Development of a multi-mode TFM beamforming solution for CANDU fuel channel inspection

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Ultrasonic arrays have been increasingly used in the non-destructive evaluation (NDE) field in recent years. Alongside this development, the Full Matrix Capture (FMC) technique and its related post-processing algorithms can provide improved array image quality and improved defect characterisation. This benefit comes from advanced array imaging algorithms and good understanding of acoustic wave interactions with defects and surrounding materials. In particular, FMC data allows multiple TFM images of the same structure to be formed by using different wave modes and reflections. In this paper, a procedure to optimise multi-view TFM imaging for defect detection and characterisation is developed for the inspection of CANDU fuel channels. Defects in the channels include inner surface defects such as frets, blisters and corrosion, outer surface defects such as garter spring frets, hydride blisters and surface-breaking defects on both inner and outer surfaces. In the procedure, the wave mode combinations leading to large defect scattering amplitude are chosen and the resultant scattered signals are fused for defect detection and sizing. This is demonstrated for detection and characterisation of defects from CANDU fuel channel samples. It is shown that, for some defects, typically surface-breaking defects, defect detectability and sizing accuracy can be improved using the optimised multi-mode TFM imaging algorithm and data fusion techniques.