EFFECT OF DEFECT ORIENTATION IN PIPE ON ACOUSTIC WAVE PROPAGATION

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Report
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A report submitted
in fulfilment of the requirements for the degree of
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DECLARATION

I declare that this project report entitled "Effect of Defect Orientation in Pipe on Acoustic Wave Propagation" is the result of my own work except as cited in the references.

Signature	:	....
Name	:	Saddam Hamood Ali Mohammed Abbas
Date	:	17 June 2017

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant and Maintenance)

Signature :. ....

Name of Supervisor :Dr. Nor Salim Bin Muhammad

Date : 17 June 2017

DEDICATION

I would like to dedicate this humble effort to

Those who care about me when I need support and motivation

My father

HAMOOD ALI MOHAMMED ABBAS

To whom I miss, my late mother

MALEKAH AL-SHERHARI

To my supporting

Family

To whom give me much of his time and knowledge

My supervisor,

DR. NOR SALIM BIN MUHAMMAD

To my lovely country

YEMEN

To my second home

MALAYSIA

and

To all my friend,

for their assistances & supportive efforts.

ABSTRACT

Guided wave in non-destructive testing (NDT) and structural health monitoring (SHM) is a technique to perform an inspection in large or long structures such as in pipes from single position of transducer. There are three types of guided wave modes in axial direction of the pipe, which are torsional *T* (0, *n*), Longitudinal *L* (0, *n*) modes, and flexural *F* (*M*, *n*) modes. In low frequency range, the guided wave can only propagate in modes of *L* (0, 1), *L* (0, 2) or *T* (0, 1) in pipe structures. *L* (0, 2) mode is a typical mode that use in inspection technique due to its fastest wave speed and small dispersion in low frequency range. Therefore, we decided to investigate its behavior on the orientations of defects, which placed at the similar location in two aluminum pipes. The study used two-angle beam transducers consist of piezoelectric of transducers and acrylic shoes to find the artificial defects with placed in perpendicular and oblique orientations, respectively. The two angle beam transducers is used on the top and bottom of pipe and measured at five different locations with distance of 14 mm between each location. The five signals are then used to enhance the defect echo, which obtained from the excitation of five cycles of tone burst signal generated at central frequencies of 80 kHz to 150 kHz. The location of perpendicular defect is successfully located approximately at the exact location of the defect while the location of oblique defect is not unsuccessfully identified by using the two-angle beam transducer. This indicated that the reflected wave from defect is affected by the orientations of defects in pipes.

ACKNOWLEDGEMENT

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LIST OF ABBEREVATIONS

NDT	Non-Destructive Testing
SHM	Structure Health Monitoring
UT	Ultrasonic Testing
GW	Guided Wave
PZT	Piezoelectric Transducer

LIST OF SYMBOL

A0	=	Antisymmetric mode 0
A1	=	Antisymmetric mode 1
L (0, 1)	=	Longitudinal mode 0, 1
L (0, 2)	=	Longitudinal mode 0, 2
S0	=	Symmetric mode 0
S1	=	Symmetric mode 1
T (0, 1)	=	Torsional mode 0, 1
T (0, 2)	=	Torsional mode 0, 2

CHAPTER 1

INTRODUCTION

1.1 Background

In line to the high demand in manufacturing and services there are many companies involved in business of power plant and petrochemical industries which use storage tanks, pressure vessel, and pipes in their facilities for storage, transfer and distribution. There are different ways for the installation of pipes on ground installations or underground installations. In addition, some of the installations have external coating of bitumen, polyethylene, polypropylene or asphalt. The flow of fluids and foreign materials in fluid transfer and distribution cause internal corrosion in the pipe networks. The cyclic loading on the pipe network also contribute into pitting in the pipeline while the effect of the environment also possible to cause external corrosion on the pipes. Therefor a predictive maintenance needed to ensure the quality of the pipe works, as well as to ensure non-stop operational capability of the factory and to prevent leakage in the pipes that carry the fluid materials or the gases as these fluids or gases might be harmful to human or caused the pollution into the environment. Moreover, in order to detect or screen the structure even for external failures using traditional ultrasonic technique will be very expensive due to the excavation, removal of the pipe insulation, and reinstallation of the pipe structures.

Therefore, the scientists have worked out on the development of a fast and reliable method for the detection of corrosion under insulation and underground pipelines. Ultrasonic guided wave in Non-destructive testing (NDT) structural health monitoring (SHM) contributed to solve these industries failure (Saeed Izadpanah, Gholam Reza Rashed, Sina Sodagar, 2008).

By using the guided wave technique, the maintenance activity can be carry out with the sufficient knowledge and skills to perform the inspection for the pipes above ground and underground. The guided wave can be utilized to locate defect externally or internally to ensure the quality of the pipe works, as well as to ensure non-stop operational capability of the factory and to prevent the pollution in the environment (Alobaidi et al., 2015).

Ultrasonic guided wave in solid media have become a critically important subject in NDT and SHM. New faster, more sensitive and more economical ways of looking at materials and structures have become possible when compared to the previously used normal beam ultrasonic or other inspection techniques. (Joseph L. Rose, 2014).

There are many advantages of using guided wave summarized as follows:

i. Perform an inspection for long distance as in the pipe from only single position of transducer, that’s means no need to scan entire structure under consideration, data can be obtained from a single probe position.
ii. Provide greater sensitivity even in lower frequencies can produce a better picture of the health of the material than the obtained data in normal beam ultrasonic inspection or the other NDT techniques.
iii. The ultrasonic guided wave analysis techniques can perform inspection even for the hidden structure, coated structure as in Figure 1.2 below.
iv. The inspection and guided wave propagation are cost effective because it is simple and rapid.

Guided wave inspection named” long range inspection” as technical name, the volumetric inspection is also known by a guided wave inspection used mainly to locate the pipe integrity as a fast screening tool for corrosion. Guided Waves are ultrasonic waves that guided by the object geometry in which they propagate. (Saeed Izadpanah, Gholam Reza Rashed, Sina Sodagar, 2008).

The guided wave inspection on pipe will conducted in this research experiment using an angle beam transducer, which consists of a transducer and a shoe. However, multiple of transducers might be required for a specific application when the inspected pipe defect in different orientations. Thus, a technique on transducer and equipment development must realize to suit the requirement on inspection to perform the inspection for pipes to detect the location of defects in different orientations to reduce the cost and provide competitive services.

1.2 Problem Statement

Applications of guided wave technique in pipe inspection become more dominance for inspection of underground pipelines. However, corrosion defects in pipes occurs in verity of depths, sizes, geometries, and orientations. In some cases, the guided wave screen in pipes might fail to locate severity defects due to low sensitivity of the transducer against the defect geometries or orientations.

This study aimed to investigate the effect of defect orientations on the guided wave inspections by using a perpendicular and an incline defects in pipes. The results then will extended for signal enhancement to improve the sensitivity of defect screening in pipe structures.

1.3 Objective

The objective of the research to achieve following:

- Observe the effect of defect orientation on the sensitivity of a guided wave pipe inspection.

1.4 SCOPE OF STUDY

The scope of this research consists the experimental works to cover the following:

1. Design and fabricate the matching layers, backing layers, and casings for the PZT transducer and its shoes.
2. Create an oblique defects in the aluminum pipes to detect this effect with 45 degree.
3. Development of guided wave measurement system.
4. Analysis of defect locations in pipe using the measured signal from angle beam transducer.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter covers the literature review about guided waves inspections in two common structures use in industry, which are pipes and plates. It discusses dispersion curves and the transducers used in the guided wave inspection.

2.2 Ultrasonic bulk wave and guided wave propagation.

Ultrasonic bulk wave that propagate in the media with no boundaries, such as the waves traveling in infinite media. Nevertheless, guided wave characterized by it is required boundaries in order the propagation like in rods, pipes, plates. Guided waves naturally can propagate for the long distance provide tremendous potential for time in order to cost savings during the inspection for deferent structures. As shown in the Figure 2.1 below the guided waves able to achieve much ranges of inspection than conventional “bulk” ultrasonic testing methods, because the guided wave use the structure as a waveguide by using resonances between the boundaries of the structure itself, such as the plate surface or the outer diameter and inner diameter of a pipe. Conventional “bulk” wave UT systems able only to inspect an area that is very close to or directly under the transducer. In the bulk wave inspection, the transducer also must scanned along the surface of the structure in order to access to information in axial direction. On the other hand, guided wave systems can detect flaws for long distance from single probe transducer. It also able to locate defects at very low frequencies compared to conventional “bulk” wave UT, which reduce attenuation of the wave modes (Joseph L. Rose, 2014).

Traditional ultrasonic and guided wave techniques as shown in Figure 2.1, to cover inspection on a large area of the structure. The ultrasonic technique introduces wave in thickness direction at higher frequency range (1 MHz - 15 MHz) while the guided wave generates acoustic wave in longitudinal direction either from an angle beam transducer or an array of transducers at lower frequency (50 kHz - 15 kHz). (Joseph L. Rose, 2014).

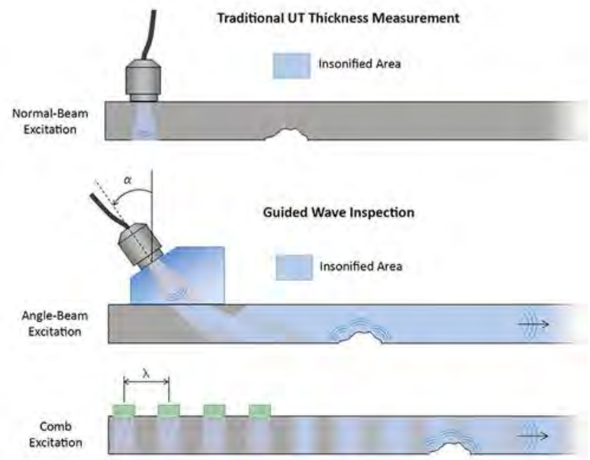

Figure 2.1: Comparison between bulk wave and to guided wave method (Joseph L. Rose, 2014).

2.3 Guided Waves

Guided waves started in industries in early 1990s for cost reduction on screening large structures. It is one of non-destructive testing (NDT) in structure health monitoring (SHM). The guided wave (GW) well known by its ability to perform inspection over long distance of pipelines or large structures. The Guided Wave (GW) typically used on inspection of whole structures from single probe location. The technique than can be used for service inspection in many different structures such as rods, pipes, thin plates, and multilayer structures. Its ability to perform rapid screening in long or large structures significantly reduce the operation costs during the inspections.

Furthermore, guided waves have the ability in inspection of hidden structures such as under water or ground structures, insulated pipes and concrete structures as shown in Figure 2.2, it is due to the behavior of the excited guided wave modes which can propagate through fluids or along the solid medias from a fixed probe(Rose, 2007).

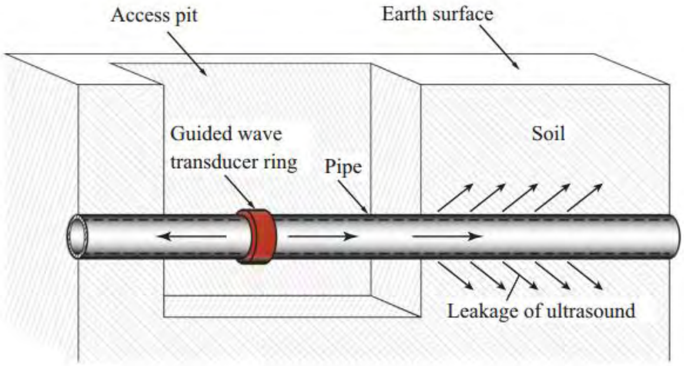

Figure2.2: Performing inspection for hidden pipe with by guided waves

2.3.1 Lamb wave propagation in plate

Horace Lamb studied the wave propagation at an isotropic solid plate with free surface (Lamb, 1917), Lamb waves a common waves used in plate detection of NDT. Lamb waves propagation are parallel to the surface plate during the thickness of the pate materiel. Properties of the plate, that effect the propagation of Lamb waves such as density and the elastic. In addition, they can effect a great deal by test frequency and material thickness. Lamb waves propagate at incident angle at which the wave velocity in the source is similar to the wave velocity in the plate material. Lamb waves is capable to travel long distance of the plate. A several modes of particle vibration are possible, and the most common are fundamental symmetrical and non-symmetrical modes as illustrate in Figure 2.3. Symmetrical modes (S-mode) has motion in a symmetrical pattern around the medium of plate surface. It is known as the extensional mode because of the wave is "stretching and compressing" the plate in motion direction of the wave. Symmetrical mode of wave motion is most efficiently propagated when excitation force parallel to the plate surface (Auld, 1990; Rose J. L., 1999).

Asymmetrical (A- mode) commonly denoted as flexural mode due to a large portion of motion moves at normal direction into the plate, also small portion of motion moves parallel direction in the plate.