Current Construction Advancements of an Ultrasonic Phased Array Transducer for Future Deployment Within an Advanced Test Reactor Loop for in-use Monitoring

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Ultrasonic inspections in harsh industrial environments, such as elevated temperature, pressure and radioactivity create difficulties for current commercially available phased array ultrasonic transducers, current high temperature ultrasonic phased array solutions, as well as other non-destructive live inspection methods used for the assessment of critical components. The research being performed outlines a proposed NDE method utilizing commercially available materials to deliver a phased array ultrasonic transducer that will be used to detect component failures such as cracks/flaws, and corrosion, thereby determining component quality or service lifetime. The ultrasonic phased array sensor will be placed in an Advanced Test Reactor (ATR) loop. It will need to operate in a deaerated primary water (DPW) at a temperature of 700 °F and fast (>1 MeV) neutron fluence of $1x10^{10}$ n/cm^2. This project is broken up into two goals. First, a coarse flaw detection of 1 mm diameter, then later a fine flaw detection of 0.125mm diameter. For both systems the specimen thickness change, and bowing sensitivity measurements are specified, as well as scan rates of 75 and 155 mm/sec. To determine feasibility, phased array transducers and a Stainless Steel target plate with simulated defects, such as a 1 mm diameter v-bottom hole drilled partially through the sample were purchased. These transducers were then tested in a similar setup to the initially proposed inspection criteria but at room temperature. This was to determine feasibility of flaw detection. In parallel with this work, testing of differing brazing techniques and materials were evaluated and continue being evaluated to assess thickness of bond lines and bonding coverage area. Building on previous work and current experiments and trials, are being used to determine likelihood of success at each milestone within the multiple prototype construction process. Experiments such as crosstalk measurements of high temperature cable, piezoelectric material selection and plating trials have shown that multiple approaches need to be considered. A prototype room temperature version of the final proposed transducer has been manufactured and is undergoing testing. The initial tests using the commercially available transducer coupled to a 3mm thick steel plate, 20 mm away from the simulated target was able to resolve a 1 mm flaw. The piezoelectric material chosen for the deliverable transducer was Aluminum Nitride due to its radiation tolerance and high melt temperature. If proven successful, a phased array transducer that can operate in this harsh environment with currently available materials can lead to the capability to manufacture phased array transducers for severe environment industrial applications without the need for costly system shut downs.