46th Annual Review of Progress
in Quantitative Nondestructive Evaluation
QNDE2019
July 14-19, 2019, Portland, OR, USA

QNDE2019-1234

CRACK GROWTH MONITORING USING LOW FREQUENCY SHEAR GUIDED WAVES

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ABSTRACT

Low frequency guided waves are currently being used in pipeline corrosion monitoring because of a multitude of advantages offered, including the possession of a high inspection coverage per transducer and long-range capabilities, in comparison to conventional high frequency testing methods. However, they are not sufficiently sensitive for many crack detection applications. Recent work has shown that for a crack located in a pipe, a larger reflection signal amplitude can be obtained by measuring the backscattered waves before mode conversion into the pipe guided wave modes, as illustrated in Figure 1. This study evaluated the performance of using the fundamental shear horizontal (SH0) guided wave mode at frequencies just below the higher order cut offs, for the purpose of crack growth monitoring in critical sections of plates and plate-like structures. Baseline subtraction with temperature compensation was applied to experimental data generated by a ring of transducers on a 6-inch diameter pipe. It was found that the residual signals after baseline subtraction were normally distributed so the random fluctuations could be reduced by coherent averaging, as indicated by the solid red line in Figure 2. These results were in good agreement with values obtained by finite element simulations, given by the solid blue line in Figure 2. Therefore, it was possible to reliably detect a 2x1 mm notch, simulating a crack located one pipe diameter along the pipe from the transducer ring.

The damage detection performance at different locations along the pipe was assessed by analyzing receiver operating characteristic (ROC) curves generated by adding simulated defects to multiple experimental measurements without damage. At a fixed standoff distance, the damage detection performance increases with the square root of the number of signals averaged and is also improved by averaging the signals received by transducers covering the main lobe of the reflection from the defect. When the defect is located more than about one pipe circumference from the transducer ring, the optimum performance is obtained by averaging across all the transducers in the ring, corresponding to monitoring the T(0,1) pipe mode. Therefore, an SH0 mode monitoring system has great potential for crack monitoring in pipes and other applications because full circumferential coverage can be obtained using a modest number of transducers and the transduction system can be located up to around a pipe circumference away from the region of interest. This is likely to be attractive in, for example, monitoring crack development at welds.

Keywords: Cracks, guided waves, structural health monitoring, receiver operating characteristic

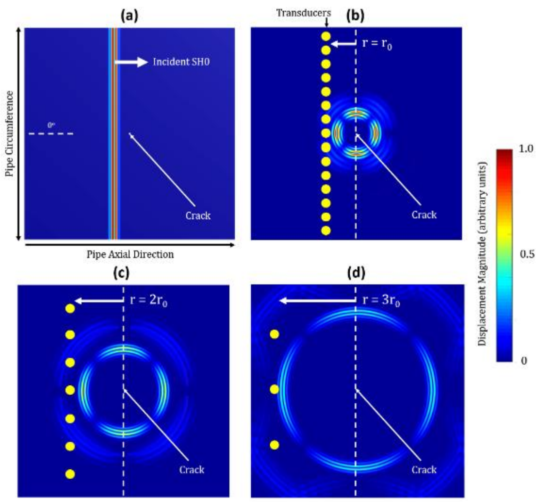

Figure 1: *Snapshot of finite element prediction of wave propagation in unrolled pipe (a) incident torsional wave (b-d) scattered field from a 2 mm x 2 mm crack, with illustration of the minimum number of transducers required for full circumferential inspection coverage, when the transducer standoff distance is equal to (b)* r_0 *(c)* $2r_0$ *and (d)* $3r_0$ *where* r_0 *is the pipe radius of a 8" pipe with 10 mm wall thickness.*

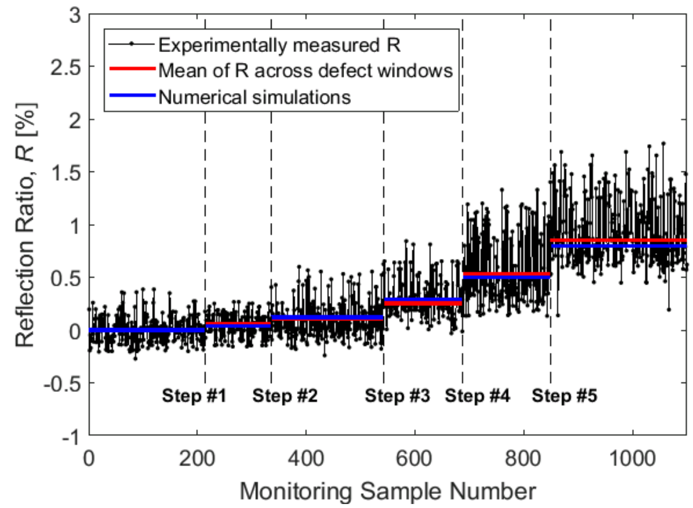

Figure 2: *Plots of SH0 reflection ratio, R, from a single receiving transducer against monitoring sample number over the entire experiment period in a 1.2 m long, 6-inch nominal bore steel pipe (NPS6 Schedule 80/XS ASTM A106-B) with an 11 mm thick wall.*