Ultrasonic Geometrical Full Waveform Inversion of Defects

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Accurate characterisation of defects provides vital information for evaluating the remaining lifetime of critical engineering components, such as those used in the nuclear industry. Ultrasonic phased array has been successfully implemented to obtain subsurface imaging of defects and to obtain their features, such as Total focusing method (TFM), diffraction tomography and parametric manifold mapping. In this study we propose a new method that makes use of measured full waveform data to achieve fully automated and high-resolution defect inversion. The new method is called geometrical full waveform inversion (GFWI), developed in the light of the concept of full waveform inversion (FWI) from the geophysical community. Currently the majority of FWI algorithms applied in seismic or ultrasonic imaging aim to recover a spatial map of the material property, such as density or wavespeed. In Non-destructive evaluation (NDE) defects and cracks are often impenetrable; this causes difficulties in achieving targeted convergence during inversion and it requires different mathematical treatment. GFWI alternatively seeks to reconstruct the full geometry of defects following the FWI philosophy. This procedure will iteratively invert the defect until it matches the real shape. We demonstrate the successful reconstruction results using typical defect types such as voids and cracks, showing subwavelength accuracy of defect inversion/imaging. In addition, experimental results using an ultrasonic phased array are performed to further evaluate the developed method in practice.