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Effects of Hygrothermal Ageing and *In-Service* Temperature on Mode I Fatigue Delamination in CFRPs

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Abstract

Studies have shown that temperature and moisture play a critical role in altering material properties, with both factors contributing to the overall degradation of structural components. This research aims to provide a deeper insight into the complex interplay between environmental factors and fatigue delamination behaviour in composite materials. To this end, the effect of hygrothermal aging and *in-service* temperature conditions on mode I fatigue delamination was investigated considering the relationship between fracture surface patterns and fatigue propagation behaviour. To investigate the effects of *in-service* temperature, Mode I delamination tests followed standardised protocols with pristine (unaged) samples tested at -40, 22, and 80ºC. Hygrothermal ageing (HA) was performed in a climatic chamber at 90ºC and 90% relative humidity for 60 days. After reaching an equilibrium moisture content of 1.2%, the samples were tested at *in-service* temperature levels of -40, 22, and 80ºC. The *in-service* humidity was set at 50% in all cases to ensure control of the absorbed moisture under the previous HA conditions. The fatigue curves were remarkbly affected by hygrothermal ageing, as a consequence of the change in the material properties. The individual effect of *in-service* temperature leads to a temperature-dependent variation in the slope of the *da/dN versus dU/dN* curves. On the other hand, hygrothermal ageing consistently reduced the slope of all curves, compared to pristine samples (Fig. 1a). The results confirm that temperature inversely affects the slope of the fatigue propagation curve, while hygrothermal ageing promotes a tougher fracture behaviour. The fractography investigation reveals that the surface roughness (Fig. 1b) follows the same trend as the *dU/dN* slope: higher slopes (lower temperature) correspond to less damage (lower tortuosity), while lower slopes (higher temperature) indicate more damage represented by hifher surface roughness.

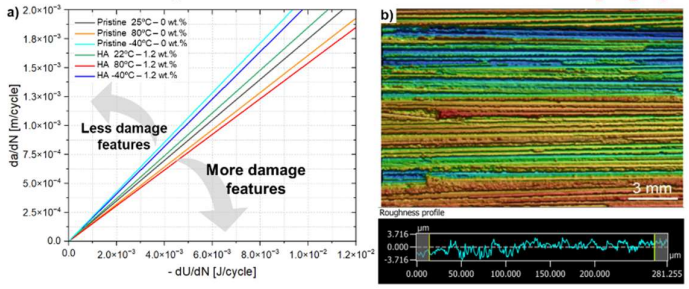

Figure 1. a) *dU/dN* vs *da/dN*, and b) surface fracture roughness.

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