DESIGN AND DEVELOPMENT OF NOISE REDUCTION DEVICE FOR HAND DRILLING MACHINE

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ABSTRACT

Noise was defined as an unpleasant or unwanted sound and the drilling process emits high levels of noise. This project aims at determining the best absorber material which included coconut fiber, sponge and fiberglass in reducing the noise during the drilling process. This was followed by designing and fabricating the noise reduction device. The absorber device was built based on the standard size of hand drill machine. This experiment was conducted in the semi anechoic chamber. Sound level meter and microphone were used to acquire data from the experiment. Then, DASYLab software was used to analyze the data. Experimental test on the sponge, fiberglass and coconut fiber give an impressive result. From this experiment, the noise can be reduced for up to 7.18% or 7.2 dB when using the sponge as absorber material. While the fiberglass was able to reduce about 8.58% that is 8.8 dB and coconut fiber was able to reduce more than the other two materials used that is about about 15.5 dB or 15.12% . The coconut fiber is the best absorber material. The improvement of the device's design and use of multilayer absorber is highly recommended for the future research.

ABSTRAK

Hingar ditakrifkan sebagai bunyi yang tidak menyenangkan atau yang tidak diingini dan proses penggerudian mengeluarkan tahap bunyi bising yang tinggi. Projek ini bertujuan untuk mengkaji bahan penyerap terbaik iaitu serat kelapa, span dan kapas kaca dalam mengurangkan bunyi bising semasa proses penggerudian. Ini diikuti oleh mereka bentuk dan membuat alat penyerap bunyi bising. Alat ini telah dibina berdasarkan saiz mesin gerudi tangan. Eksperimen ini telah dijalankan dalam bilik separuh anechoic. Meter paras bunyi dan mikrofon telah digunakan untuk memperolehi data daripada eksperimen. Kemudian, perisian DASYLab telah digunakan untuk menganalisis data tersebut. Uji kaji pada span, kapas kaca dan serat kelapa memberikan hasil yang mengagumkan. Dari eksperimen ini, bunyi bising boleh dikurangkan sehingga 7.18% atau 7.2 dB apabila menggunakan span sebagai bahan penyerap. Manakala kapas kaca telah mengurangkan kira-kira 8.58% iaitu sebanyak 8.8 dB dan serat kelapa telah mengurangkan lebih banyak daripada dua bahan lain yang digunakan kira-kira 15.5 dB atau 15.12%. Serat kelapa adalah bahan penyerap terbaik. Peningkatan reka bentuk alat dan penggunaan penyerap berlapis amat disyorkan untuk penyelidikan pada masa akan datang.

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LIST OF SYMBOLS

α_θ	Absorption coefficient
dB	decibel
f	Frequency
L_I	Sound intensity level
L_p	Sound pressure level
ρ	reflection coefficient
λ	Wavelength
t	Time
W	Sound power
X	Maximum displacement or amplitude
m/s	Meter per second
W/m^2	Watt per meter square
N/m^2	Newton per meter square
N/m^3	Newton per meter qube
Hz	Hertz

LIST OF ABBREVIATIONS

RMS	Root Mean Square
SPL	Sound Pressure Level
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Acoustic may be defined in general as the transmission of energy through solid, liquid or gaseous media in the form of vibrations (Finch, 2004). Two essential factors for sound energy to exist are sound source that is vibrating body and a medium. In a medium, each vibrating particle moves only an infinitesimal amount of either side of its normal position, it is first displaced in the direction of propagation of wave, and then it will move back to its undisturbed position and continue towards a maximum negative displacement, due to the action of the rarefaction.

The time for completing a full circuit by a displaced particle is called the period, *T*. Usually the oscillations are repeated and the repetition rate is described by reciprocal of the period that is frequency, *f*. In other words, frequency is the number of oscillations per second. The unit of frequency is Hertz (Hz). The distance between adjacent regions where identical conditions of particle displacement occur is called the wavelength. It is the distance a sound wave travels during one cycle of vibration.

Noise has been defined as unpleasant or unwanted sound (Imran, 2010). Noise from a variety of working environment and processes can reach workers ears by various means that are from reflection of other surfaces, directly from the surrounding air, by vibration of the building floor or supporting beams in the workplace. Noise adversely affects the people and workers and they suffer from various health problems physically, psychologically and socially. The most common problem associated with the excessive noise exposure is noise-induced hearing loss (NIHL) which can be either temporary or permanent which is termed as the 'sensor-neural' hearing loss. This involves the damage to the hearing organ and this case not medically-treated. NIHL usually progresses unnoticed until it begins to interfere with communication, posing a serious safety hazard and a decrease in the quality of life (Imran, 2010).

1.2 PROBLEM STATEMENT

Noise is an unavoidable part of everyday life and technology development has resulted in an increase in noise level from machines, factories, traffic and more. It is therefore important that steps towards a reduction in noise are taken so that noise is not something we have to accept. The effects of noise from drilling process need to be avoid by produce the device that can reduce and absorb the airborne noise.

1.3 OBJECTIVE

These are the objective of this research:

i. Study which is the best material that is coconut fiber, sponge and fiberglass in reducing the noise during the drilling process.

ii. Design and fabricate the noise reduction device

1.4 SCOPE OF PROJECT

These are the scope of this research:

i. The acoustic source is airborne sound.
ii. The range of sound is audible, range is below 20 kHz.
iii. The hand drill is used in this project in order to produce noise.
iv. The material used is coir fiber, the porous material (sponge) and fiberglass.

1.5 HYPOTHESIS

The porous material has ability to absorb sound. Based on theory, the absorption of sound can be done at certain frequencies. The expected result in this experiment is to minimize the noise with using porous material as absorber.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In general as the transmission of energy through solid, liquid or gaseous media in the form of vibrations (Finch, 2004). Many people mistakenly think that the music is strictly acoustic or architectural in nature. Although no research instruments including acoustic music and architectural space, it also includes a variety of topics, including noise control, sonar for submarine navigation, ultrasound for medical imaging, thermoacoustic refigeration, seismology, bioacoustics, and communication electroacoustic. Here's "Wheel Lindsay Acoustics" is called in Figure 2.1, which was created by R. Bruce Lindsey on 1964. This wheel starts to explain the scope of the acoustics of the four broad areas of Earth Science, Engineering, Life Sciences, and Arts.

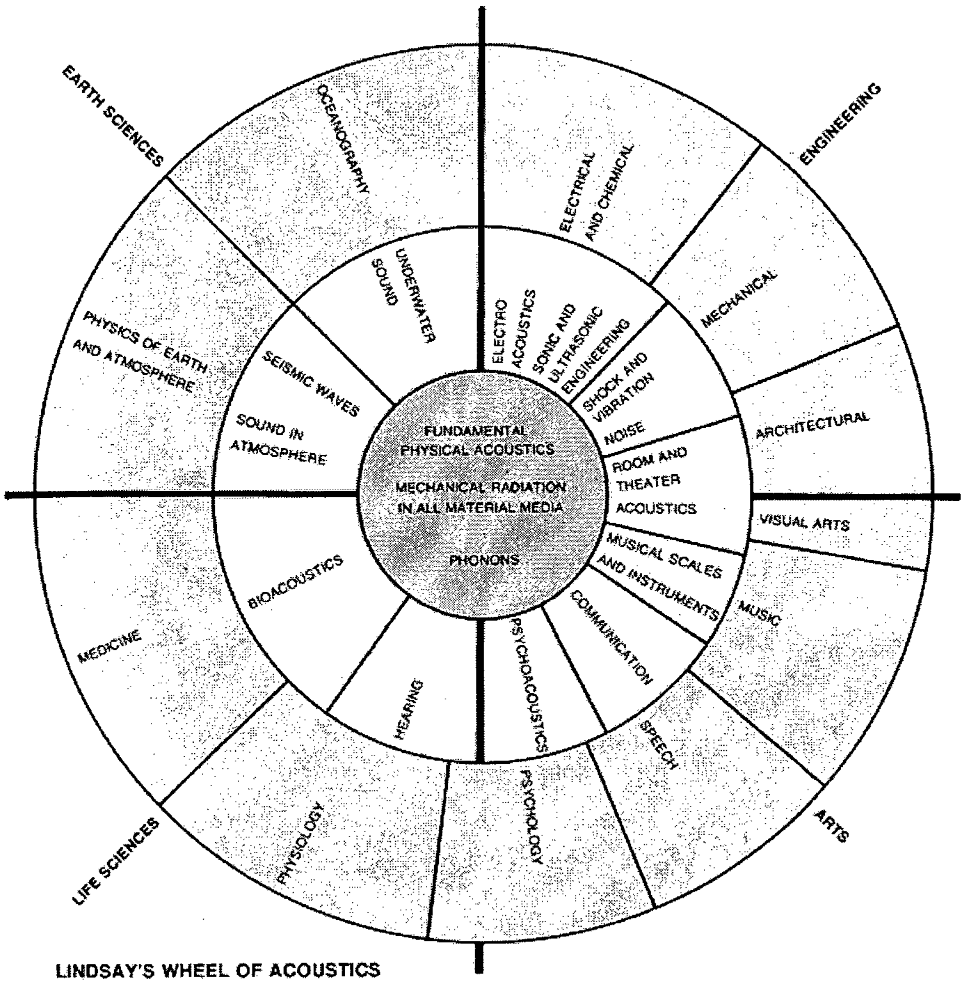

Figure 2.1: Lindsay's Wheel of Acoustics

Source: Kee, 2011.

2.2 BASICS MEASUREMENTS OF ACOUSTIC

2.2.1 Frequency

Frequency is the number of vibrations or pressure fluctuations per second (Sujatha, 2010). Unit of frequency is hertz (Hz). The entire spectrum can be divided into three parts such as audio, ultrasonic and infrasonic. A variety of audio fall between 20 Hz to 20,000 Hz. This is important because different frequencies can be detected by the human ear. This variety has several applications, including speech communication and music.

Various ultrasonic refers to a very high frequency is 20,000 Hz and higher (Smith, 1996). This variety has a shorter wavelength which allows better resolution in imaging technology. Medical applications such as ultrasound and elastography depends on the ultrasonic frequency range. This frequency can be used to study the geological phenomena such as earthquakes.

2.2.2 Wavelength

This is the distance traveled by sound in one complete vibration (Smith, 1996) as shown in Figure 2.2. In the case of infrared radiation, visible light, ultraviolet, and gamma rays, the wavelength of the most frequently expressed in nanometers (units of 10^{-9} meter) or Angstrom units (units of 10^{-10} meter). The wavelength is inversely related to frequency. The higher the frequency the shorter the signal wavelength.

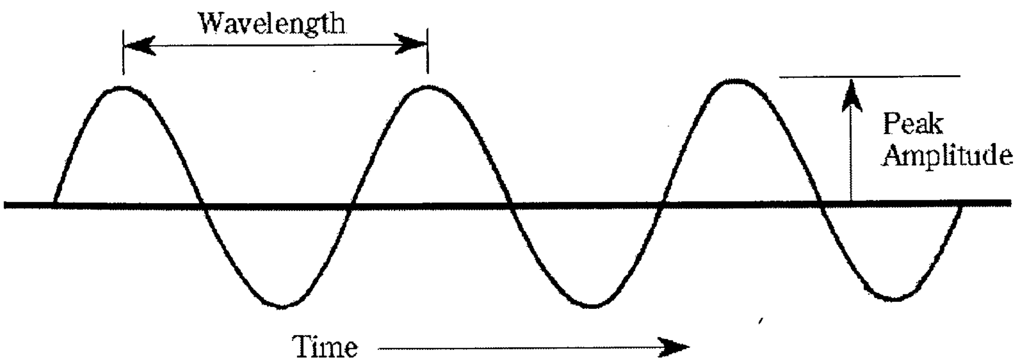

Figure 2.2: Wavelength

Source: Everest, 2011

2.2.3 Propagation of Sound Waves

Air cannot sustain a shear force so that the only type of waves possible is longitudinal where the vibration is in the direction of motion (Smith, 1996). This illustrated in Figure 2.3. These pressure fluctuations are of a vibration nature causing the neighboring air pressure to change but no movement of the air takes place. Air pressure which can be assumed to be steady has these fluctuations superimposed upon it.

Reflection of sound takes place when there is a change of medium. The larger the change, the greater the amount of reflection and the smaller the transmission. The laws of reflection for sound are similar to those for light (Smith, 1996).

i. The angle of incidence is equal to the angle of reflection
ii. The incident waves, the reflection wave and the normal all lie in same plane.

There is a limitation on the first of these. The reflecting surface must have dimensions of at least the same order of size as the wavelength of the sound. If the reflecting object is much smaller than the wavelength, then diffraction will take place (Smith, 1996).

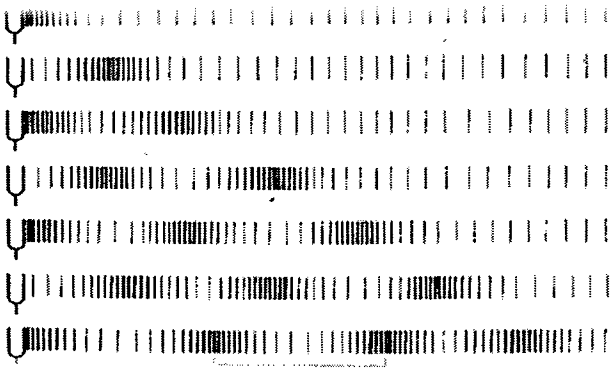

Figure 2.3: The Propagation of Sound Wave

Source: Chan, 2011.

2.2.4 Simple Harmonic Motion

A pure sound consists of regular vibrations such that the displacement of the vibrating object from its original position is given by:

Displacement, $x = X \sin 2\Pi f.t$ (2.1)

Where f = frequency in Hz

t = Time in seconds from its original position

X = Maximum displacement or amplitude.

The pressure fluctuations in the air are due to molecules of air vibrating back forth about their original position but passing on some of their energy movements. If a particular molecule has a displacement at time t of

$$x = X \sin 2\Pi f.t \tag{2.2}$$

Then it is moving at a velocity of vibration given by

$$\frac{dx}{dy} = 2\Pi fX \cos 2\Pi ft \quad (t = 0 \text{ when } s = 0) \tag{2.3}$$

And is being accelerated at a rate

$$\frac{d^2x}{dt^2} = -4\Pi^2 f^2 X \sin 2\Pi ft \tag{2.4}$$

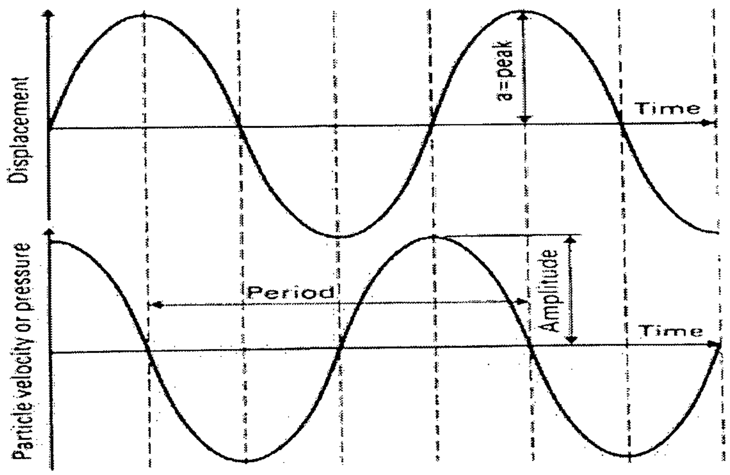

Figure 2.4: Displacement and Pressure Variation

Source: Smith, 1996

It can be seen from Figure 2.3 that the average displacement and pressure fluctuation is zero due to equal positive and negative changes. To overcome this problem it is convenient to make measurements of the root mean square pressure change (RMS value). For pure tones the RMS value is equal to 0.707 times the peak value or amplitude of the wave. The most commonly used measurable aspects of sound are particle displacement, particle velocity, particle acceleration, and sound pressure (Smith, 1996).

2.2.5 Sound Pressure

The sound can be sensed by the measurement of some physical quantity in the medium that is disturbed from its equilibrium value. The sound pressure is a commonly used index. The instantaneous sound pressure at a point is the incremental change from the static pressure at a given instant cause by the presence of sound wave. The effective sound pressure at a point is the root mean square (RMS) value of the instantaneous sound pressure over a time interval at that point. For periodic sound pressures, the interval should be an integral number of periods. The unit of sound pressure is N/m^2. Sound pressures are extremely small, at the distance of a meter from talker; the average pressure for normal speech is about $0.1\ N/m^2$ above and below atmospheric pressure where the atmospheric pressure is about 1.013 N/m^2 at sea level.

Sound pressure level (SPL) can be found by the following formula:

$$L_p = 10\log\left(\frac{p^2}{p_o^{\,2}}\right) \qquad \text{or} \tag{2.5}$$

$$L_p = 20\log\left(\frac{p}{p_o}\right) \tag{2.6}$$

Where p_o is the reference pressure, 2×10^{-5} N/m^2. It is chosen that the numerical values for intensity and pressure are approximately the same at standard atmospheric conditions (Kang, 2002).

2.2.6 Sound Intensity

The sound intensity is measured in a specified direction. It is the average rate at which the sound energy is transmitted through unit area perpendicular to the specified direction. The unit of sound intensity is W/m^2.

The sound intensity level (dB) can be found by the following formula:

$$L_1 = 10\log\left(\frac{I}{I_o}\right) \tag{2.7}$$

Where L_I is the sound intensity level (dB), I is the intensity of sound (W/m^2) and I_0 is the reference intensity, 10^{-12} W/m^2. I_0 is the minimum of sound intensity audible to the average human ear at 1000 Hz (Kang, 2002).

2.2.7 Sound Power

The sound power of as source is the rate at which acoustic energy is transferred from a vibrating source to the medium. This power is measured in watts. The sound energy density is the sound energy in a given infinitesimal part of the gas divided by the volume of that part of the gas. The unit is N/m^3.

The sound power level of a source is given by:

$$L_w = 10\log\left(\frac{W}{W_o}\right) \tag{2.8}$$

Where W is the sound power $(W)$and W_o is the reference sound power, $10^{-12}W$.

2.3 NOISE

High noise levels can cause hearing problems. This is a serious problem in the industrial workplace in which much progress has been made but not enough. Thousands of workers are still exposed to levels that will damage their hearing.

Noise is a major environmental problem. Traffic is the dominating source of community noise. The bulk of the population exposed to road noise from the noise of the plane or train. There are also other important sources of noise such as noise from the neighbours and installation of the building for example, air-conditioning equipment, is usually more convenient to control the traffic noise. However, the resources that often destroys the acoustic environment which would otherwise have been a quiet and relaxing, like the back, gardens, parks, and so on. Most people are usually exposed to several sources of noise. Unlike many other environmental problems, noise pollution is still expanding. In addition, the environmental impact of noise complaints public which has increased since 1992. The development is unsustainable (Barron, 2003).

Noise affects human health and well-being in some way. Task Force on World Health Organization (WHO) has identified specific health effects of the following:

interference with communications, the noise caused by hearing loss, annoyance responses and effects on sleep, cardiovascular and psycho-physiological systems, performance, productivity, and social behaviour. Combination of these effects is important for certain environments such as homes, schools, hospitals, concert halls, outdoor concerts and discotheques as well as for a sensitive period (night and day, weekends). In choosing the values of specific guidelines for environmental impact based on specific, vulnerable groups considered, for example, those with a hearing deficit, shift workers, the elderly, babies and young (Imran, 2010).

2.4 PRINCIPLES OF NOISE CONTROL

There are three basic elements in any noise control system, as illustrated in Figure 2.5:

i. The source of the sound
ii. The path through which sound travel
iii. The receiver of the sound

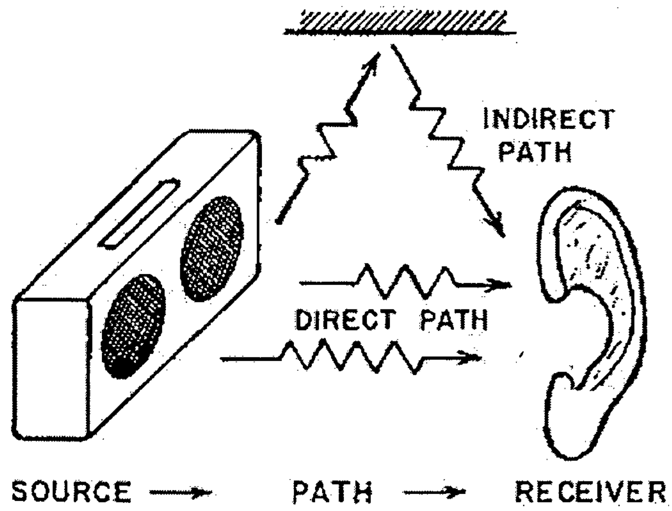

Figure 2.5: Three components of a general noise system

Source: Barron, 2003

In many situations, of course, there are several sources of sound, various paths for the sound and more than one receiver, but the basic principles of noise control would be same as for the simpler case. The objective of most noise control programs is to reduce noise at the receiver. This may be accomplished by making modifications to the source, the path or the receiver or to any combination of these elements.

Sources of noise or unwanted sound is a vibrating surface, such as the panel in the details of machinery, or small vortex velocity fluctuations in fluid flow, such as eddies in the jet stream leaving the air holes.

The path for the sound may be the air between the source and receiver, as in the case for machinery noise transmitted directly to the operator's ears. The path may also be indirect, such as sound being reflected by a wall to a person in the room. Solid surface, such as piping between a vibrating pump and another machine element, may also serve as the path for the noise propagation. It is important that the acoustic engineer identify all possible acoustic paths when considering a solution for the noise problem (Barron, 2003).

The receiver in the noise control system is usually the human ear, even if the receiver can be sensitive equipment that would have affected operations if excessive exposure to intense noise. It is important that the acoustic designer specify the "failure mode" for the receiver in any noise control project. The purpose of the noise control procedure may be to prevent hearing loss for personnel, to allow effective face-to-face communication or telephone conversation or to reduce noise so that neighbors of the facility will not become intensely annoyed with the sound emitted by the plant. The engineering approach is often different in each of these cases (Barron, 2003).

2.4.1 The Source of the Sound

Modifications to the sound source is usually considered the best solution to the problem of noise control. Machine components can be modified to affect significant change in noise emission. For example, in the machinery used to produce paper bags, by replace the mechanism of the effect of the blade used to cut individual bags from the feasibl