ONLINE IMPLEMENTATION OF A LEAK ISOLATION ALGORITHM IN A PLASTIC PIPELINE PROTOTYPE

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***Abstract*— In this paper, a real-time application of a Leak Detection and Isolation (LDI) algorithm for a plastic pipeline is presented. This LDI algorithm is fed with flow and pressure signals coming from sensors placed at the ends of the pipeline. It uses a flow observer based on a model obtained from the Method of Characteristics, and it is designed in order to assure an acceptable real-time leak isolation by taking into account various practical difficulties. In particular it incorporates an adaptation law for the friction coefficient in order to compensate for possible variations. The whole scheme is successfully tested on a plastic pipeline prototype, transporting water and built as a possible benchmark.**

***Keywords*— Fault diagnosis, Leak detection, Nonlinear estimation, Plastic pipelines, Water.**

I. INTRODUCTION

Nowadays, freshwater requires special attention in order to avoid its waste and pollution (UN/WWAP, 2003). Regarding the first aspect, implementation of pipeline monitoring systems to automate the detection and isolation of leaks is an important issue. Leak detection can obviously be easily realized by straight considerations, for instance as simple as a mass balance, i. e. just looking for any difference between the inlet and outlet flows but the real challenge is to find the exact position of a leak (leak isolation), as it will be seen along this paper.

As it is well known, a leak can produce damage to environment, water waste and economic effect. The methods most commonly used to locate leaks are the so-called Direct Methods. In those methods the leak is searched directly along the pipeline (Scott and Barrufet, 2003). This search can be just a visual inspection or by using some sophisticated equipment. Some direct leak detection methods are, for example, acoustic leak detection systems, infra-red thermography, ultrasonic methods or electromagnetic techniques as reported in Eiswirth and Burn (2001). The use of such systems allows to locate a leak in a precise way, but the price to pay for it is expensive equipment and a long time to locate the leak, meaning high costs, water waste and sometimes service disruption due to the necessity to empty the pipes for inspection.

An alternative way to detect and isolate leaks is by the analysis of the transient pressure waves. When a leak appears a pressure wave is generated, which travels throughout the pipeline and reflects from the boundaries as well as from the leak. This response can be analyzed to determine the location of the leak as in Misiunas *et al.* (2005) and Covas *et al.* (2005). A complete survey about these techniques can be found in Colombo *et al.* (2009).

Another commonly used LDI technique is the one known as Analytical or Model-based Method (API, 2007; Kowalczuc and Gunawickrama, 2004). In such a technique, a model of the system under study is necessary in order to detect and isolate a leak. Based in that model, an entity, such as an observer, a Kalman filter or an adaptive system, can be designed to detect any discrepancy between the predicted model behaviour and the measured one, in order to isolate the leak. Such an entity is usually implemented in a digital computer system as an algorithm whose inputs are available measurements from the monitored system and the outputs of this algorithm are both an alarm signal, when a leak is detected, and the leak parameters (location and magnitude). About the measurements, such LDI algorithms generally require flow and pressure signals coming from sensors placed at the ends of a pipeline, since they are available in many long pipeline systems, such as oil pipelines or aqueducts. In this work, a copy of the model in the leak-free case is directly used to design an observer (state estimator), whose input signals are the inlet and outlet pressure heads and the output signals are the estimated inlet and outlet flows. These estimates are then compared with the actual pipeline flow measurements, in order to generate the so-called residuals (i.e. the difference between the measured an the estimated flows). When the system operates normally, the estimated and measured signals must be practically equal. When a leak appears