ranging from a temporary loss of composite strength to a total or catastrophic breakdown of the composite structure.

Ideally composites are light-weight, strong and corrosion resistant. But over a long period of time a composite part behaves like a sponge and absorbs moisture which leads to increase in weight and degradation of mechanical properties. This loss in mechanical properties may be due to plasticization of matrix by water and degradation of fiber-matrix interfacial bond. The moisture absorption characterization of polymer composites is broadly governed by internal and external factors. The most important internal factors are micro-voids, cracks, molecular holes, fiber orientation angle, fiber volume fraction and fiber nature. The most important external factors are fluids, radiation, hailstones, ambient temperature, relative humidity and erosion; of these the most important are temperature and relative humidity.

Blaga & Yamasaki[1] reported for the first time, the physical deterioration of glass fiber reinforced polyester composites subjected to cyclic variations in moisture, temperature and radiation. Wright et al.[2] noted that the absorbed moisture in epoxy composites caused dimensional changes and internal stresses leading to inferior mechanical properties. Ray[3] concluded that inter laminar shear stresses is one of the important failure phenomenon dependent on the adhesiveness of the epoxy bond energies cross linkages and molecular orientations. Springer[4] noted that the moisture absorption of polymer composites changed considerably when they were exposed to sudden and large temperature variations (200-400K). Sottos et al.[5] reviewed the literature on aging of plastics and reported that the type of resin often governed the initial weathering effects as well as rate of moisture absorption. They noted that the flexible resins were generally less resistant to weathering than the rigid ones. Accordingly, the flexible resins were noted to absorb high amounts of water and exhibited poor weather resistant characteristics. Against this background after a careful analysis of various research studies conducted so far it has been observed that there is an insufficiency of literature in the moisture absorption studies of composites. Hence the present study analyses the moisture absorption behavior of E-Glass epoxy Inter Laminar Shear Strength (ILSS) stressed and unstressed specimens of fiber weight fraction 60:40.

Methodology

E-Glass ILSS stressed and unstressed specimens of fiber weight fraction 60:40 (W_2) after exposure to 55°C and - 18°C were removed for subsequent period and immersed in distilled water bath at 50°C. To study the moisture absorption behavior, specimens were placed in a constant temperature distilled water bath maintained at 50°C after taking its initial dry weights**.** The specimens were periodically taken out from the water bath to measure their weight gain as outlined below:

i. The specimens were first taken out of the bath and were placed on a filter paper. Each specimen was wiped with the filter paper to remove the free moisture adhering to its surfaces as well as the edges.

ii. The wiped specimens were weighed on an electronic balance and immediately returned to the water bath. This was done in order to minimize any possible loss of moisture from the specimen at room temperature conditions.

iii. The measured weights of the wet specimen were tabulated along with the square root of immersion time.

iv. The percentage moisture gain by the specimen was calculated by the equation as follows: $M=(W-W_d) / (W_d)*100$ where W=Weight of moist specimen, W_d=Weight of dry specimen.

The percentage moisture gain by the specimen was plotted as a function of square root of immersion time (in hours).

Results and discussions

a. Moisture gain (%) values generated for specimens of W_2 at room temperature are indicated in Table 1.

b. From the Table 2 Moisture gain (%) value generated for stressed and unstressed specimens of W_2 (exposed to +55°C± 2° for 1week), it is inferred that for the stressed specimen, the initial rate of moisture absorption and maximum moisture content is higher than that of unstressed specimen.

c. From the Table 3 Moisture gain (%) value generated for stressed and unstressed specimens of W_2 (exposed to +55°C±2° for 2weeks), it is inferred that for the stressed specimen the initial rate of moisture absorption and maximum moisture content is higher than that of unstressed specimen.

d. From the Table 4 Moisture gain (%) value generated for stressed and unstressed specimens of W_2 (exposed to -18°C±3° for 1week) it is inferred that for the stressed specimen the initial rate of moisture absorption and maximum moisture content is higher than that of unstressed specimen.

e. From the Table 5 Moisture gain (%) value generated for stressed and unstressed specimens of W_2 (exposed to -18°C±3° for 2weeks) it is inferred that for the unstressed specimen the initial rate of moisture absorption is higher than that of stressed specimen but maximum moisture content of stressed specimen is higher than the unstressed specimen.

Table 1 Moisture gain (%) and Sqrt time (hrs) for specimens of W_2 at room temperature immersed in distilled water at 50°C

Time (hrs)	Sqrt (Time)	Average moisture gain (%)
0	0	0
24	4.89	0.435
48	6.92	0.755
120	10.95	1.109
264	16.24	1.197
312	17.66	1.285
336	18.33	1.373
648	25.45	1.431
768	27.71	1.489
840	28.98	1.547
1008	31.74	1.606
1344	36.66	1.617
1512	38.88	1.619

Table 2 Moisture gain (%) and exposure time (hrs) for stressed and unstressed specimens of W_2 (exposed to +55°C±2° for 1week) immersed in distilled water at 50°C

Time (hrs)	Sqrt time (hrs)	Average moisture gain (%) of stressed specimen	Average moisture gain (%) of unstressed specimen
0	0	0	0
24	4.89	0.248	0.194
48	6.92	0.652	0.553
144	12	0.773	0.699
216	14.69	0.859	0.794
336	18.33	0.958	0.9
408	20.19	1.013	0.956
528	22.97	1.09	1.062
576	24	1.174	1.101

Table 3 Moisture gain (%) v/s exposure time (hrs) for stressed and unstressed specimen of W_2 (exposed to+ 55°C ± 2° for 2weeks) immersed in distilled water at 50°C

Time (hrs)	Sqrt time (hrs)	Average moisture gain (%) of stressed specimen	Average moisture gain (%) of unstressed specimen
0	0	0	0
24	4.89	0.244	0.19
48	6.928	0.602	0.46
144	12	0.768	0.655

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Table Continued....

Time (hrs)	Sqrt time (hrs)	Average moisture gain (%) of stressed specimen	Average moisture gain (%) of unstressed specimen
216	14.69	0.832	0.734
336	18.33	0.921	0.835
408	20.19	0.984	0.898
528	22.97	1.111	1.024
576	24	1.13	1.08

Table 4 Moisture gain (%) and exposure time (hrs) for stressed and unstressed specimens of W_2 exposed to -18°C±3° for 1week

Time (Hrs)	Sqrt time (Hrs)	Average moisture gain (%) of stressed specimen	Average moisture gain (%) of unstressed specimen
0	0	0	0
24	4.89	0.200	0.163
48	6.92	0.487	0.408
144	12	0.643	0.539
216	14.69	0.751	0.587
336	18.33	0.779	0.635
408	20.19	0.838	0.679
528	22.97	0.95	0.797
576	24	0.992	0.861

Table 5 Moisture gain (%) v/s exposure time (hrs) for stressed and unstressed specimens of W_2 (exposed to -18°C±3° for 2weeks)

Time (hrs)	Sqrt time (hrs)	Average moisture gain (%) of stressed specimen	Average moisture gain (%) of unstressed specimen
0	0	0	0
24	4.89	0.172	0.202
48	6.92	0.438	0.522
144	12	0.598	0.584
216	14.69	0.667	0.669
336	18.33	0.765	0.767
408	20.19	0.831	0.798
528	22.97	0.885	0.899
576	24	1.006	0.949

Conclusion

i. The present study has analyzed the moisture absorption behavior in E-Glass ILSS stressed and unstressed specimens of fiber weight fraction 60:40 and the results are discussed.

ii. The study can be further continued under different operating conditions.

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Conflict of interest

The author declares no conflict of interest.

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