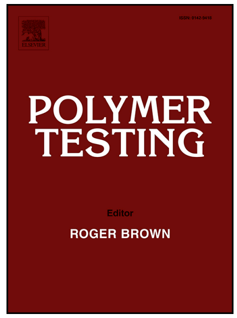
Accepted Manuscript



Damage resistance of carbon fibre reinforced epoxy laminates subjected to low velocity impact: Effects of laminate thickness and ply-stacking sequence

M.A. Caminero, I. García-Moreno, G.P. Rodríguez

PII: S0142-9418(17)31094-2

DOI: 10.1016/j.polymertesting.2017.09.016

Reference: POTE 5171

To appear in: *Polymer Testing*

Received Date: 2 August 2017

Accepted Date: 11 September 2017

Please cite this article as: M.A. Caminero, I. García-Moreno, G.P. Rodríguez, Damage resistance of carbon fibre reinforced epoxy laminates subjected to low velocity impact: Effects of laminate thickness and ply-stacking sequence, *Polymer Testing* (2017), doi: 10.1016/j.polymertesting.2017.09.016.

Damage resistance of carbon fibre reinforced epoxy laminates subjected to low velocity impact: Effects of laminate thickness and ply-stacking sequence

M.A. Caminero[a*], I.García-Moreno[a], G.P. Rodríguez[a]

[a]Escuela Técnica Superior de Ingenieros Industriales, INEI, Universidad de Castilla-La Mancha. Campus Universitario s/n, 13071-Ciudad Real, Spain
[*]Corresponding author, Email address: miguelangel.caminero@uclm.es

Abstract
A major concern affecting the efficient use of composite laminates is the effect of low velocity impact damage on the structural integrity [1-3]. The aim of this study is to characterize and assess the effect of laminate thickness, ply-stacking sequence and scaling technique on the damage resistance of CFRP laminates subjected to low velocity impact. Drop-weight impact tests are carried out to determine impact response. Ultrasonic C-scanning and cross-sectional micrographs are examined to assess failure mechanisms of the different configurations.
It is observed that damage resistance decreases as impact energy increases. In addition, thicker laminates show lower absorbed energy but, conversely, a more extensive delamination due to higher bending stiffness. Thinner laminates show higher failure depth. Furthermore, quasi-isotropic laminates show better performance in terms of damage resistance. Finally, the results obtained demonstrate that introducing ply clustering had a negative effect on the damage resistance and on the delamination area.

Keywords: Reinforced epoxy composites, impact damage resistance, stacking sequence, size-scale effects, ply clustering.

1. Introduction

Advanced fibre reinforced composites have been extensively used in high-performance structural applications, such as aeronautical, automotive and marine industries [1], [4-8]. However, the potential weight saving offered by advanced reinforced composites is still restricted by the current conservative design philosophy. This conservative approach is mainly associated with the underestimated allowable design strength due to the concern about the effect of low velocity impact damage on the performance of advanced composite laminates.

Structural components made from composites exhibit relatively brittle behaviour when they are subjected to tensile, compressive or mixed-mode loadings [6]. In addition, aircraft composite structures remain vulnerable to impact damage, such as accidental impact (vehicles and other moveable service equipment), bird strike, hailstones, tyre rubber, metal fragments, lightning strike or from deterioration caused by the absorption of moisture or hydraulic fluid. In an impact event, several types of damage occur in composite materials such as matrix cracking, fibre breakage and delamination [1], [9] leading to a reduction of load carrying capacity of the composite structure. These failure modes under low-velocity impact loading conditions are strongly dependent on the fibre type, resin type, lay-up, thickness and loading velocity. Furthermore, catastrophic failure may occur when the composite laminates are in service in such damaged state [1], [6], [8], [10]. Among the low velocity impact induced damage, delamination is the dominant failure and may cause severe degradation of the structural strength. In most cases, this type of impact leaves damage that is hardly detectable by visual inspection,