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FEATURE GUIDED WAVE INSPECTION OF WEDGE-LIKE COMPONENTS IN AERO ENGINES

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ABSTRACT

Aero engines comprise a number of stages between which temperature and pressure are changed to ultimately generate thrust. The thermodynamic performance of the engine is improved by seal fins; wedge shaped structures a few mm in height that run circumferentially between stages and reduce inter-stage leakage. An inspection method is required for screening of radial cracks that may arise through service in these structures.

Anti-symmetric flexural edge-modes ('edge modes') can propagate in wedge features. The waves are guided along the length of the feature with the energy localised to the apex of the tips, making them sensitive to tip defects and ensuring little attenuative leakage out of the fin structure. Despite the positive attributes of the edge wave, to date, there has been little reported use in industrial applications. This study aims to address some of the issues limiting uptake; namely determining dispersion characteristics and localization of ultrasonic energy in irregular wedge-features, and developing a means of excitation and detection.

Semi-analytical finite element (SAFE) analysis is used in order to characterise the dispersion of the edge mode in generic wedge-like structures; the seal fin has a truncated tip and is built into a larger structure, both of which introduce dispersion. A separate SAFE study is also used to evaluate leakage and anticipated sensitivity to tip defects. It is concluded that measurement frequency of around 500 kHz provides sufficient localisation and minimal dispersion.

The practical challenge in implementing edge mode inspection is the mm-scale wavelengths. In order to excite the edge mode a sub-wavelength transducer footprint is required, which in this case means excitation through effectively a single point. A pointed tip waveguide has been developed which serves this purpose and allows pulse-echo operation with conventional piezoelectric transducers and flaw detectors.

An experimental demonstration using ex-service components with machined defects is presented. The technique is now being adopted by the industrial partner, and the transfer to industry is discussed.

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