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Development and Demonstration of Ultrasonic Under-Sodium Viewing System for SFRs

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In a sodium-cooled fast reactor (SFR), an under-sodium viewing (USV) system will be essential for real-time monitoring of core operation and/or in-situ inspection and repair of components. The USV system must be capable of operating in the high-temperature, high radiation, and highly corrosive environment of SFRs. Argonne National Laboratory (ANL) has successfully developed ultrasonic waveguide transducers (UWTs), brush-type ultrasonic waveguide transducers (BUWTs), and submergible transducers that can be used for defect detection, component identification, loose part location, and operation monitoring in the harsh sodium environment. A USV facility was constructed for the development and in-sodium testing of instruments and nondestructive evaluation techniques that potentially could be used for SFRs. An integrated USV imaging system, including data acquisition, signal and imaging processing, and different automated scanning mechanisms, was developed for real-time and faster defect detection and visualization.

Special UWTs were designed and used as a waveguide to isolate a conventional ultrasonic transducer from the harsh core environment. The Argonne UWTs have shown a detection resolution of 0.5 mm in width and depth in water and hot oil, and have also demonstrated defect detection and component recognition capabilities in sodium at elevated temperatures up to 343℃. Prototypes of high-temperature submergible transducer were also developed and tested successfully in water, hot oil, and sodium. Different piezoelectric elements and backing materials were evaluated. The prototypes have demonstrated a detection resolution of 1 mm in width and 0.5 mm in depth in sodium at elevated temperatures up to 343℃. To reduce imaging time, we have also developed BUWTs. Multiplexing technique was tested first. The results generated from a water mockup have shown great defect detection capability. Argonne is currently integrating the BUWT and phased array (BUWT-PA) techniques for better defection resolutions and faster inspection. Feasibility study of BUWT-PA was conducted in water and preliminary results have shown that the inspection speed is 10 times faster. However, the resolutions of BUWT-PA are not as good as that of the UWTs and submergible transducers. The future USV R&D plan is presented.

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