Curtin University

CURTIN CORROSION CENTRE

STRATEGIC RESEARCH COLLABORATION – CORROSION UNDER INSULATION (CUI)

Make tomorrow better.

Corrosion under insulation (CUI) is considered an insidious threat to many industries, which accounts for around 40 to 60% of the total cost of piping maintenance[1].

The presence of insulation materials and jacketing creates an annular space where water can accumulate and be in contact with the steel substrate. Over time, corrosion proceeds undetected and failure occurs. Despite the vast amount of research and development on mitigation, CUI remains a recurrent unresolved problem.

OBJECTIVE

The CUI-JIP will develop multifaceted CUI management strategies covering monitoring, prediction, and mitigation. Specifically, the CUI-JIP will advance our understanding of the CUI mechanisms and enable transformative solutions to the industry.

CURTIN CORROSION CENTRE (CCC)

The interdisciplinary research team at the Curtin Corrosion Centre has developed world-class unique research facilities to investigate all aspects of CUI including, the choice of insulation materials, effects of wet-dry cycles, extreme thermal variations, coatings (both organic and metallic) performance, the efficacy of volatile corrosion inhibitors and self-inhibiting thermal insulations, in situ CUI monitoring using sensors, data analytics, and atmospheric corrosion simulations including UV exposures, etc. We have used these facilities to support industry partners by, e.g., validating the benefits of drain holes[1], evaluating the behaviour of insulation materials under simulated CUI environment[2], demonstrating the feasibility of electrochemical techniques in CUI real-time monitoring[2], and quantify the efficacy of inhibitors and self-inhibiting thermal insulation[3].

The CUI-JIP will consist of three research themes, as follows.

RESEARCH THEMES

Theme 1: Coating degradation and life prediction

The use of protective coatings, both organic and metallic, is the primary means for controlling external corrosion of assets. Indeed, coatings are regarded as the most important barrier to prevent CUI[4]. Unfortunately, coatings often degrade in the aggressive under insulation conditions, leading to defects and the potential to the localization of the corrosion attack[5].

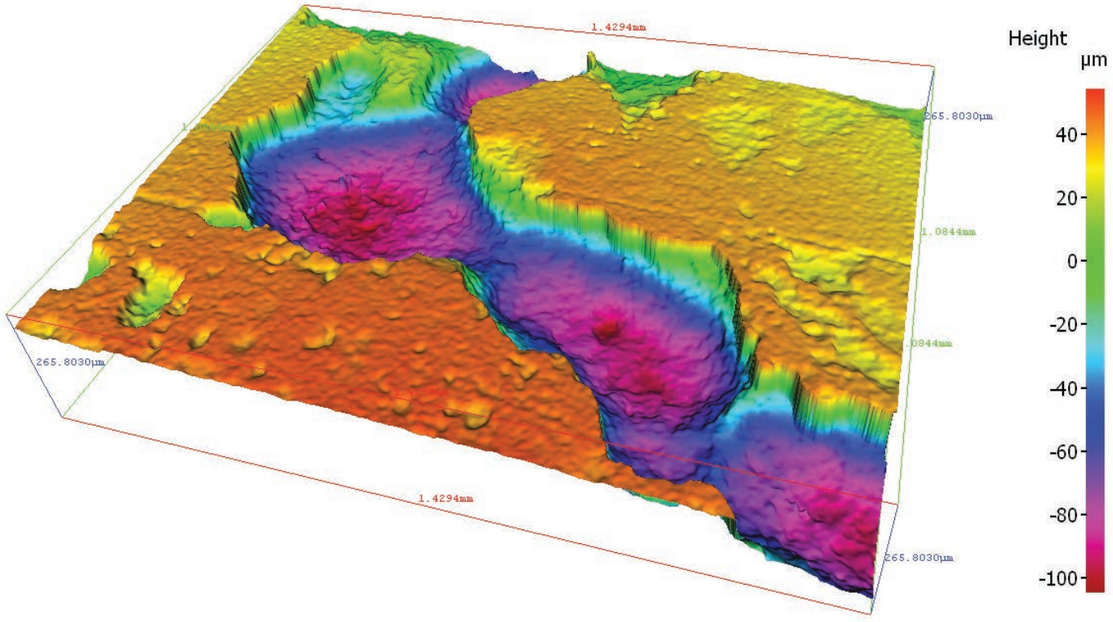
Coatings used under thermal insulation are exposed to high temperature, extreme temperature fluctuations, and wet/dry cycles, which affect their long-term performance. The constant actions of evaporation and condensation impose cyclical stress from thermal expansion and contraction on to the coating and substrate. There is, unfortunately, limited information on coating degradation mechanisms and rates in conditions relevant to thermal insulation applications.

Theme 1 objectives

The goals of Theme 1 are to i) advance a mechanistic understanding of how operating and environmental conditions influence coatings' behaviour and ii) develop a predictive tool for estimating the coating remaining life to assist with inspection planning and prioritisation.

Theme 1 scope

A non-identifying database of existing coatings—e.g., chemistry, application and maintenance history, their service life and exposure conditions—will be populated from information provided by JIP participants. Laboratory aging studies will provide a mechanistic understanding of coating degradation. The project will conduct field exposure at sites nominated by JIP members to evaluate the combined effects of environmental and operating parameters on the behaviours of selected coating systems. The comprehensive results from laboratory ageing, field exposure, and maintenance database will be used to develop a coating life prediction model.

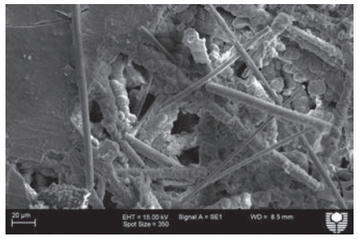


INDUSTRY 4.0 FOR CUI MANAGEMENT

Theme 2: Sensors and Monitoring

Conventional CUI management relies on periodic inspection, which can be quantitative (e.g., complete or partial removal and visual inspection, radiography, etc.) or qualitative (e.g., nuclear magnetic resonance or thermography, etc.). Risk-based inspection methodologies such as those described in API 581 and API 583, are commonly used to identify when and where to inspect. Incorporating relevant in-situ monitoring can aid that decision process, which, in turn, can increase the effectiveness of inspection and reduce CUI risks.

Sensor and data acquisition technologies have improved drastically. Today, several of the old "pain points" have been overcome. Sensors can be deployed to monitor tell-tale signs of CUI such as (i) the presence of water, (ii) metal loss, (iii) electrochemical and chemical activity, and operating parameters (temperature, pH, internal pressure, etc.). Moreover, sensor data can be used to train predictive models.



Theme 2 objectives

The objective of Theme 2 is to develop a best practice for CUI detection based on market-ready real-time monitoring technologies.

Theme 2 scope

The first activity will be to collect information on the monitoring programs currently utilised by JIP participants. A comparative review of the current practices and other commercially available sensors and data collection technologies will provide insights to the benefits and shortfalls of each solution. A pilot scale CUI rig of varying piping configurations will be utilised to develop the best monitoring strategies. Sensor data will also serve as inputs of a predictive maintenance machine learning-based engine.

Theme 3: Predictive maintenance

Risk-based methods are conventionally used to prioritise high-risk areas for CUI inspection and rectification. Probabilistic models and backpropagation approaches are sometimes incorporated to fine-tune the prediction outcomes[6]. Yet, maintenance approaches remain only partially effective and are costly. The CUI management cost may be reduced if unnecessary direct physical assessments are minimised.

Theme 3 objectives

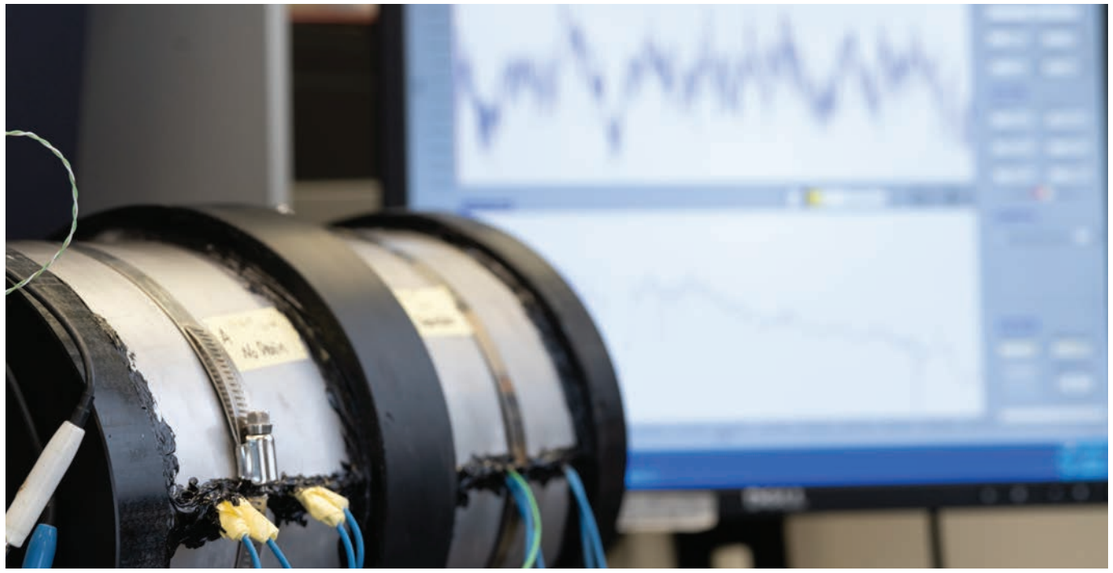
The objective of Theme 3 is to improve our understanding of how interrelated operating and environmental variables affect the likelihood of CUI and its extent. A CUI risk prediction tool will be developed based on the mechanistic knowledge gained in this JIP, maintenance history, and sensor data inputs.

Theme 3 scope

The scope of this phase will be divided into two parts: (i) model development and (ii) model validation.

1. Model development
Theme 3 will review existing external corrosion prediction frameworks and modify them to account for the conditions that lead to CUI. For example, models based on machine learning and Bayesian networks will consider (i) water diffusion and evaporation rates under various forms of insulation materials to improve wet-dry cycle prediction, (ii) the acceleration of the anodic reaction, (iii) the influence of electrolyte thickness, etc. Other contributing factors such as insulation materials, pipe geometry, environment, operating temperature and insulation condition will also be incorporated.

2. Model validation and training
Machine learning algorithms will also be trained based on fuzzy data extracted from, for example, past inspections and maintenance records, engineering reports, visual rankings, end-user experience, etc. The data will be anonymized and treated as confidential. Specific information related to locations and projects will be removed.



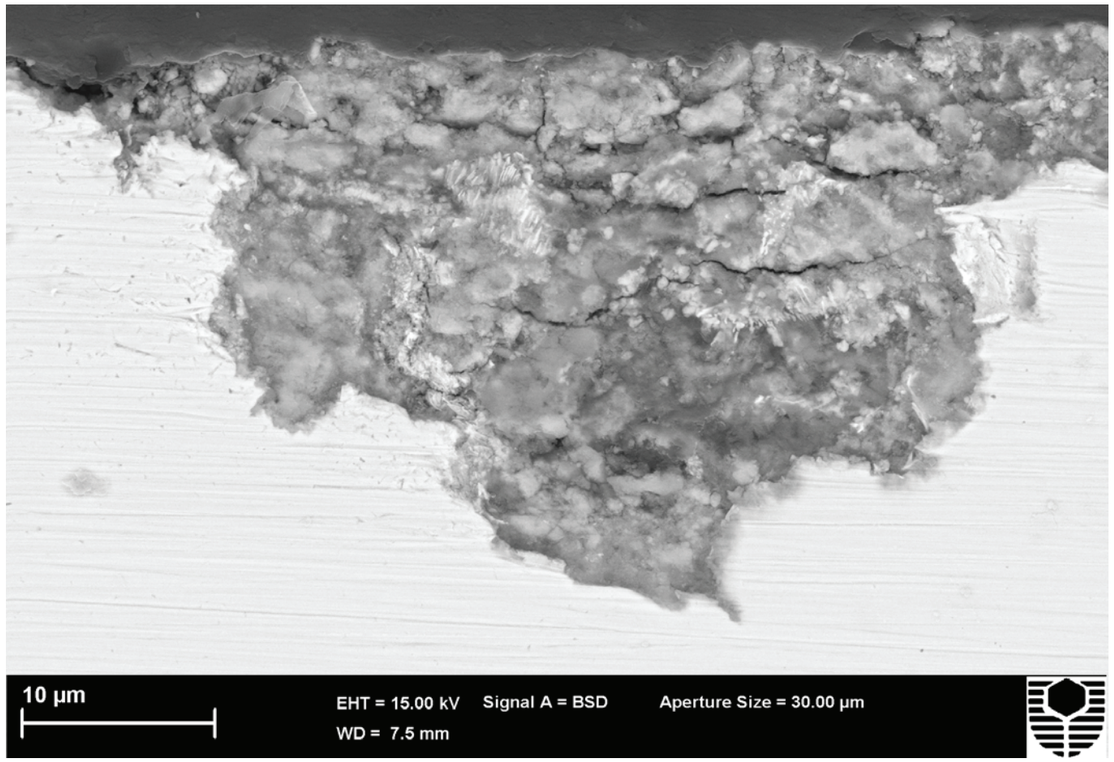
"The CUI management cost may be reduced if unnecessary direct physical assessments are minimised."

"Sensor data will be used to train predictive models."

PROJECT GOVERNANCE

The CUI-JIP steering committee will consist of representatives from the JIP participants and Dr Thunyaluk Pojtanabuntoeng and Prof. Mariano Iannuzzi as Curtin Corrosion Centre delegates. Monthly updates will be provided via a project management portal. Project updates will be presented in technical workshops to be held twice per year.

- Participation fee: AU$60,000 per annum
- Deadline Expression of Interest: 15 March 2021
- Contract negotiations: March-September 2021
- CUI-JIP Kick-off: January 2022
- Duration: 3 years
- A minimum of 5 companies is required.



References

1 T. Pojtanabuntoeng, L.L. Machuca, M. Salasi, B. Kinsella, M. Cooper, Influence of drain holes in jacketing on corrosion under thermal insulation, Corrosion. 71 (2015),p. 1511-1520.

2 T. Pojtanabuntoeng, H. Ehsani, B. Kinsella, M. Brameld, Comparison of insulation materials and their roles on corrosion under insulation, in Corrosion Conference and Expo 2017, Paper no. 9287.

3 F. Dabre, D. Campbell, H. Ehsani, T. Pojtanabuntoeng, Assessing Inhibitive Effects iof Leachable Silicate Ions on Corrosion under Insulation of Carbon and Stainless Steel, in Corrosion and Prevention 2019, Paper no 114.

4 SP0198-2016 Control of Corrosion Under Thermal Insulation and Fireproofing Materials, NACE International.

5 M. Chauviere, J.W. Krynicki, J.P. Richert, Managing CUI in Ageing Refinery Pressure Vessels, in Corrosion Conference and Expo 2004.

6 F. Varela, M. Yongjun Tan, M. Forsyth, An overview of major methods for inspecting and monitoring external corrosion of on-shore transportation pipelines, Corros. Eng. Sci. Technol, 50 (2015), p. 226-235.

Contact us to find out how you can participate and help us tailor a research program that will benefit your organisation.

We can come to you to present technical capabilities and opportunities in the proposed research themes, assess your corrosion issues and assist with selecting a suitable research scheme.

Contact

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