APPLICATION OF ACOUSTIC EMISSION IN THE DETECTION OF LEAKS IN WATER MAINS

LAU NGOH HUET

Universiti Malaysia Sarawak
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This project report entitled "APPLICATION OF ACOUSTIC EMISSION IN THE DETECTION OF LEAKS IN WATER MAINS" was prepared by Lau Ngoh Huet as a partial fulfillment of the requirement for the degree of Bachelor of Engineering with Honours (Mechanical and Manufacturing System) is hereby read and approved by:

Dr. Ha How Ung

8/4/2002

Date

APPLICATION OF ACOUSTIC EMISSION IN THE DETECTION OF LEAKS IN WATER MAINS

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To My Beloved Family

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ABSTRACT

This research describes the application of Acoustic Emission (AE) Method in the detection of water leakage in pipeline. The pipe used in this project was a PVC pipe with internal diameter of 15 mm. Generally, PVC pipes are "quieter" and do not transmit sound or vibration as efficiently as metallic pipes. Thus, from the results it is possible to know what is the sensitivity level of AE in water leaks detection through the PVC pipe in this research. This project involved laboratory works, and setup of instrumentation using acoustic sensor and computer to carry out the data acquisition, analysis, and displays. The actual leak of water was not applied in this project. Therefore, this research done by the pressing a cracked pipe by assumption that water is leaking during the continuous pressing performed. Analysis that was carried out was to correlate AE wave signal parameters, such as amplitude, energy, and frequency displays from difference locating of sensor and configuration of pipe.

ABSTRAK

Penyelidikan ini menerangkan penggunaan kaedah Pancaran Akostik dalam pengesanan kebocoran air dalam saluran paip. Paip yang digunakan dalam projek ini adalah paip PVC dengan 15 mm diameter dalaman. Secara umumnya, paip PVC adalah "lebih senyap" dan tidak memancarkan gelombang bunyi atau getaran secekap paip logam. Oleh itu, melalui keputusan yang diperolehi, tahap kepekaan kaedah pancaran akostik dalam pengesanan kebocoran air dalam paip PVC boleh ditentukan dalam penyelidikan ini. Kajian bagi projek ini dijalankan dalam makmal. Ia melibatkan pemasangan peralatan seperti alat pengesan dan computer yang melaksanakan tugas analisis dari data yang diterima dan seterusnya ditunjukkan pada skrin computer. Penyelidikan ini tidak mengunakan sumber air untuk menentukan kebocoran paip. Oleh itu, ia dilakukan dengan menekan bahagian paip yang retak dengan menganggap bahawa kebocoran air berlaku apabila paip ditekan berulang kali. Analisis yang dijalankan termasuk perbandingan parameter isyarat gelombang pancaran akostik dalam pengesanan pada jarak yang berlainan dan konfigurasi paip yang berbeza. Parameter isyarat yang akan dianalisis termasuk amplitud, tenaga pemancaran dan frekuensi

CHAPTER 1

INTRODUCTION

1.1 Overview

A significant lost of water can sometimes occurs in the water distribution system while it is being transferred from the water treatment plants to the consumers, or to the reservoirs. Unaccounted for water lost can generally be attributed to several causes including leakage, metering errors, and theft. However, water losses through leakages represent the majority of this unaccounted for water lost. The leakages can be from the valves or the pipes, thus the necessity of leakage detection and prevention.

One of the methods used for detection is based on the analysis of casual or continuous acoustic noise generated by the water leaking from the pipeline and carried out by cross-correlation technique. This cross-correlation method is Acoustic Emission Test (AET) that can be used to detect and locate the leaks. The method can be used to detect the underground supply and distribution of water in different types of pipe material including steel, ductile iron, cast iron, polyethylene and polyvinyl chloride (PVC). From AET, it allows the repair and service to be carried out immediately once the leakage in pipelines have be detected so as to prevent continuous loss of water.

However, the effectiveness of Acoustic Emission Test in leakage detection plastic pipe such like PVC pipe has not be widely reported because plastic pipes are "quieter" and do not tend to transmit sound or vibration as efficiently as metallic pipes. The problems that are normally encountered with locating leaks with acoustic equipment, e.g., interfering traffic signals, and attenuation of leak signals along pipes, become more detrimental in the case of plastic pipes.
[Dr Osama Hunaidi, Institute for Research in Construction]

1.2 Project Aims and Objectives

The main aim of this project was to evaluate the effectiveness of Acoustic Emission Test for the detection of leak or cracks in PVC pipes. Objectives of the research included.

- To analyze acoustic signal of leak in PVC pipe.
- To analyze correlation of signal for difference distance of sensing point from cracking part.
- To evaluate the effectiveness of AET in different configuration of pipe connection.
- To study the nature of acoustic emission.

1.3 Definition of Acoustic Emission

Acoustic Emission (AE) is an acoustic wave generated by the release of energy from localized sources in a material that is subjected to mechanically loading deformation or cracking. The AE generally differs from most other nondestructive methods in two significant respects. First, the release of energy that would be detected is released from the test object rather than being generated by the nondestructive testing devices, as in ultrasonic or radiography. The acoustic waves are picked up by sensors and converted into the electrical signal and analysed. Second, the acoustic emission method is capable of detecting the dynamic processes associated with the degradation of structural integrity, not geometric discontinuities. It is different from most of other non-destructive techniques, where there must be some forms of geometric discontinuities for detection

Acoustic Emission Test is a rapidly maturing nondestructive testing method with capabilities for monitoring structural, detecting leaks and incipient failures in mechanical equipment, and for characterizing material behavior.

CHAPTER 2

LITERATURE OF REVIEWS

2.1 Water Leak Detection Methods

2.1.1 Water Audits

Water audits are types of water leak detection methods that involve a detailed accounting of water flow into and out of the distribution system or parts of it. This method helps to identify the areas having excessive leakage of water but do not provide information about the location of leaks.

2.1.2 Visual Inspection

Visual inspection is a simple method can be used to detect many of water leaks. The visual inspection requires the distribution staff to continuously watch out for signs of leakage and should make it a routine to inspect the whole of the district on regular basis. However, this method is more effective for leak detection of onto ground surface pipe compare with buried underground pipe.

2.1.3 Ultrasonic Leak Detection

During a leak, the water will flow from high pressure to low pressure and producing a turbulent flow at the leaks site. This turbulence has strong ultrasonic components which able sensed by Ultraprobe and translated into audible range where they are heard in headphones. The intensity of the ultrasonic signal falls rapidly from the source will allowing the exact spot of a leak to be located.

2.1.4 Acoustic Emission Detection

For this method, acoustic equipment has been used to detect water leaks by detecting the sound or vibration induced by water as it escapes from pipes under pressure. Acoustic equipment used includes the listening devices and leak noise correlators.

The function of listening devices such listening rods, aquaphones, and geophones is to listen for leak sound at contact points with the pipe. The leak noise correlators which are the modern computer-based instrument that have a simple field setup and used to measuring leak signals (sound and vibration) at two points that bracket a suspect leak. Then, the automatic determination based on the time shift between the leak signals would be calculated to locate the position of the leak.

2.2 Leak Concepts and Terms

According to Gerald L. Anderson, American Gas & Chemical Co., Ltd. (Leak Testing Large Container, 2000), leakage testing defined as a branch of nondestructive testing used for the detection of fluid leakage in either a pressurized or and evacuated system. The word 'leak' refer to the physical hole and not to the quantity of gas or liquid flowing through the hole. In other words, leaks are flaws which affect the safety or performance of a system or which result in environmental contamination or energy loss.

For the word 'leakage', it refers to the flow of a fluid through a leak without regard to the physical size of the hole. Leakage typically occurs as a result of a pressure differential across the hole. However, capillary effect can also be a cause of leakage. When fluid flows through a small leak the rate of flow depends upon the geometry of the leak, the nature of the leaking fluid and the prevailing pressure and temperature.

The characteristics of a leak are often referred to as the conductance of the leak. The leak hole actually cannot be seen or measured, thus the measure of conductance or leakage rate of a given fluid through the leak under certain condition used to describe the leak size

2.3 Water Leakage Causes

Normally, the pipe fractures are main cause of water leak and waste that supplied through the pipe in water distribution system: either defective material or bad lying of pipe may cause these fractures of pipe. The types of pipe that are commonly used in water distribution system are cast iron pipe, PVC pipe, steel pipe and G.I. pipe. The pipes may sometimes fracture due to brittleness and thickness of the pipe; such as small thickness and brittle characters of PVC pipe, uneven wall thickness of cast iron pipe and steel pipe, and improper galvanization in G.I. pipe. For bad lying of pipe, it includes the settlement of pipe bedding in direct contact between stones and pipes will creating stress fractured and accelerated corrosion of pipe. Beside that, welding points in steel and G.I. pipe are considered as defective point if it is not properly done and left out with protection

The use of steel pipe will result in the corrosion of pipes caused by external rust attack due to inadequate protection from sulfates in the ground and internal chemical attack due to aggressive water. Thus, to connect the pipe to the determined destination, the joining of pipe is inevitable. The leaking in pipe joints will occur if joint assembly is poorly constructed and excessive joint defect within sockets.

Furthermore, leaks may be caused human either intentionally or unintentionally. For example, the farmers may intentionally break the pipe for farming, for domestic use or for irrigation purposes. Also, the removal of taps from standpipes and unauthorized connection by the villagers will also cause leak and thus waste of water.

Apart from that, water leakage in water valves and saddles may also occur as a consequence of fitting such as the use of excessive force during operation causing the breaking of spindle; encrustation of water valves; damaged of frame due to badly placed road surface box and exist of stones and sludge in gate seating.

2.4 Acoustic Emission Concepts and Terms

Formally defined, *acoustic emission* (AE) is "the class of phenomena where transient elastic waves are generated by the rapid release of energy from localized sources within a material". Generally, there are two types of AE, which are burst and continuous. Burst AE are individual emissions with distinct rise and decay segments of the waveform such as would result from fracture while continuous AE are the result of emissions occurring in rapid succession such that the signal level appears sustained. Continuous type of AE normally produced by plastic deformation and fluid leaking on a pressure boundary.

Acoustic emission analysis (AEA) is a non-destructive testing method capable of detecting and locating faults in mechanically loaded structures, components and Specimens. AEA provides comprehensive information on