Real-time adaptive plane wave imaging with dual linear array applied to the detection of cracks in welds

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Nuclear and petrochemical plants contain kilometers of piping and a large number of welds where cracks can appear. Fine controls of the integrity of pipes have to be performed regularly in order to ensure the safety of installations. Phased array ultrasonic testing is mainly used for these inspections which have to be carried out on site with difficult access to the piping. This task is particularly challenging due to the types of austenitic stainless steels that are generally used in piping which creates structural noise in the ultrasonic signals. In addition, the deformation of the surface profile in the vicinity of pipe bends leads to image reconstruction problems and the appearance of non-inspectable areas. In order to efficiently address these issues, we implemented a real-time Adaptive Plane Wave Imaging (APWI) technique using a Dual Linear Array (DLA). The Plane Wave Imaging technique provides great performances for weld inspections. It enables inspection of a large area with fine resolution, and careful selection of the range of angles to be transmitted within the medium. Unlike the standard Total Focusing Method (TFM), each plane wave excitation is generated by all transducers. Therefore, it delivers a large amount of energy inside the weld which is strongly attenuative due to the scattering. A large part of plant's piping system is straight and can be inspected efficiently with standard PWI. Nevertheless, standard technique cannot adapt to the curvature of elbow pipes that present various kind of geometries and material distortions. For these geometries, we have implemented an innovative adaptive algorithm that can be used in a DLA configuration and in real-time. A first shot of plane waves is used in pulse-echo in order to detect the surface profile and monitor the coupling. The second plane wave shot is used in pitch-catch with higher angles in order to reach the region of interest and is then reprocessed by taking the surface into account. This adaptive algorithm is compatible with the use of phase coherence techniques which offer enhanced performance for diffraction echoes detection.