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IDENTIFICATION OF DAMAGE MECHANISMS IN CFRP COMPOSITES BY COUPLING ACOUSTIC EMISSION AND INFRARED THERMOGRAPHY

V. MUNOZ[1], M. PERRIN[2], M.L. PASTOR[2], H. WELEMANE[1], A. CANTAREL[2] & M. KARAMA[1]

1 : Univ. Toulouse, INP-ENIT, LGP, 47 avenue d'Azereix, 65016 Tarbes, France,
victor.munozcuartas@enit.fr, helene.welemane@enit.fr, moussa.karama@enit.fr

2 : Institut Clément Ader, IUT de Tarbes, département GMP, 1 rue Lautréamont, 65016 Tarbes, France,
marianne.perrin@iut-tarbes.fr, marie-laetitia.pastor@iut-tarbes.fr, arthur.cantarel@iut-tarbes.fr

To study the mechanical behavior of CFRP composites, two methods of damage monitoring are coupled: the acoustic emission (AE) and the infrared thermography (IT). Several studies on the coupling of these two techniques have shown, for example, that it is possible to determine the fatigue strength of ceramic matrix composites under fatigue loading [1]. Other authors have shown the link between the temperature variation and the acoustic parameters evolution (like energy and the number of signals) during fatigue tests on epoxy glass composites [2] and on metallic materials [3]. The similarity of these studies concerns the kind of loading used: a cyclic loading. The aim of this study is to be able to improve the understanding and the characterization of damage mechanisms of unidirectional CFRP composites by coupling acoustic emission and infrared thermography. Besides, damage behavior of CFRP composites samples under static and cyclic loadings are compared.

The unidirectional laminate studied is composed of 14 plies of prepreg carbon-fiber with epoxy resin. The quasi-static loading is controlled by an electromechanical tensile testing machine INSTRON 100 kN. An hydraulic INSTRON machine is used for the cyclic loading. The acoustic emission monitoring is made with a MISTRAS acquisition device with a PCI8 card and the signal processing with AEwin for Samos and Noesis software. The thermal acquisition is done with a FLIR Titanium SC7000 retrofitted camera whose data are recorded and analyzed with Altair software.

During the test, many acoustic events are recorded. Besides, their shapes are very variable (frequency, amplitude, counts…). The AE characterization, particularly the damage mechanisms identification, needs a primary step of acquired data processing. The various algorithms and the number of descriptors are analyzed with Noesis software by using statistical parameters and also by comparing with thermal observations.

Concerning the thermal aspect, the temperature is not an intrinsic information because it can be influenced, for example, by boundary conditions. Nonetheless, an energetic analyze based on the heat equation allows to consider dissipation sources. For this purpose, a processing of temperature field signals is used to extract the measurement noise and the artefacts coming from derivations. Besides, the material anisotropy is included in the determination of thermal conductivity.

On this basis, AE et IT results (damage mechanisms identification and heat sources determination) are analyzed spatially and temporally. Figure 1 shows an example of this analyze. The selected event (blue arrow) matches with the fiber breakage. Figure 1b is a thermal image at the moment of the acoustic event and figure 1c presents the heat sources mapping at the same time. With different graphics, we can observe the link between acoustic events and heat sources for different ranges of amplitude and/or acoustic energy which are directly related to damage mechanisms.

This methodology is also used for fatigue loading tests. Results confirm the efficiency of the coupling of these two techniques to have a better understanding of damage mechanisms.

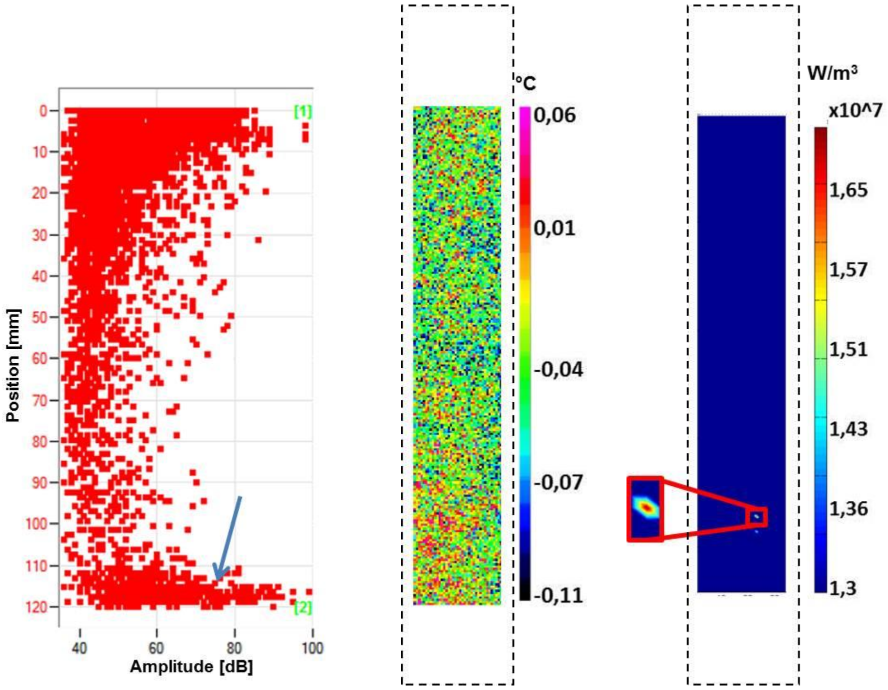

Figure 1. Temporal and spatial correlation of an acoustic event with its heat source for a CFRP composite loaded at 0°.

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