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EFFECTS OF ACCELERATED AGEING ON THE TENSILE PERFORMANCE OF GFRP/ EPOXY COMPOSITE AND THERMOSET EPOXY

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ABSTRACT

This work discusses the tensile performance of unidirectional GFRP composite laminates, and their epoxy resin matrix, after having undergone accelerated ageing in simulated ocean water. Exposed specimens were evaluated at various stages of exposure via mechanical testing at a range of temperatures. This revealed significant differences in mechanical performance between pristine and variably aged specimens.

Keywords: accelerated ageing, PMC, GFRP, thermoset, degradation.

INTRODUCTION

Glass fibre reinforced polymers (GFRPs) are experiencing an increase in demand due to their excellent corrosion resistance, specific material strength and flexibility in manufacturing. Glass fibre is present in more than 90% of all resin/filament GRP manufacturing (K. Nalli, 2012). That being said, the durability of a material is ultimately one of the deciding factors in its use due to operational costs. Understanding the processes which influence durability is critical when designing for safety and long operating life (T. Gates, 2008). Long term exposure of GFRPs to various environments will eventually lead to irreversible changes in their performance and the effective limitation of their operating life.

Over 200 individual tests were performed. Type I thermoset resin dumbbells, and both 0° and 90° unidirectional composite specimens were prepared following the dimensions provided in ASTM D638 and D3039. A performance baseline was established after which additional specimens were exposed to simulated ocean water at 55°C, to be extracted and tested after firstly, reaching effective equilibrium (saturation), and secondly a total exposure duration of 4 months. The mechanical tests were performed at a cross-head displacement rate of 2 mm/minute and the following temperatures: 25°C, 40°C, 55°C, 68°C and 80°C, on a Zwick Z250 machine equipped with a temperature controlled chamber. The influence of both temperature and exposure time are clearly visible in the results.

RESULTS AND CONCLUSIONS

The results from the tensile tests are shown in Figure 1. It is worth noting that fibre orientation and specimen geometry have a minimal effect on the overall performance degradation trend. The aged thermoset epoxy specimen strength was found to be 10% higher on average than saturated levels. This is most likely due to a residual cross-linking effect that has continued during the exposure period, due to the elevated temperature employed. Both types of unidirectional composite laminates follow a similar pattern in terms of strength degradation.

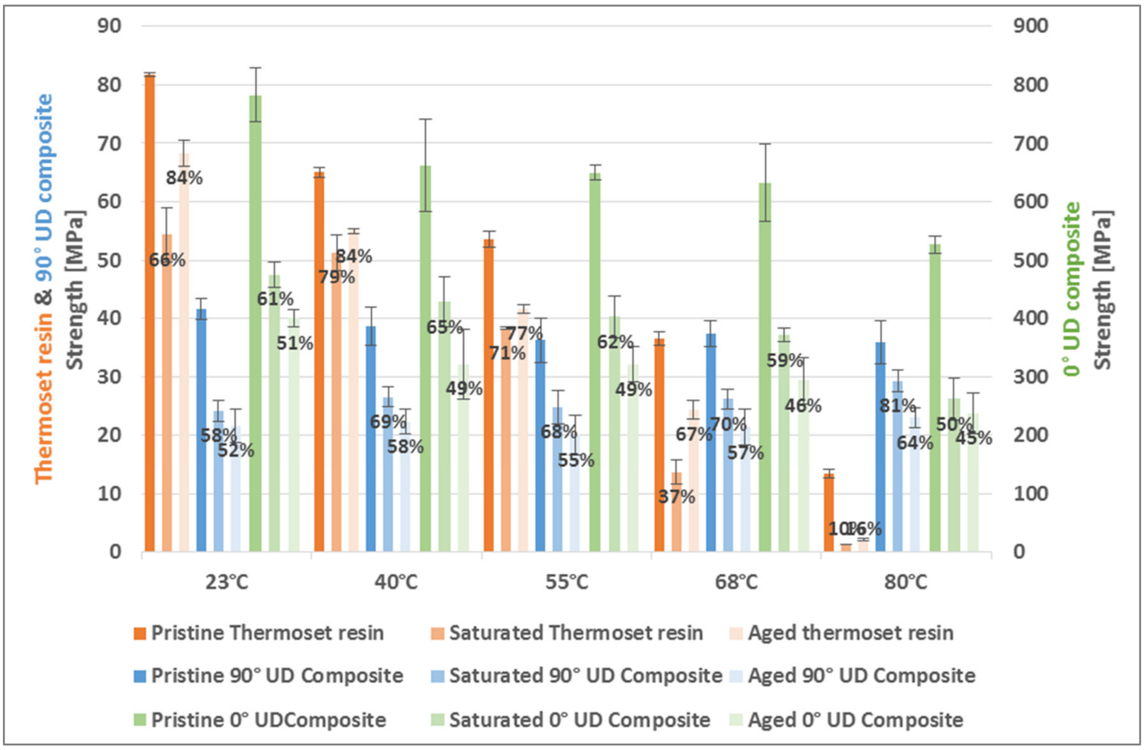

Fig. 1 - Tensile test results

This study shows the complex effect of both simulated ocean water absorption and temperature, over time, on the mechanical performance of different GFRP composite laminates. An average decrease in strength of 45 to 50% was found for the laminates, and 18% for the thermoset resin (the matrix material) in just four months of accelerated ageing. Data resulting from testing at temperatures over 55°C has not been taken into account in the aforementioned averages as the materials exhibit viscoelasticity. The results offer a good baseline in terms of data for longer term accelerated testing.

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