Optical fibre sensor for damage monitoring in composite laminate

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Abstract:

Composite structures integrity is sensible to service life. To insure their integrity NDE evaluations are required. Acoustic emission is a nondestructive technique that allows detection in real-time of defects under evolution.

For cross-ply laminates and for uniaxial loading, the early stage of damage is dominated by transverse matrix cracking in 90° plies. Transverse matrix cracking consists on the rupture of matrix in the layers oriented at 90° in relation to the loading direction. Transverse cracks are initiated at the free edges of the test specimens and extended to the full width of the specimens almost instantaneously. After the first transverse crack occurs, the number of cracks increases progressively as the applied load is increased. As the elongation increases, crack distribution becomes uniform until a saturation state is reached and delamination, between 0° and 90° plies, appears at the free edges, together with longitudinal cracking in 0° plies and fibre fracture in 0° plies [1]. So, in those tests, the fracture process is well established.

The purpose of the present study is to monitor, by acoustic emission, transverse cracking process in glass-fibre/polyester cross-ply laminates submitted to static tests. An innovative optical fibre sensor system which has been successfully used for detection of simulated acoustic emission signals [2] is used for acoustic emission waves sensing. Acoustic emission signals are recorded from an embedded optical fibre Fabry-Pérot interferometer. Fibre Bragg gratings are used for the interrogation of the Fabry-Pérot cavity [3]. The scheme is based on the generation of two quadrature phase-shifted signals using two fibre Bragg gratings that allows the recovering of the change in the cavity length [3]. A time-frequency analysis of the signals recorded is implemented in such a way to investigate the characteristics of transverse cracking events.

Keywords: Optical fibre Fabry-Pérot interferometer, composite materials, transverse matrix cracking, acoustic emission, time-frequency.

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