EFFECT OF FOIL WIDTH IN MAGNETOSTRICTIVE TRANSDUCER ON THE EXCITED LONGITUDINAL WAVE IN PIPE

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DECLARATION

I declare that this project report entitled *"Effect of Foil Width in Magnetostrictive Transducer on the Excited Longitudinal Wave in Pipe"* is the result of my own work except as cited in the references.

Signature : ....

Name : AYUOB SULTAN SAIF ALNADHARI

Date : 22/6/2017

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 & Maintenance).

Signature	:	
Name of Supervisor	:	DR. NOR SALIM BIN MUHAMMAD
Date	:	22 / June / 2017

DEDICATION

Every time when I need them the most,

They are always by my side.

This humble work of mine I would like to dedicate to

My lovely father,

SULTAN SAIF ALNADHARI

My lovely and caring mother,

FAWZIA SAEED ALWAN

My siblings and family,

My supervisor,

DR. NOR SALIM BIN MUHAMMAD

And

All my friend,

For their assistance & support.

ABSTRACT

Pipelines are one of the main parts in many industrial structures. Cracks and corrosion within the pipeline lead to huge damages. To detect these problems, guided wave testing (GWT) is used. GWT is implemented by using different transducers. One of the most frequently used is magnetostrictive (MS) transducer due to many reasons, such as ease of fabrication and mode excitation, reasonability of price and high storage of energy. However, the application of GWT using MS sensors on pipes depends on the width of sensor. This study aims to investigate the relation between width of MS sensor and wavelength by modelling an aluminum pipe. In this study, mainly four software programs have been used. Firstly, MATLAB software is used to calculate the dispersion curve and to generate a tone burst signal. Secondly, ANSYS software is used to model the pipe. Thirdly, LS-PREPOST software is used to visualize the wave propagation and to extract the time waveforms. Lastly, LABVIEW software is used to enhance the signals. An aluminum pipe of 6 mm thickness and 100 mm outer diameter has been modelled to observe the relation at different frequencies of 50 kHz, 75 kHz and 100 kHz in the longitudinal excitation mode L (0, 2).

ACKNOWLEDGMENT

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SHM	Structure Health Monitoring
NDT	Non-destructive Testing
UGW	Ultrasonic Guided Wave
GW	Guided Wave
GWs	Guided Waves
GWT	Guided Wave Testing
Ms	Magnetostrictive
MsT	Magnetostrictive Transducer
SH	Shear Horizontal
PZT	lead Zirconate Titnate
EMAT	Electromagnetic acoustic transducer
DC	Direct Current

LIST OF SYMBOLS

λ	=	Wavelength
w	=	Width of sensor
n	=	Circumferential order
m	=	Mode order
T	=	Torsional mode
L	=	Longitudinal mode
K	=	Wave number
ω	=	Angular frequency
C_p	=	Phase velocity
D	=	Medium thickness.
l	=	Size of the element
v_g	=	Group velocity
f	=	Frequency
t	=	Time
Δl	=	Distance between two fixed points
Δt	=	Time needed to shift to the central point
N	=	Number of cycles
A	=	Amplitude

CHAPTER 1

INTRODUCTION

1.1 Overview

In this chapter, a brief introduction of the research background is presented which consists of background information about guided wave techniques used in pipes, problem statement, objective and the scopes of the research.

1.2 Background

It is very important for human beings to go for a medical inspection regularly in order to make sure that our parts of body are functioning well and identify symptoms of health problem at the early stage. In industrial prospective, the vital machines are also very important and critical to undergo maintenance to ensure a reliability of a system, high production of the system and good performance of all the components. However, these vital machines or structures are normally exposed to different kinds of failures in which affect their performance adversely leading to catastrophic consequences. One way to avoid these consequences from happening is to perform a structure health monitoring method.

Nowadays, people are aware enough of the importance of defects prognosis systems for the mechanical structures. A defect prognosis will provide a guideline or clear indications to the users about the current condition or situation of the damage, the exact location of the damage and the estimation of the usefully remaining life for the detected structure. From indications, structure health monitoring (SHM) becomes a very important tool in investigation of the defect prognosis. SHM is a method that used to examine the condition of the detected structure and to provide valuable information about any detected defects or damages. The SHM system, in most cases, is composed of transducers for defect detection, pulser-receiver for wave excitation, data acquisition and central processor to assess the health of the structure. There are many approaches used under the SHM. One of the most important approaches is using the non-destructive technique. Among many techniques used under the NDT, Ultrasonic Guided wave testing is one of the latest, the most valuable and important (Raghavan & Cesnik, 2008).

Guided waves are stress waves in which they are forced to propagate along a path bounded or guided by the geometry of detected the structure. Ultrasonic guided wave (UGW) inspection is nowadays applicable to investigate the defects or cracks along vital structures such as pipes, plates, rails and multilayer structures. In industry, UGW has contributed to the industrial revolution due to the variety of huge advances that UGW made in terms of inspection methodologies. In comparison to ultrasonic bulk waves, GWs have many advantages and benefits over the ultrasonic bulk waves which are as follow (Rose, 2004):

1. A single sensor can cover inspection for long range distances.
2. A Great defect detection will be done by selecting the right frequency and mode.
3. A higher sensitivity obtained compared to other NDT inspection method.
4. Hidden, coating, insulation or underwater structures can be detected easily.

Pipelines are very critical elements in any industrial structure. A small crack within the pipeline can cause a leakage which then lead to huge damages to the industrial structure. GW can inspect the underground pipe without the need of excavation, without removing coating and insulations. In pipe, guided waves propagate only in three different modes. The three modes are torsional mode (T), longitudinal mode (L) and flexural mode (F). The properties of the propagating guided waves are very complicated. However, with careful selection of the frequency and wave mode, GW can cover the inspection with single probe of the whole area. In most cases of guided wave inspection, they use a low ultrasonic frequencies from 25 kHz up to 100 kHz to ensure that a defect area will be exposed to enough transmitted energy and higher depth penetration. The GWT technique has the ability to calculate the distance of the defect from the location of the sensor from the time of the reflected wave of defect and the group velocity of the selected mode (Cawley, Cegla, & Galvagni, 2012). Figure 1.1 illustrates the actual wave propagation of nondestructive inspection in pipe using GW.

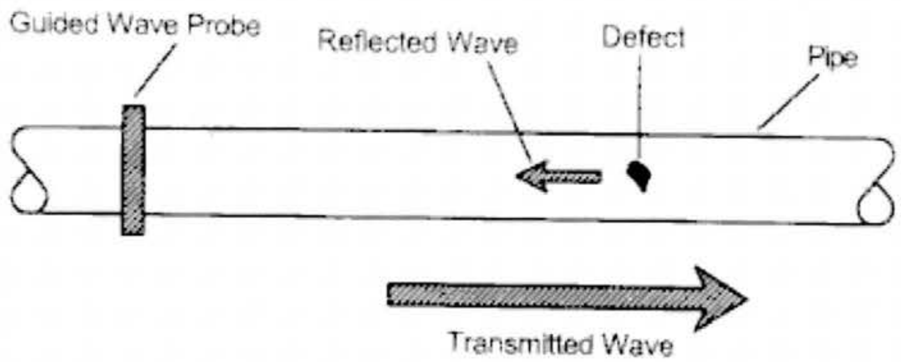


Figure 1.1: Mechanism of inspection pipe using GW (Hegeon Kwun, Sang-Young Kim, and Glenn M. Light, 2011).

UGWs can be performed by using different kinds of transducers. One of the frequently used commercial transducer is the type of magnetostrictive transducer (MsT). The MsT excites and receives guided waves in electromagnetic mechanism within the detected structure. We choose this magnetostrictive transducer for our study due to many reasons such as it is cheap compared to other commercial transducers, easy to fabricate, easy to control and excite modes and has high energy.

In this study, a model and guided wave simulation will be conducted by using ANSYS computer aided simulation software. The study aims is to visualize the relationship between the wavelength and width of magneostrictive transducer in three different directions when a specific wave cycles of burst signal introduced at a selected central frequency of the wave mode. The suitable width will be investigated to produce the acoustic wave according to tone burst input signal.

1.3 Problem Statement

GW transducers represent a very critical element in structure health monitoring due to the major role that GW transducers play. The application of GW technique using Ms sensors on pipes are conducted at different width of the sensors according to the environment of the inspection which considers the thickness, frequency and energy to be introduced to the structures. Thicker pipes will be introduced with lower frequency of L (0, 1), L (0, 2) or T (0, 1) compared to the thinner pipes due to guided wave dispersion curve properties. At the same time, the number of cycles is also varying for inspection of coated pipe or with flowing fluids.

This study aims to investigate the relation between the width of MS sensors and the wavelength of the selected wave mode. Figure 1.2 shows the schematic diagram of the problem statement.

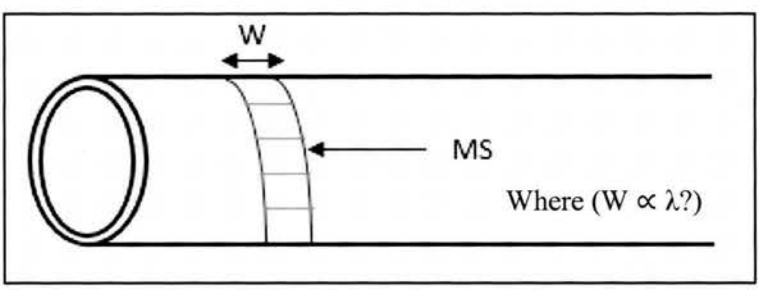


Figure 1.2: Schematic diagram of the problem statement.

1.4 Objective

This research is conducted to achieve the objective below.

1. To study the effect of width on magnetostrictive transducer for excitation of guided wave propagation in pipe at L (0, 2) mode.

1.5 Scope of Project

The scopes of this research are:

1. A simulation of wave mode propagation excited by magnetostrictive sensor at different wavelengths using ANSYS.
2. Observation the amplitude of time waveform using LABVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

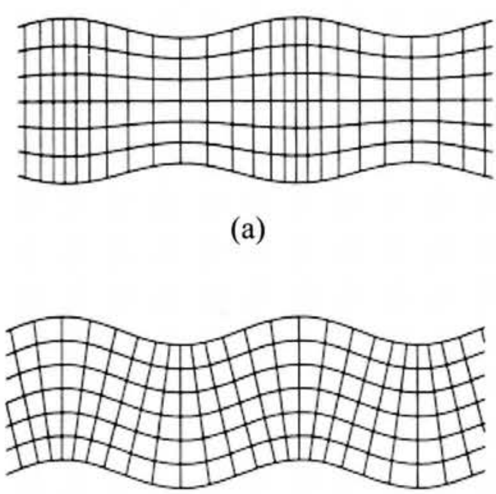
This chapter will discuss the literature review related to the GW technique and its implementation in real life applications. Also, the fundamentals of this techniques will be discussed in details such as the concept of guide wave propagation in pipes and plates, piping inspection, dispersion curve to determine the phase and group velocity of the modes and guided wave's transducers.

2.2 Guided Wave Propagation

A very effective diagnostic tool used in the field of nondestructive testing (NDT) or structural health monitoring (SHM) is guided waves (GW). In order for GW to propagate in any structure, the structure must be of a known geometric boundary. In other words, when the structure is being excited by any ultrasonic GW transducers, stress waves will be generated and forced to propagate along a path guided by the geometry of detected the structure. Guided waves can propagate in many structures such as thin plates, rods, tubes and multilayers structures. Of the many structures, a literature review herein will focus on the most two common structures used in industry which are pipes and plates.

2.2.1 Guided Wave Propagation in Plates

In plate structures, the propagating guided waves used are lamb waves and shear waves. In 1917, Lamb waves were firstly discussed by Lamb who produced the dispersion equation. Lamb waves are waves that propagate parallel to the surface of the thickness of the material. Thus, propagation of lamb wave depend strongly on the material properties such thickness and density. The most two common motions of vibrations modes occur while lamb wave propagating are symmetrical modes (S-mode) and anti-symmetrical modes (A- mode). The name of symmetric mode comes from the symmetry of wave propagation of the guided wave along the mid-plane of the plate and is noted as S. On the other hand, the anti-symmetric mode comes from the anti-symmetry of wave propagation of the guided wave along the mid-plane of the plate and is noted as A. Each mode has its Own Characteristics and Speed which is controlled by the plate thickness and wave frequency (Ryden, Park, Ulriksen, & Miller, 1965). Figure 2.1 shows the types of lamb wave modes.



(a)

(b)

Figure 2.1: Types of lamb wave modes (a) symmetric mode (b) anti-symmetric mode (Diligent, 2003) .