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Towards Ultrasound-Driven, In-Process Monitoring & Control of GTA Welding of Multi-Pass Welds for Defect Detection & Prevention

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Technical Presentation

Many industrial sectors, such as nuclear and defence, employ ultrasonic Non-Destructive Testing (NDT) as a means of ensuring the strength and safety of welded components both before they reach service and throughout their service-life. Often these welded components are composed of thick sections, which necessitate the need for high-integrity welding processes and the use of a multiple pass weld deposition strategy. Traditionally, ultrasonic inspection takes place only after the deposition of all weld runs which means that defects introduced in early weld runs can remain buried until the final inspection. This greatly complicates the re-work procedure, resulting in increased material wastage, part scrappage and associated costs.

In recent years, there have been increasing industrial and economic drivers to reduce manufacturing costs, especially as the nuclear sector is being called upon to play a significant role in the delivery of low-carbon energy production in the future. The application of innovative in-process inspection and control strategies is one way the NDT sector can strive to support the achievement of this aim. In-process monitoring and inspection of welding processes make it possible to detect the formation of defects at the earliest possible point to enable quicker and more cost effective correction and repair.

As the most critical weld run within any multi-pass weld is the root pass, it is vital that this be monitored precisely to ensure integrity of the welded joint. Here, traditional phased array ultrasonic approaches are used to interrogate and analyse the molten weld pool during robotic deposition of a Gas Tungsten Arc Welding (GTAW) root pass of a common multi-pass weld joint (90 degree included bevel angle, 1.5mm root face height and 2.5mm root gap). Through processing and analysis of the received shear and longitudinal ultrasonic waves, this technique is shown to be capable of screening root pass width and height, whilst also critically indicating lack of root penetration (LORP).

This capability directly informs in-process inspection and monitoring with the potential for closed-loop control and the opportunity to correct for any defects as they are formed. The potential for utilising a similar strategy for upper passes within multi-pass welds is discussed with reference to the challenges encountered during discrimination of the solid lower and molten upper passes.