AN ULTRASONIC SYSTEM TO MEASURE THE STRENGTH OF WOOD

WASI HYDER

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School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

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DEDICATION

This project report is dedicated to my parents, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to wife , my siblings and my friends who supported me in every way so that I can fulfil my dreams of higher education.

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ABSTRACT

This project report purposes the design and development of low cost 40kHz ultrasonic system for measuring the strength of the wood. Ultrasonic measurement techniques now a days are advancing exponentially because there is no need to alter the physical or chemical properties of the subject sample. These techniques also provide the internal specification of the sample in the field. In this project through transmission method is used to determine the strength of the wood. To test the proposed technique, wood samples of good wood and biological decayed wood are developed of same volume. Later on the hardware is developed to transmit and receive the acoustic wave as per requirement. The acquired data of the received signal is analysed using MATLAB platform. In which cross-correlation technique is used with earliest peak detection to determine the time of flight of the received signal. Accurate measurement of TOF is later used to determine the modulus of elasticity of the samples in longitudinal direction, which interprets the overall strength of the wood. Number of experiments were conducted in lab environment to avoid noise, temperature and moisture effects. The proposed method successfully completed and an obvious variation in the MOE of samples of good and decayed wood was observed. So it is envisaged that proposed method in this system can be transformed to low cost hand held gadgetry for the large scale wood industry.

ABSTRAK

Laporan projek ini bertujuan untuk membentangkan rekabentuk dan pembangunan sistem ultrasonik untuk mengukur kekuatan kayu. Teknik-teknik pengukuran ultrasonic kini berkembang secara eksponen kerana penggunaan ultrasonic tidak melibatkan perubahan sifat-sifat fizikal atau kimia ke atas sampel yang diukur. Teknik-teknik ini juga membolehkan kita mengetahui spesifikasi dalaman sampel. Dalam projek ini kaedah penghantaran laluan digunakan untuk menentukan kekuatan kayu. Untuk menguji teknik yang dicadangkan, beberapa sampel yang terdiri daripada kayu yang elok dan kayu yang mengalami kemerosotan secara biologi telah diuji. Perkakasan dibangunkan untuk menghantar dan menerima gelombang akustik seperti yang dikehendaki. Data isyarat yang diterima telah dianalisis menggunakan perisian MATLAB. Teknik korelasi silang digunakan untuk menentukan masa penerbangan (TOF) isyaratyang diterima berasaskan pengensanan puncak terawal. Pengukuran tepat TOF digunakan untuk menentukan Modulus Kekenyalan sample dalam arah longitude yang membolehkan penafsiran ke atas seluruh kekuatan kayu dilakukan. Ujikaji telah dilakukan dalam makmal untuk mengelak daripada kesan hingar, suhu dan kelembapan. Kaedah yang dicadangkan telah berjaya disiapkan dan perubahan dalam Modulus Kekenyalan telah diamati.. Oleh itu kaedah yang dicadangkan dalam system ini boleh ditransformasikan menjadi alat kos rendah yang boleh dipegang dengan tangan untuk kegunaan industry perkayuan berskala besar.

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LIST OF ABBREVIATIONS

FFT	-	Fast Fourier Transform
IOT	-	Internet of Things
MC	-	Moisture Content
MOE	-	Modulus of Elasticity
NDT	-	Non Destructive Testing
SNR	-	Signal to Noise Ratio
TOF	-	Time of Flight
UT	-	Ultrasonic Testing
UTM	-	Universiti Teknologi Malaysia

LIST OF SYMBOLS

c	-	Speed of Sound
D	-	Distance
F	-	Frequency
GPa	-	Giga Pascal
T	-	Time
V	-	Velocity
Z	-	Acoustic Impedance
α	-	Attenuation coefficient
B	-	Bulk Modulus
P	-	Density
λ	-	Wave length

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CHAPTER 1

INTRODUCTION

1.1 An Historic Overview of Ultrasonic Testing System

In history sonar, the technique of sending sound waves through water and evaluating the echoes to identify the submerged objects especially prior to the world war II, later on this concept was applied to medical science. Between 1929 and 1935, Sokolov used the technique of ultrasonic to detect metal objects(Senalik et al., 2014). In 1931, Mulhauser obtained the first patent for detecting flaws in solid materials using through transmission ultrasonic technique. Later pulse echo technique was developed by Firestone and Simon in 1940's(Tallavo, 2009).

The concept of non-destructive testing has been used for decades, but rapid development in this field was started after world war II. With the boost in the industrial revolution, and advancement in the field of instrumentation new techniques were emerged for detection of flaws via NDT. Most of them are being used even in this era such as eddy currents, x-rays, dye penetrant, magnetic particle and etc. After all these advancements and technological revolution, a new challenge was presented to NDT community. Flaw detection technique were available, but that was not enough. The Industrial and metallurgical scientist community demanded for the quantitative information about the flaw size. which led to the emergence of quantitative non-destructive evolution.

1.2 Introduction of Ultrasonic Testing

Ultrasonic Testing commonly termed as UT uses high frequency sound energy to conduct examination on different materials for the detection of flaws, material characterization and more. Most typical systems consist of a transducer, a pulse transmitter / pulse receiver and a display or data logging apparatus. UT is a commonly used system in the field of NDT due to its versatility. Such as depth of penetration for flaw detection which make this method superior to other NDT methods(Le Hoang, 2015, Tallavo, 2009).

Ultrasonic testing technique is basically based on time varying vibration in materials known as acoustic in the language of science. Every material available in the universe is made up of atoms. Each atom can be subjected to vibration in its restricted domain as per property of the material. Acoustics is only focused on the vibrational motion of the atoms that move in unison to produce a mechanical wave. In solids, sound waves can propagate in four modes known as longitudinal wave, shear wave, surface wave and plate waves in case of thin materials.

1.3 Project Background

Wood is one of the oldest and most commonly used material used by humanity and it still being used in daily life. In past before the evolution of steel and cement industry, wood was only the main source for constructing houses, bridges, carts and even used for the war fare. Today after the construction revolution, obviously trends have changed and even for the protection of the world environment we have to cut down the use of wood. Now the government organizations of the tropical region specially Malaysia are concerned about the preservation of the traditional heritage of the country. In past most of the living house were constructed by wood in Malaysia and we can still found them in national heritage sites or old kampongs. Secondly palm oil is one of the biggest industry of Malaysia. Palm tree farms are usually monitored by manpower on monthly bases to inspect the quality of palm tree. The trunk of any plant/tree is the backbone of that plant/tree. If the pests or environmental effects

continue to make degradation in tree from the inside. Even with the visual inspection, one cannot predict about the health of the tree. So by keeping the above facts in mind an idea was knitted to develop a low cost system to measure the strength of the wood using ultrasonic technique. Which can later be used in forestry to save specified species or palm tree farms by continuous monitoring using latest technology known as internet of things (IOT). Some facts and figure about the timber industry and palm oil industry of Malaysia

(a) Malaysia is the eighth largest exporter of wood furniture in the world.

(b) Estimated growth of timbers industry to meet RM53 billions of worth by 2020.

(c) Palm tree is the most important commodity crop of Malaysia.

(d) Total planted area with palm tree is around 5 million hectares.

1.4 Problem Statement

Wood is being used for structures and other necessities of human being from ages. Modernization have changed the construction techniques but still old structures are standing and providing shelter to the mankind. Government of every country is concerned about the soundness of these structures, because every single human life is valuable. The idea of this project is to investigate the wood samples by low cost using ultrasonic technique to determine the strength / stiffness of the wood used in old standing structures.

1.5 Objectives

(a) To design and develop a low cost hardware to transmit and receive the ultrasonic wave for the purpose of testing different wood samples.

(b) To Measure the accurate Time of Flight so that precise longitudinal velocity of acoustic waves in different samples of wood can be determined.

(c) To distinguished the sound wood and the decayed wood samples based on the values of modulus of elasticity.

1.6 Scope of the Project

(a) Low cost 40KHz Ultrasonic sensor is used to transmit and receive the signal by through transmission method.

(b) Arduino Mega is used to generated the required frequency and signal.

(c) Electronic hardware for transmitting/ receiving the signal and amplification.

(d) Oscilloscope is used to capture the transmitted and received signal.

(e) A program using MATLAB software is used to determine the modulus of elasticity from the data captured by oscilloscope.

(f) Four different wood samples are used for experimentation

(g) Every sample has two sub samples consisting of one sound wood sample and one decayed wood sample.

1.7 Limitations of the Project

Following are the limitation of the project.

(a) The size of the sample is maintained to the maximum of 129mm.

(b) Sample are prepared along the grain structure of the wood.

(c) Experimentation is done in the lab environment, having controlled temperature and noise free environment.

(d) The system is not a complete online measurement

1.8 Organization of the Project Report

This project report has five chapters beginning with the introduction and the research problem. It is followed by the literature review, methodology used in the project, description of results and discussion. The explanation of each chapter is discussed below.

Chapter 1 is about the introduction, In the chapter historic overview on ultrasonic testing is elaborated with the project back ground, problem statement, objectives and scope of the project.

Chapter 2 comprises of literature review related to wood, techniques used in ultrasonic testing, principle of ultrasonic testing and other important features such as medium stiffness, density and modulus of elasticity.

Chapter 3 describes the methodology of the project, starting with selection of ultrasonic traducer, hardware and software development.

Chapter 4 discuss about the results of the different samples of wood used in the project. Each sample is discussed individually using Matlab plots and mathematical calculations of modulus of elasticity.

Chapter 5 is about the concluding remarks for the project and recommendation for future work.

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