Novel Methodology for Monitoring Skin-Stringer Delamination Growth In Thermoplastic Composite Panels

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Abstract

Thermoplastic composite specimens, representative of fuselage panels, are tested under quasi-static compressive load to investigate a novel methodology for continuously monitoring stable skin-stringer delamination growth in the post-buckling regime. The experiment is designed using finite element analysis with the objective of maximizing stable delamination growth during post-bucking. The panel has an initial delamination parallel to the stringer that exhibits stable growth until a critical load is reached that triggers the final collapse (unstable final failure).
To monitor the stable growth of the delamination during the test, a novel methodology is developed that estimates the position of the crack front based on strain concentrations on the outer mould side of the panel. These strain concentrations on the surface are measured through a multi-scale Digital Image Correlation (DIC) technique that provides a local high spatial resolution in the surroundings of the skin-stringer delamination front (1). This local 3D-DIC is complemented by a global 3D-DIC that captures displacements across the entire panel. The crack front monitoring method involves two aspects, namely (i) determining the spatial resolution required to properly capture the superficial strain concentration at the delamination fronts and (ii) the strategy for estimating the actual location of the fronts based on the measured strain data.

The accuracy of the damage characterization based on digital image correlation measurements is evaluated by comparing results with ultrasonic scans. To this end, tests are interrupted during loading, and specimens are unloaded to enable detailed characterization of damage through the thickness via ultrasonic inspection. Novel information on damage morphology such as area, location, and depth is obtained at different instances of the stable crack growth process using a portable C-Scan system. In addition to enabling validation of the DIC-based crack front monitoring method, the C-Scan data provides valuable information on damage area as a function of load, which itself is useful for calibrating and validating numerical models of crack growth.

Retrieving this experimental data is essential not only for understanding the failure behaviour of thermoplastic composites but also for calibrating and validating simulations of damage evolution in stiffened panels under post-buckling conditions.

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References:

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