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“I hereby declare that I have 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)”

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Date	: ……………………………...

EFFECT OF SIZE PZT ELEMENTS ON THE EXCITATION OF PHASED ARRAY TRANSDUCER IN BEAM STEERING AND BEAM FOCUSING TECHNIQUE

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Faculty of Mechanical Engineering
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DECLARATION

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

Signature : ……………………………..

Name : MUHAMMAD SHAZWAN BIN ABDUL RAZAK

Date : ……………………………...

Dedicated to my parents,

Abdul Razak bin Hussain and

Zaiton binti Ramli

My supporting siblings,

Muhammad Shamier bin Abdul Razak

Muhammad Shauqi Izham bin Abdul Razak and

Nur Hidayah binti Abdul Razak

and

My entire friends in UTeM

for their encouragement.

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ABSTRACT

Ultrasonic testing has widely used in industry for defect evaluation. However this technique has several limitations such as fixed beam separator and mechanical scanning. These limitations can be solved by using phased array technique which used multiple element of arrangement with time delay that can be steering of focusing. A study is being carried out to study the effect of size PZT element on the excitation of phased array transducer. Several design parameters of phased array model need to be considered such as number of elements, distance between elements, frequency, and aperture size affect the excited beam of transducer. The guided wave with different modes which is symmetrical and anti-symmetrical is used as a principle to propagate wave in large structured using a single fixed point. Simulation of aluminium plate without defect for beam steering and beam focusing with time delay is being modelled using ABAQUS software. The visualization of wave propagation on defect is observed and compared with the different model.

ABSTRAK

Ujian ultrasonik telah digunakan secara meluas di dalam industri untuk penilaian kecacatan. Walaubagaimanapun, teknik ini mempunyai beberapa kekurangan seperti pengimbasan mekanikal dan pancaran spektra yang tidak boleh dikawal. Kekurangan ini boleh diselesaikan dengan menggunakan teknik „phased array‟ yang menggunakan gandaan susunan elemen dengan masa tertangguh yang membolehkan gelombang dikawal aataupun ditumpu. Kajian dilaksanakan untuk mengkaji kesan saiz elemen „PZT‟ dalam pengujaan „phased array‟ transducer. Beberapa design kriteria perlu diberi perhatian seperti jumlah elemen, jarak antara elemen, frekuensi dan saiz „aperture‟. Gelombang selari dengan mod berbeza iaitu symetri dan anti – symetri telah digunakan sebagai prinsip untuk menyebarkan gelombang di struktur yang besar menggunakan satu titik tetap. Simulasi kepingan aluminium tanpa kecacatan dengan masa tertangguh dimodelkan menggunakan perisian ABAQUS. Viusalisasi gelombang penyebaran terhadap kecacatan diperhati dan dibezaakn dengan model yang lain.

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d	=	Element width, m
c	=	Material wave speed, m/s
ω	=	Angular velocity, rad/s
k	=	Wave number
C_l	=	Bulk longitudinal velocities, m/s
C_T	=	Shear velocities, m/s

LIST OF APPENDIX

CHAPTER I

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

Ultrasonic testing is a versatile technique in Non-Destructive Testing (NDT) which is been used to most materials, metallic or non-metallic including various industries such as oil and gas, aerospace, forest industry and building construction. By using this ultrasonic testing, surface and internal discontinuities such as slags, inclusions, laps, seams, voids, cracks and lack of bond can be detected accurately from one side. Ultrasonic testing utilizes a high frequency acoustic wave which is varied according to the application ranging from 1 to 10 Mega Hertz (MHz) generated by piezoelectric transducer. (Baldev Raj, T. Jayakumar, and M. Thavasimuthu, 2008)

PZT elements is defined as lead zirconate titanate (Pb[Zr(x)Ti(1-x)]O3) that have been widely used in piezoelectric transducer. According to (Ting hai Cheng, Xiang-dong Guo and Gang Bao, 2011), PZT elements is used to produce bending cylindrical transducer that transforms input electrical energy to output mechanical energy in ultrasonic transducer, their excitation position and excitation modes. Length and thickness of PZT elements need to consider in order enhancing the output characterization type transducer.

Pulse-echo inspection technique is most widely used for ultrasonic inspection of components. In pulse-echo inspection technique, ultrasonic sound energy is transmitted between the face of the transducer and the surface of the test component. When ultrasonic energy penetrates into a material and strike a discontinuity or flaw, part of energy will be reflected back to the probe and the remaining part propagates in the material in forward direction as shown in **Figure 1.1 (a)** and **(b)**. To facilitate the transmission of ultrasonic energy between the transducer and the test component, a couplant that made from water based material is used between the transducer and the surface of the plate. (Baldev Raj, T. Jayakumar, and M. Thavasimuthu, 2008).

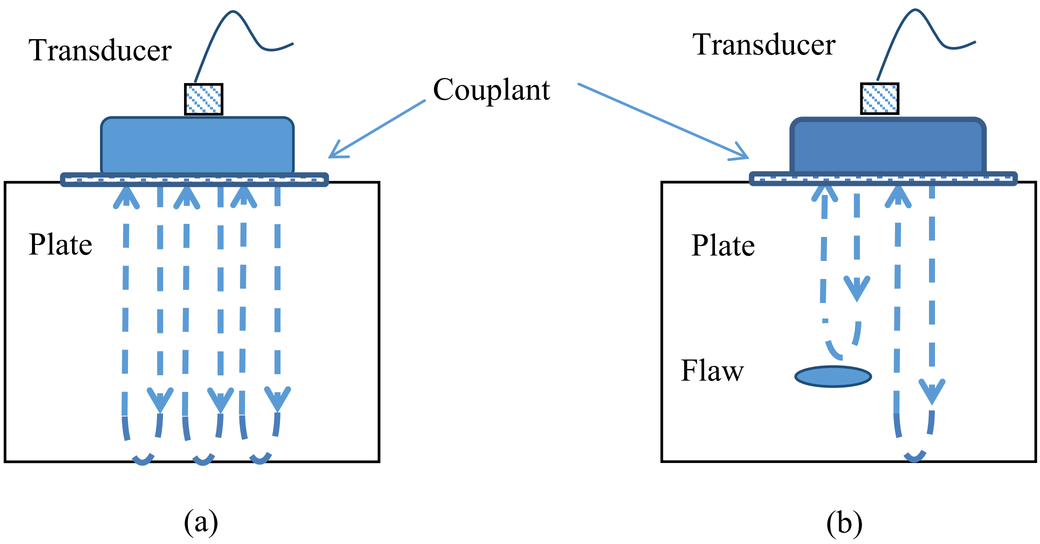


Figure 1.1: Ultrasonic waves from transducer (a) without flaw and (b) with flaw.

Ultrasonic sound wave that transmitted from a transducer can travel in longitudinal wave and transversal or shear wave. In longitudinal waves, the direction of oscillation is parallel to the direction of propagation meanwhile transversal wave is perpendicular the direction of oscillation as shown in **Figure 1.2** and **Figure 1.3**. (Josef Krautkramer & Herbert Krautkramer, 1990)

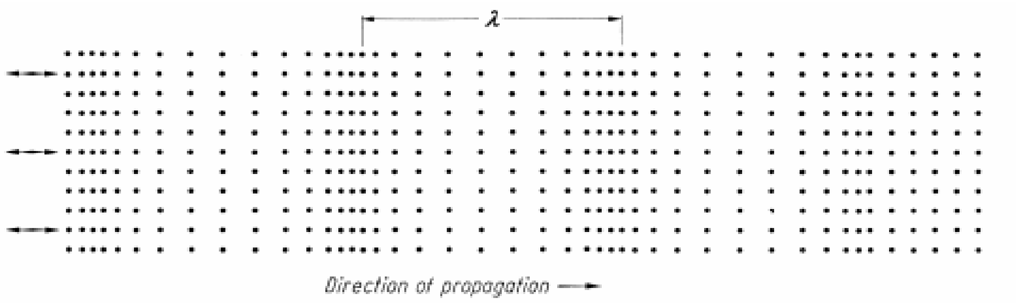


Figure 1.2: Longitudinal wave

(Source: Diligent, (2003))

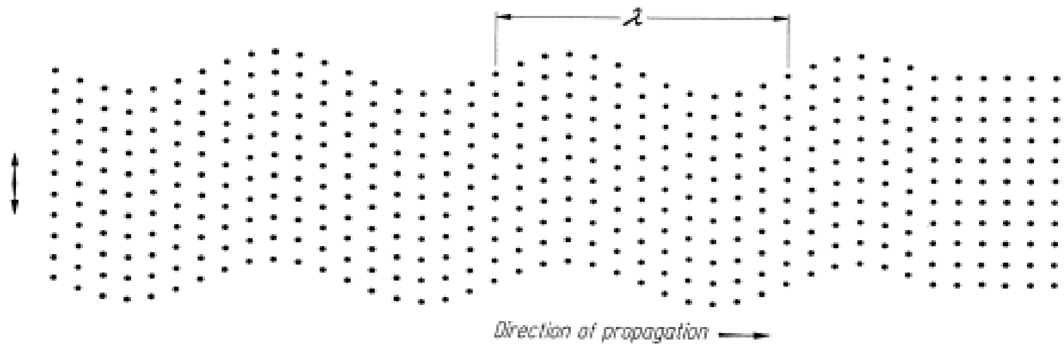


Figure1.3: Transversal wave

(Source: Diligent, (2003))

Guided wave technique is the latest technique for non-destructive testing and material evaluation for any defects in plate and pipe. This technique has advantages since the guided waves can propagate in perpendicular direction with lower frequency ranging 10 to100 kHz which covers for a long range inspection. The guided waves for damage monitoring in plates used pulse-echo method to evaluate the corrosion defect. This experiment used pulser or receiver system which generates an ultrasonic spikes pulse driven through the corrosion plate in the form of longitudinal waves as shown in **Figure 1.4**. Ultrasonic signals were taken in pulse echo mode for the corroded plate at each level of corrosion and the readings were compared with the healthy readings. (Ramandeep Singh, Shruti Sharma & Sandeep Sharma, 2014)

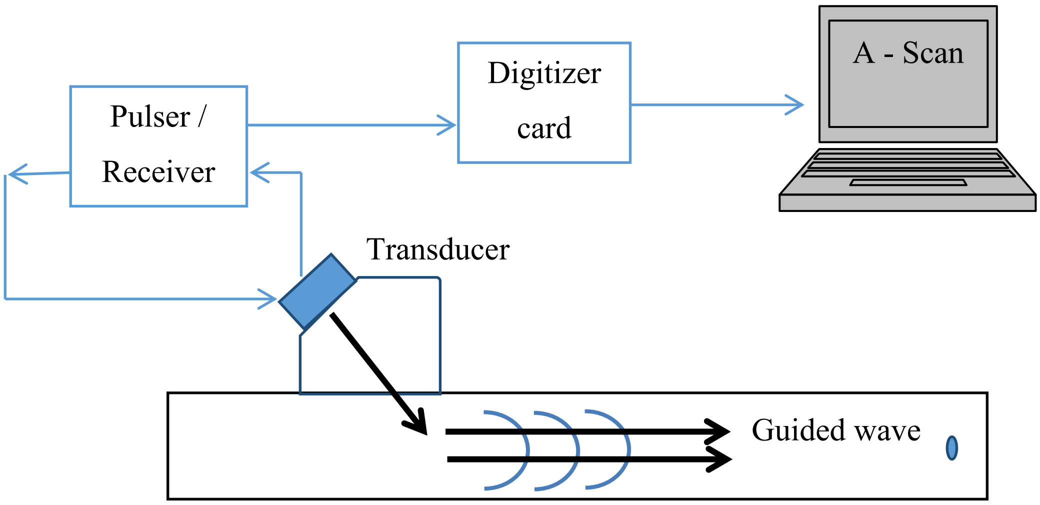


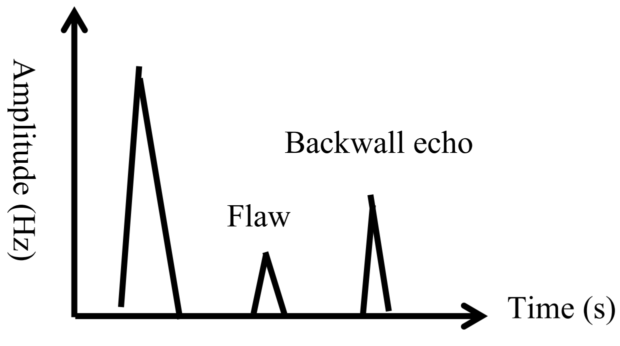
Figure 1.4: Guided wave inspections for corrosion defect on plate

In ultrasonic testing, the results can be displayed in several conditions which called A-scan, B-scan and C-scan presentation.

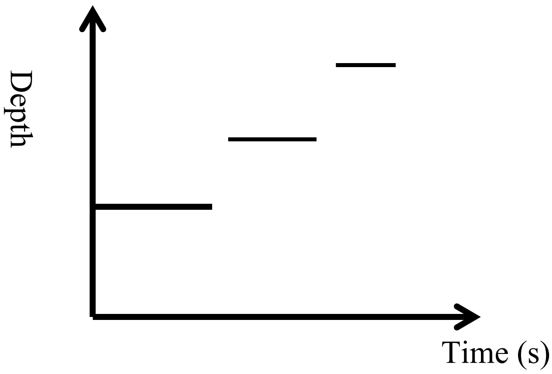
Figure 1.5 (a) shown A-scan that display amount of received ultrasonic energy as a time waveform. The relative amount of received energy is plotted in along the vertical axis against the time elapsed in horizontal axis. Relative discontinuity size can be estimated in A-scan by comparing the signal amplitude obtained with unknown reflector to known reflector.

Figure 1.5 (b) shown B-scan that display the cross sectional view or depth of the test material. In this B-scan presentation, the depth of reflector and its linear dimension in the scan direction can be visualized

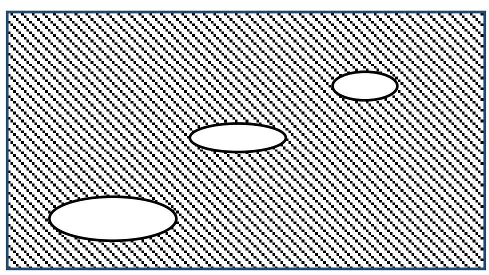
Figure 1.5 (c) shown C-scan presentation that visualise the image in two dimensions that from reflected ultrasound signal that provides a top view of the location and size of the test material using an automated data acquisition system.



(a)



(b)



(c)

Figure 1.5: Data presentation in ultrasonic testing (a) A-scan (b) B-scan (c) C-scan

Ultrasonic testing had been used since 1940’s applied by Firestone and Simon that developed pulsed ultrasonic testing using a pulse-echo technique. This testing is continually improved after World War II when a group of researchers from Japan develop medical diagnostic using ultrasound (History of Ultrasonic, 2014). At the same time, Nobel Laureate Luis Alvarez used phase array transmission in a rapidly-steer in “ground controlled approach”, a system to help the landing aeroplanes in Britain (Swapana Koganti & Kaapaarapu Satish Babu, 2012). A phased array consist several sets of elements that pulsed to produce sound beam by means controlled interference pattern in a desired direction. The ultrasonic phased array is widely used in medical applications that used multi-elements piezoelectric device which individually excited by electric pulse at programmed time delay (Joon Hyun Lee & Sang Woo Choi, 2000).

1.1.1 ULTRASONIC TESTING ON PLATE

Manufacturing stages of plate type nuclear fuel elements produced structural discontinuity such as cracks and bonding due to mechanical and thermal processing conditions. This discontinuity reduces the performance of the nuclear fuel during its operational life. Mucio Jose and teammates has conducted the non-destructive test using ultrasonic testing to detect bonding failures at core interface during hot rolling process. They has been used two different types of ultrasonic transducer which is contact transducer as shown in **Figure 1.6(a)** range in 10 MHz and 15 MHz and immersion transducer as shown in **Figure 1.6(b)** range from 4 MHz and 10 MHz.

The response and results by each transducer based from artificial discontinuities on the plate such as flat bottom holes with different diameter and slits with different length and width of the plate is observed. They conclude that contact transducer with high frequency and low focus transducer is more sensitive and obtain good visualization compared with immersion transducer (Mucio jose Drumond de Brito, Wilmar Barbosa Ferraz, Donizete Anderson de Alencar and Silverio Ferreira, 2009).