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In-service corrosion monitoring of an 11-bar steam line

Low entry-cost corrosion monitoring increases safety and decreases corrosion risks for in-service pipe assets at elevated temperatures.



Overview

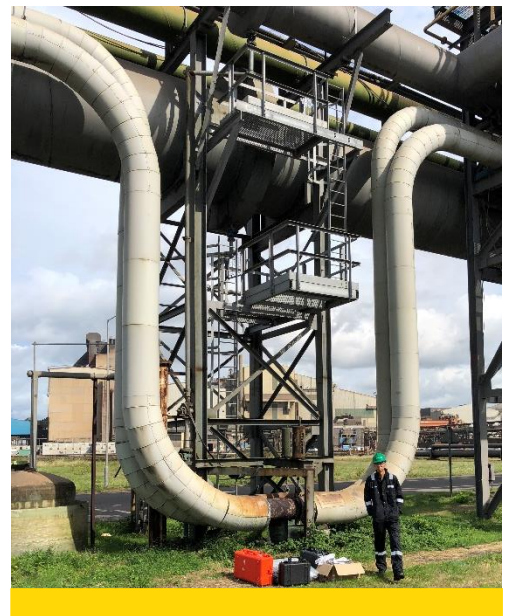
A solution for high-temperature spot thickness measurements on a series of steam expansion loops was sought by **TATA Steel UK**, with the requirement to monitor any changes in remaining wall thickness due to corrosion / erosion whilst in-service with no loss of productivity.

The 12" NPS schedule 40 carbon steel pipe work carries 11 bar steam (up to 230 °C) from the boiler to areas of the steel making plant in Port Talbot, Wales. Due to a process change, an increased risk of corrosion was identified and required monitoring to schedule any maintenance appropriately. In the first instance, a baseline measurement was required to prove efficacy of the monitoring system.

Issues

In-service inspection of high-pressure, high-temperature expansion loops poses a risk for conventional NDT asset integrity due to the hazardous environments involved, e.g. working at height and high process temperatures. This increased risk also introduces increased cost of inspection. The steam lines are also relatively difficult to isolate, often requiring expensive outages.

Additionally, accuracy in measurement requires a conservative tolerance to compensate for operator error, temperature compensation of velocity and the inherent inconsistencies in varying thickness measurement location (TML), transducers, coupling and operator. These tolerances increase with elevated temperatures as operators have a reduced ability to compensate accurately for velocity variations.



Productivity and cost also play a factor, where numerous or more frequent measurements are required, it becomes impractical to repeatedly isolate and cool down the pipe work for accurate measurements. Recurrent insulation and cladding removal and replacement is costly and exposes the asset to external corrosion risks.

The Solution

The asset integrity team turned to the TRND system to overcome the challenges and risks posed by high-temperature, in-service inspection. The system, comprises HotSense™ high-temperature resilient, installed ultrasonic transducers (Ionix, UK), and an inductively coupled patch and a wireless data collection WAND™ (Inductosense, UK). TRND subsequently allows wall thickness data from the expansion loop pipe assets to be collected at temperatures up to 350 °C, with the low-profile sensors installed under insulation and weatherproofing, in a matter of seconds. This hybrid approach to inspection and monitoring removed the need for isolation of the asset, reduced costly estates & fabrics resources from not having to remove insulation or cladding, and prevented exposure of operators to unnecessary hazards.

► Even with dynamic changes of internal temperature & external environment, the ultrasonic A-scan measurements are compensated automatically to give precise and accurate metal wall thickness data...

Execution

A short, straight section of the 12" NPS expansion loop was prepared, removing a nominal 1 m section of insulation and surface preparation of a 30 mm diameter patch to SA 2.5 at cardinal points around the 12 (top), 3 (north), 6 (bottom) and 9 (south) 'o' clock positions.

For comparison, thickness readings with commercial EMAT and UT sets were completed, before HotSense™ ultrasonic transducers were installed with straps at each location, and a flexible thermal jacket wrapped around, covering the sensors to maintain corrosion-under-insulation protection and restoring an insulating layer. Thickness measurements were recorded with each HotSense™ sensor using a flaw detector, before the TRND inductively coupled patches were connected and secured under the weatherproofing insulation layer for access by an operator with the wireless WAND™.



An operator was then able to initially take 1 to 2 measurements per week during rounds. The advantage of this system is that the operator can adjust the number of readings taken per week depending on the resultant wall loss rate, and fitness for service assessment. Note, during the study, the sensor 'south' was removed for operational reasons and so no data is presented.

Results

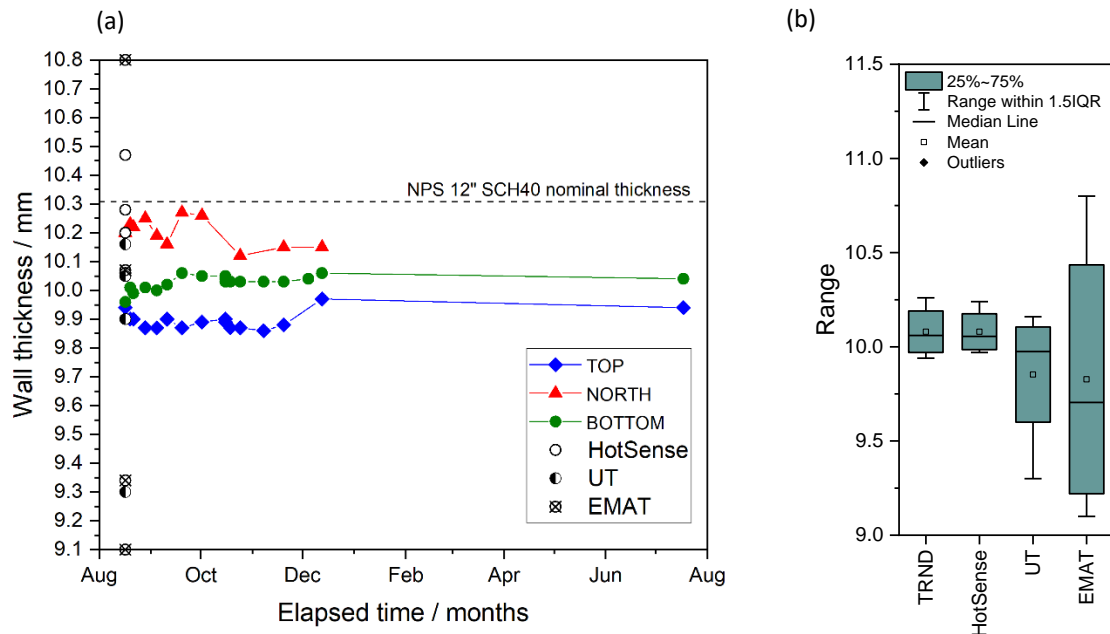


Figure 1: (a) Plot of wall thickness as a function of elapsed time for 3 positions on the 12" NPS, Schedule 40 steam pipeline using TRND, plus initial thickness readings from HotSense installation, conventional UT and EMAT techniques. (b) Box plot of the initial prepared locations thickness measured using the 4 techniques.

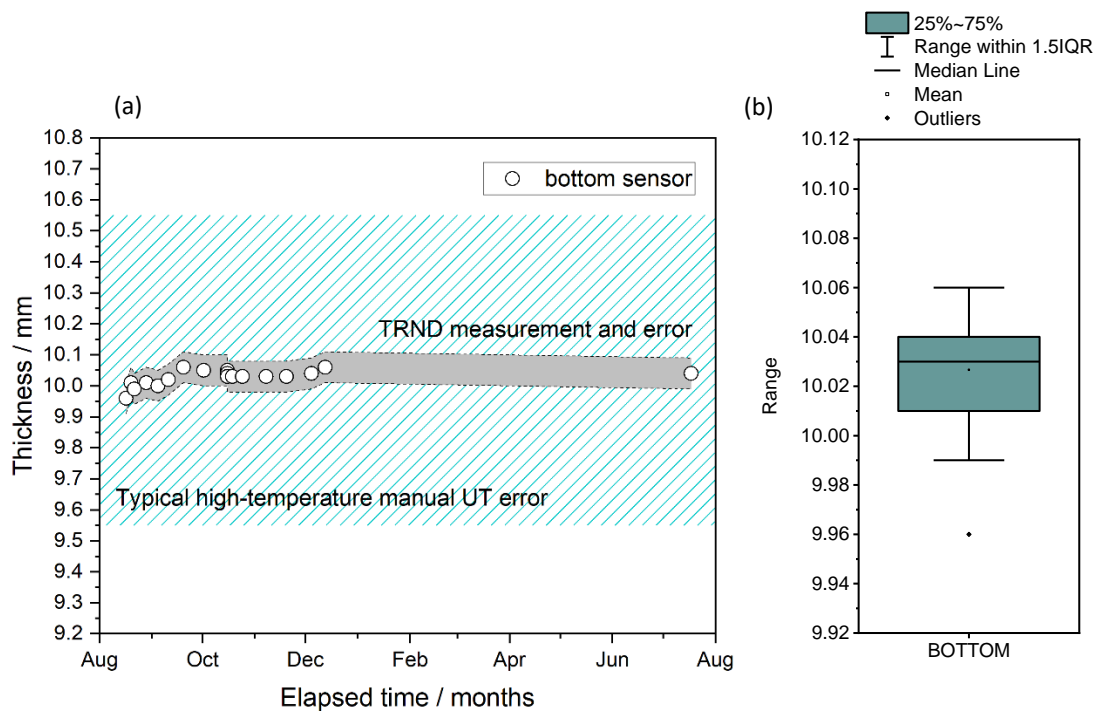


Figure 2: (a) Focussed plot of the 'bottom' sensor from TRND with associated error (± 0.05 mm), overlaid with the typical measurement error for conventional in-service HT ultrasonic inspection (hatch, ± 0.5 mm), (b) Box plot for the 'bottom' sensor.

Wall thickness data was collected and reviewed over 11 months for any significant errors or anomalies in the section chosen to offer a baseline, where negligible corrosion was previously recorded.

Figure 1(a) shows that all 3 sensors give good repeatability for wall thickness compared to the current conventional techniques such as manual UT and EMAT, indicating negligible wall loss and excellent dynamic temperature compensation. This is further highlighted in the box plot (Fig 1b), where the resultant wall thicknesses recorded for the cardinal points vary up to ~0.3 mm with the TRND technique, compared to ~0.9 mm for conventional UT and ~1.6 mm with EMAT, although access for the larger EMAT equipment was limited leading to an increase in contact variation and subsequent error.



Focussing on one sensor, 'bottom', it is shown that the measurement precision with the installed HotSense™ sensors is increased significantly compared to the tolerances generally accepted for in-service high-temperature inspection measurements (± 0.5 mm).

The ability to monitor corrosion, and take measurements without additional infrastructure, makes TRND well suited where flexible data collection frequency, reduced operator exposure to hazardous environments and reduced insulation replacement time and cost are required.

Highlights

- ▶ Increased repeatability and reliability over conventional inspection techniques
- ▶ Using installed sensors offered up to 4X reduced tolerance in wall thickness measurement realising better quality data for plant operators.
- ▶ Increased data collection rate, reducing the number of personnel and time on-site or in hazardous locations, and is data collection frequency is flexible to meet changing requirements.
- ▶ Reduced operators hazard and risk from high process temperatures with insulation maintained throughout measurement.
- ▶ Increased productivity with reduced downtime with installation and measurements taken in-service and without removal of insulation or pipe preparation.
- ▶ Reduced cost with no additional infrastructure for the remote analysis and reporting normally required for autonomous systems.



TRND System Specification

Parameter	Value
Operating Temperature	Up to 350°C continuously
Deployed	Under insulation on pipe up to 16" diameter including elbows
Total Deployed Mass	<1.2kg
Lifetime	5 years, with battery free sensor
Extreme Environment	Certified to ATEX/IECEx intrinsic safety standards, Zone 0
Resolution	Absolute thickness better than 0.1 mm across temperature range

For more information, see www.trnd.tech

