High-frequency Total-focusing Method Imaging in Strongly Attenuating Materials with the Decomposition of the Time Reversal Operator Associated with Orthogonal Coded Excitations

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This communication presents a study that aims to improve the ultrasonic array imaging in High Density Polyethylene (HDPE). This material has been used in place of steel alloys in the power, petrochemical and mining industries because of its notable resistance to corrosion. The HDPE is also desirable to be used in nuclear power stations. Compared to metallic welds, the HDPE fusion welds can be considered as homogeneous and isotropic, but the high viscoelastic attenuation of the material makes the weld inspection very difficult. At high frequencies, pulse-echo images present a dramatic electronic noise introduced by the signal acquisition system.

In order to enhance the image quality, different signal acquisition strategies based on modified Walsh-Hadamard coded transmissions are presented. Then, the DORT method (French acronym for ‘decomposition of the time reversal operator’) is applied to the experimental data to remove as much noise as possible. After the noise filtering operation, the final images are calculated in the time domain with the synthetic aperture technique TFM (Total Focusing Method) that provides good resolution and contrast. The DORT method combined with coded transmissions reduces significantly the uncorrelated noise at the array excitation frequency.

In our experiment, small porosity-type defects are imaged in a HDPE fusion weld with a 5-MHz array. When the focusing TFM algorithm is applied to the data of a conventional full matrix capture, the detection is not achieved because of the strong wave attenuation (around 1 dB/mm at 5 MHz). The new image calculated with a modified Walsh-Hadamard coding combined with the DORT method exhibits a signal to noise ratio larger than 40 dB.