

NDT methods to quantify Joule heating induced degradation in carbon fibre reinforced polymers.

Kwopnan M. Dikwal¹, Vedran Tunukovic¹, Ehsan Mohseni¹, Catherine E. Jones², Katherine M.M. Tant³, Randika Vithanage¹, Charles MacLeod¹, Gavin Munro⁴, Gareth S. Pierce¹

¹*SEARCH: Sensor Enabled Automation, Robotics & Control Hub, Centre for Ultrasonic Engineering (CUE), Department of Electronic & Electrical Engineering, University of Strathclyde, Royal College Building, 204 George Street, Glasgow, G1 1XW, kwopnan.dikwal@strath.ac.uk*

²*Institute for Energy and Environment, University of Strathclyde, 204 George Street, Glasgow, G1 1XW.*

³*James Watt School of Engineering, University of Glasgow, Glasgow, UK.*

⁴*Spirit AeroSystems, Aerospace Innovation Centre, Glasgow Prestwick Airport, Monkton, KA9 2RW.*

Carbon-Fibre Reinforced Plastic (CFRP) composites are extensively used for modern aerospace structures for their high strength-to-weight ratio and corrosion resistance. A parallel technology supporting decarbonisation of aviation is increased electrification of power and propulsion systems. However, due to its poorly understood electrical response, and associated mechanical degradation from Joule heating, systems design ensures that CFRP structures do not conduct electrical current. This leads to over-engineered solutions. This research develops a diagnostic framework that integrates ultrasonic Non-Destructive Evaluation (NDE) with varied electrical loading conditions for the early detection and characterization of electrical degradation in aerospace-grade CFRP. In this study, quasi-isotropic carbon-fibre/epoxy laminates were subjected to controlled electrical currents of up to 5 A, raising local temperatures to 30°C, 20°C, and 10°C below and above the glass transition temperature (T_g), of the polymer matrix. Real-time infrared thermography monitors temperature during conduction. Post-conduction phased array ultrasonic testing assesses thermal damage relative to T_g . Phased array ultrasonic testing enables waveform features from A, B and C scans to be correlated with internal damage and conductivity, non-contact, and non-destructive characterization. Visual changes and changes in electrical properties. Initial NDE results indicate threshold temperatures and associated current levels for delamination.