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Tomographic-Holographic Acousto-Optic Imaging of the 3D Nonlinear Air-Coupled Emission Field of Delaminated Composites

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Defects in plates significantly affect the local propagation characteristics of ultrasonic guided waves. Specifically, crack-like defects can introduce various non-classical nonlinear wave responses due to clapping, friction and hysteretic effects. These phenomena not only introduce nonlinear elastic wave components into the plate, but also lead to the emission of nonlinear acoustic wave components into the surrounding air. Hence, airborne nonlinear emission analysis offers potential to detect and localize defects in the plate.
In this study, SLDV measurements have been performed using the acousto-
optic principle, i.e. the SLDV probes the air column above the plate, rather than the plate surface itself. In our approach, the SLDV scans a single line at a certain distance above the plate, capturing a 1D fan-beam projection of the nonlinear emission field. The plate is mounted on a rotation stage, and multiple fan-beam projections are recorded for various rotation angles. Using the concept of computed tomography, this set of 1D fan-beam projections is used to reconstruct a 2D cross-section of the nonlinear emission field. By coupling the tomo-graphic reconstruction to acoustic holography, a 3D volumetric representation of the nonlinear emission field is obtained.
Our results show that the developed tomographic-holographic methodology is able to convert 1D measurement data to a full 3D volumetric representation, even for nonlinear emission signals having low signal-to-noise ratio. Apart from getting a direct view on the presence and location of the defect, the proposed approach allows to get further insight on the elastic and acoustic radiation behavior of nonlinearly activated defects. Results are presented from both numerical and experimental datasets obtained on composites with delamination-like defects.

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