In-process Monitoring and Control of Multi-Pass Fusion Welding Using Phased Arrays

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Many industrial sectors, such as nuclear and defence, employ high-integrity fusion welding processes for the manufacture of safety-critical components. Often these parts consist of thick-sections which necessitate the use of a multiple-pass weld deposition strategy. Ultrasonic Testing (UT) is a common volumetric testing technique used to ensure the safety of these components before they reach service. However, as testing traditionally occurs as a final step within the manufacturing timeline it is often regarded as a bottleneck in the supply chain, especially where defects are found in early weld runs which require a large amount of rework to correct.

In recent years, there have been increasing economic and industrial drivers toward employing innovative in-process inspection techniques to reduce overall manufacturing costs and improve schedule certainty. Through in-process monitoring of the welding process, it is possible to detect the formation of defects at the earliest possible point to enable quicker, more cost effective repair.

Here, traditional phased array ultrasonic technologies are used to monitor the deposition of a multi-pass Gas Tungsten Arc Welding (GTAW) process. Through processing and analysis of the received longitudinal ultrasonic signals, this technique is shown to be capable of inferring the suitability of the chosen welding parameters while screening for appropriate joint fusion. Crucially, this strategy is also shown to be effective at discriminating between solid lower and liquid upper passes in a multi-pass weld through appropriate phased array steering and focussing.

This capability directly informs in-process inspection and monitoring and enables the potential for closed-loop control with the opportunity to correct for any defects as they are formed.

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