Non-Destructive Testing of Fuel Storage Tanks Using Nonlinear Guided Waves

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Storage tanks are essential facilities within the petrochemical industry, with most of these tanks being constructed by welding bottom plates and shell plates. These welded regions become progressively corrosion vulnerable due to external and internal environmental factors. The resultant metal loss at the tank's bottom is typically a significant defect beneath the welding joints and is often challenging to access. Therefore, conducting inspections to identify corrosion defects in these tanks is essential for maintenance. Ultrasonic testing has garnered recognition as an effective method for detecting corrosion in these tanks. However, wave propagation in these objects with complex geometry introduces intricate challenges, including the reflection of signals from defects and dispersion phenomena resulting from changes in the waveguide. These complexities often result in uncertain outcomes during non-destructive testing. Nonlinear ultrasound is a technique employed to evaluate the characteristics of a structure by analyzing the changes in the energy of waves at various frequencies. Second harmonic modes emerge when guided waves fulfill specific criteria, namely phase velocity matching and the presence of a non-zero power flux. In the context of this study, the fundamental frequency SH0 mode and the second harmonic S0 mode were selected. These two modes exhibit a dual-frequency relationship and have polarizations that are orthogonal to each other. The selection of the appropriate sensor type enables the measurement of specific polarization signals. This study advanced our understanding by developing a numerical model to gain insights into how metal loss affects the conversion of SH0 and the second harmonic S0 modes within T-joint structures. Ultimately, experiments were conducted using commercial probes to generate the fundamental frequency SH0 mode to validate and compare the simulation results. A C-scan image, based on the reflection of second harmonic signals, proves more effective in identifying the precise location and dimensions of the metal loss compared to the conventional linear ultrasound method.