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Determination of Thermal Wave Reflection Coefficient to Better Estimate Defect Depth using Pulsed Thermography

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Abstract

Thermography is a promising method for detecting subsurface defects, but accurate measurement of defect depth is still a big challenge because thermographic signals are typically corrupted by imaging noise and affected by 3D heat conduction. Existing methods based on numerical models are susceptible to signal noise and methods based on analytical models require rigorous assumptions that usually cannot be satisfied in practical applications. This paper presents a new method to improve the measurement accuracy of subsurface defect depth through determining the thermal wave reflection coefficient directly from observed data that is usually assumed to be pre-known. This target is achieved through introducing a new heat transfer model that includes multiple physical parameters to better describe the observed thermal behaviour in pulsed thermographic inspection. Numerical simulations are used to evaluate the performance of the proposed method against four selected state-of-the-art methods. Results show that the accuracy of depth measurement has been improved up to 10% when noise level is high and thermal wave reflection coefficients is low. The feasibility of the proposed method in real data is also validated through a case study on characterising flat-bottom holes in carbon fibre reinforced polymer (CFRP) laminates which has a wide application in various sectors of industry.

Keywords

Non-destructive testing (NDT); Least-squares fitting (LSF); Optimisation; 3D heat conduction; Signal-noise-ratio (SNR); composite defects;