A COMPARISON OF DAMAGE MECHANISMS IN SCALED STATIC INDENTATION TESTS ON GLASS AND CARBON FIBRE LAMINATES

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ABSTRACT

The past three decades have seen a notable increase in the use of composite materials for industries such as aerospace. Applications of composites in the aerospace industry are typically to make light and strong structures. With lighter parts, fuel consumption decreases and flight duration improves. However, these materials have often been held back by susceptibility to Barely Visible Impact Damage (BVID) that can lead to a dramatic decrease in compression strength. Therefore, to design reliable composite structures, it is essential to understand and characterise the damage evolution in composites. Damage under impact has been found to be governed by many parameters [1-4] of which four are of foremost importance: in-plane dimensions, laminate thickness, lay-up configuration and material properties.

The aims of this study include analysing both global behaviour and damage evolution in low-velocity impact for different material types with different scale parameters in quasi-isotropic (QI) layups, and then using the knowledge obtained to construct efficient hybrid laminates (carbon-glass/epoxy) with advanced impact resistant. Therefore, a unique series of scaled tests are performed on QI S-glass/8552 epoxy and IM7/8552 laminates, covering scaling of in-plane dimensions and full three-dimensional scaled cases. A quasi-static indentation test configuration with close similarities to the low-velocity impact test of the ASTM D7136 standard [5] was used. For low-velocity impact, the plate can only be examined after the impact testing, therefore it is not possible to observe the succession and evolution of the degradation mechanisms during the test. Whereas, in indentation tests, it is easily possible to interrupt the tests at different stages to observe the damage evolution. Static indentation tests and low-velocity impact tests have revealed similar damage states and global behavior [6].

Mechanical and acoustic emission data collected during the test showed three distinct stages in the damage evolution: (i) an elastic regime before the initiation of delamination, (ii) initiation and propagation of delamination, and (iii) fibre breakage close to the final failure. The shape of the global loading curve of the S-glass laminates was similar to that for the IM7 carbon laminates, with load drops appearing due to the onset and propagation of delamination and final failure caused by fibre breakage. Non-destructive techniques including ultrasonic scan (C-scan) and X-ray Computed Tomography (CT scan) were used to provide a detailed assessment of the damage evolution. It was observed that the shape of delamination was influenced by the ply angles at the interface. The size and proportion of the damage mechanisms were found to be dependent on the ply thickness, in-plane dimensions and materials properties. For the laminates with thinner plies, a higher critical load for initiation of delamination was observed. The S-glass/8552 epoxy laminates had smaller load drops, higher deflection and more gradual damage propagation, compared to the IM7 carbon/8552 epoxy laminates.

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