Investigations on improvement of corrosion monitor reliability, calibration and coverage

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Background
Corrosion costs $1.4 billion annually for Oil and Gas industry in US alone [NACE, 2016]. According to PHMSA* US 2016 report, the internal corrosion incidents in oil pipelines increased from 23% in 1970 to 67% in 2013. The incidents in gas pipelines increased from 18% to 27% for the same time period. This shows that corrosion becomes severe with ageing of pipelines. Continuous monitoring of corrosion for long time periods in pipelines is required to avoid catastrophic failures.

Ultrasonic thickness gauges are used for continuous corrosion monitoring. They require special mechanical devices to install them with pipes. These devices may relax with time and result in less reliable results. Magnetic flux leakage technique can be used for continuous monitoring because it is more tolerant to loss of contact and surface roughness. However, to use the sensor for continuous corrosion monitoring for long time, the sensor should be highly reliable and ensure complete coverage.

I. Reliability based design
Reliability is an important aspect to be considered during design phase. The components and material selected need to be reliable in the long term.

(a) Corroded pipe sample (b) UT test results (c) Prototype sensor results

Magnetisation unit
Corrosion Sensor System
Power System
Sensing Element
Interface Communicating component

II. Sensitivity studies
Factors affecting probability of detection are studied using finite element modelling and experimental investigations. The aim of sensitivity studies is to achieve high signal to noise ratio.

Magnet
Electronic components
- Temperature
- Corrosion
- Radiation
- Electrical stresses
- Degradation

Failure modes in each component of sensor are identified using literature and testing. The effects of these on the performance of sensor will be investigated using finite element modelling and testing...

IV(a). Accelerated life testing
ALT is carried out to replicate in days or months, the ageing which may occur in years. This will be achieved by testing the sensor under high stresses (failure modes) to accelerate failure rates. The factors important for designing ALT are:

- Stresses
- Time
- Standard Model

IV(b). Real life ageing
The sensor will be tested on the pipe samples for long time interval (one year or more) to validate the results of accelerated life tests.

Conclusion
- Sensor working on magnetic flux leakage principle can potentially be used for continuous corrosion monitoring of steel pipelines
- Reliability is crucial for sensors used in long term condition monitoring
- Failure modes and effects analysis is a useful tool for studying and improving reliability of sensors
- Accelerated life testing along with real life aging tests can predict the useful life of sensors under design conditions

Future work
- Optimisation of sensor
- Design of accelerated life test conditions
- Design of real life aging tests
- Reliability modelling and useful life predictions

Acknowledgment
This publication was made possible by the sponsorship and support of Lloyds register foundation. The work was enabled through, and undertaken at, the National Structural Integrity Research Centre (NSIRC), a postgraduate engineering facility for industry-led research into structural integrity established and managed by TWI through a network of both national and international Universities.

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