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On acoustic emission for failure investigation in CFRP: Pattern recognition and peak frequency analyses

R. Gutkin [a,*], C.J. Green [a], S. Vangrattanachai [a], S.T. Pinho [a], P. Robinson [a], P.T. Curtis [b]

[a] Imperial College London, South Kensington Campus, SW7 2AZ, London, UK
[b] Physical Sciences Department, DSTL, 415 BLDG, Porton Down, SP4 0JQ, Wiltshire, UK

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ABSTRACT

This paper investigates failure in Carbon Fibre Reinforced Plastics CFRP using Acoustic Emission (AE). Signals have been collected and post-processed for various test configurations: tension, Compact Tension (CT), Compact Compression (CC), Double Cantilever Beam (DCB) and four-point bend End Notched Flexure (4-ENF).

The signals are analysed with three different pattern recognition algorithms: k-means, Self Organising Map (SOM) combined with k-means and Competitive Neural Network (CNN). The SOM combined with k-means appears as the most effective of the three algorithms. The results from the clustering analysis follow patterns found in the peak frequencies distribution.

A detailed study of the frequency content of each test is then performed and the classification of several failure modes is achieved.

1. Introduction

In metallic structures, Acoustic Emission (AE) techniques are often used as a structural health-monitoring system to detect and monitor the size and location of growing defects. In transport applications, the current trend is to replace metallic components with higher performance composite counterparts. AE techniques therefore need to be adapted to account for more intricate wave propagation features [1], caused by the orthotropic nature of composite materials, and to enable identification of a larger variety of failure modes.

AE studies typically rely on signals recorded during tensile tests of various ply orientations and lay-ups to give rise to specific failure modes [2–5]. Three main techniques are used to characterise AE signals: (i) classification according to a single parameter (typically amplitude, frequency or wavelet level), (ii) classification according to several parameters using pattern recognition techniques and (iii) classification according to the extensional and flexural mode content.

A large body of literature can be found on amplitude-based classification. Valentin et al. [2] and Berthelot and Rhazi [3] have studied amplitude distribution of AE signals collected from various tests on unidirectional and cross-ply carbon/epoxy composites. Both studies reveal contradictory amplitude ranges for the failure modes observed. Longitudinal matrix microcracking is characterised by high amplitude signals, and fibre fracture by low amplitude signals in [2], but this is in marked contrast to [3], which reports that high amplitude signals are associated with fibre failure and low amplitude signals with transverse/longitudinal matrix cracking and delamination.

* Corresponding author.
E-mail address: r.gutkin07@imperial.ac.uk (R. Gutkin).

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