CONDITION MONITORING OF GAS PIPELINES IN CRITICAL LOCATIONS USING ULTRASONIC GUIDED WAVE TECHNOLOGY

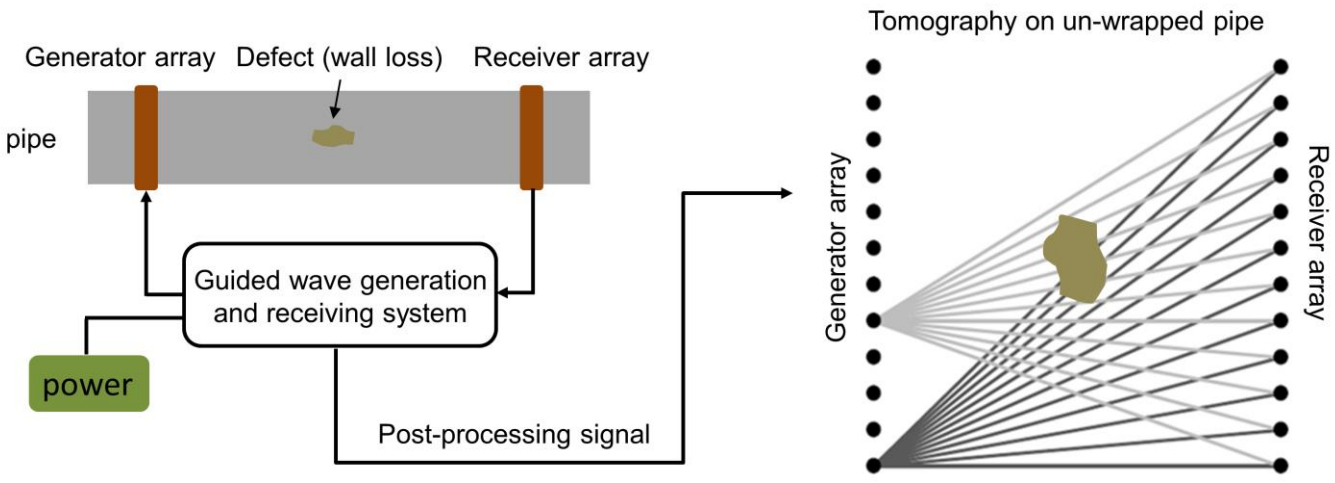
PROJECT SUMMARY

To ensure safe and cost-effective operations in the gas industry, it is essential to identify potential damages to gas pipelines early to prevent gas leakages. This includes monitoring the changes in wall thickness of gas pipelines to estimate the corrosion rates of gas pipelines and alerting the pipeline operators via advance warning signal on possible pipeline corrosion for rectification prior to gas leakage incidences.

Conventional thickness evaluation processes require manually scanning the gas pipelines using probes, which is tedious and challenging for remote locations. Furthermore, high upfront costs (~75%) of a conventional non-destructive evaluation (NDE) could be required for the setup before each measurement for pipeline thickness evaluation. This could be even higher if the pipeline locations are inaccessible or located in a harsh environment.

To address these challenges, we developed an innovative **guided wave monitoring system** that can be permanently installed at critical locations along the pipeline network to **continuously monitor pipeline wall thickness and evaluate potential corrosion damage**.

Compared to other NDE techniques, this new monitoring system is able to **accurately measure the corrosion rate, send early warning signals immediately when the wall thickness is below a threshold, and save costs of setting up measurement equipment in inaccessible environments**.



Schematic of corrosion mapping in pipeline using ultrasonic guided wave tomography technique

Thickness mapping on a 10 mm thick pipeline carrying Carbon Monoxide at Jurong Island.

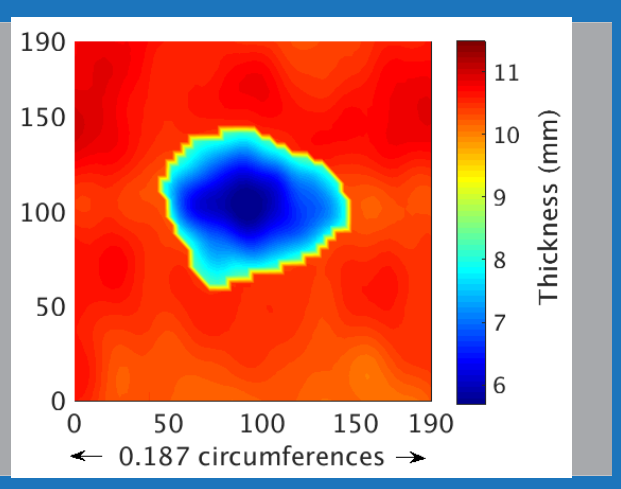
PROJECT OUTCOMES

Conventional ultrasonic thickness measurement methods are manpower-intensive and expensive, especially for inaccessible areas. The developed solution utilises guided wave tomography, which offers good **potential to monitor the thickness of corrosion patches without requiring access to all points of the surface**.

A **novel guided wave tomography method based on full waveform inversion (FWI)** is applied for the developed solution's corrosion mapping. It uses a forward solver to predict the scattering of guided wave through defects in the acoustic model, and an iterative inverse model to reconstruct the corrosion profile. At each iteration, numerical modeling is carried out with the aim of least-square minimisation of the residual data between the modelled and the observed data. This approach overcomes the limitation imposed by ignoring crucial low frequency effects in travel-time tomography, but allows higher order diffraction and scattering to be taken into account in its numerical solver, thus provides more accurate inversion results. The guided wave tomography based on FWI is first applied to measure the defect from an accelerated corrosion site. The reconstructed thickness map is compared with measurements from a laser profilemeter. The technique is also used to **predict the corrosion rate**, which can be compared with the prediction from the Faradays Law.

Following the success of the proof-of-concept experiment in the lab, on-site trials have been carried out at several locations at Jurong Island. An ultrasonic guided wave tomography system was installed permanently on a 6.5 mm thick pipeline for 8 months to monitor the thickness loss due to corrosion damage, demonstrating **excellent accuracy of up to 0.2 mm thickness change**. With such monitoring system installed, it is expected that the reliability of gas pipeline networks could be improved via more **predictive maintenance**.

Proof-of-concept experiment in the lab



Thickness mapping under accelerated corrosion

On-site trial of the developed solution using guided wave tomography at Jurong Island

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