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MIT Leak Detector: An In-Pipe Leak Detection Robot

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***Abstract*— In this work we present a new in-pipe leak detection robot, the *MIT Leak Detector*. The system performs autonomous leak detection in gas pipes in a reliable and robust fashion. Detection in based on the presence of a pressure gradient in the neighborhood of the leak. As the *MIT Leak Detector* travels through pipes, it picks up the pressure gradient in case of leaks via a carefully designed detector. In this work we demonstrate the performance of the system in a lab setup, which consists of $100mm$ ID pipes containing pressurized air.**

I. Introduction

Losses through leaks represent a significant portion of the water supply, hence identification and elimination of leaks is imperative to efficient water resource management. In addition to water losses there are thousands of miles of natural gas and oil pipelines around the globe that are poorly maintained. Thus, a significant portion of the total oil and natural gas production is lost through leakage annually.

In this work we introduce a new complete system for the reliable sensing of leaks in gas pipes. The system is able to autonomously inspect the network and send signals wirelessly via relay stations to a computer. Leak signals stand out clearly on occurrence of leaks, via a smart mechanism [1], [2], that eliminates the need for user experience. The detector is based on identifying a clear pressure gradient in the vicinity of leaks [3] in pressurized pipes.

II. The MIT Leak Detector

The *MIT Leak Detector* is designed to operate in 4" ($100mm$) ID gas pipes. The system consists of two modules, namely the carrier and the detector (Fig. 1). The carrier assures the locomotion of the system inside the pipe. The module is carrying actuators, sensors, power and also electronics for signal processing and communications. The module's locomotion is materialized via a pair of traction wheels. On the other hand, the detection concept is based on the fact that any leakage in a pipeline alters the pressure and flow field of the working medium. More specifically, the detection principle is based on identifying the existence of a localized pressure gradient [3]. In addition, the phenomenon is independent of pipe size and/or material. It also remains relatively insensitive to fluid medium inside the pipes, which makes the detection method widely applicable (gas, oil, water pipes, etc).

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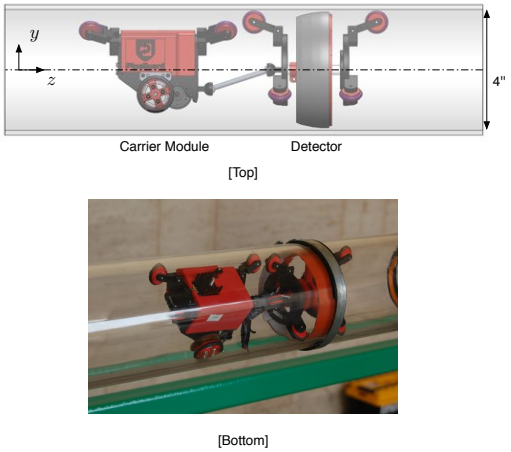

Fig. 1. Side view of the *MIT Leak Detector*. [Top]: Solid Model. A pipe section (4") is drawn for reference. [Bottom]: The actual developed prototype inside a 4" pipe.

In the attached video we present the *MIT Leak Detector* operating in our compressed air pipe setup. More specifically, different cases are presented, where we run the system under different speeds and leak configurations and evaluate its performance. Data is transmitted wirelessly to a host-PC and the user is able to see the identification and localization of one or multiple leaks in real-time. In all cases the pressure in the pipe was regulated to be 0.7 bar.

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References

[1] Chatzigeorgiou D., Wu Y., Youcef-Toumi K. and Ben Mansour R., "Reliable sensing of leaks in pipelines," *ASME Dynamic Systems and Controls Conference (DSCC)*, 2013.

[2] Chatzigeorgiou D., Ben-Mansour R., Khalifa A. and Youcef-Toumi K., "Design and evaluation of an in-pipe leak detection sensing technique based on force transduction," *ASME International Mechanical Engineering Congress & Exposition (IMECE2012)*, 2012.

[3] Ben-Mansour R, M.A. Habib, A. Khalifa, K. Youcef-Toumi and D. Chatzigeorgiou, "A computational fluid dynamic simulation of small leaks in water pipelines for direct leak pressure transduction," *Computer and Fluids*, p. doi:10.1016/j.compfluid.2011.12.016, 2012.