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Identification of Damage Mechanisms in Interlock Reinforced Composites Using a Pattern Recognition Approach of Acoustic Emission Data

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Abstract : The latest advances in the weaving industry, combined with increasingly sophisticated means of materials processing, have made it possible to produce complex 3D composite structures. Mainly used in aeronautics, composite materials with 3D architecture offer better mechanical properties than 2D reinforced composites. Nevertheless, these materials require a good understanding of their behavior. Because of the complexity of such materials, the damage mechanisms are multiple, and the scenario of their appearance and evolution depends on the nature of the exerted solicitations. The AE technique is a well-established tool for discriminating between the damage mechanisms. Suitable sensors are used during the mechanical test to monitor the structural health of the material. Relevant AE-features are then extracted from the recorded signals, followed by a data analysis using pattern recognition techniques. In order to better understand the damage scenarios of interlock composite materials, a multi-instrumentation was set-up in this work for tracking damage initiation and development, especially in the vicinity of the first significant damage, called macro-damage. The deployed instrumentation includes video-microscopy, Digital Image Correlation, Acoustic Emission (AE) and micro-tomography. In this study, a multi-variable AE data analysis approach was developed for the discrimination between the different signal classes representing the different emission sources during testing. An unsupervised classification technique was adopted to perform AE data clustering without a priori knowledge. The multi-instrumentation and the clustered data served to label the different signal families and to build a learning database. This latter is useful to construct a supervised classifier that can be used for automatic recognition of the AE signals. Several materials with different ingredients were tested under various solicitations in order to feed and enrich the learning database. The methodology presented in this work was useful to refine the damage threshold for the new generation materials. The damage mechanisms around this threshold were highlighted. The obtained signal classes were assigned to the different mechanisms. The isolation of a 'noise' class makes it possible to discriminate between the signals emitted by damages without resorting to spatial filtering or increasing the AE detection threshold. The approach was validated on different material configurations. For the same material and the same type of solicitation, the identified classes are reproducible and little disturbed. The supervised classifier constructed based on the learning database was able to predict the labels of the classified signals.

Keywords : acoustic emission, classifier, damage mechanisms, first damage threshold, interlock composite materials, pattern recognition
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