Guided Wave Phased Array Inspection of Storage Tanks

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Guided wave phased array (GWPA) technology for large-area plate inspection has been robotically implemented for double-shell storage tanks (DSTs) at the Hanford nuclear site in the United States. The 27 in-service Hanford DSTs contain millions of gallons of high-level radioactive waste and are at or past their 20- to 50-year design lives. The primary tank liners are susceptible to corrosion-induced leaks that pose a significant environmental and financial risk. Conventional ultrasonic inspection has been conducted via a network of narrow air slots in the refractory pads under the primary tank liners, but 90% of the primary tank bottom area is inaccessible and has thus gone uninspected since construction. To address this critical inspection need, the US Department of Energy funded a cooperative effort to engineer, verify, and qualify a robotic air-slot volumetric inspection system (RAVIS). The RAVIS system is comprised of a deployment wall crawler that is inserted into the annulus between the primary and secondary liners, a smaller air-slot inspection crawler that is launched into the air slots by the larger crawler, and a GWPA sensor that is carried by this smaller crawler. The air slot crawler transports the GWPA sensor along the length of the air slots and dry-couples it to the underside of the primary liner floor to collect guided wave scans at 1- to 3-foot intervals. The GWPA technology is capable of focusing and steering a beam of ultrasonic guided wave energy outward from the probe and electronically rotating the beam 360 degrees to detect and locate reflections from anomalies such as corrosion and cracking in the tank bottom plates and welds. A single GWPA scan covers an area of 20-30 feet in diameter, and multiple scans are automatically compiled into a single composite image overlaid on a drawing of the tank bottom for easier evaluation by the operator. The GWPA data is analyzed to determine the presence, location, extent, and approximate severity of corrosion and cracking, including next-generation flaw characterization by a data-driven machine learning model. Verification testing was completed in 2020, qualification testing was completed in 2023, and the first field trials are planned for 2024. The robotically deployed GWPA technology is also being leveraged for remote inspection of the Hanford DST primary liner side walls and has been used for other tank floor and tank wall inspection applications.