The QUALIFY Project: Using infrared thermography and block loading schemes to evaluate the fatigue damage mechanisms and accumulation in hybrid adhesive joints

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Adhesives are more frequently being used to join structural components as they offer various advantages over mechanical fasteners [1]. Determining the fatigue life of hybrid adhesive joints is of great interest, particularly in aerospace and marine applications. The present work is carried out as part of the QUALIFY Project focusing on the long-term fatigue assessment of hybrid adhesive joints (WP1) and on-line monitoring (WP2). The authors investigate the damage mechanisms and accumulation in double strap adhesive joints during variable amplitude fatigue loading using infrared (IR) thermography. Sequential block loading is applied, as it is hypothesized that such load schemes allow to evaluate the non-linear nature of damage accumulation. The online monitoring of temperature distribution and evolution allows identifying different failure modes and better understand the fatigue damage evolution in hybrid adhesive joints. The hybrid adhesive joints used in this research are made from flat steel bars and CFRP laminates bonded together with a two-component methyl methacrylate (MMA) adhesive with nominal thicknesses of 4mm and 8mm.

During the variable amplitude loading of the hybrid adhesive joint, it is observed that the most significant temperature rise in the joint occurs due to cohesive damage, whilst it is much less pronounced during debonding (i.e. adhesive failure along the adherend-adhesive interface). The IR observations are cross-verified with fractography images (Figure 1) taken with a digital camera. This approach allows to avoid falsely identifying failure modes which may arise when high-resolution imaging techniques (eg. SEM) are used to study the failure surface of the joint post-mortem, as reported in [2].

Identification of the different failure modes and damage evolution in adhesive joints using IR thermography might also support the development of accurate damage models in numerical simulation tools for fatigue life prediction.

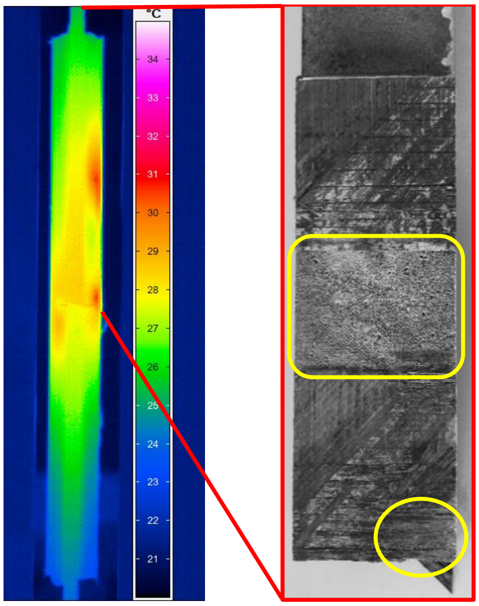

Figure 1: The thermal image (left) shows the temperature distribution in the double strap joint at around 625000 cycles during variable amplitude fatigue loading. Two regions showing higher temperature (red indications) are observed. These regions correspond to the cohesive failure regions (marked in yellow) that are observed in the factrography images (right).

References:

[1] A.J. Kinloch, "Adhesion and adhesives: Science and Technology", p.2, (Chapman & Hall, 1987).

[2] M.Davis and A.McGregor, "Assessing Adhesive Bond Failures: Mixed-Mode Bond Failures Explained 1." (2010).