Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 112 (2017) 58 – 66

Energy Procedia

Sustainable Solutions for Energy and Environment, EENVIRO 2016, 26-28 October 2016, Bucharest, Romania

Consideration on leak/fault detection system in mass transfer networks

Ciprian Lupu[a]*, Doinita Chirita[b], Serban Iftime[a], Roxana Miclaus[c]

[a] *Politehnica University of Bucharest, Faculty of Automatic Control and Computers, 313,Splaiul Independentei, 060042, Bucuresti, Romania*
[b]*Politehnica University of Bucharest, Faculty of Electronics, Telecomunications and Technology Information, Bd. Iuliu Maniu 1-3, 060042, Bucuresti, Romania*
[c]*Transilvania University of Brasov, Faculty of Medicine, 29, B-dul Eroilor, 500036, Brasov, Romania*

Abstract

Leaks and faults detection in the energy fluids and utilities distribution networks represents an objective with significant implications, where the safety of life and pollution are the included priorities. Reality and scientific literature contains dedicated solutions, validated in time by theory and industry. Starting from a few of these, this paper proposes and analyses several applicative solutions based on the models identification, (mathematical) modeling and supervision of the normal and fault operation in the transportation and distribution networks for (gas and liquid) utilities. The supervisory structure proposed is based on sensors/data acquisition and control architecture, associated with the transportation and distribution network's SCADA system. The main purpose is to detect the fault situation as fast as possible and to indicate more accurately the affected area/point. The methods have been implemented in real time, tested and validated by means of an experimental laboratory facility.

Peer-review under responsibility of the organizing committee of the international conference on Sustainable Solutions for Energy and Environment 2016

Keywords: fault detection; model identification; mass transfer; data acquisition;

* Corresponding author. Tel.: +(40) 21 402 91 37; fax: +(40) 21 402 95 87.
E-mail address: ciprian.lupu@acse.pub.ro

Peer-review under responsibility of the organizing committee of the international conference on Sustainable Solutions for Energy and Environment 2016
doi:10.1016/j.egypro.2017.03.1061

1. Introduction

The classic manner in which we can test if an element or subsystem does not work correctly in the local/global system, is to compare the evolution of the correct operation model with the effective, real time trends, as presented in [1]. To avoid the malfunctioning operation of the control system it is necessary to continuously monitor all the measured variables and to check their tolerance limits [2].

From the safety perspective, a diagnosis system has to be designed and implemented so as to detect all the unnatural changes in the real system evolution and to suggest, as fast and precise as possible, to the human operator of the possible fault and remedial solutions, or to start the procedures for automatic countermeasures. Starting from the industrial practical experience [3], there are different methods which offer different advantages, and, also their corresponding drawbacks [4], [5], [6].

In many literature approaches [1], [2], [4], [7] there can be identified several main detection methods:

- Hardware based methods: using acoustic sensors, gas detectors, negative pressure detectors, and/or infrared thermography;
- Software based methods: here, varying complexity and reliability are used. Examples include flow/pressure change detection and mass/volume balance, model based systems and pressure point analysis;
- Biological methods: the dogs walk along the pipes and looks for obvious damage, smell and sound.

Here are some interesting elements about them:

Software Based Methods

Methods based on software applications implemented on PLCs, SCADA etc.: information gathered about flow, pressure and temperature at certain points in a pipeline.

Conservation of Mass

Mass into and mass out of the system is measured. If the difference between the two is above a set threshold, a leak alarm will go off. This pure balancing method is, however, not suitable for smaller leaks because of the possible noise signals, drifting measurements and the dynamic changes of both flows. There are also improved versions of this method. For instance, one could determine the low frequency components of the flows by discrete-time low-pass filtering. More information regarding this method can be found in [1]. The localization of a leak is not possible with this simple method.

Pressure Change

Pressure sensors are almost always installed at the extremes of the pipelines. When the system has reached a steady state, a limit is set so that if the pressure falls below this limit (with some wiggle room), it is likely to have a leak within the pipe [4]. A more advanced way to look at it is to regard a long pipeline as a low pass filter with respect to pressure disturbances. A leak is one possibility if a high rate of change of pressure cannot be identified through approximations and restrictions, or no pipeline operation that could cause this pressure change is identified [1].

Change in flow

A predefined figure is used as a model for the possibilities of flow changes. If the rate of change for the flow is higher than a predefined figure within a specific time period, it is most likely a leak.

Model Based Systems

The common denominator for all model based systems is that the pipe flow is described mathematically. Leaks are detected when discrepancies between the calculated and measured values differ. The equations used to model the fluid flow in pipes are the following: Conservation of mass; Conservation of momentum; Conservation of energy; Equations of state for the fluid.

2. Proposed solution

Some interesting classical approaches (e.g. “change flow” or “model based systems”) use a nonlinear observer [8], neural networks [9], [10]; or finite difference [11]. The solution presented is based on the real time calculation and simulation, of some (linear) transfer functions, combined with parameters evolution supervision. Computed transfer functions characterize both the normal and fault operation system.