Full matrix capture ultrasonic inspection of girth welds in CS pipe and CRA clad pipe

PUBLISHABLE SUMMARY

25678

Background

The accurate sizing, positioning and characterisation of flaws in corrosion resistant alloy (CRA) clad and J-bevel carbon steel (CS) pipeline girth welds is a key requirement when laying and maintaining pipelines of high structural integrity for the oil and gas (O&G) industry.

Ultrasonic inspection techniques, including conventional and phased array, are commonly used in determination of the structural integrity of such welds in both J-bevel CS pipe and CRA clad pipe. Coherent noise contributions, caused by differences in acoustic impedance at the interface between parent, clad and weld materials, as well as the coarse grained nature of the materials typically used, create challenges for effective UT inspection. Furthermore, accurate flaw sizing and characterisation of near vertical flaws in J-bevel CS girth welds (i.e. lack of sidewall fusion (LoSF)) relies on accurate calibration using flat-bottomed holes orientated along the weld bevel. This calibration relies on a complex, time consuming and operator dependent set up process and the resulting technique is still dependent on the orientation of the defect during inspection. Slight mis-orientation can significantly affect probability of detection and sizing accuracy. This project promotes a novel approach, combining full matrix capture (FMC) data acquisition with the total focusing method (TFM) image reconstruction algorithm. This will provide: improved inspection capability through image processing techniques and reduced effect of material noise contributions; reduction in the effects of defect orientation through improved focussing and imaging; improved operator performance by removing the need for complex, time consuming calibration through a semi-automated calibration routine. The project includes a number of work phases including (i) development of optimised inspection setup (ii) FMC+TFM inspection of girth weld pipe samples (iii) validation of inspection performance, for example, through sectioning and microscopy (iv) development of a best practice guide for FMC+TFM inspection of girth welds. At the end of the project, sponsors will receive a licence for TWI's FMC+TFM software package, a report detailing all major outcomes and results, as well as a best practice guide for FMC+TFM inspection of girth welds.

TWI Ltd, Granta Park, Great Abington, Cambridge CB21 6AL, United Kingdom. Tel: +44 (0)1223 899000

Full matrix capture ultrasonic inspection of girth welds in CS pipe and CRA clad pipe

Objectives

The main aim of the project is to validate the sizing accuracy and other industrial benefits of the FMC+TFM technique and to offer best practice for use of the technology on pipeline girth welds. Specific objectives are to:

- Develop ultrasonic inspection procedures for carbon steel and CRA clad pipe components
- Perform FMC+TFM inspection of girth welds in carbon steel and CRA clad pipe
- Determine sizing accuracy of the FMC+TFM inspection technique
- Validate results from inspections through sectioning and microscopy
- Develop a best practice guide as a prerequisite to standardisation of the FMC+TFM technique for inspection of pipeline girth welds

Deliverables

- A single licence for TWI's FMC+TFM software package (Beta) including two years' maintenance and support.
- A report detailing all major outcomes and results at the end of the project.
- A best practice guide

Benefits

Benefits to the sponsors from adoption of the FMC+TFM inspection technique include:

- Reduced setup time through a simplified calibration process and reduced input parameters
- Opportunity to relax requirements relating to positional accuracy of inspection equipment and knowledge of weld profile, as the full volume focussing ability of FMC+TFM removes the need to focus a beam at a precise location.
- Ease of interpretation through use of fully focussed and high resolution (B-scan) images to replace strip charts used with the zonal discrimination technique.
- Greater reliability of flaw detection and sizing
- Increased levels of safety through improved accuracy of fitness for purpose assessments

Participants

The Sponsor Group currently comprises:

- EDF Energy Nuclear Generation
- Oceaneering
- Technip UK
- Saipem S.p.A

The Welsh Government is providing additional financial support, and TWI internal funding is supporting the development of improved software capability.

TWI Ltd, Granta Park, Great Abington, Cambridge CB21 6AL, United Kingdom. Tel: +44 (0)1223 899000

Full matrix capture ultrasonic inspection of girth welds in CS pipe and CRA clad pipe

Scope of Work

The total number of weld configurations, flaw types and flaw locations included in the project will ultimately depend on the total number of sponsors. The current scope comprises:

- Carbon steel V-prep welds (1 set)
- Carbon steel J-prep girth welds (2 sets)
- CRA clad pipe J-prep (1 set)

Additional sponsors may propose CS pipe and/or CRA pipe samples, but the total number of samples provided, per sponsor, is fixed at 1 sample set containing 29+ flaws. Prior to the start of each work phase, TWI and sponsors will agree details of the work activity. TWI's FMC+TFM software system currently facilitates automated and encoded weld inspection using half-skip, full-skip and self-tandem (alternative to ZDT) inspection modes.

Phase 1 – Develop optimised ultrasonic inspection setup

To optimise the ultrasonic inspection setup, modelling of the beam profile will be conducted. The results from modelling will be used to (1) assist with the design of a suitable ultrasonic transducer/wedge configuration (2) determine the optimum scan offset of the transducer/wedge configuration. Results from modelling will then be used to assist with optimisation of the inspection setup in conjunction with empirical studies, to be carried out using reference samples containing well defined artificial reflectors such as flat bottomed holes, side drilled holes and EDM notches located throughout the weld volume.

Phase 2 - Inspection of samples

This phase will focus on ultrasonic inspection of girth welds in CS pipe and CRA clad pipe using TWI's FMC+TFM technology. Assessment of results will be carried out against performance criteria defined by the project sponsors. TWI may provide a small number of pipe samples for use in the project, although sponsors are encouraged to provide samples specific to their requirements. Specifically this phase of work will include:

- Supply of samples and reference/calibration blocks by sponsors and possible manufacture of additional samples if required.
- Inspection of samples using FMC+TFM technique
- Analysis of results against performance criteria outlined by sponsors

Phase 3 – Validation

On completion of sample testing, TWI will seek the permission of sponsors to perform sectioning and microscopy on selected samples in order to assist with validation of the FMC+TFM technique. If sectioning is not acceptable, then radiographic inspection may be considered as an alternative.

Phase 4 – Best practice guide

A barrier to early adoption of new technologies can be a lack of codes and standards against which to ensure compliance and demonstrate due diligence. Experience has shown that a premature rush to publish standards before the technology is mature, and supporting training infrastructure is in place, can lead to exclusion of new innovative implementations and put users out of compliance due to difficulties in certifying operators.

This phase will utilise the data derived within the previous phases of this programme to develop a best practice guide for FMC+TFM inspection of girth welds in CS pipe and CRA clad pipe. The intention is to make the guide available to developers and users (including organisations outside the project participants), so that it can be used as a reference document. This will give early information to training providers, equipment manufacturers and end users and encourage feedback to enable updating of the guide.

The intention is that this guide, once mature, will form the basis of a harmonised international standard.

Full matrix capture ultrasonic inspection of girth welds in CS pipe and CRA clad pipe

Price and Duration

The overall estimated budget for the project is £865,000. The project commenced in June 2016 and currently has four sponsors, each contributing £50,000 (excluding VAT) per annum for two years (£100,000 total). Further sponsors are currently sought. Additional financial support is being provided by the Welsh Government and from TWI internal funding.

Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

http://www.twi-global.com/services/research-and-consultancy/joint-industry-projects/

JIP Co-ordinator: Tracey Stocks **Ref:** 25678/1/18

Email: jip@twi.co.uk

Project Leader: Miles Weston

Email: miles.weston@twi.co.uk