Array imaging of austenitic stainless steel welds - does precise weld map information really improve TFM images?

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Ultrasonic inspection of austenitic stainless steel welds is a long-standing issue in the NDT community. Their complex microstructure consisting of typically coarse, needle-like grains with varying preferential orientations is responsible for a high level of scattering noise and beam deviation, making the task remarkably challenging. Although array imaging offers several advantages over the conventional inspections, the reliability of the ultrasonic images is still severely affected by the aforementioned phenomena. Over the past years several authors proposed using anisotropic delay laws for the total focusing method (TFM) to at least partially enhance image quality. However, the defect location improvement, as compared to isotropic delay laws, was often practically insignificant. In this contribution we aim at revisiting these claims by testing several typical defect locations and array configurations. Rather than quantifying location and sizing improvement, we focus on determining if and under which conditions the weld map information is essential to recover the defect signature from the noise floor. A grain-scale finite element model based on the data collected during an EBSD measurement serves as a virtual test bed, allowing us to introduce an arbitrary number and type of defects but also to capture rich physics of ultrasound propagation through such a complex medium. The excitation setups include both a single array on top of the weld and a more practical setup with the arrays on both sides of the weld. The weld map (a map of dominant orientations over a regular grid across the weld) is determined using both examinations and ultrasonic inversion and used in a ray model to compute delay laws for TFM. Based on the generated set of images for different defect configurations, we debate on the potential impact of delay laws and indicate when it is likely to provide a meaningful improvement.