Public Executive Summary

ULTRASONIC GUIDED WAVE INTEGRITY ANALYSIS TOOL FOR WELL CASING

Cliff J. Lissenden and Joseph L. Rose
Department of Engineering Science and Mechanics
The Pennsylvania State University
University Park, PA 16802

Underground natural gas storage requires wells for access. The steel well casing is in a harsh environment and is susceptible to corrosion and cracking, which compromise its structural integrity. To ensure the safety of the public and the environment, and to protect the investment in the storage facility, it is necessary to monitor the integrity of these mechanical systems. Magnetic flux leakage (MFL) probes are used to diagnose the mechanical integrity of well casings. This technology is well suited for damage detection but not classification and sizing of defects.

Guided wave ultrasonic technology (GWUT) is emerging as an excellent way to inspect over long distances from a single point and has applications in the oil, gas, and power generation industries. One of the first commercial applications has been long range guided wave inspection of unpiggable pipeline sections such as cased crossings and compressor stations. Improvements to these systems continue to enhance performance and expand areas of use. Through the proper application of theoretical wave mechanics, numerical modeling, and physically-based experimentation, guided waves can be optimized by selecting the modes and frequencies with the ideal dispersion characteristics and wave structures for a particular task.

A synergistic approach would combine the advantages of MFL with those of GWUT and, in the process, overcome many of the disadvantages of the two traditionally independent methodologies. The result would be a more decisive, robust, and information-rich inspection system for detecting and sizing corrosion that neither of the individual technologies is capable of on their own. The strengths and weaknesses of MFL and GWUT for detection and sizing of corrosion anomalies will guide modeling and sensor development for integrity analysis of well casing. Since MFL tools exist, the focus of this proposal is GWUT. A multi-sensor down-hole fixture is envisioned that transmits and receives axial guided waves as well as circumferential guided waves in order to detect, locate, classify, and size defects that reduce the mechanical integrity of the casing. The objective of the project is to design an optimal sensory tool for sizing corrosion and crack defects in steel casing. Here, optimal refers to defect sensitivity, reliability, cost, and ease of use. The design will leverage findings regarding axial guided waves from a previous GSTC-funded project, as well as ongoing research and development of circumferential guided wave methodology.

The methods proposed herein include analytical modeling, numerical simulations, sensor and equipment design, laboratory experiments, and field studies. The unique aspect of the project is that it is fundamentally driven by theoretical considerations. Study of guided wave propagation and interaction with defects will enable optimal design of sensors, fixtures, data acquisition, signal processing, and pattern recognition algorithms.