USING SYSTEM RESPONSE FUNCTIONS OF LIQUID PIPELINES FOR LEAK AND BLOCKAGE DETECTION

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ABSTRACT

Two new methods of leak and blockage detection in pipelines using fluid transients are developed in this thesis. Injection of a fluid transient (a pressure variation, the input) and measurement of the subsequent response (the output) provide information concerning the state of a pipeline through the system response function. The system response function exists in two forms, the *impulse response function* in the time domain and the *frequency response function* in the frequency domain. Provided that the system is unchanged, the response function does not change from one test to the next even though the injected transient signals may be different. A procedure that saves many hours over previous methods was developed for extracting frequency response information from experimental data. The procedure was verified both numerically and experimentally. It uses the linear time-invariant system equation. The approximation of linearity was tested by comparing calculations using the linear transfer matrix model to those of the nonlinear method of characteristics.

The system response function allows direct comparisons of the information content of transient traces. Events that create sharp variations in time were shown to have transient signals with the greatest information content. For this reason, transients generated by fast-acting electronic solenoid valves are preferable to slower transients from manual closures or pump trips.

A variety of signals were used to determine their effect on the information content of the system response. This investigation includes the use of step, pulse and pseudo-random binary signals. The use of pseudo-random binary signals was shown to provide the same information as a discrete signal that is many times its magnitude, which is attractive when system damage is of concern or the amplitude of an injected transient is limited for any reason. A specialised solenoid valve was designed and constructed as part of this research to generate pseudo-random binary signals in a laboratory pipe.

Two new methods of leak and blockage detection are developed in this thesis and these methods do not require the use of an accurate simulation model or a leak-free benchmark.

Knowledge of the pipe topology, flow and roughness values, or the role of unsteady friction on the transient event is unnecessary. Leaks and blockages induce a non-uniform pattern on the peaks of the frequency response function and the properties of this pattern allow the accurate location of the problem. In the time domain, leaks and blockages create additional reflections in the impulse response function. The arrival times of these reflections can be used to locate the fault.

Both methods have been validated using numerical and experimental results. The methods were tested under both low and high flow conditions, and a procedure for applying the methods in complex pipeline networks was developed. The time domain method can detect multiple leaks and discrete blockages. The frequency-domain technique provides a higher degree of noise tolerance but is sensitive to system configuration and requires a large bandwidth in the injected signal. In comparison, the time domain technique does not have these limitations and is more versatile; it is usually the better technique. The combination of methods provides an attractive alternative for leak and blockage detection and quantification.

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