PhD thesis

Ultra-high speed imaging for the validation of accoustic wave analysis for early detection of cracks.

within e-WARNINGS ANR project: Early detection of fatigue and intermittent failure using full-field approved Acoustic Emission multiplets

Supervision

Rian Seghir, GeM Nantes, rian.seghir@ec-nantes.fr
Julien Réthoré, GeM Nantes, julien.rethore@ec-nantes.fr

Context

Fatigue, i.e the failure of mechanical structures under cycling loading, has been studied from the beginning of the industrial revolution, more than 150 years ago, owing to its importance in naval and rail industries. This failure mechanism is one of the most dangerous for engineering infrastructures and remains nowadays a considerable technological challenge as it can occur unexpectedly when the structure is operating apparently in a safe and steady state regime, without apparent sign of mechanical damage. Even if lifetime and safety prediction methodologies based on the non-destructive monitoring of mechanical properties have been proposed, the early detection and monitoring of fatigue crack growth remains a crucial challenge. A common limitation of these non-destructive methods is that they detect a modification of a physical property averaged at the scale of the structure or the component, hence are hardly sensitive to the effect of a single (or few) crack in its early stages of propagation, and faced with classical signal/noise issues. This can lead to too late alarms. We have recently reported, for the first time, in different metallic materials, the detection of acoustic emissions specific of fatigue crack growth during cyclic loading [Deschanel 2018a, Deschanel 2018b, Deschanel 2017]. These so-called acoustic multiplets are characterized by highly correlated waveforms, signature of a unique source. We interpret these AE multiplets as the specific signature of the slow, incremental propagation of a fatigue crack at each cycle or the rubbing along its faces.

Deschanel, S., W. Ben Rhouma and J. Weiss (2017). "Acoustic emission multiplets as early warnings of fatigue failure in metallic materials." Scientific Reports 7(1): 13680. web
Deschanel, S. and J. Weiss (2018a). "Contrôle de la fatigue des matériaux par émission acoustique." Les Techniques de l'Ingénieur.
Deschanel, S. and J. Weiss (2018b). "Vers une détection précoce de la rupture par fatigue par émission acoustique." Traitements & Matériaux 450: 41-44.

Objective

The main objective of the proposed thesis is to understand the origin of these multiplets, identify the physical processes involved, for different materials, under different loading conditions by means of Imaging techniques. To achieve this goal, controlled crack growth tests will be performed, in different conditions, with combined AE and DIC (digital image correlation)

monitoring. Associated with Ultra-high speed imaging of the displacement fields, we should be able to follow and analyze, from the crack tip to the AE sensor, the wave formation arising from a single crack propagation event. Several points will be developed:

- develop model experiments for analyzing single crack propagation event
- use high speed imaging to analyze experimentally, using full-field measurements, the origin of the signal acquired by AE sensors
- obtain data allowing for the validation of AE source models
- confirm that AE originate from the same mechanisms during cyclic loading

Collaboration

This thesis is part of the e-WARNINGS ANR project. The scientific and industrial consortium is composed of 4 laboratories (Mateis - INSA Lyon, GeM – EC Nantes, ISTerre – UGA-Grenoble and LaMCoS - INSA Lyon) and 1 industrial partner (Mistras Group, SAS, Sucy en Brie).

The proposed thesis will take place in the GeM laboratory, at the Centrale Nantes.

Position

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