Anisotropic shear velocity calibration based on array measurements

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Material properties have a fundamental effect on the focal laws required for ultrasound imaging methods such as phased array (PA) and inverse wave field extrapolation (IWEX). For pipeline material, the production process based on rolling of steel sheets may lead to structural changes inducing anisotropy. This results in variation of sound velocities with varying propagation angle, which is dominant for shear waves. These speed variations need to be taken into account in calculating the focal laws. Currently, the calibration step for obtaining the shear velocities requires special blocks manufactured from the pipe material, as described in the DNV offshore standard for submarine pipelines. These blocks have parallel surfaces milled under different angles. Measurements with a special shear probe provide information on the velocities for a number of discrete angles. A physical model is fitted to these measurements to predict the anisotropic shear velocities. This former approach has several disadvantages. The fabrication of special calibration blocks is costly and time-consuming and the manual measurements result in only a few data points. It is therefore desired to replace the manual determination of velocities by measurements performed with ultrasonic arrays, which are already being used for the imaging inspection techniques. This has the advantages that there is no need to change probes and that the measurement provides data points for a range of propagation angles in the material. An algorithm has been developed to determine automatically the anisotropic shear velocities from the obtained full matrix capture, using a physical anisotropic velocity model. This new velocity calibration approach is tested and shown to be able to measure the direction-dependent shear velocities with sufficient accuracy.