FATIGUE DELAMINATION PROPAGATION IN A WOVEN MULTI-DIRECTIONAL COMPOSITE IN MODE I

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Double cantilever beam (DCB) specimens fabricated from 15 plies of a plain woven prepreg (G0814/913) arranged in a multi-directional (MD) layup were tested by means of constant amplitude fatigue cycles under displacement control. The prepreg consists of carbon fibers in an epoxy matrix. The plies were stacked in a multi-directional arrangement in which each ply was rotated by 45^0 in the ply plane with respect to each succeeding ply. Eight specimens were tested. Four different displacement cyclic ratios R_d were used, where

$$R_d = \frac{d_{min}}{d_{max}} \tag{1}$$

with d_{min} and d_{max} are the minimum and maximum displacements in a fatigue cycle. These included 0.1, 0.33, 0.5 and 0.75. It may be noted that the tests were carried out with frequencies between 4 and 6 Hz, many of them running continuously up to 3,000,000 cycles.

The delamination propagation rate da/dN was calculated from the experimental data and plotted using a modified Paris law with different functions of the mode I energy release rate $\mathcal{G}_I$. In Fig. 1a, results of the delamination propagation rate da/dN are plotted vs the range of the effective energy release rate given by

$$\Delta\hat{\mathcal{G}}_{Ieff} = \left(\sqrt{\hat{\mathcal{G}}_{Imax}} - \sqrt{\hat{\mathcal{G}}_{min}}\right)^2 \tag{2}$$

where $\hat{\mathcal{G}}_{Imax}$ and $\hat{\mathcal{G}}_{Imin}$ are, respectively, the maximum and minimum values of the mode I energy release rate which has been normalized with respect to the fracture toughness. It may be observed in Fig. 1a that there is a good correspondence between results obtained with the same R_d-ratio. But the delamination propagation rate increases as the R_d-ratio increases for a given value of $\Delta\hat{\mathcal{G}}_{Ieff}$. Using a different parameter, it is possible to obtain a master curve for all R_d-ratios. Define

$$\Delta\overline{\mathcal{K}}_I \equiv \frac{\sqrt{\hat{\mathcal{G}}_{Imax}} - \sqrt{\hat{\mathcal{G}}_{Ithr}}}{\sqrt{1-\sqrt{\hat{\mathcal{G}}_{Imax}}}} \tag{3}$$

where $\hat{\mathcal{G}}_{Ithr}$ is the normalized value of the threshold energy release rate. Using the parameter in eq. (3), it may be observed in Fig. 1b that the eight curves for different R_d-ratios unify into one master curve.

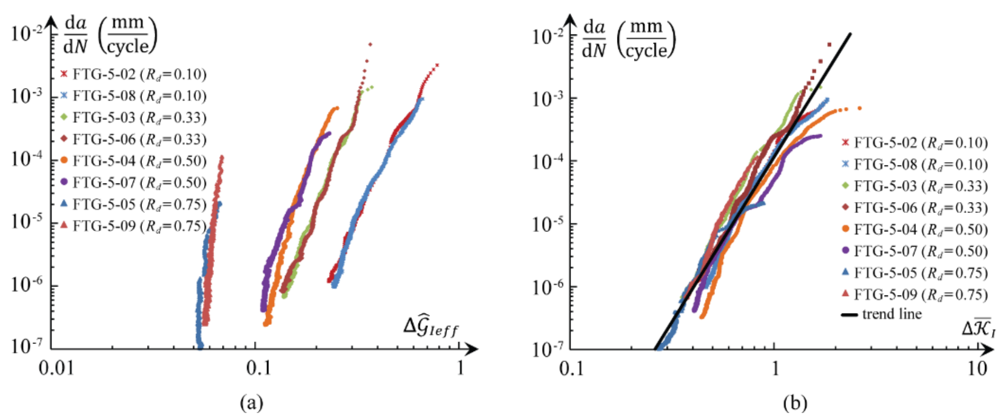

Figure 1. Delamination propagation rate as a function of (a) $\Delta\hat{\mathcal{G}}_{Ieff}$ and (b) $\Delta\overline{\mathcal{K}}_I$.