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Novel Strain Based NDE (SBNDE) methodology for online inspection and prognostics of composite sub-structures with manufacturing induced defects

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Background

- Current manufacturing stage inspection approaches for composite components described in [1] cannot provide details directly on how a defect may affect service life.
- To save time and reduce wastage it is essential that an inspection technology is developed that can intervene at the manufacturing stage and provide high fidelity data for model based prognostic capability.
- A novel inspection procedure for cured composite components is proposed [2] known as Strain Based NDE (SBNDE).
- A high fidelity means of obtaining local strain/stress data to inform model-based prognostics will be developed to define how a given defect will evolve under service load.

Project Aim

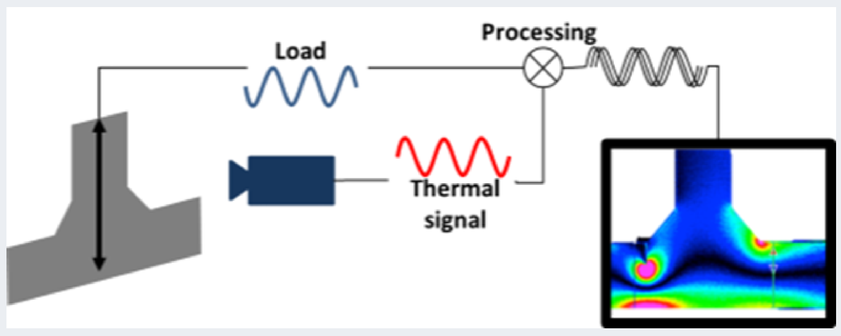
To develop a system deployed alongside current inspection approaches, e.g. [3], in the production environment.

When defects have been detected, the new technology would be deployed to determine if the component is fit for service, requires repair or is scrapped.

The system is flexible, portable, lightweight and robust. The focus of the feasibility study is to demonstrate the viability of the experimental methodology providing the data necessary for the model based prognosis system by demonstrating the viability of the approach at a sub-structural level.

The focus of the feasibility study is to demonstrate the viability of the experimental methodology (shown below) providing the data necessary for the model based prognosis system by demonstrating the viability of the approach at a sub-structural level.

Thermoelastic stress analysis (TSA)



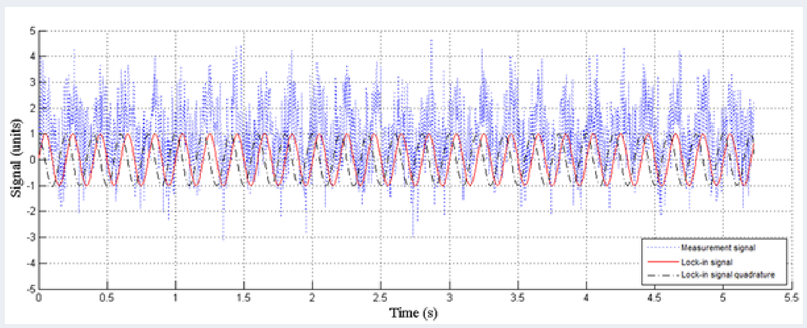
$$\Delta T = -\frac{T}{\rho C_p}\left(\alpha_1 \Delta\sigma_1 + \alpha_2 \Delta\sigma_2\right)$$

⇨ Provides a stress metric

Digital Image Correlation (DIC)

Uses surface contrast to track displacements between two images to provide the component strains ε_x, ε_y and ε_{xy}

TSA uses lock-in processing to extract ΔT from a noisy signal



Lock-in DIC (LIDIC)

Uses lock-in processing to extract strains during cyclic loading so DIC and TSA are performed simultaneously to provide $\Delta\varepsilon_x$, $\Delta\varepsilon_y$ and $\Delta\varepsilon_{xy}$ and ΔT

References

1. Adams, R.D. and Cawley, P., A review of defect types and non-destructive testing techniques for composites and bonded joints. NDT International. 21 (4) 1988, 208-222.
2. Fruehmann, R.K., Waugh, R.C. and Dulieu-Barton, J.M., A fresh look at assessing structural performance using imaging techniques. 2015 SPIE Newsroom, DOI: 10.1117/2.1201506.005788, 3 pages online.
3. Drinkwater, B.W. and Wilcox, P.D., Ultrasonic arrays for non-destructive evaluation: A review. NDT&E International. 39 (7) 2006, 525-541.

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