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On the fatigue response of a bonded repaired aerospace composite using thermography

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Abstract
Lock-in thermography was employed to investigate the repair efficiency of a bonded repaired aerospace composite subjected to step-wise cycling mechanical loading. The studied component (substrate) was artificially damaged with a 5 mm circular notch and subsequently repaired with a tapered bonded patch. Critical and sub-critical damage of the repaired component was monitored via thermography during 5Hz tension-tension fatigue. The examination of the acquired thermographs enabled the identification of the patch debonding propagation as well as the quantification of the stress magnification at the patch ends and the locus of the circular notch. It was found that fatigue mechanical loading yields both thermoelastic and hysterestic phenomena with the latter being more prominent prior to the failure of the studied repaired component.

Keywords: Epoxy, Composites, Non-destructive testing, Repair, Thermography

Highlights
- Thermography was capable of identifying and monitoring the debonding of the patches (critical damage) and the subsequent failure of the repaired strips at the notched areas (subcritical damage).
- Critical failure preceded the subcritical final failure.
- Hysteretic phenomena superseded thermoelastic after the 1st significant crack incident.
- Recorded amplitude signal peaks correspond to accumulated damage or stress concentration.

1 Introduction

Fibre reinforced polymers (FRPs) are increasingly being employed for aerospace and marine structures due to their high specific stiffness and strength [1]. FRPs have also been attractive as repair elements of aircraft, civil and naval structures as they can easily be applied to geometrically complicated configurations where repair or local stiffening is needed. Bonded repair in particular, offers distinct advantages over mechanically fastened repair systems. The application of innovative repair concepts in aircrafts requires novel non-destructive techniques which will assess the repair efficiency throughout the service life of the component and subsequently establish the process reliability for airborne structures. More importantly, enabling non-destructive technologies may also guide repair methodologies away from the widely accepted "repair and forget" principle [2].

Infrared Thermography (IrT) is a non-contact, full field non-destructive technique that can be readily applied for structural integrity assessment of structures during both in-service (lab environment) and maintenance operations. By definition, IrT operates at infrared frequencies and is sensitive to both temperature and emissivity variations [3]. IrT employs the infrared radiated energy to provide information about internal defects and discontinuities [4, 5], and thus may be employed for typical inspections during maintenance. In Lock-in Thermography (LT), the thermal camera is synchronized with a periodic excitation source [6-8]. For in service applications in particular, LT is a powerful tool able to identify and follow in real time, internal damage evolution processes during cyclic mechanical loading (Figure 1) [9, 10]; in this case, the oscillating stress field can be directly acquired by monitoring the temperature variations along the surface of the loaded