

Leakage Detection in Galvanized Iron (GI) Pipelines Using Ensemble Empirical Mode Decomposition Analysis (EEMD)

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Abstract. There are many numbers of possible approaches to detect leaks. Some leaks are simply noticeable when the liquids or water appears on the surface. However many leaks do not find their way to the surface and the existence has to be checked by analysis of fluid flow in the pipeline. The first step is to determine the approximate position of leak. This can be done by isolate the sections of the mains in turn and noting which section causes a drop in the flow. Next approach is by using sensor to locate leaks. This approach involves strain gauge pressure transducers and piezoelectric sensor. The occurrence of leaks and know its exact location in the pipeline by using specific method which are Acoustic leak detection method and transient method. The objective is to utilize the signal processing technique in order to analyse leaking in the pipeline. With this, an EEMD method will be applied as the analysis method to collect and analyse the data.

Keyword: Waves propagation, Transient signal, Ensemble empirical mode decomposition.

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INTRODUCTION

Water is an important crop for human beings to live. The world scenario nowadays, water is a global issue. The World Water Vision Report, 2000 acknowledge that there is a global water crisis. The crisis is not about having too little water to satisfy our needs but it is a crisis of water management so badly for billions of people in the world and other words "suffer badly". The lack of water services is one of the most important physical signs of extreme poverty. As estimated in Global Water Supply and Sanitation Assessment 2000 Report by World Health Organisation (WHO) and United Nations Children' Fund (UNICEF) [1], 780 million people had no access to improved water supply and 2.5 billion were without access to improved sanitation. If current trends continue, these numbers will remain unacceptably high in 2015, 605 million people will be without an improved drinking water source and 2.4 billion people will lack access to improved sanitation facilities.

Currently, over 1.4 billion people live near water resources where the use of water already exceeds minimum recharge level resulting depletion of ground water [2]. As time goes, every generation tries to improve the previous system and existing.

Pipe leaking can be happen in many forms such as burst, hole and cracks. In global world water loss or water leaking can vary between 10 to 40% of total water volume produced, which can be great economic importance [1]. In Malaysia, there had been recorded 21.90% of physical and 14.70% of commercial water losses in year 2009.

WATER HAMMER PHENOMENON

Water hammer phenomenon also known as hydraulic transient usually occur at fast flow changes in pressurized water pipelines [3]. This phenomenon can be considered problem event in water pipeline. This is because water hammer usually occurs and creates damage to the pipeline due to strong pressure peaks and fatigue.

Water hammer phenomenon often brought strong vibration on the pipeline. Therefore, the calculation of water hammer is important especially in designing at operates pressurized piping system [4]. When a change happen in water velocity occurs, it will resulted rise and drop of pressure happen in the pipeline. Water hammer propagates as elastic wave along the pipes. Water phenomenon can be induced both in one-phase and two-phase system during pipeline transients [5]. In one-phase system, fluid flow in the channel is described with the mass, momentum and energy balance equations. In two-phase system, both velocity and thermal equilibrium in case of

two-phase flow. In this system, friction and vapour condensation plays important roles to induced water phenomenon.

SIGNAL ANALYSIS METHOD FOR LEAKS DETECTION

Ensemble Empirical Mode Decomposition

EEMD analysis is generally known as time space analysis method [6]. EEMD principle is by added white noise, it will populate whole time frequency space uniformly with constituting components of different scales. The general equation that can be used in EEMD is:

$$x(t) = \sum_{j=1}^n c_j + r_n \quad (1)$$

Where: r_n is the residue data
 n is number of IMF extracted
 c_j is number of zero-crossing

The ensemble mean is effective result that can be obtained by using EEMD, where data are collected by separate observations, each of which contains different noise.

DEVELOPMENT OF EXPERIMENT

The experiment is involving 1 inch GI pipe. Test rigs were connected to hydraulic bench which consist water tank and average power water pump. The experiment was designed by followed schematic diagram as in Figure 1, where involve U-shaped pipeline with features.

Based on Figure 1 the experiment was conducted to find calibration value. Leak was created based on pin hole type and this was controlled by stop valve. The captured signal was transferred to data acquisition. For the study for GI pipeline, 6400 of sample size and 6400 Hz sample rate was required to get the reading data more equate and easy to transfer the data to MatLab. Other tools that been used was DASY Lab software where strain value and transient graph was recorded.

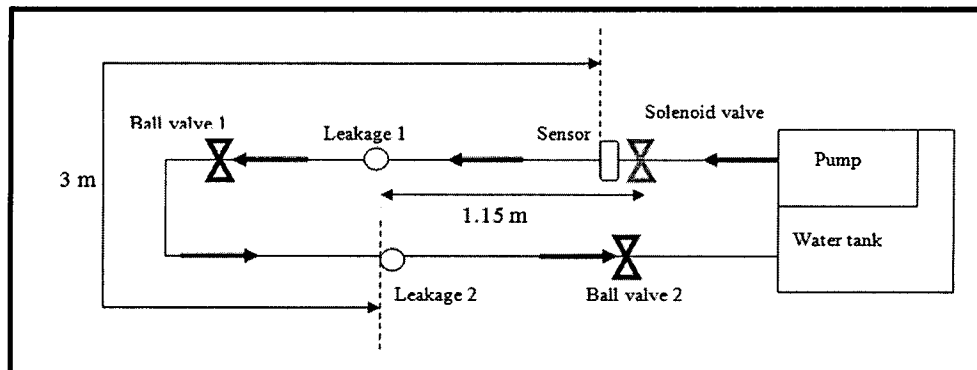


FIGURE 1. U-shape pipeline with features schematic diagram for GI pipeline.

RESULT AND DISCUSSION

Galvanized iron pipelines.

Galvanized iron (GI) pipelines have slightly higher speed of sound compare to medium density polyethylene pipelines. As the experiment conducted, there are some limitation happen where the strain gauge pressure transducer was unable to read and measure signal due to low resistance ability of strain gauge to tension and compress at high pressure of water flow in the GI pipelines. By using piezoelectric sensor, sample size and sampling rate was set up at 6400 and the signal was successfully recorded. To many sample rate will cause to many data after pressure transient is create. the analysis will not accurate with many data to analysed.

Sample size 6400 with leakage in the GI pipelines.

The result is show the signal captured in GI pipeline with second leakage within 10 seconds. The signal is decomposed into six IMFs with the final component indicating the residual of the signal. Transient of signal was stimulated by solenoid valve at zero seconds. From the signal data set, it shows an obvious signal transient point at 8.5 and 8.96 seconds. The transients was unable to be recorded in signal wave data without leakage, so the data is assume as a disturbances or as a potential leakage that happen in 10 seconds time frame. After been decomposed by using ensemble empirical mode decomposition with addition of 0.2 amplitude of white noise and 100 ensemble, the signals were removed and only the transient signal at 8.5 seconds still can be detected until at fourth IMF.

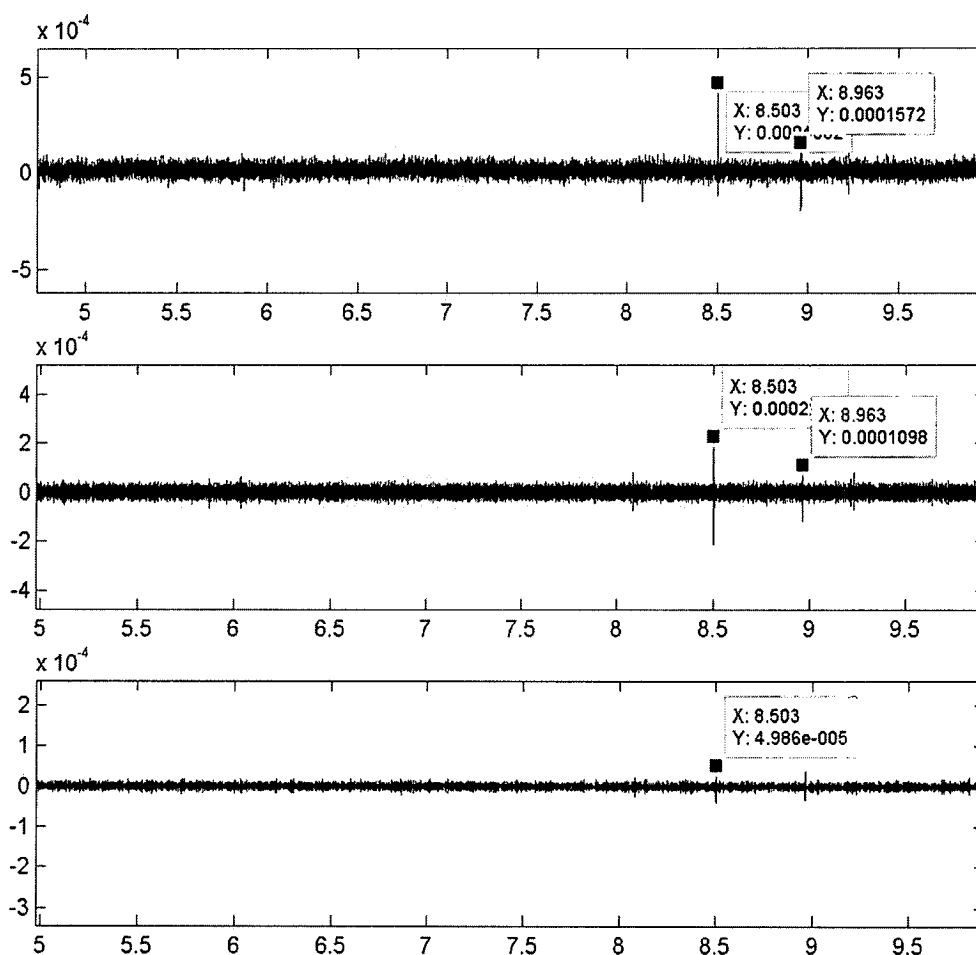


FIGURE 2. EEMD analysis leakage for GI pipeline

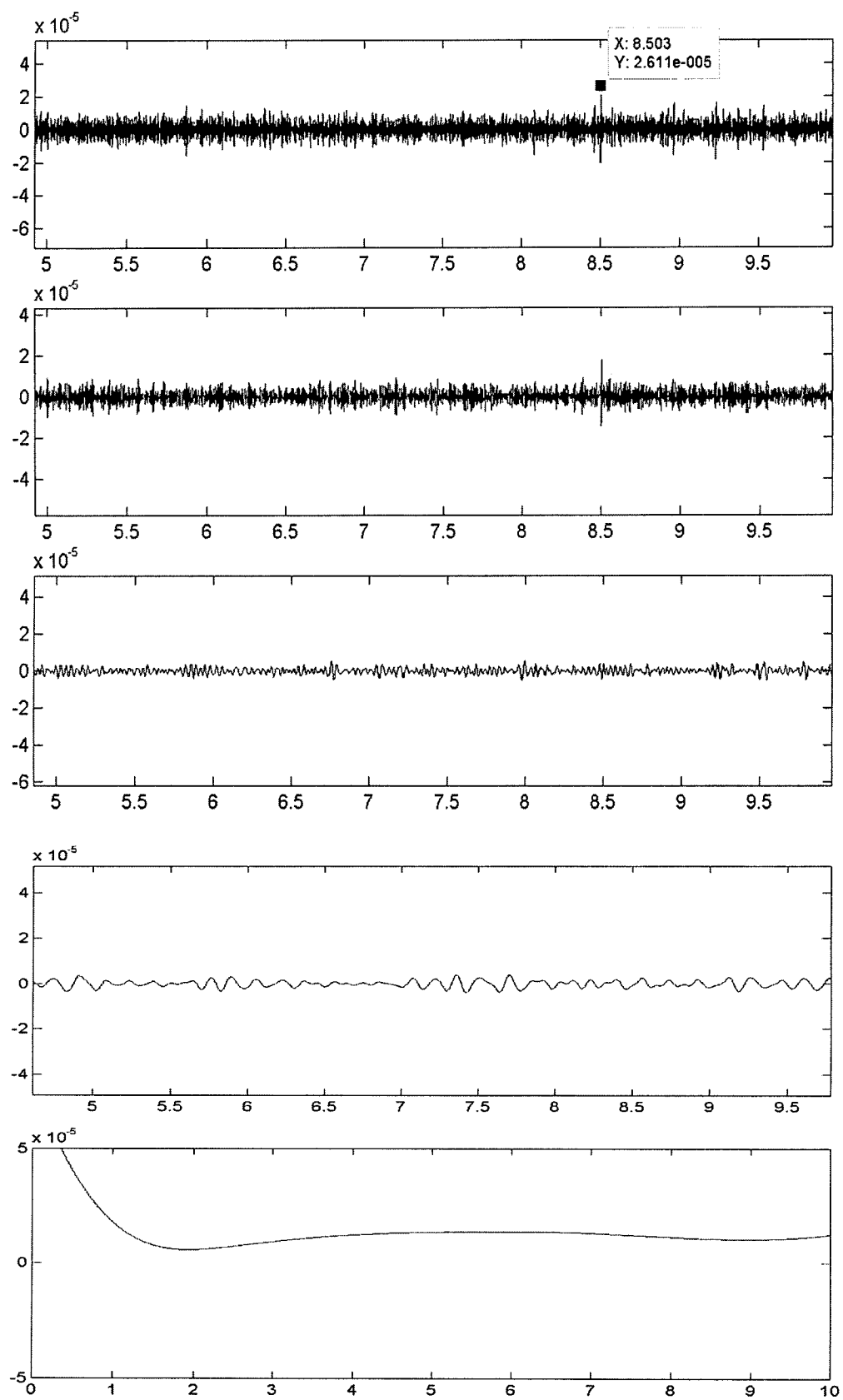


FIGURE 3. Continued

In GI pipeline, the propagation speed is 4512 m/s . The equation needed to be divided with 6400 because of the data was recorded in sample rate 6400 in one second. The result is 2.99 m. The signal at 8.5 seconds is second leakage time captured in the pipeline. The measured distance of leakage is 3 m and this shows that there only 0.33% of error that happens in the measurement. The error may causes by additional noise and disturbance influenced by motor pump that was located not far away from the leakage, undetectable leakage at joint of figure and lag happen when the data was captured and recorded.

Both of transient signal time was calculated into following equation.

$$s_{\ell} = \frac{\Delta t_{\ell} a}{2} \left(\frac{1}{6400} \right) \quad (2)$$

Where:

s_{ℓ} is distance of pressure wave produced and leakage.

ΔT_{ℓ} is changes time between initial and reflected wave.

A is wave propagation speed.

CONCLUSION

The data obtained then was calculated in leakage detection equation influence by sample size of the signal was recorded. From the study, EEMD analysis predict satisfactorily the location in GI pipelines as it can detect and locate the leak up to error of 0.33% in GI pipeline. The EEMD method had perform the best and already produce an acceptable result.

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