1. Introduction

Wave and tidal stream energy is electricity generated from the movement of wave and tidal flows. It is sustainable, environmentally friendly and much more predictable than wind power so it has great potential for future electricity provision. Polymer Matrix Composites (PMCs) are widely utilised to manufacture key components for wind energy systems due to lightness, high strength, stiffness, corrosion resistance and good manufacturability. PMCs would be ideal candidates to be used for wave and tidal stream energy sector.

It has been widely recognized that degradation of PMCs varies depending upon many parameters such as matrices, reinforcements, aging environment and manufacturing process [1, 2]. In the case of PMCs components for wave and tidal energy, they are exposed to harsh environment in which they are consistently submerged in sea water and subject to hydrostatic pressure. The knowledge of durability and degradation behaviours of PMCs in such environment is limited but is becoming increasingly important [3]. In this study, aging test on specifically formulated glass fibre reinforced epoxy composites for wave and tidal energy generator components was carried out by using increased temperature and pressure in an attempt to understand their durability and degradation behaviours.

2 Experimental

Laminate with lay-up configuration of [±45,0,±45] was manufactured by resin vacuum infusion using Momentive M135 epoxy resin and E-glass. Specimens were cut according to BS EN ISO 14130:1998 for determination of water absorption and apparent interlaminar shear strength by short-beam method. The resulting specimens were 35 mm long, 17.5 mm wide and 3.5 mm thick.

Three types of aging test were selected to investigate the degradation and durability behaviours of PMCs. They were seawater at ambient temperature and pressure, seawater at 40°C and ambient pressure and seawater at 40°C and 4 barg pressures, respectively.

Ageing tests in sea water at 40°C were set-up in a temperature controlled circulating water bath. Tests in sea water combining pressure and temperature utilised a pressure vessel using air pressure to 4 barg. This is equal to the pressure caused by the static head of 40 meters of sea water and the atmosphere, which a tidal energy device are likely to be exposed. Vessel pressure and temperature were monitored and recorded.

3 Results and Discussion

3.1 Water Absorption

Specimens were weighed and calculated before and after each periodical immersion up to 1500 hours. Fig.1 shows the water absorption behaviours of three different environmental ageing conditions. They all exhibit a rapid water up-take in the beginning of the immersion test and then a progressive increase up to 1500 hours. It also shows that temperature and pressure did intensify water absorption. Water uptake is approximately doubled when being exposed to elevated temperature under ambient pressure. This is due to the fact that water diffusion is a thermodynamic phenomenon. In the meantime, similar trend can be observed for samples being exposed to elevated pressure and temperature. Specimens with exposure to increased pressure...
absorb moisture at an increased rate compared to specimens under ambient pressure.

**Fig. 1.** Water absorption (%) as a function of time at three different ageing conditions

### 3.2 Interlaminar Shear Strength (ILSS) test

ILSS was tested on specimens which were aged for 0, 500, 1000 and 1500 hours. ILSS was calculated using equation below.

\[
ILSS = \frac{3}{4} \times \left( \frac{F_{\text{max}}}{W \times T} \right)
\]

Where: \(F\) is the failure load, \(W\) is specimen width, and \(T\) is specimen thickness.

**Fig. 2.** Comparison of ILSS versus immersion time at three different environmental ageing conditions

Fig. 2 shows a slight increase in ILSS after the first immersion period for all ageing conditions. This is subjected to further investigation. In the case of weathering at ambient temperature and pressure, the ILSS value only exhibited 2% reduction after 1500 hours of immersion while the ILSS value decreased 7% at 40°C with same immersion duration. In the case of weathering at elevated temperature and pressure, the ILSS value decreased by the most significant drop to a total of by 11% after 1500 hours. This indicates that sea water at ambient temperature has limited effect on ILSS but elevated temperature would significantly reduce the ILSS. The reduction of ILSS was further exacerbated by the combination of temperature and pressure. There is a good correlation between water absorption and reduction of ILSS but they are not in linear proportion.

### 4. Conclusions

Glass fibre reinforced epoxy composites formulated for wave and tidal energy generator components exhibited different water absorption behaviours and subsequent reductions in ILSS. More water was absorbed at elevated temperature and pressure subsequently more pronounced reduction in ILSS. The findings from this study can help to develop good understandings on durability and degradation behaviours of composites for wave and tidal energy generating components. It also indicates that temperature in combination with pressure can be employed for accelerated aging and degradation tests.

### References

