Untethered Leakage Robot

Cadent Lane Rental Industry Publication

TRANSPORT FOR LONDON

Introduction

There are thousands of kilometres of pipework running through the city across Cadent's London network, with the majority in Central London.

Due to the nature of the network, there are a considerable amount of emergency gas escapes reported which need to be repaired, leading to disruption, noise pollution and carbon emissions.

To address the increasing number of gas escapes, Cadent set out to find a solution which could travel within pipes untethered, searching and detecting leakage to repair and could essentially 'live' within the gas network, repairing as it goes.

A concept of this nature would have significant benefits in reducing noise pollution, traffic delays and carbon emissions, while ultimately eliminating emergency gas escape excavations on London roads. This would also provide a considerable benefit to cyclists, pedestrians other vulnerable road users.

A less obvious benefit could be through an improved understanding of asset management data, which could be generated via the robot's constant surveillance.

Cadent in collaboration with ULC undertook a feasibility study into the concept in order to determine if a solution of this nature had the potential to be realized, now and with the future transition to a hydrogen network.

The Project

Divided into three strategic phases/aims, the feasibility focussed on leak detection capability in pipe walls and pipe joints. Leak detection testing was performed in a laboratory setting using decommissioned, 18-in diameter cast iron pipe samples procured from Northern Gas Networks. Two pipe samples were tested, one with manufactured holes in the pipe wall and the other with a joint that was leaking when decommissioned. The phases aims:

- determine of the smallest sized leak and internal pipe pressures, over which wall leaks could be detected
- attempt to characterise these leaks
- demonstrate a method for detecting a leak in a lead-yarn joint from inside a pressurised pipe using a proof-of-concept sealing and pressure-flow measuring system.

For leak detection through holes in pipe walls, test bench gantry system was modified for operation. Using a leak detection sensor, a dynamic pressure sensor mounted to a motorised gantry system and moved around its axis and circumference in the pipe. Automation scripts were generated and two electronics control boxes were developed for automating the scanning of the leak detection to the position within the pipe moving the sensor across different leaking holes. Both cast-iron pipe samples were cleaned, prepared and custom flanges were mounted on the pipes with end caps for pressurisation. An instrumented, internal bladder system with a central hole for gas flow was designed, fabricated and tested for demonstrating the concept of inline joint leak detection.

Outcomes

Leak detection of holes in the pipe walls was successful for hole sizes from 0.018-in to 0.125-in diameter under operating pressures from 0.4 PSIG (28 millibars) to 30 PSIG (2 bar). Detection was successful in most of the combinations of pressure and hole sizes. The ability to characterise the holes requires more testing to generate a large defect library and it is recommended that machine learning algorithms be used to develop a robust characterisation solution that considers multiple features of the leak signal.

Leak detection in the pipe with the lead yarn joint was also successful. Differential pressure readings between the enclosed volume around the joint and the rest of the pipe proved that an internal bladder could seal a circular space around the joint while allowing gas to flow through the pipe. Flow readings were used to successfully determine a joint leak rate of 74 ccm (cubic centimetres per minute) at 54 millibars gauge pressure using air as the gas medium.

Lessons Learnt

The project timeline was delayed due to shipment issues caused by COVID-19, moving forward a contingency plan would minimise time lost. The project team would also consider how the pipes are sourced.

Conclusion

A laboratory demonstration of leak detection, was successfully implemented in a cast iron pipe joint and through holes in the pipe wall.

The next stage of the project, would be to build and demonstrate a robotic platform prototype, which could navigate a straight, pressurised pipe in the lab and detect leaks in the pipe wall and joint.

Since an early prototype of the robot platform has already been developed by ULC Technologies, the work under this phase will focus on developing and testing an enhanced prototype with the necessary leak detection capabilities.

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