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PIPELINE LEAK MONITORING NOW AND FUTURE

Pipelines are the key to transporting petroleum products around the globe. It is the fastest and the most economical means to deliver fluids over long distances. Unfortunately, pipelines started to malfunction and may end up with an incident mainly due to leakage. These incidents are nothing but catastrophes and thus require a reliable and robust leak monitoring system. Various strategies have been proposed thus far, each with its own advantages and disadvantages. This book offered a method to timely and accurately detect small leaks in gas mixture pipes over long distances.

There are various techniques available for leak detection. These techniques can be broadly divided into two categories: software-based techniques and hardware-based techniques. Software-based techniques are preferred as they are cheaper than hardware-based techniques. The fundamental principle of leak detection is to monitor for unusual changes in the mass flow rate of the pipeline. The challenge is distinguishing the changes due to a fault and the system's dynamic behaviour. These dynamic changes are due to transient boundary conditions, gas compressibility, vibrations, and leakage in realistic conditions.

Software-based leak detection techniques can be further classified as model-based and data-driven techniques. Model-based techniques require a physics-based system model, whereas data-driven techniques require the process data to model the system. Data-based techniques are

preferred over model-based techniques where mathematical modelling of the system is intricate.

A data-based system can be identified by separating its data into input and output variables. The objective is to identify the relationship between input and output variables. There are various techniques to determine the system model. Some of them that are discussed in chapter three are the stochastic Hammerstein and Volterra model, support vector machine, artificial neural network, fuzzy system, neuro-fuzzy system and statistical methods.

This book shows natural gas flow in a pipeline modelled in an 80 km pipeline under transient conditions. Gas thermodynamic properties like compressibility, density, viscosity, etc., were calculated using GERG 2008 EOS. An OLGA dynamic simulator is used to simulate a one-dimensional, non-isothermal, compressible, and transient gas mixture flow in a pipeline using mass, momentum, and energy conservation. The pipeline length was discretised into a hundred sections to obtain accurate mass flow rate, temperature, and pressure measurements at the inlet and outlet. OLGA Model accuracy was validated against the pipeline simulation and experimental data from the previous literature. A leak detection system based on the system model identification technique was developed. The significant part before model identification is the simulation to generate quality data and to identify a sensitive pipeline model. Amplitude-modulated pseudo random binary mass flow rate signals were imposed at the pipeline inlet to excite the system behaviour to generate training, validation, and leak testing data. Three model structures, Hammerstein, ARX and Wiener were tested. Only the Hammerstein model showed the potential to identify small changes. So, the Hammerstein model was used to identify system models using various parameters. The mass flow rate and pressure at pipeline inlet were used as model inputs, and mass flow rate at pipeline outlet was the model output. Models with more than 500 parameters yielded highly accurate mass flow rate measurements at the outlet with less than 2% error.

After that, input signals (pressure and mass flow rate at the pipeline inlet) generated adaptive thresholds around the measured mass flow rate at the pipeline outlet. Upper and lower control intervals were specified to monitor the outlet mass flow rate under transient conditions. As thresholds were set for normal operating conditions, actual mass flow rate measurements started violating limits during the testing phase when the leak happened.