Journal of Loss Prevention in the Process Industries 41 (2016) 97–106

Contents lists available at ScienceDirect

Journal of Loss Prevention in the Process Industries

journal homepage: www.elsevier.com/locate/jlp

A review on different pipeline fault detection methods

Shantanu Datta, Shibayan Sarkar*

Department of Mechanical Engineering, ISM, Dhanbad, India

ARTICLE INFO

Article history:
Received 15 August 2015
Received in revised form
12 March 2016
Accepted 12 March 2016
Available online 15 March 2016

Keywords:
Pipeline
Fault detection methods
Overview
Leakage and blockage
Safety

ABSTRACT

Pipeline faults like leakage and blockage always create problem for engineers. Detection of exact fault quantity and its location is necessary for smooth functioning of a plant or industry and safety of the environment. In this paper brief discussion is made on various pipeline fault detection methods viz. Vibration analysis, Pulse echo methodology, Acoustic techniques, Negative pressure wave based leak detection system, Support Vector Machine (SVM) based pipeline leakage detection, Interferometric fibre sensor based leak detection, Filter Diagonalization Method (FDM), etc. In this paper merit and demerits of all methods are discussed. It is found that these methods have been applied for specific fluids like oil, gas and water, for different layout patterns like straight and zigzag, for various lengths of pipeline like short and long and also depending on various operating conditions. Therefore, a comparison among all methods has been done based on their applicability. Among all fault detection methods, Acoustic reflectometry is found most suitable because of its proficiency to identify blockages and leakage in pipe as small as 1% of its diameter. Moreover this method is economical and applicable for straight, zigzag and long, short length pipes for low, medium and high density fluid.

1. Introduction

Pipes are widely used for transportation or conveying fluids from one place to another, generally found in domestic areas, industries and for sewage. The pipeline networks are extended for several kilometres and consist of number of pipe segments that are connected by joints. These pipelines are subjected to many incidences such as traffic and surface loads that cause the overstress on the pipes and joints, which may lead to leak and burst in pipeline (Mansour et al., 2012). Moreover, bad workmanship, destructive cause, pitting corrosion and water hammer may also lead to pipeline leaks (Sun, 2012; Lazhar et al., 2013). Incidence of a leak in pipeline causes a sudden decrease in the pressure (Silva et al., 1996) that would cause inefficiency in terms of delivering time and the volume flow rate of fluid being transferred. Sometimes, impurities and clogging also disturb the usual flow in piping system. Blockages begin in the form of a small growth in the wall roughness that increases with time due to physical or chemical processes and can finally encroache a significant part in the internal cross sectional area of pipe (Duan et al., 2014). Generally, fluid flow rate through pipeline may get reduced due to presence of various pipe faults i.e. blockage, leakage etc. Due to insufficient flow of water or other fluid causes the failure of pipe network. If the pipeline faults are not quickly detected and repaired, that may result to product loss and other serious damages (Sandberg et al., 1989).

In this paper some selective processes of pipe line fault detection have been discussed and compared corresponding to their applicability. At present, the general methods for pipeline leakage detection range from manual inspection by trained linesmen to advanced satellite imaging. Usually, two types of methods can be noticed for the detection of pipeline failure such as hardware-based and software-based. In hardware-based methods, special sensing devices are used to detect pipe leakage. Hardware-based methods can be further classified depending on the type of sensors and equipments used for fault detection such as acoustic monitoring, optical fibre, cable sensor, vibration analysis etc. Similarly, the methods based on softwares depend on various software programs (Jin et al., 2014). Different soft computing techniques have also been effectively used for fault detection in pipe networks (Laurentys et al., 2011, Zadeh, 1965, Zidani et al., 2008 & Poulakis et al., 2003). Moreover, in some methods, hardware and software both are used simultaneously. A detailed classification of fault detection methods for blockage and leakage is given in Fig 1.

The aim of the paper is to focus towards the process and measurement principles that are used for the detection of pipe line

* Corresponding author.
E-mail address: shibayan.sarkar@gmail.com (S. Sarkar).

http://dx.doi.org/10.1016/j.jlp.2016.03.010
0950-4230/

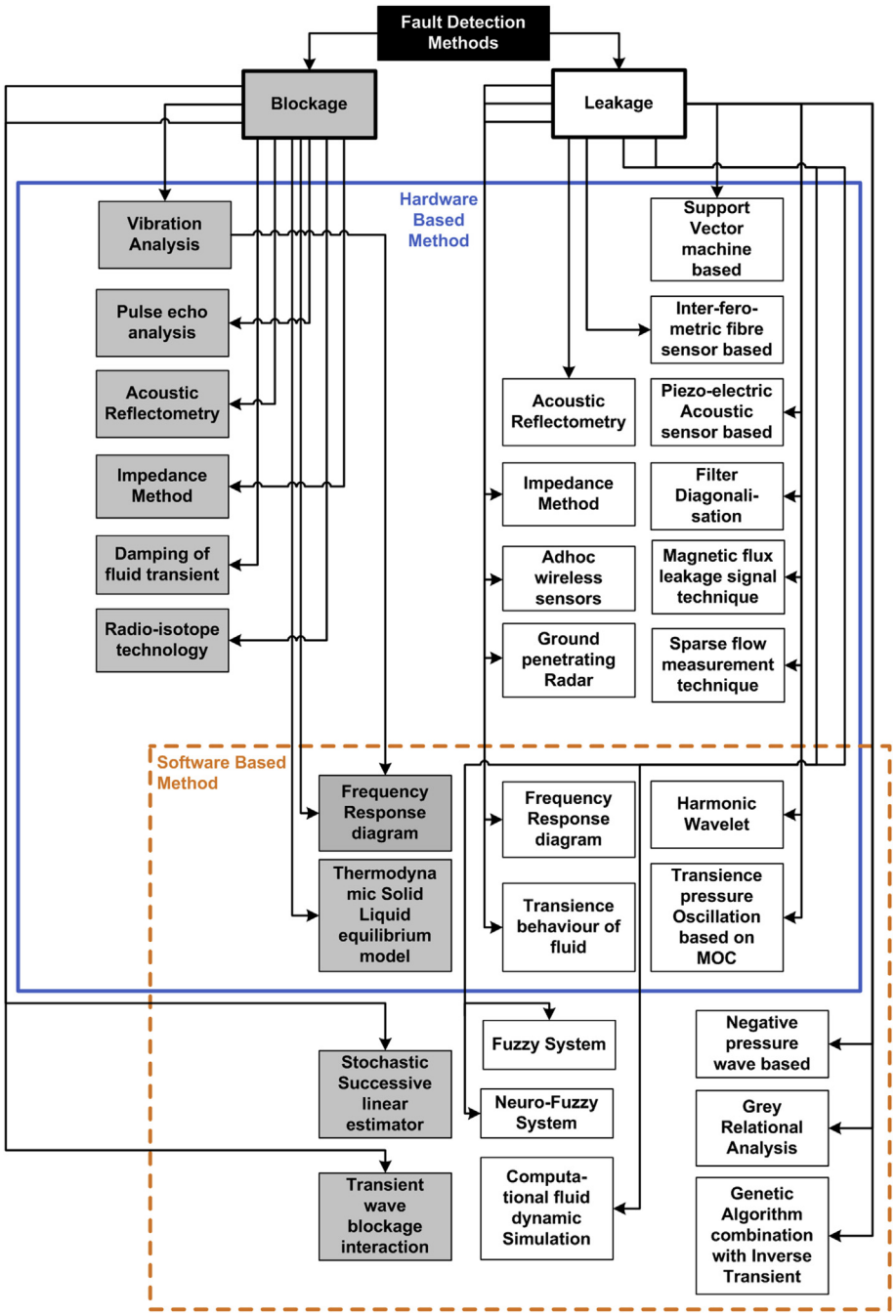

Fig. 1. Flowchart of different fault detection methods.

faults. The initial section of the paper will provide an overview of the various methods that are used to detect blockage and leakage in pipeline and finally, a comparative discussion will be provided based on their applicability.

2. Determination methods for fault detection

Some of the important methods applied for accurate detection of pipeline blockage are discussed below:

2.1. Blockage detection techniques

2.1.1. Vibration analysis

Lile et al. (Lile et al., 2012) used vibration analysis method to describe blockage effects in circular pipe where Fast Fourier Transform (FFT) graph has been presented to describe the correlation of blockage levels to vibration signal. In case of fluid flows through an obstacle, the flow cross section area reduces and as per continuity equation fluid velocity increases. As per Bernoulli's principle, pressure of the fluid then decreases. Due to this fluctuating pressure and high velocity, prominent vibration response is observed in the pipeline (Kim et al., 2007). The vibration