Abstract

Non-Destructive Testing and Evaluation (NDT&E) is an inspection technique broadly used to assess a material's properties without altering its physical integrity. NDT&E is deployed across various segments of the industry for detecting the presence of defects occurring either during the manufacturing or its in-service stage in a wide variety of materials. The process of identification of defects located inside the material by mapping the surface temperature distribution without affecting its serviceability is known as Thermal Non-Destructive Testing and Evaluation (TNDT&E). TNDT&E involves capturing thermal images by mapping the temperature distribution over the test object to detect subsurface defects, cracks, moisture damage, and corrosion. The temperature mapping over the test object can be carried out in two different ways: passive and active. The limitation of passive thermography is its inability to detect defects located deep inside the test sample for which it does not provide sufficient contrast. Active thermography requires an external thermal stimulus imposed over the test object to obtain significant temperature difference and the resultant thermal response is recorded for analysis. The most commonly used active TNDT technique is Infrared Thermography (IRT) which has gained importance due to its fast, safe, remote, and full-field inspection capabilities, which allows testing of various materials regardless of their electrical and magnetic properties. Among the recently introduced IRT techniques, Frequency Modulated Thermal Wave Imaging (FMTWI) provides continuous depth scanning of the object and ensures feasibility of implementing moderate peak power heat sources in a single experimentation by probing thermal waves into the test sample. Since the captured raw thermograms are limited by insufficient contrast as well as other additive and multiplicative noises recorded during experimentation, the aim of post processing on the acquired data is to minimize the effects of non-uniform lateral heat diffusion around defective and sound regions.

The objective of this research mainly focuses on advancing pulse compression–favourable thermal wave imaging and statistical post-processing methods for automated defect detection through experimental studies on Glass Fibre Reinforced Polymer (GFRP) sample with known subsurface defects. It aims to achieve accurate quantification, localization and classification of defects through unsupervised learning while significantly reducing dependence on large training datasets.

Keywords: Non-Destructive Testing and Evaluation, Infrared Thermography, Frequency Modulated Thermal Wave Imaging, Glass Fibre Reinforced Polymer, Unsupervised Learning