Ultrasonic AI Inspection Tool for Intermediate Assessment of Multi-pass Arc Welds

JOINT INDUSTRY PROJECT OUTLINE

PROP309340

Background

Welding processes are complex, so achieving quality in terms of reducing or eliminating flaws is a key goal when fabricating most industrial components, especially for those of high value or those put into harsh service conditions. Inspection for flaws is often performed after welding is complete and if unacceptable flaws (classified as defects) are found, then a repair procedure is often required. However, the repair activity can in fact be detrimental to the overall integrity of the joint and so it is possible to make the joint condition worse following the repair. Hence, technology that can carry out an assessment of the welded joint as it is created offers significant advantages. For the most commonly used arc welding processes, which are the focus of the proposed development activities, the ability to establish the integrity of the weld root and hot pass prior to filling the rest of the weld has significant advantages for the overall joint integrity, cost and production time. However, this requires the deployment of ultrasonic inspection equipment that can reliably operate on components at elevated temperatures. Performance of the inspection equipment and automated interpretation of the ultrasonic signals obtained from the partially completed weld joint are key issues that will be addressed in this Joint Industry Project (JIP).

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Project Concept

TWI has investigated and provided industry with ultrasonic array techniques for inspection of arc welds during fabrication at ambient conditions in an earlier JIP [1] and has developed a weld monitoring system for electron beam welding (EBW) operating at temperatures around 180°C through a Core Research Programme (CRP) project [2]. It also has experience of countering the effects of elevated temperatures and partially completed weld geometries when interpreting ultrasonic signals.

The aim of this new JIP is to develop a user-friendly tool, which is operated manually by the welder for rapid assessment of arc weld passes, as a multi-pass weld is being produced. The motivation remains the same as for monitoring automated welding systems: early detection of flaws likely to be classified as defects, so that effective mitigation actions can be performed. Ultrasonic techniques in pulse-echo and pitch-catch configurations using conventional single element probes will be utilised. The techniques and tool will be robust for use during fabrication at elevated temperatures and will make use of commercially available off-the-shelf equipment.

This JIP is possible due to recent developments in Artificial Intelligence/Machine Learning (AI) technologies and the arrival on the market of a new generation of ultrasonic probes and scanners able to operate on component surfaces at elevated temperatures. With its experience in developing technology in this area, this JIP will harness TWI's expertise to make an independent assessment of emerging equipment and technology. The resultant procedures and validation documents will inform the Sponsors on technology capability and provide guidance on use during operations.

Objectives

- Select and validate a probe system for intermediate inspection of multi-pass arc-welded joints, which is used while the component is higher than the inter-pass temperature.
- Produce an integrated inspection system using off-the-shelf components, including probes, scanner, instrumentation and software.
- Develop an AI module for reliable automated assessment of typical flaws in components at high temperature, including accurate characterisation.
- Develop, test and validate suitable inspection procedures.

Benefits

- Reduced likelihood of finding unacceptable flaws (defects) after welding is complete, thereby significantly reducing risk and repair related costs.
- Inspection of components at elevated temperatures, enabling rapid assessment for a range of integrity issues prior to completion of the welding process.
- Automatic compensation to minimise/eliminate any errors due to variations in sound propagation caused by the temperature profiles within the material when interpreting the ultrasonic data.
- Automated flaw detection using the latest AI techniques.
- Straightforward modification of the developed inspection procedures by the Sponsors for arc welding scenarios, using similar processes, materials and joint designs.

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Approach

The work programme will be divided into five tasks:

- Task 1: Review and select off-the-shelf equipment to produce a robust inspection system. Produce design specifications for any necessary accessories. Procure the system components and manufacture any necessary accessories.
- Task 2: Fabricate the required test pieces to different stages of completion, introduce artificial weld flaws and optimise the inspection technique.
- Task 3: Develop an AI model that can be used to automate the detection of flaws in intermediate welds.
- Task 4: Perform optimisation trials using the welded test pieces from Task 2 to develop draft procedures and validate the inspection techniques. Produce suitable training documents to ensure that operators can be trained effectively for safe use of the system.
- Task 5: Produce validation reports, procedures and the final project report. Carry out a live system demonstration to the Sponsors for evaluation purposes.

Deliverables

- Validated high-temperature ultrasonic welder's inspection tool that uses AI for automated flaw detection.
- Procedures and training manuals.
- JIP final report.

Estimated Price and Duration

The project will commence with a minimum of four (4) Sponsors, each contributing £50,000.

The expected duration of the project is 12-18 months and the total estimated price is £200k.

References

[1] Nageswaran C, Gooch R and Bourgeon A, 'Evaluation of ultrasonic phased array and laser optical techniques for the intermediate inspection of the root and hot pass in girth welds for clad pipelines', Insight Vol 54 No 11, November 2012.

[2] Majidnia S, Kotropoulou I, Ptaszek G, Sanderson R and Nageswaran C, 'Ultrasonic monitoring of electron beam welding', TWI Industrial Member Report 1134, July 2020.

Further Information

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