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Hybrid effects in thin ply carbon/glass unidirectional laminates: accurate experimental determination and prediction

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Abstract

Experimental results are presented which allow the hybrid effect to be evaluated accurately for thin ply carbon/epoxy-glass/epoxy interlayer hybrid composites. It is shown that there is an enhancement in strain at failure of up to 20% for very thin plies, but no significant effect for thicker plies. Hybrid specimens with thick carbon plies can therefore be used to measure the reference carbon/epoxy failure strain. The latter is significantly higher than the strain from all-carbon specimens in which there is an effect due to stress concentrations at the load introduction. Models are presented which illustrate the mechanisms responsible for the hybrid effect due to the constraint on failure at both the fibre and ply level. These results give a good understanding of how variability in the carbon fibre strengths can translate into hybrid effects in composite laminates.

Keywords: A. Carbon fibres; A. Laminates; B. Fracture; B. Fragmentation; Hybrid effect

1. Introduction

Ever since Hayashi reported in 1972 that the failure strain of the carbon fibre layers in a carbon/glass hybrid composite was 40% higher than in the reference carbon fibre composite [1] there has been much interest and controversy over the so called hybrid effect. In a recent review Swolfs et al. concluded that the effect for tensile failure strain is well established, with a typical range of 10-50%