EWI Strategic Technology Committee for Oil & Gas: Research for 2017

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Introduction

The EWI Strategic Technology Committee for Oil & Gas (STC) was formed in 2013 to bring together companies interested in furthering research and addressing technical needs related to materials and welding with the goal of enhancing the safety, reliability, and integrity of infrastructure for the energy industry. Members of the STC range from major oil and gas companies to steel makers, engineering procurement construction and installation companies (EPCIs), fabricators, and welding consumable suppliers. Member companies are located in North America, Europe, and Asia. Major projects completed or in-process since 2013 include:

- Characterization of weld properties for arctic service
- Assessment of potential welding approaches for casing materials
- Integrity aspects for unintended subsea pipeline/flowline blowdowns
- Improved fracture toughness correlations for advanced high-strength steels and forgings
- Weldability of grade 70 and 80 plate steels for offshore structures
- Assessment of Inconel girth-weld strength mismatch effects
- Engineering critical assessment (ECA) guidance for subsea and offshore systems
- Comparison of nondestructive evaluation (NDE) methods for dissimilar metal welds (DMWs)

The results of these projects have provided the industry with 1) valuable insight into optimized welding approaches and selection of materials to ensure adequate in-service performance, and 2) updated guidance on performing engineering integrity assessments for offshore infrastructure.

Current Work on the Inspection of Dissimilar Metal Welds

A new project is beginning in the spring of 2017 to evaluate the relative accuracy and reliability of NDE methods for the inspection of DMWs. The oil and gas industry has been increasingly using corrosion-resistant alloys (CRAs) in subsea infrastructure in an effort to achieve enhanced corrosion protection and corrosion fatigue resistance. A typical scenario involves a carbon steel or high-strength, low alloy (HSLA) material clad with Inconel or stainless steel. CRA filler metals are used with these materials to make butt and/or girth welds for the fabrication of pipelines, flowlines, jumpers, manifolds, and similar subsea hardware.

Inspection of DMWs following fabrication is an important part of an integrity assurance program, and the most common inspection method is radiographic testing (RT). Performed using either a single shot or multiple shots, RT can provide excellent detection of volumetric flaws such as lack of fusion or trapped slag, but may not provide high detection probabilities for sharp flaws such as hot cracks or tight lack-of-fusion defects, depending on flaw orientation.

Phased-array automated ultrasonic testing (PA-AUT) systems have been employed by the oil and gas industry in some circumstances for increased flaw detection and sizing sensitivity; however, the use of PA-AUT is not universal and in most cases RT remains the standard inspection methodology. Ultrasonic techniques are well known across industry and have been widely used for inspection of carbon-steel welds for many years; however, when applied to DMWs, complications can arise from grain coarsening and anisotropic microstructure, which may produce scattering of the ultrasonic wave, signal attenuation, and beam skewing. While numerous vendors are qualified to conduct PA-AUT inspection, it can be more expensive to perform compared to RT, and it requires more skilled personnel to setup and calibrate instrumentation, perform scans, and interpret results. In addition, since the number of qualified PA-AUT inspectors is limited, project delays can occur due to decreased personnel availability.

Figure 1 shows the bevel profile in an etched cross-section of a CRA weld. In this image the etchant reveals the carbon steel of the base materials to highlight the weld bevel and heat-affected zone regions but does not show the weld microstructure. In these welds, the ability to find discontinuities along the fusion line and near the weld root region is of particular concern.

Figure 1: Cross-section of a nickel-based-alloy girth weld on clad pipe

The first phase of this project is to be completed in 2017 and will provide a side-by-side comparison of RT and PA-AUT methods in three specially made pipe girth welds with seeded defects. Each coupon contains approximately 18-20 defects of various types and in various locations. The outcome of this project will be a direct comparison of detection sensitivity between RT and PA-AUT. This will provide the industry with an independent evaluation of the suitability of these two NDE methods for DMWs as well as guidance on when each is most appropriate for use on subsea infrastructure.

Additional Research

The STC is conducting two additional projects. The first of these will focus on the brittle fracture resistance properties of welds in seamless pipe operating just below the design temperature of the system. This is a topic of concern since events such as depressurization can reduce the temperature of the pipeline below its design temperature under certain circumstances. A 2016 project on the fracture resistance of seamless pipe showed that there were opportunities to improve estimates of brittle fracture at these temperatures. This year’s work will focus on the weld zones, as estimating toughness in welds can involve several complicating factors which can be critical to ensuring the integrity of the system.

The STC is also conducting a project to create guidelines for engineering critical assessment (ECA): the analysis that determines what inspection results are acceptable prior to the start of fabrication. The guidance document that will be produced will identify what inputs and data are needed to perform an ECA, including appropriate formats for these data. The document will also outline different ECA approaches and how to effectively implement results.

Future Work

The EWI STC plans to extend its work on NDE for DMWs in 2018 to include further advances in phased-array ultrasonic testing. New equipment at EWI that uses both full-matrix capture and total focusing method (FMC-TFM) has shown interesting potential for improved sizing of imperfections. Improved sizing of small imperfections can make pipelines and other industry structures easier to fabricate and accept since inaccurately sized imperfections will no longer need to be removed and repaired. In addition, the FMC-TFM technique may be less sensitive to ultrasonic beam scatter, undesirable beam reflections, and the problematic signal attenuation that occurs with conventional ultrasonic testing methods.

The next meeting of the STC will be in September 2017 to discuss and direct research and define topics for 2018. If you'd like to learn more about the STC and its research, please click here or contact Bill Mohr (614.688.5182 or bmohr@ewi.org).

Bill Mohr *is a Principal Engineer in EWI's integrity group. He is an expert in the areas of fitness-for-service assessment, design, and fatigue of welded structures. Bill has authored more than 50 technical papers in addition to numerous reports of sponsored projects, failure analyses, and fitness-for-service assessments.*