A study on efficient approaches for modeling Lamb wave propagation in joint metal plates with embedded defect

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Abstract

Ultrasonic Guided Wave (UGW), particularly Lamb waves propagating in plate-like media, has gained significant popularity among NDE methods for damage detection and structural health monitoring (SHM) due to its low attenuation and high frequency. Structure boundaries, discontinuities, and damages reflect or diffract Lamb waves during their travel through the structure. The UGW propagation characteristics of a structural waveguide provide information about the structure's health, defects, and locations. An SHM framework can use this function to evaluate a structure by comparing its signal to a database of potential responses and identifying damage through pattern recognition (1). This research aims to search for and present an efficient modelling approach based on the existing analytical and numerical methods for UGW propagation through damaged and scattering plates and verify the results with a high-precision full 3D elastic finite element model (FEM). In the case study, we investigate the propagation of Lamb wave through a two-piece metal plate made of steel and aluminum with an embedded circular hole. To achieve the best accuracy and efficiency, several analytical (2,3,4), semi-analytical and hybrid (5), and ray tracing approaches (6,7) will be examined, discussed, and selectively applied to the case study to model the transducer-excited ultrasonic field, the steady-state and transient propagation of UGW, and scattering at defects and boundaries. The quantitative validation of the received UGW signals is performed at different sensor locations in the case study. As the outcome of this study, we will provide an efficient and robust approach for modelling ultrasound propagation in damaged and scattering plates, which will be potentially useful in developing a digital twin to structural health monitoring.

References

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