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

Signature :…….

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Date :…….

GUIDED WAVE DEFECT LOCATION IN PLATE USING WAVELET TECHNIQUE

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A thesis submitted in partial fulfilment of the

Requirement for the award of the degree of

Bachelor of Mechanical Engineering (Plant& Maintenance)

Faculty of Mechanical Engineering

UniversitiTeknikal Malaysia Melaka

JUNE 2015

DECLARATION

" I hereby declare that the work in this thesis is my own except for summaries and quotation which have been duly acknowledged "

Signature :……

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Date :……

Praise to Allah the Almighty and to my beloved Father and Mother,

And to my beloved siblings and friends

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my supervisor, Dr. Nor Salim Bin Muhammad for the continuous support of my final year project 1 and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better supervisor for my final year project.

Besides my advisor, I would like to thank the rest of fellow labmates, friends and technician for the sleepless nights we were working together before deadlines.

Last but not the least, I would like to thank my family for supporting me spiritually throughout my life.

ABSTRACT

Guided wave is a method that widely acknowledged as one of the most encouraging tools for quantitative for identification of damage in large structures. The technique has potential to be improved by using signal processing to visualize defects in the inspected areas. The visualization of defect is important for interpretation of complicated waveform in structures. This paper is trying to analyse the guided wave signal by using a wavelet approach. The wavelet response is an efficient method to detect and characterize a discontinuity in the acoustical impedance profile of a material. The wavelet technique that been approached was used a scalogram and spectrogram which created images from the measured waveform to give an option for defect identification and location in large structures.

ABSTRAK

Gelombang berpandu adalah satu kaedah yang diperakui secara meluas sebagai satu alat yang menggalakkan pengukuran quantitatif untuk mengenalpasti kerosakan di dalam struktur yang besar. Teknik ini mempunyai potensi untuk dipertingkatkan dengan menggunakan pemprosesan isyarat untuk menggambarkan kerosakan di kawasan yang diperiksa. Penggambaran kerosakan adalah penting untuk tafsiran gelombang yang kompleks di dalam struktur. Kertas kerja ini cuba untuk menganalisis isyarat gelombang berpandu dengan menggunakan pendekatan „wavelet". Hasil keluaran data wavelet adalah satu kaedah yang berkesan untuk mengesan dan mencirikan ketakselanjaran dalam profil galangan akustik kepada sesuatu bahan. Teknik wavelet yang telah diberi pendekatan telah menggunakan „scalogram" dan „spectrogram" yang mewujudkan imej dari bentuk gelombang yang diukur untuk memberi pilihan untuk mengenal pasti kecacatan dan lokasi dalam struktur besar

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.0 OVERVIEW

This chapter covers the introduction of this project that involved the project background, problem statement, objectives of the project and scope of study.

1.1 BACKGROUND

Wavelet theory started from research activities in many areas of science and engineering. As a result, it finds applications in a wide range of practical problems. Wavelet techniques are indicatively suited for non-stationary signals for which classic Fourier methods are ineffective. Evolvements over the last decade have led to many new wavelet applications such as image compression, turbulence, human vision, radar, and earthquake prediction (Jaideva C.Goswami, 2011).

Basically wavelets transform is an another approach to the short time Fourier transfom which is to run-over the resolution problem. Principle of wavelet transform is divided the signal into a bunch of signals which will representing the same signal but all correspond to different frequency bands.

There are resemblances between fast fourier transform (FFT) and wavelet analysis which FFT and discrete wavelet transform are both linear operations that develop a data structure that contains $log_2 n$ segments of various lengths, usually filling and trnsforming it into a different data vector of length 2^n. (Graps 1995)

Without us noticing, wavelet already been used as an application since 1980‟s which David Marr, an expert on human visual system, work at MIT‟s Artificial Intelligence Laboratory on artificial vision on robots. His goal was to learn why the first attempts to create a robot capable of compassionate its surrounding were unsuccessful (Meyer, 1993). Marr theorized two things which he claims that intensity changes occur at different scales in an image, so that their optimal detection requires the use operators of different sizes. And the theory that he theorized is the sudden changes produce a peak or stiff in the first derivative of the image. His hypothesis require a different operator and it should be able of being turn to act at any desire scale which that operator was a wavelet referred as a “Marr wavelet”.

The other famous application that used nowadays is denoising noisy data. In world of science, scientists are faced with the problem of recovering a signal from a noisy data. This can be done through a technique called wavelet shrinkage and thresholding methods, which David Donoho had been worked on for several years (D.Donoho, 1993). This denoised technique is an important step forward in conducting noisy data because the denoising is carried out without smoothing out the sharp structures. The final result then is a cleaned-up signal that still shows important details.

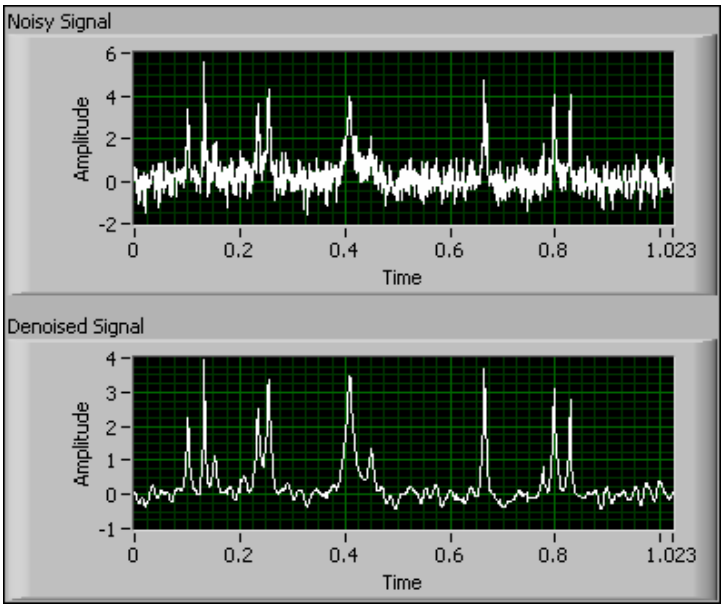

Figure 1.1: Differentiation between noise signal and denoised signal

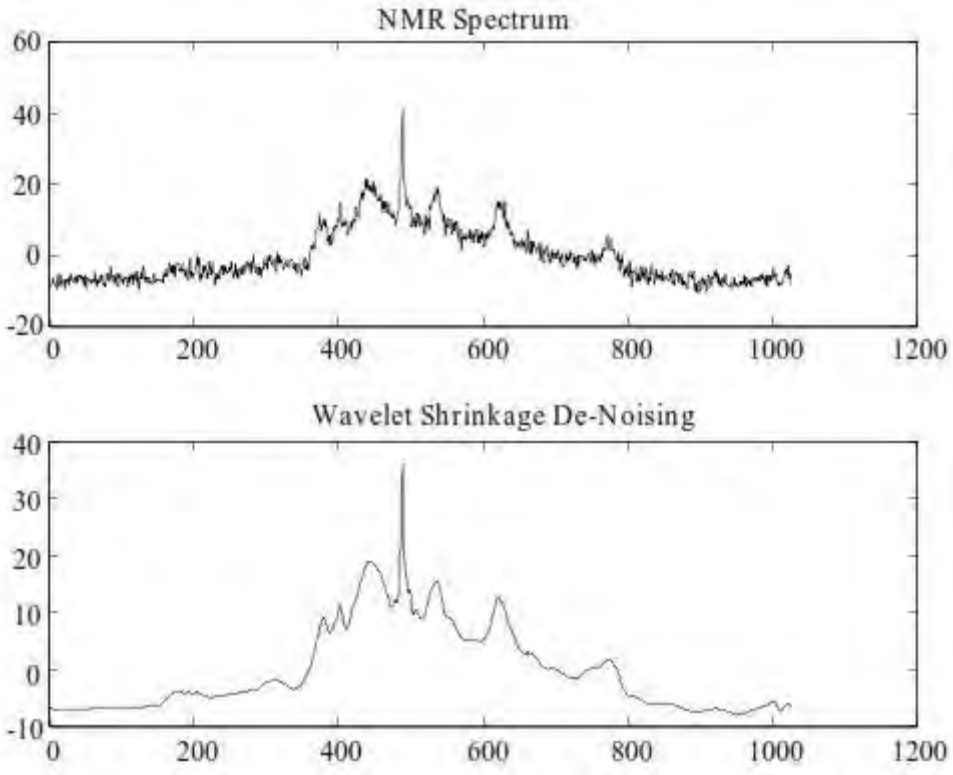

Figure 1.2: Signal after been recovering form wavelet shrinkage technique

(D.Donoho, 1993)

1.2 PROBLEM STATEMENT

Guided waves, such as Lamb waves have found many applications towards damage defection, location and measurement. Permanently mounted transducer can be used to generate and detect guided waves in structures. However, the number and location of the bonded transducers limit resolution and fidelity of defect detection and measurement in amplitude and frequency monitoring FFT technique. The conventional time waveform does not provide the frequency information whilst the FFT is only valid for steady-state vibration in machinery. The wavelet response is a method which enables an easy probing of depth dependent properties of material which display amplitude changes in scalogram and frequency changes in spectrogram. The use of this technique gives an option to analyse on defect response in structures.

1.3 OBJECTIVES

The objectives of this study are as below:

1. To apply wavelet analysis for structural health monitoring.
2. To study effect of depth on frequency component in reflected waveform defect.

1.4 SCOPE OF STUDY

The scopes of this study are as below:

1. Study on benefit of wavelet in defect analysis.
2. Develop wavelet application for defect response in Labview.
3. Analyze the effect of wavelet analysis on defect response by varying parameters in wavelet visual method, scalogram and spectrogram.

CHAPTER 2

LITERATURE REVIEW

2.0 OVERVIEW

This chapter covers the review about guided wave, what is defect location and also wavelet technique itself. The review gathers is collected from the past journals, articles, technical paper and reference book that involved the area of this chapter.

2.1 INTRODUCTION TO GUIDED WAVE AND LAMB WAVE

2.1.1 GUIDED WAVE

Guided wave testing (GW) is one of the Non-Destructive Testing (NDT) that had been recognized and approved through worldwide especially in term of the testing which is much easier. In industrial and civil structures, the inspection to

detect defect or damage is very important because it involve safety of the structure and people. Speak about guided wave, the wave will travel along the surface and are guided by the geometry of the surface (Singh, 2014). The guided wave can be generated as various modes with respect to frequency, thickness, and incident angle and they can propagate a large distance along the geometry of a structure (Lamb, 1989). Guided wave technique is particularly useful in NDT of thin plate and tubular structures which are very hard to test.

For one-dimensional wave propagation, the assumption is stated that it is used for conventional surface reflectance technique which used to control the quality, such as test or impact echo impulse response.

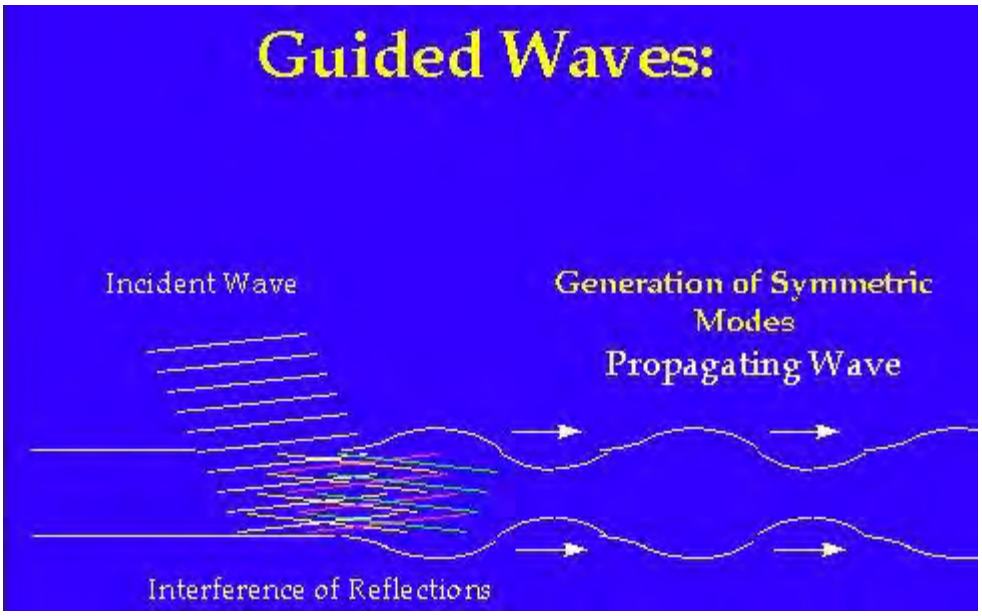

Figure 2.1: Guided wave's wave propagation through medium

Since 1980s, application of guided wave studies had been carried out by plentiful of researchers such as Rose and Cawley and it was demonstrated that guided waves can be applied to safety insurance of nuclear power station and aircraft successfully (Y. Cho, 1995).

2.1.2 LAMB WAVE

When two boundaries in solid plates are close together, the elastic wave motion on each surface will interact to produce lamb waves (Scruby, 1990). The lamb wave theory was originally developed by Horace Lamb in 1916 to describe the characteristics of waves propagating in plates. Lamb wave can be generated with free boundaries with an infinite number of modes for both symmetric and anti-symmetric displacements with the layer.

The usual way to describe the propagation characteristics is by the use of dispersion curves based on the plate mode phase velocity as a function of the product of frequency times thickness. Normally the dispersion curves are labelled as $S_o, A_o, S_1, A_1$and so on which is depending on the mode whether it is symmetric or anti-symmetric

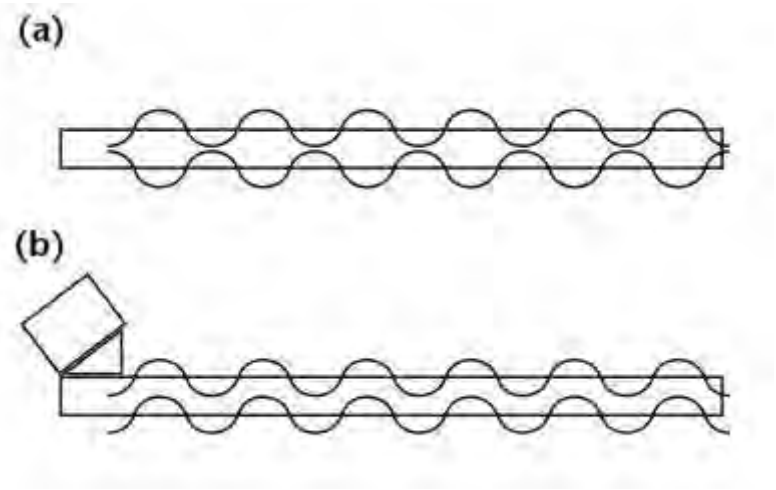

Figure 2.2: Lamb wave propagating in plate: (a) symmetric; (b) anti-symmetric