**Defect detection in homogeneous solids and honeycomb sandwich panels using low-frequency vibration response and a statistical process**

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The inspection of thick-section sandwich structures with composite skins around various core materials (e.g., honeycomb, balsa, and foam-core) relies on low-frequency vibration inspection techniques. These techniques identify changes in a structure’s amplitude or phase response, signalling the presence of defects. However, the methodology used often has limitations, as the system is typically set up to detect specific types of defects, potentially overlooking others. Additionally, artifacts and noise are common occurrences in experiments, and they can bring about obscured defects, leading to difficulty in interpreting the results.

In this work, experiments were conducted on various test specimens, including monolithic aluminium specimens and honeycomb sandwich specimens. The 'pitch-catch' method was employed, utilising two sprung pins—one for transmitting and one for receiving—to couple the transducers to the surface of the specimen. The waveform responses of the structure were then captured on a point-by-point basis from the surface of each specimen. Subsequently, these responses were converted into the frequency domain by performing a fast Fourier transform (FFT), resulting in a 3D dataset where the third dimension corresponds to the relevant frequency spectrum of the response at each point on the specimen. Further analysis in the frequency domain was conducted based on the insights gained from an in-depth modelling study, which revealed that different defect types produce responses with different spectral information.

This work also describes a method of point-by-point classification and imaging based on statistical characterisation of the amplitudes and phases observed at the known non-defective points on the structure, compared to those observed at defective points. It employs the use of receiver operating characteristic (ROC) curves to identify frequencies that can effectively separate amplitudes and phases arising from defective points, from those arising from non-defective points on the structure. This is achieved by a combination of thresholding at 90% probability of detection (POD) and selecting only frequencies for the defect detection process that have a relatively low probability of false alarm (PFA). A pixel smoothing function is used to resolve artifacts and requires calibration for different material types. The accuracy of the method is shown to depend on correct characterisation of the non-defective distribution of amplitude and phases, as well as good calibration of the parameters of the smoothing function for different material types. Lastly, the sizes of some defects are accurately estimated on both the aluminium and composite specimens for defects larger than the pin-spacing of the probe used in the experiment. The accuracy of the defect size estimation on all specimens is influenced by the depth and size of the defect.