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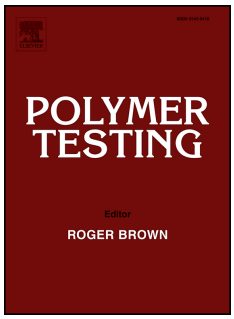

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Comparing damage from low-velocity impact and quasi-static indentation in automotive carbon/epoxy and glass/polyamide-6 laminates

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Abstract

The results of a low-velocity impact programme on both carbon/epoxy and glass/polyamide-6 composite laminates are compared to the results of quasi-static indentation. Cross-ply and quasi-isotropic stacking sequences are impacted and quasi-static indentation tests are performed up to the same maximum displacement. The response of the laminates to both test methods is compared in terms of force-displacement behaviour, dissipated energy and resulting damage. Significant differences between low-velocity impact and quasi-static indentation are found for both material systems. It is therefore concluded that the test methods cannot be interchanged for material characterisation.

Keywords: Polymer-matrix composites (PMCs); Low-velocity impact; Quasi-static indentation; Ultrasonics; Optical microscopy

1. Introduction

It is important to know the damage development sequence in composites to be able to validate predictive models and create a safe vehicle design. An impact test generally has only a short duration, making it hard to tell anything about the damage sequence. Some authors turn towards quasi-static indentation (QSI) in an attempt to overcome the difficulties, *e.g.* [2]. Compared to low-velocity impact (LVI), QSI is much easier: low acquisition rates suffice and there is an absence of oscillations. Also, a series of tests with an increasing maximum displacement can be performed to investigate the damage sequence. The standard states that QSI can be applied to *simulate the force-displacement relationships of impacts governed by boundary conditions* [4]. Many composites, however, are rate-dependent [12]. Rate-dependency invalidates the use of QSI to simulate LVI, because time becomes an important factor, as noted by the standard. Some composites only show

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