Fracture of quasi-isotropic composite sheets with sharp notches

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Abstract

Continuous fibre composites are materials that exhibit rather linear elastic deformation behaviour: suggesting brittleness and notch sensitivity. However, notched composites may sustain significant mechanical load. The notch resistance of composites is investigated on quasi-isotropic composite sheets with sharp crack like notches. This allows the use of analytic solutions of the stress field around a crack in a similar way as is used for linear elastic fracture mechanics (LEFM) in homogeneous isotropic solids. Similar to the small scale yielding boundary condition in fracture mechanics, applied on homogeneous isotropic solids, a small-scale non-linear damage condition should be fulfilled for valid LEFM application on quasi-isotropic composites. Indeed, it appeared to be possible to define critical stress intensity factors (K1c) for the quasi-isotropic composite. Moreover, K1c values can quantitatively be related to laminate parameters and to the related damage and deformation processes occurring in a small near crack tip zone with intense non-linearity and strain gradients in the thickness direction. Before the final explosive fracture occurred, stable crack growth was observed. This could be described with R-curves, as done for homogeneous metal sheet specimens. Indeed, also in this case, the R-curves were identical, independent of the length of the initial crack-like notch. The R-curves can be estimated adopting a crack-bridging model. Crack growth occurs at the notch tip in the 0° plies. The other plies bridge the fractured 0° plies. The fracture mechanisms, determining the K1c-values and the shape of the R-curve, are quite different for composites and metals. Yet, the method of fracture mechanics, well established for metals, can obviously also be applied to quasi-isotropic composites.

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