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Targeted Eddy Current Inspection based on Ultrasonic Feature Guided Wave Screening of Resistance Seam Welds

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Non-Destructive Testing (NDT) of manufactured components has traditionally been expensive and labour intensive. Such issues are compounded further in safety-conscious industries such as nuclear and aerospace. With the advent of industry 4.0, an opportunity to exploit the intersection of many different NDT modalities to increase the productivity of current inspection regimes presents itself via robotic control.

Two of the most common inspection modalities are ultrasonic and eddy current testing, with many benefits being derived from leveraging their respective advantages. Within the broader family of ultrasonic NDT, guided wave inspection has mainly been used as a screening tool to test long lengths of components from a single transducer location. It has also been shown that Feature Guided Waves (FGWs) that have their energy confined to a topological feature within a component's geometry exist. As a result, FGWs offer much promise when it comes to targeted screening of key structural features such as welds or adhesive bonds. Moreover, due to the inherent dispersion, guided wave testing has proven to be complex, making operator training paramount and increasing the cost of industrial deployment. Furthermore, it is common to use a localised NDT modality in combination with guided wave testing when attempting defect characterisation creating further cost and time demands on operators.

To relieve these pain points and realise the benefits of using multiple inspection modalities, the authors present the use of a flexible robotic system to flag potential defective regions within

resistance seam welded (RSW) components via a novel ultrasonic FGW technique, and then perform targeted raster scans using an eddy current array on any of the identified defective regions. RSWs are used to seal nuclear grade canisters and represent a key industrial area that could benefit from data sharing across NDT modalities. A novel FGW was studied in detail through simulations and experiments. A weld guided mode like that of the fundamental antisymmetric mode of a free plate was discovered to have high energy concentration in the RSW joint and could readily detect transversal defects of ≥1mm in depth. The FGW technique was deployed in a semi-autonomous fashion lowering the aforementioned technical deployment barriers. Control of the robotic system as well as the ultrasonic and eddy current data acquisition, was performed within the LabVIEW software environment. This common integration allowed for seamless sharing of key parameters between the FGW and eddy current inspection modalities.

For simplicity, flat RSW plates with transversal EDM notches ranging from 1mm depth and above were manufactured where the EDM notches represented transversal cracks within the component. Several experiments were performed on these samples where the inspection time associated with targeted raster scanning of the eddy current array on defective regions was compared to that of untargeted raster scanning of the entire component. It was shown that combining such techniques within a robotic environment greatly increases the productivity and lowers the time taken to effectively scan for defects within key structural features by at least a factor of 5. Future work is now focusing on expanding the results observed for the flat plate RSW samples to cylindrical RSW samples representative of sealed nuclear canisters.

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