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Leak Detection in Pipeline Using Wavelet and Ceptrum Analysis

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ABSTRACT

Background: Piping system is one of the important features in either home of industrial user. It is essential for transporting fluid from a point to another point. For example, for home user, piping systems functioning as carrier for the water from the damp to every home. Whereas, for industrial user, the fluid that is carried are from different type such as water, gas, oil and many more. But due to many reasons, leaks may occur in the pipelines. This paper is focusing on the leakage detection in the pipelines using wavelet on cepstrum analysis. The basic principle is the fact that water spouting out of a leak in a pressurized pipe generates signal, and this signal contains information to whether a leak exists and where it is located. The present transient methods for finding leaks are mainly based upon correlation analysis, where one sensing device is installed at each side of a leak. This method is hard to operate because it needs a lot of operators to operate it due to equipment in different place. To overcome this limitation a pressure transducer is used as the sensing device and ceptrum analysis to show the data obtained.

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INTRODUCTION

Pipelines are very important in transporting fluid for many applications and sectors. But due to many reasons, there are many problem arise when this process take place. The Association of Water and Energy Research Malaysia (AWER) expressed concern over findings that an estimated RM1.74 billion in treated water was lost in 2010. This is due to the phenomenon of what is known as non-revenue water (NRW) [2]. NRW can be defined as the water that has been produced but lost or disappeared before it reaches the customer or the user. Furthermore, a recent media statement from SuruhanjayaPerkhidmatan Air Malaysia (SPAN) shows that the level of NRW in Malaysia for 2010 range from 15% to 55% which is different for every states depending on the amount of the user (Level Of NRW in Malaysia, 2012).

There are many reasons which affect the level of the NRW such as aging factor of the pipe. For example, it is estimated that 40% of 50000km of the pipe networks were laid 40 to 60 years ago or even earlier. Furthermore, the poor maintenance of the pipe networks makes the problem become a huge issue. This is usually cause by the lacked of funding for asset replacement and maintenance which lead to leaking or any other problems which could increase the level of NRW in Malaysia. All of this problem will grow considerably over the coming years and if there is no action taken, this will be a huge issue to Malaysia.

Cepstrum Analysis:

Cepstrum analysis can be categorized as new method among the others. This method is developed because current method of locating the leakage is too complicated, imprecise and time consuming. So by using cepstrum analysis, the existence and position of very small leakage can be detected. The advantage of this method is that it is fast, accurate and cheap to employ. In addition cepstrum analysis is easier to use as it only requires filtering using wavelet and cepstrum analysis using MATLAB. Compared to other method, the peaks are sharper and have more defined peak when using cepstrum analysis.

The basic theory is that cepstrum is defined as Fourier transform of the logarithm of the Fourier transform. There are two types of cepstrum which is complex cepstrum and power cepstrum (Bayissa, W.L., N.S. Haritos,

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2007). Cepstrum analysis has been used in many area of application such as automotive, oil and gas, instrumentation and many more. Example of cepstrum analysis are machine diagnostic in monitoring of gearbox and rolling element bearing vibrations, gearbox testing to detect early gear faults, bearing fault detection, echo detection and removal and speech analysis. The basic calculation or formula behind the cepstrum is that complex cepstrum is defined as the inverse Fourier Transform of the logarithm of the forward Fourier Transform of time signal. Cepstrum is capable of identifying the echoes.

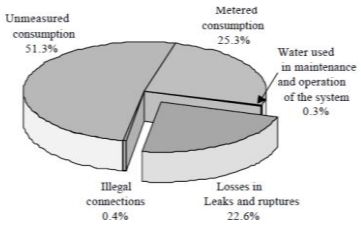

Fig. 1: Water Volume distribution and loss of fluid in piping system (Stafford, M., N. Williams, 1996).

Experimental Design:

Transient method will be used as the main method in this study. This method is basically one of the commonly used techniques in the leakage detection method. It is the idea of using pressure transient flow. Pressure transient happened when there is sudden change in flow by closing or opening the valve in the pipelines. This will create wave propagation along the pipelines and this propagation will be used as a medium to detect the leaks.

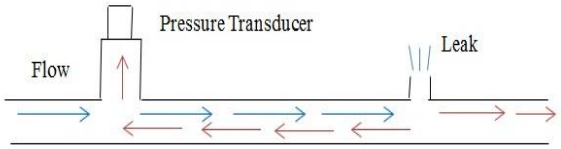

Fig. 2: Transient method (Seth, D.A., 2012).

The present technique of transient method is by using two sensors that have been oppositely placed between the leaks. Disadvantages of that method is that the operation needed two operates the two sensors. Furthermore, the noise also must be heard by both of the sensors in order for the leaks to be detected so the distance between the sensors is important to successfully detect the leak. The equipment is modified by using just only one sensor which is pressure transducer place at in front of the pipelines. The concept is that when the pressure transient travels down the pipe and there is contact with the leaks, a reflection of the signal is created. This signal will be collected by the pressure transducer. Then the data will be analyzed by using another method of signal processing

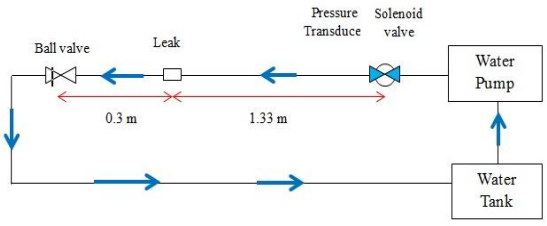

Fig. 3: Pipeline Diagram complete with water flow and symbol.

RESULT AND DISCUSSION

When raw data is collected, wavelet analysis will firstly take place. The data will be load on the wavelet toolbox of one dimensional in the MATLAB. Figure 4 shows the sampled data after being decompose. The type of wavelet use to decompose the signal is db-3 with 5 levels because of its compatibility to the raw signal which looks like the noise mishmash. The main objective of using the wavelet analysis is to filter and remove noise from the data. Only when the noise from the data which is not needed is removes, the signal of the features will be clearly seen.

The process of removing the noise is called de-noising process. It is done by selecting the scaled white noise which exists in the data due to pump noise, surrounding noise and many other disturbances. Figure 8 shows the pressure signal when both leaks are open, Figure 7 shows the pressure signal when opening leak 1 and Figure 8 shows the pressure signal when leak 2 is open. The entire figure shows graph of distance versus amplitude. In Figure 7,8, the red colour represents the no leak signal and the blue colour represents the leak signal.

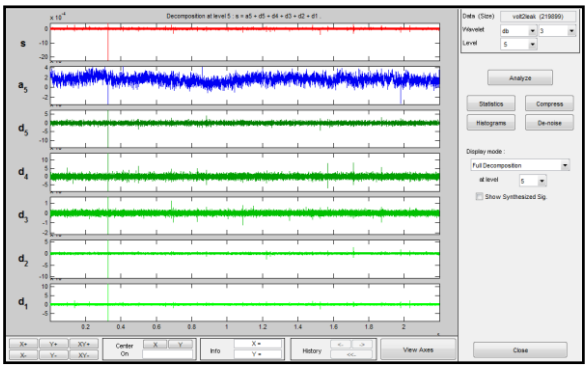

Fig. 4: Sampled data of wavelet filter & decompose.

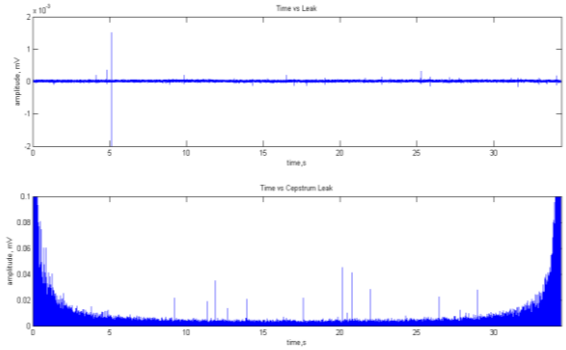

Fig. 5: Pressure signal of raw data and cepstrum analysis for leak.

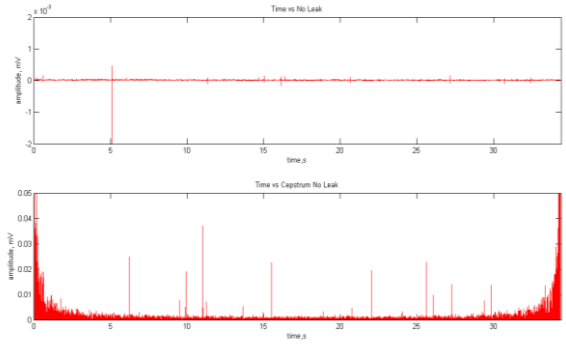

Fig. 6: Pressure signal of raw data and cepstrum analysis for no leak.

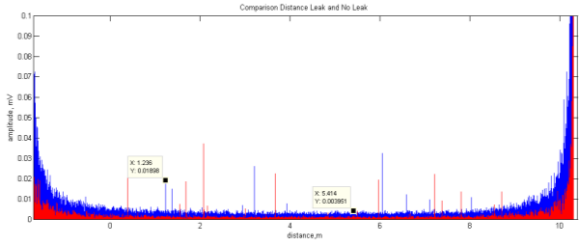

Fig. 7: Pressure signal when opening leak one.

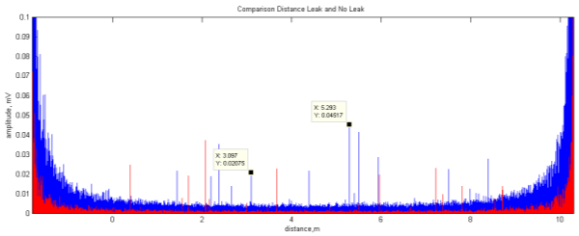

Fig. 8: Pressure signal when opening leak two.

Theoretically, the signal of features between leak and no leak should be in the same position except the signal of leak 1 and leak 2. But due to time lag the no leak signal is delayed and results is different distance from leak signal.

Conclusion:

All the data collected, result and analysis is obtained from the experimental process by using transient analysis of waves for leakage detection. Transient is occurs when there is disturbance is the flow of the fluid and it this study the solenoid valve is used to create the pressure transient. The wave will propagate throughout the pipe and will be reflected when it encounters the features such as leak, elbow, junction and many more. The signal reflected will then be collected by using only one pressure transducer and in cases of this study which are using strain gauge pressure transducer and Piezotronics pressure sensor.

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