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Thursday 23 January 2025 - Session 2 - 10:42 -- Talk 8

Reconstruction of 3D Slowly Varying Thickness Waveguide Using Adiabatic Lamb Modes and Critical Thicknesses.

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In recent years, the utilisation of Additive Manufacturing (AM) processes for producing components with intricate geometries has expanded considerably. These complex 3D-printed structures frequently consist of thin shells, plates with varying thicknesses, or materials exhibiting functionally graded properties. The enhancement of Non-Destructive Testing (NDT) methods, especially with guided waves, presents a distinctive challenge, particularly when employing localised, contactless, or all-optical techniques such as laser-ultrasound. The utilisation of elastic waveguides permits the propagation of waves with complex dispersion characteristics, even in instances where the waveguides exhibit graded elasticity or non-uniform geometric features. Such properties give rise to atypical wave propagation phenomena. A substantial body of theoretical, numerical, and experimental studies has been devoted to the investigation of guided wave behaviour in free elastic plates with varying cross-sections and in graded elastic materials [1]. Nonetheless, the study of ultrasound propagation in these specific waveguides remains a relatively unexplored area of research.

The objective of this study is to deepen our understanding of the physical behaviour of adiabatic modes [2] in inhomogeneous elastic plates, with a particular focus on their adaptability to small perturbation. This study specifically examines higher-order adiabatic Lamb mode propagation in waveguides with linearly varying thickness. The analysis focuses on the impact of critical thicknesses, including cut-off ($k=0$) [3] and Zero-Group Velocity ($V_g \sim 0$) [4] thicknesses, on mode propagation. By employing a pulsed laser with broadband excitation, the study enables the generation of Lamb modes, facilitating the observation of these pivotal points. Furthermore, thickness variations in all directions introduce substantial effects on mode behaviour, imparting an “anisotropic-like” character to the plate. Leveraging the observed cut-off phenomena, this experimental approach enables accurate reconstruction of the elastic waveguide profiles in AM-plate (aluminium) exhibiting such thickness variations.

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