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Full paper

Early Detection of Pipeline Leakage Using Ultrasonic Sensor

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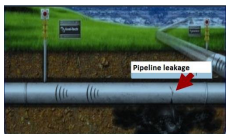
Graphical abstract



Abstract

Pipelines leakage is the main problem faced by industries. The main causes of leakage on pipelines are corrosion, crack and disaster. This problem must be detected early to ensure that maintenance work can be done quickly to prevent pipe bursts, as well as to minimize operational costs. The objective of this research is to review a method for early detection of leakage on pipeline that affect by the changing water level in the pipeline. The method used in this research is ultrasonic sensor that is implanted on the outer surface pipeline.

Keywords: Component; leakage pipeline, ultrasonic sensor

1.0 INTRODUCTION

Water is the most important element needed by humans and is used in various places such as industries, domestic, and also power plants. The most effective way in transporting water is by pipelines as it is the safest and cheapest in terms of resources and maintenance. It is very important to have an effective way to control the operation of water usage between the supplier and the consumer to prevent water loss. So, this project focuses on the pipeline systems in industries, for example the cooling tower that has a constant flow rate of water.

As water is the most important resources, various measures are being implemented to control the loss of water. One of the ways is by using a microcontroller and some sensors to produce a device that can overcome the water loss problem due to pipeline leakage.

2.0 OBJECTIVE

The main objective of this research is to develop a device and system using ultrasonic sensor to detect the leakage in pipes as shown in Figure 1. This covers the development of sensor's fixture, excitation circuits, signal conditioning, and hardware interfacing.

Specifically, this research aims to:

i. design a circuit of transmitter and receiver of ultrasonic sensor
ii. detect a leakage on a constant flow rate pipeline.

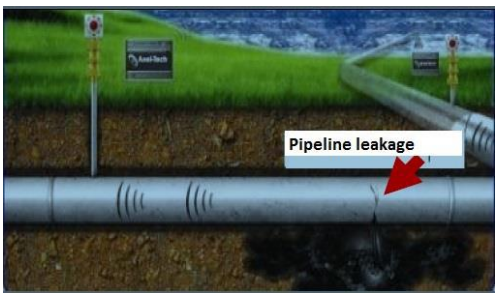


Figure 1 Crack that caused leakage

3.0 RESEARCH METHODOLOGY

Ultrasonic transceiver is a type of transducer that converts electrical energy into high frequency sound waves and changes back to electrical energy. It contains piezoelectric crystal materials that have the ability to transform mechanical energy into electrical energy and vice versa (Mohd Hafiz *et al.*, 2010). Piezoelectric crystals have the property of changing size when a voltage is applied. This means, applying an alternating current (AC) across them causes them to oscillate at very high frequencies, thus producing very high frequency of sound waves (Mohd Hafiz, F. R, 2005). Certain characteristics need to be considered to determine the properties of the transceiver that are suitable for specific applications. For example, the size,

frequency, beam angle and others. Selection of the right transceivers must be the first priority to achieve the best outcomes.

For this project, transceiver 400EP14D had been chosen as it fulfilled the characteristic of this sensor and the project requirement. The dimension of the sensor provided by the manufacturer is 14 mm in diameter. This sensor was chosen because it had a beam angle of 125, compared to ultrasonic sensors from other companies with a beam angle of less than 100. Figure 2 shows the outline of the ultrasonic sensors (400EP14D).

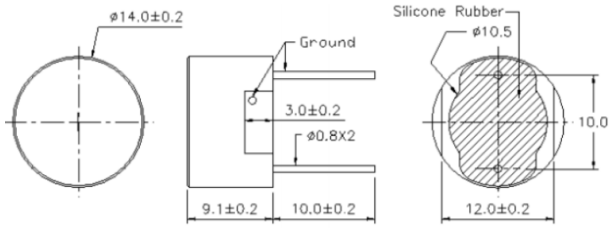


Figure 2 Outline of the ultrasonic sensors (400EP14D**)**

The actual hardware of early detection of pipeline leakage using ultrasonic is shown in Figure 3.

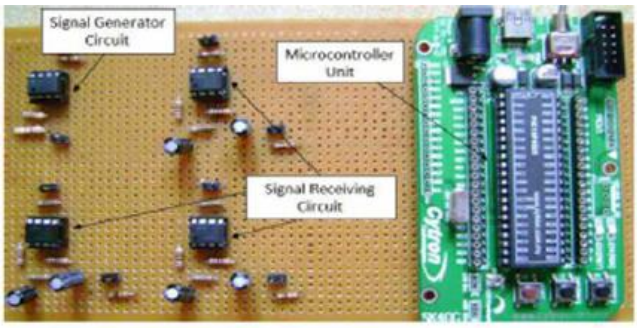


Figure 3 The actual hardware

■4.0 RESULTS AND DISCUSSION

Results from the measurement based on three conditions - a pipe with no flow of water, a normal flow of water and finally a flow of water with a leakage on the pipe-will be discussed. All measurements used PVC pipes of the same diameter. The results obtained from the experiments are then compared with the theoretical value. The comparison between these two experiments is made in terms of accuracy and repeatability. Results for the three experiments are shown in Table 1 and the plotted graph in Figure 4.

From the data collected in experiment 1 (empty pipe), the voltage measured for this condition was 4.44 volt peak to peak while the time of flight (which is the time travel for the signal from the transmitter to the receiver) was 126 µs. The data is used to make an early assumption for the next experiment. For this condition, the pipe only consisted of air. For the other two experiments, we assumed that the voltage would increase when there is water flow in the pipe and will drop when there is a leakage in the pipe but the value for leakage would not be less than the empty pipe. For experiment 2 (constant flow rate), the voltage increased from 4.44 volt to 5.24 volt and the time of flight was 1.62 ms. This result shows that the voltage increased due to the difference in value of permeability of water. For the last experiment, which is flow with leakage, the voltage decreased from 5.24 volt to 5.00 volt and the time of flight was 1.52 ms. This result shows that the voltage decreased due to the difference in value of permeability of mix composition of water with air.

Table 1 Overall results

Condition	Voltage(V)	Time(ms)
Empty pipe	4.44	0.126
Constant flow rate	5.24	1.62
Flow with leakage	5.00	1.52

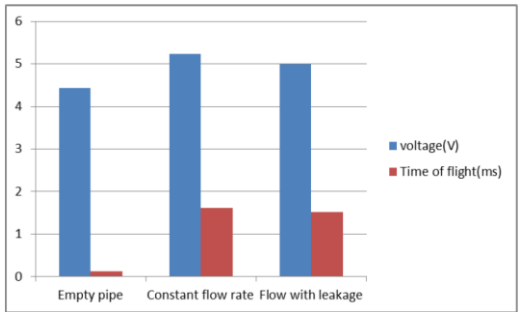


Figure 4 Plotted result

■5.0 CONCLUSION

A nondestructive or noninvasive method to detect leakage in a pipe using the ultrasonic sensor system with a constant flow rate of water has been developed successfully. The conclusion based on the experiment on the three different conditions is also made. The study meets its specific objectives i.e.:

- successfully developed a design for a circuit of transmitter and receiver. The critical problem for designing the circuit is in finding a suitable gain for the receiver circuit with respect to the diameter of the pipe. Different pipe diameter requires different value of gain. So, the circuits that have designed is suitable for a pipe with 4 cm diameter.
- successfully developed a method for detecting leakage in a constant flow rate of water in a pipeline using three different conditions for the experiments :
  1. A pipe with no water flow
  2. A pipe with a constant flow rate of water
  3. A pipe with a leakage

In the experiments, the first condition is functioning as a reference for the other two conditions. For the first condition, the voltage at the receiver circuit was 4.44 volt and for the second condition the output voltage was 5.24 volt. However, for the third condition the voltage dropped to 5.00 volt. This indicates that the pipe contains a combination of water and air and thus a leakage in the pipelines.

Acknowledgement

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References

[1] Mohd Hafiz, F. R., Ruzairi. A. R. and Nor Muzakkir, N. A. 2011. The Front-End Hardware Design Issue in Ultrasonic Tomography. *IEEE Sensor Journal*. 10(7): 1276–1281.

[2] Mohd Hafiz, F. R. June 2005. Non-Invasive Imaging of Liquid/Gas Flow Using Ultrasonic Transmission-Mode Tomography. Universiti Teknologi Malaysia.