**In-Process Ultrasonic Inspection During Fusion Welding**

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AWESIM (Advanced Welding Equipment System Inspection and Monitoring)

**Abstract (300 Word Minimum)**

High-integrity fabrications found in the Nuclear, Defence and Energy sectors are often safety-critical and require thick section multi-pass welds when joining multiple components together. Traditionally, the manufacture and inspection of these welded joints are performed as entirely separate processes. This ultimately limits productivity and fabrication throughput along with increasing re-work when defects are found post-build. There are, therefore, several tangible commercial and economic benefits which may be realised by introducing in-process inspection directly into the welding process.

The welding environment poses significant challenges for traditional Ultrasonic Testing (UT) inspection hardware and imaging approaches. Component surface temperatures are significantly higher than the maximum specified operating temperatures of traditional contact transducers. Furthermore, couplant use in the region surrounding an active welding process poses considerable risk of introducing gross defects such as porosity. As a result, any in-process weld inspection technique must be couplant-free. The thermal gradients generated during welding have significant negative effects on the trajectory of ultrasonic beams, results in complex beam-bending and defocussing which require appropriate imaging compensation.

The Advanced Welding Equipment System for Inspection and Monitoring (AWESIM) project introduces phased array ultrasonic inspection directly at the point of welding to allow detection of imperfections and flaws at an earlier point, this reducing rework, repair and removing redundant mid-production inspections, delivering high-quality welds right, first time.

High-temperature, fully dry-coupled Phased Array Ultrasonic Testing (PAUT) is introduced during Gas Tungsten Arc Welding (GTAW) deposition. New sensor hardware in the form of a novel roller-probe for weld inspection is introduced and presented alongside algorithms to compensate for the negative effects previously mentioned and further effects from thickness variation and Electromagnetic Noise Interference (EMI).

The development and results of this work are presented on sub-scale plate and pipe demonstrators with intentionally embedded defects. The Signal to Noise Ratio (SNR) of the imaging and inspection system is measured, evaluated and compared against traditional PAUT inspection techniques. The in-process inspection system developed here shows SNR values comparable with that of traditional post-weld ultrasonic testing techniques, showing an average SNR value of 31.2dB.

**How does this presentation reinforce or address the conference theme of "Exploring the Future of NDE"?**

Welding is an integral part of manufacturing and plays an important role in almost every aspect of everyday life. The adoption of automated practices in the 1980’s saw a swift rise in productivity within manufacturing. Comparatively, NDE has remained a primarily manual process and has not seen the same adoption of automated processes and techniques As a result, NDE is often considered a major bottleneck within production environments. In order to change the shape and trajectory of NDE in light of NDE 4.0 goals, evolution and development are an imperative. This presentation brings forward novel and revolutionary ideas and methods for in-process inspection, providing a step-change in ultrasonic inspection capabilities within manufacturing environments.

**Presentation Challenge: How would this presentation challenge attended to think differently about this topic?**

This presentation brings forward the idea of in-process weld inspection which provides a step-change in ultrasonic inspection capabilities. There are significant commercial and economic benefits which can be realised by employing these inspection techniques at the point of manufacture.