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# THE EFFECT OF PROBE FREQUENCY IN ULTRASONIC TESTING

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**Laporan ini dikemukakan sebagai memenuhi syarat sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Design&Inovasi)**

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Untuk ayah dan ibu tersayang

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# ABSTRACT

This research is conducted to investigate the effect of different probe frequency in Ultrasonic Testing. From the literature, the investigation about the probe frequency in Ultrasonic Testing has not been clearly investigated until now. Ultrasonic Testing is part of Nondestructive Testing and used widely to detect flaws and thickness of specimen without destroying the specimen. In the methodology chapter, the test sample is design using Catia V5R16 and fabricated using CNC Universal Milling Machine for 5-Axis. For the experiment work, dual crystal probe type is used, whereby the probe frequency that is manipulated during experiment are 2 MHz, 4 MHz and 5 MHz. The result for this experiment is the reflected sound energy from A-scanned. From the observation, it is shows that high frequency probe has low amplitude, low noise and sharp peak while low frequency probe shows high amplitude, high noise and wide peak. Through this result, the different characteristic for each level frequency that is high (5 MHz) and low (2 MHz) is discussed. The characteristic of high frequency is high attenuation, narrow beam and less penetration in contrast, low frequency has less attenuation, more penetration depth and flaw sensitivity. From this characteristic, it shows that high frequency probe suitable to detect small thickness, thin material and suitable in noisy environment, meanwhile low frequency probe is suitable for rough surface, grainy materials, small size and high depth defects.

# ABSTRAK

Kajian ini khusus untuk mengkaji kesan frekuensi pemindaharuh ultrabunyi yang berbeza di dalam penggunaan pemeriksaan ultrabunyi. Dari kajian literatur, kajian mengenai kesan penggunaan frekuensi pemindaharuh ultrabunyi yang berbeza masih tidak jelas lagi dibincangkan sehingga ke hari ini. Pemeriksaan ultrabunyi merupakan cabang Kajian Tanpa Musnah yang digunakan secara meluas untuk mengesan kecacatan serta menguji kedalaman spesimen tanpa memusnahkannya. Dalam bab metodologi, bahan ujikaji telah direka dan difabrikasi menggunakan mesin CNC Universal Milling Machine for 5-Axis. Untuk eksperimen ini, jenis pemindaharuh bunyi satu kristal akan digunakan dengan pemindaharuh bunyi frekuensi sebagai pembolehubah yang dimanipulasikan di mana 2 MHz, 4 MHz dan 5 MHz digunakan. Hasil eksperimen ini ialah pantulan tenaga suara dari 'A-scanned'. Dari pemerhatian, pemindaharuh berfrekuensi tinggi mempunyai amplitud yang rendah, kurang gangguan bunyi dan puncak yang tajam sementara pemindaharuh berfrekuensi rendah menunjukkan amplitud yang tinggi, gangguan bunyi yang tinggi dan puncak yang lebar. Melalui keputusan ini, perbezaan ciri untuk setiap peringkat frekuensi di mana tinggi (5 MHz) dan rendah (2MHz) dibincangkan. Ciri-ciri pemindaharuh berfrekuensi tinggi ialah mudah kehilangan tenaga, pancaran kecil dan kadar penembusan rendah dan berlawanan dengannya, pemindaharuh berfrekuensi rendah lebih susah untuk kehilangan tenaga, kadar penembusan yang tinggi dan sensitif dengan kecacatan. Ciri-ciri ini menunjukkan bahawa pemindaharuh berfrekuensi tinggi sesuai untuk mengesan kecacatan pada kedalaman yang rendah, bahan yang nipis dan persekitaran yang bising

manakala pemindaharuh berfrekuensi rendah pula sesuai untuk permukaan yang kasar, ‘grainy material’, kecacatan yang bersaiz kecil dan sangat dalam.

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# CHAPTER 1

# INTRODUCTION

Nondestructive Testing or NDT is a testing where the test object is not been destroyed. There are different methods to detect different defects. NDT techniques has two categories. The first category is only detect and size defects or damage present on the surface; and second category can detect and size defects/damage embodied within a component. There are various NDT technique that are used in industrial. This include the Dye Penetrant Inspection (PT), Eddy Currents (EC), Magnetic Particle Inspection (MPI or MT), Radiography (RT) and Ultrasonic Testing (UT). Each of these various technique suitable in certain application and be of little or no value at all in other application. To enhance performances of NDT, choosing the right techniques is essential. Types of defects that can be detects are planar defects, laminations, voids and inclusions, wall thinning, corrosion pits and structural deformities such as dents, bulges and ovality. However, UT has been chosen for this project due to it abilities and advantages than the other techniques. UT can be carried out from a single surface, can detect internal flaws with accurate location and provides reliable crack depth.

## 1.1 Background of the project

Ultrasonic sound waves used to help measure material thickness, integrity and other physical properties in manufacturing or in-service situations. In the Ultrasonic Testing, sound waves are applied that are too high so cannot be detected by human ears, which is more than 20 kHz. To detect flaws in metal material, a range of 1 MHz to 6 MHz is used [1]. This high frequencies ultrasound are produce from Piezo-electric Effect. Flaws are detected by moving the probe over surface of the material that will be checked. However, layer of liquids (water, oil, grease) used in between of material and probe and material. This probe will produce a beam of ultrasound that passes inside the material and reflected if there is any flaws and discontinuity. Then, the same probe will receive the ultrasound. This reflected ultrasound in the form of signal with an amplitude representing the intensity of the reflection and the distance taken for the reflection to return to the probe will be seen in the screen on the calibrated diagnostic machine. The parameters that affecting the reading of Ultrasonic Testing is the probes type and frequency. For probes type, there are single crystal, dual crystal and also angle beam probe. Probes are also one-half-wavelength-long section that act as mechanical transformers to increase the amplitude of vibration generated by the converter. Probes are made to resonate at a specific frequency. The environment factors should be concern when using Ultrasonic Testing devices. Frequency is measured in cycles per second or Hertz. The more vibrations or oscillations each molecule makes in a set period of time, the higher the frequency. By increasing the probe diameter or increasing the frequency, the solid angle of beam will decrease. The factors consists of temperature, air turbulence and convection currents, atmospheric pressure, humidity, acoustic interference, radio frequency interference and splashing liquids. The other possible factor that will affecting Ultrasonic Testing experiment are composition, shape, target orientation to sensor and averaging.

## 1.2 Problem Statement

Transducer or probe is one of the basic component for an ultrasonic testing system. It is manufactured in variety of forms, shapes and sizes to suit for varying applications. Selection of correct probe frequency is one of the critical parameter to optimize the Ultrasonic Testing capabilities. Proper selection is important to ensure accurate inspection data as desired for specific applications. Therefore, an investigation is required to specify the suitability of different range of probe frequency.

## 1.3 Objective

This project is conducted to investigate the effect of selection of probe frequency in Ultrasonic Testing results and specify the suitability of different range of probe frequency in Ultrasonic Testing. In this project, the test sample for the experiment will be design and the suitability of probe frequency in Ultrasonic Testing will be investigated experimentally.

## 1.4 Scope

The Ultrasonic Testing test sample is designed and fabricated, the experimental procedure to investigate the effect of different probe frequency is developed and the experiment is conducted based on the procedure to study the suitability of probe frequency in Ultrasonic Testing is specified. The planning and execution of PSM 1 and PSM 2 can be referred in Appendix 1A.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 An overview of Ultrasonic

Since the publication of Lord Rayleigh's work on sound in "The Theory of Sound"; this work explained the nature and properties of sounds waves which led to the development of the techniques that are currently in use in nondestructive testing [2].

Ultrasounds or Ultrasonics is a sound that generated above the human hearing range. Vibrations above 20 KHz are termed "Ultrasonic waves". 0.5 MHz to 20 MHz is the usual frequency range for ultrasonic flaw detection[2,3]. However, from [1], the frequency range for ultrasonic nondestructive testing and thickness gage is 0.1 MHz to 50 MHz. The Piezo-Electric Effect is used to produce these high frequencies [2,4,5]. Although ultrasound behaves in a similar manner to audible sound, it has a much shorter wavelength. This means it can be reflected off very small surfaces such as defects inside materials. It is this property that makes ultrasound useful for nondestructive testing of materials.

The Acoustic Spectrum in Figure 2.1 below shows the breaks down sound into 3 ranges of frequencies. The Ultrasonic Range is then broken down further into 3 sub sections [1].

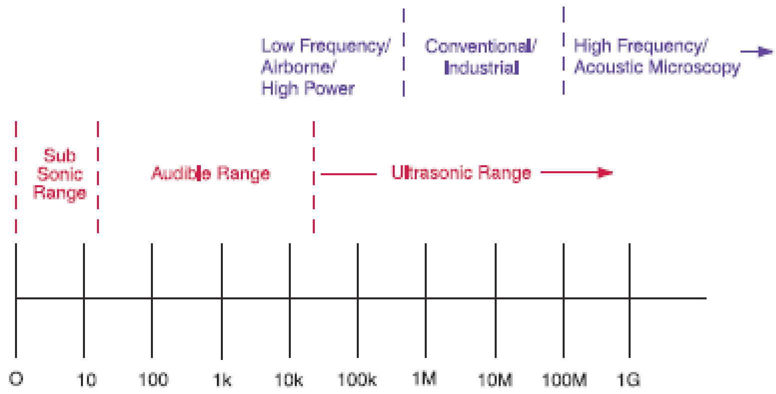


Figure 2.1: Acoustic Spectrum [1]

From the figure above, the part of the spectrum from zero to 16 Hz is below the range of human hearing and is called the 'Subsonic', or 'Infrasonic' range. From 16 Hz to 20 KHz is known as the 'Audible' range and above 20 KHz as the 'Ultrasonic' range. Ultrasonic flaw detection uses vibrations at frequencies above 20 KHz.

Most flaw detection takes place between 500 KHz and 20 MHz although there are some applications, for example in concrete, that use much lower frequencies and there are special applications at frequencies above 20 MHz. In most practical applications in steels and light alloys, frequencies between 2 MHz and 10 MHz predominate. Generally the higher the test frequency, the smaller the minimum detectable flaw, but it will be shown in following articles that higher frequencies are more readily attenuated by the test structure. Choosing an appropriate test frequency becomes a compromise between the size of flaw that can be detected and the ability to get sufficient sound energy to the prospective flaw depth [3].

### 2.1.1 Piezo-electric Effect

In the Ultrasonic Testing, the crystal given a sharp knock by mechanical means so it will be vibrate for a short period at its resonant frequency producing an alternating potential across its surfaces at the same frequency. Such devices which convert electrical