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COMPARISON OF NDE TECHNIQUES FOR DAMAGE DETECTION IN FIBRE-REINFORCED COMPOSITES

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ABSTRACT

Pre-preg carbon-based fibre-reinforced composites are widely used in the aerospace industry due to their low weight and high strength. However, the occurrence of barely visible impact damage can compromise the structural integrity and potentially lead to the failure of the composite structure. Ultrasonic imaging and radiography are non-destructive evaluation (NDE) techniques widely used in industry for damage detection in fibre-reinforced composites. However, conventional radiography encounters difficulties for the detection of damage in carbon-based composites, due to the similar absorption coefficients of the different components involved. X-ray Phase Contrast imaging (XPCi) is an X-ray imaging technique that uses the phase effects induced in an X-ray beam due to the presence of an object to create improved contrast. Edge Illumination (EI) XPCi is a differential phase imaging technique, meaning it uses the refraction angle of the X-ray beam accompanying the phase change to create variations in detected intensity. This imaging technique allows for the simultaneous retrieval of three types of images: absorption, refraction, and dark field, which represents the ultra-small-angle scattering induced by features in the sub-pixel scale. In this project, EI XPCi was compared to ultrasonic immersion C-scan imaging for the detection and classification of different types of defects present in a carbon-based cross-ply sample suffering from severe impact damage. It was observed that the EI XPCi allowed to locate and identify the different types of defects present in the sample, whereas the ultrasonic imaging allowed the localization of the damage and quantification of the delamination area, but could not separate between different defects. Moreover, it was observed that the retrieval of the refraction and dark field images allowed for a better understanding of the extent of the damage in the sample, as well as a better identification of the types of damage involved. The dark field images allowed for a more accurate representation of the micro-damage accompanying the main defects that are usually detected in classic radiography. As a result, a much better understanding of the propagation of the damage on the micro-scale was achieved, as inhomogeneities that are not visible in conventional absorption radiography were observed in the areas surrounding the impact damage, thus revealing the existence of micro-damage such as micro-cracks or fibre damage.

Keywords: XPCi, radiography, ultrasound