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OPTIMIZATION ON THE USE OF A HOME-MADE IMPEDANCE TUBE TO MEASURE SOUND ABSORPTION COEFFICIENT

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This Report Is Submitted In Partial Fulfillment of Requirements For the Bachelor of Mechanical Engineering (Structure & Materials) with Honor

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2011

"I declared that this project report entitled measurement of sound absorption coefficient using impedance tube of my own result except as cited in the references."

Signature : ……………………………………

Name of Candidate : Mohd Zulfadzli Bin Zulkifili

Date : 20 April 2011

For my beloved father and mother,
Dearest family members,
Lecturer and friend

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Grace be upon ALLAH the Almighty, with HIS blessings, final project (PSM 1) and (PSM 2) had been completed with successfully around this Two semesters. Along the PSM progress, I'm, Mohd Zulfadzli Bin Zulkifli had studied various kind of knowledge, design, function of project and vibration and acoustic. This PSM report is written based on the PSM activities and progress that started on from last semester.

The PSM report packages for each chapter have fulfilled and complied with the requirements of the PSM to ensure students acquire the necessary knowledge and skills needed, and to applied it in the future

.

Thank also to person that have been allowed me to further mine study at Universiti Teknikal Malaysia, Melaka. Otherwise, this university has various type of certificate, example Degree in Mechanical Structure that I am taking now and it covered studying theory and practical such as conduct the experiment in the laboratory. This final project is one of conditions that should be do for certified students certificate.

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ABSTRAK

Di Malaysia, masalah dengan bunyi sangat teruk dan dan perlu di atasi. Bahan akustik secara meluas digunakan untuk mengurangkan kebisingan. Contoh bahan akustik adalah wul kaca, permaidani, dan tempat terminasi Anechoic. Micro-panel berlubang juga dianalisis untuk projek ini. panel Micro-panel berlubang adalah penyerap baru untuk generasi akan datang dan mempunyai potensi yang baik untuk di ketengahkan. Untuk membuktikan potensi panel tersebut, perlu di analisis dengan teori. Untuk mengukur penyerapan bunyi bg bahan akustik dan panel, mempunyai dua kaedah iaitu , iaitu tabung impedansi dan bilik gema. kaedah bilik Gema memerlukan bilik khas sehingga memerlukan lahan dan kos maka tinggi berbanding dengan kaedah tabung impedansi. Projek ini bertujuan untuk mengoptimumkan tabung untuk mengukur penyerapan bunyi gunakan suara yang di hasilkan sendiri. Beberapa bahan yang digunakan untuk mendapatkan data pengukuran dan dianalisa. Beberapa kkekurangan tabung impedansi buatan sendiri juga di bincangkan.

ABSTRACT

In Malaysia, an issue with the noise is very severe and should be solved . Acoustic material are widely used to reduce noise. Example for acoustic material is glass wool, carpet and anechoic termination box. Micro-perforated panel also analyzed for this project. Micro-perforated panel is a new absorber for next generation and have a good potential to commercialized. To prove their potential, need to validate with theoretical. There are two methods to measure sound absorption of an acoustic material, namely impedance tube and reverberation chamber. Reverberation chamber method requires a special room therefore need area and hence high cost compare with the impedance tube method. This project is aimed of optimizing tube to measure sound absorption of sound use of a home-made. Several material are used to obtain measurement data and are analyzed. Several limitation of the hand-made impedance tube is also discussed.

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LIST OF SYMBOLS

SYMBOLS	DESCRIPTION
α	Absorption coefficient
a	Acceleration
ν	Kinematic Viscosity
P	Pressure
F	Force
θ	Angle
Z	Impedance
f_l	The lower working frequency of the tube
f	The operating frequency
f_u	The upper working frequency of the tube;
c_0	Speed of sound
H_I	The imaginary part of H_{12}
H_R	The real part of H_{12}
S_{12} & S_{11}	The value from Experimental result (G11 & G12)
x_1	Distance between sample and the further microphone location
∅	Phase angle of normal incidence reflection factor
$\mathrm{H_I}$	The transfer function for the incident wave alone
$\mathrm{H_R}$	The transfer function for the reflected wave alone
S	Distance between two microphones
K_o	Acoustic wave number
M	The surface density of MPP leaf
P	The air density
η	The coefficient of viscosity of the air
ω	Angular frequency;
k	Wave number

CHAPTER 1

INTRODUCTION

1.1 Background

1.1.1 Noise

Noise means is any audible sound or as an unwanted sound that is loud, unpleasant, unexpected or undesired in the air [1]. In addition, noise also can be defined as "disagreeable”. Noise traveling through air is normally characterized as "air borne" . Noise can cause hearing damage and ringing in the ears. It can interfere with communication, cause fatigue and tiredness, reduce efficiency, affect morale, and distract and disrupt job performance. Noise can be measured in unit is called “ decibels” or “dB”. It is often not appreciated that an extra 3 decibels doubles the noise level. Because the human ears is not equally sensitive to sound at all frequency, occupational noise is measured in a way which simulates the response of a healthy human ear. This is generally referred to as decibels with ‘A’ weighting, or called dB(A). Refer Table 1 as typical noise levels for common sounds are given below. These are general values and will vary with environmental factors [2].

Typical noise level for common sound (in sound power)	dBa
Rustle of leaves	15
Soft whisper	30
Mosquito buzzing	45
Normal Conversation	55
Typing pool	67
Normal street traffic	75
Alarm clock ringing	80
Heavy city traffic	92
Permanent hearing loss (exposed full time)	95

Table 1.1: Typical noise levels for common sounds

Noise is the result of pressure variations, or oscillations, in an elastic medium such as air, water, and solid, generated by a vibrating surface, or turbulent fluid flow. Sound propagates in the form of longitudinal (as opposed to transverse) waves, involving a succession of compressions and rarefactions in the elastic medium. When a noise wave propagates in air, the oscillations in pressure are above and below the ambient atmospheric pressure.

Many sounds have a tune quality, that is, a certain pitch can be ascribed to them. Such sounds form the basic elements of music. Besides that, there are other sounds which although having a more general character such as muffled, do not have a distinct pitch. Imagine, such as noise of an air stream. Based on the figure 1.1 (an element of its surface is sketched as a solid line), when it moves from the left side to the right as shown in the upper part of the figure, it cannot displace all the air in front of it but it will press some of it together. When moving in reverse direction the body will suck in some air, again not by moving the whole column of air but by expanding some of it.

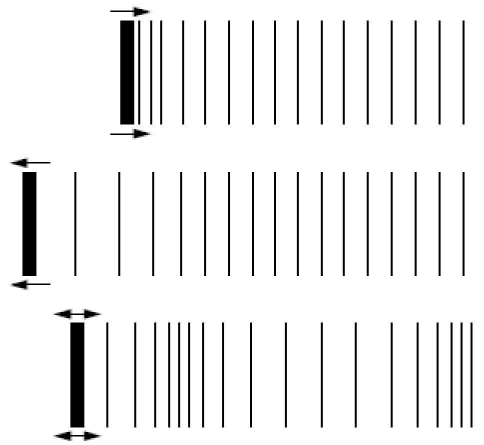

Figure 1.1: Radiation of sound waves from a moving body [3]

Now any density change of the air is associated with a change in air pressure. Because of that the compressed air tends to transfer the pressure increase to the neighbouring air volume such as decompressed air volume exertsunderpressure to its vicinity. Basically, all pressure disturbances induced by the body’s movement will travel into the resting air. When assume the surface of the body to move backor oscillate and then the alternating compressions and expansions of the air will detach from the body and travel into the medium, so the result is a sound wave.

In hearing sounds the reverse process takes place in a way, when a sound wave hits the head of a listener a tiny part of it enters the ear channel. At its end it impinges on the eardrum which is set into vibrations by the pressure fluctuation. These oscillations undergo further processing by the middle ear and the inner ear and are finally led to the brain. So can state that the propagation of sound is bound to the presence of a suitable medium, for instance air such as in the empty space there is no sound.

1.1.2 Environmental Noise

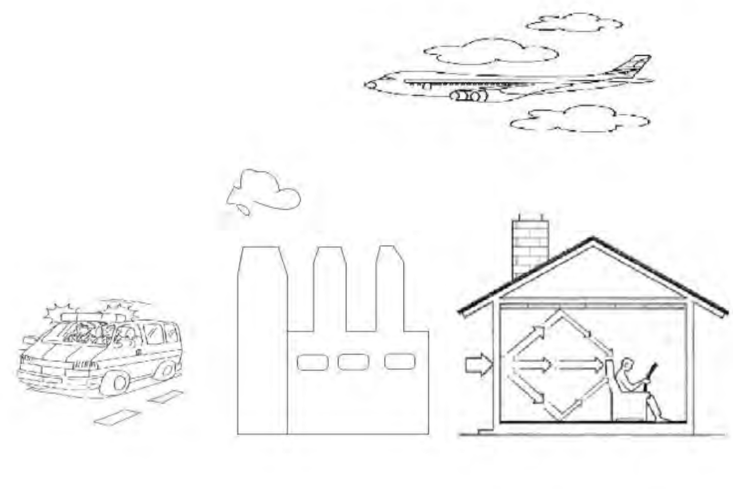

Figure 1.2: Environmental noise

Environmental noise is that which is experienced throughout the community, particularly in, built up areas, public parks, near schools, or other noise sensitive areas. Sources of environmental noise include sites of industrial activity or means of transport such as, rail, air or road traffic. Occupational noise is experienced in the workplace as a result of various processes or the use of industrial machinery. Industries such as construction and manufacturing can have high noise levels but it can be a wide ranging problem affecting other workplaces such as schools or call centre too. Refer Table 1.2 Guideline Values For Community Noise In Specific Environments [4].

Environment	**Critical health effect**	**Sound level dB(A)***	**Time hours**
Outdoor living areas	Annoyance	50 - 55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	Sleep disturbance	30	8

School classrooms	Disturbance of communication	35	During class
Industrial, commercial and traffic areas	Hearing impairment	70	24
Music through earphones	Hearing impairment	85	1
Ceremonies and entertainment	Hearing impairment	100	4

Table 1.2: Guideline Values For Community Noise In Specific Environments

The terms environmental noise describe the noise generated by all the aspects of our society as it impinges on the usual activities of our daily lives, excluding occupational noise. Its only rarely that the level of environmental noise would be sufficient to produce permanent hearing damage. Transportation is widespread sources of noise and is heard to some extent by the majority of those living in urbanized areas and some of those living in rural areas. Other forms of environmental noise are related to the activities associated with industry and mining, with commercial activities, with recreation and with neighbours. Annoyance, speech interference and sleep disturbance are considered to be the main effects of environmental noise. Speech interference is also an important part of the overall assessment of annoyance. For Specific situations where the level of environmental noise is high speech interference is possible inside buildings, such as school or office near busy roads or airports. For the sleep disturbance, the most common metrics for assessing the impacts of community noise such as DNL already contain a strong 10-db penalty for nighttime noises, and community noise exposure policies typically do not include separates criteria for sleep disturbances. However, there are circumstances where a separate analysis of the impacts of nighttime noise is warranted. The annoyance produced by industrial and commercial noise is very similar to that produced by road traffic noise when the long term energy equivalent sound pressure levels are the same.

1.1.3 Noise Insulation

For the basic concept of noise insulation, when noise strikes a structure such as a wall or a window, most of it is reflected, with the remainder being transmitted through by vibrating the structure, as shown in Figure 1.3. Since only a small portion appears on the other side of the structure, we say that the noise has been reduced [5].

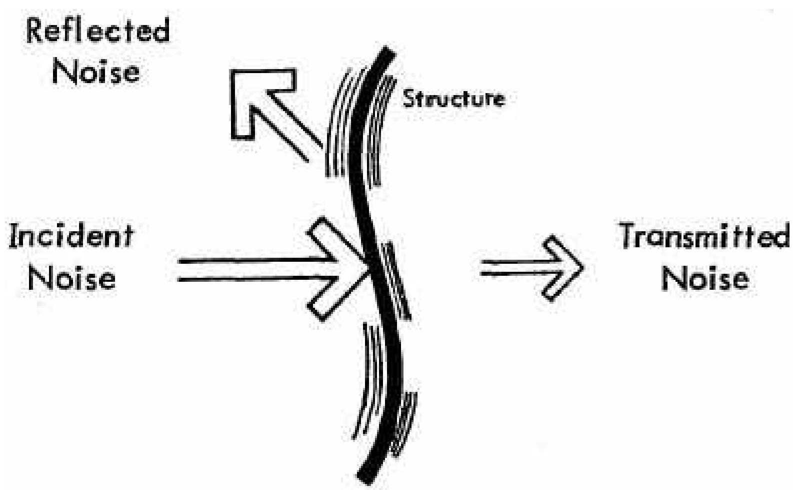

Figure 1.3: Basic concept

Below are examples of noise insulation in practical applications:

a. Insulation noise in building

Two important properties of a wall that contribute to its ability to reduce noise are its weight per unit area, and its stiffness or resistance to bending when a force is applied [6]. In general, the heavier a wall is, the better it will act to reduce noise. The term noise reduction has been used generally to this point to mean the decrease in level as noise passes through a wall. Once the noise manages to pass through the wall into a room, it may then be partially absorbed by soft materials such as drapes and carpets. Hence, noise reduction is really two separate mechanisms - one due to the blocking properties of the wall, and one due to the acoustic environment on the receiving side of the wall. These two mechanisms are shown conceptually in Figure 1.4 [7]. The exterior noise is first attenuated while passing through the exterior wall, attaining a level which is prevented from further build up by the absorptive materials normally found in residential buildings. The first mechanism, which is the reduction due only to the physical properties of the wall, is termed Transmission Loss (TL). The second mechanism, interior absorption, is due to absorption of the noise materials inside the room.

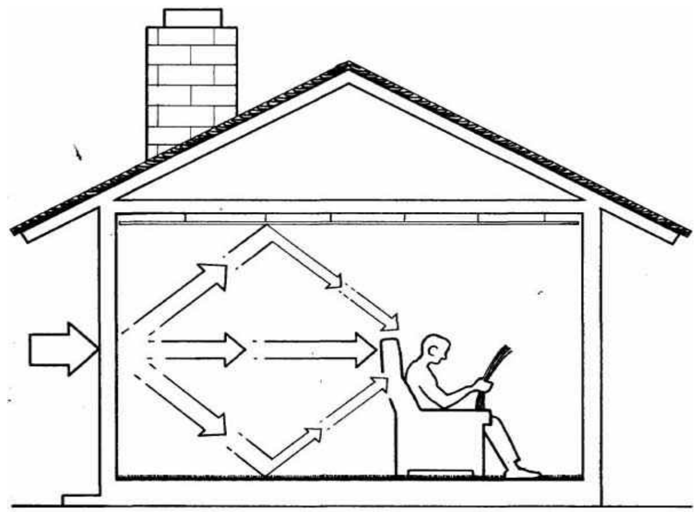

Figure 1.4: Concept two mechanism

When noise enters a building from the outside, it undergoes a reduction in level have been defined as Noise Reduction (NR). The amount of NR obtained depends on the type of construction used for the walls of the building, the sizes and types of windows and doors, the presence of noise leaks such as ventilation openings, and the amount of acoustically-absorptive material inside the building.

b. Insulation noise in aircraft and car

Aircraft cabin noise can be generated by a variety of sound and vibration sources and transmitted into the cabin by airborne and structure born paths. The sources may be inside or outside the fuselages and depending on the type of airplane, can includes engine, propellers, turbulent boundary layer, air conditioning system and propulsion system gearbox as shown in figure 1.5. A successful passive noise control program often has to address several noise sources and transmission paths. A balanced noised control treatment would consider all combination of source and paths such that all contribute approximately equally. Reducing the noise from one sources to a level well below the contribution for the other sources would not be a cost or weight effective.

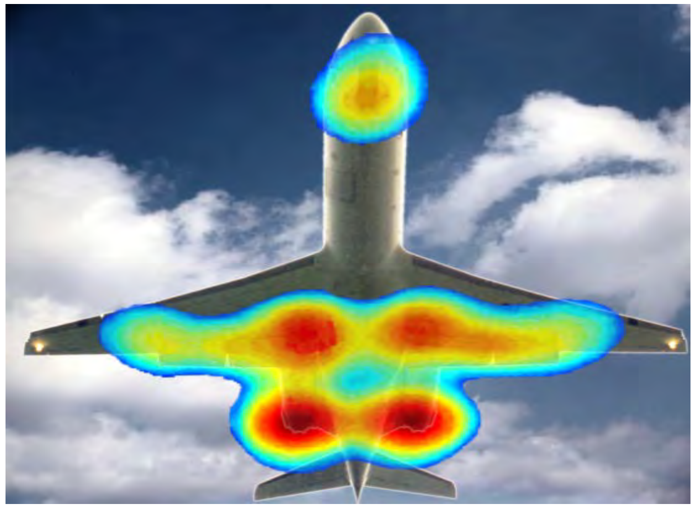

Figure1.5: Element Aircraft

Interior noise in car or vehicle as shown in figure 1.6 is caused primarily by the engine , exhaust, transmission and driveline component or is called power trained noise, tire interaction (road noise) and air flow around the car (wind noise). From the sources, vibration or sound energy is transferred by airborne or structure borne paths to the passenger cabin interiors. The noise in the cabin a negative impact on security, because the driver gets tired more quickly and reduces alertness. The car is a combination of many components and units.

"The weak resistance to external noise" affects those machines, elements of which are not treated with appropriate noise-canceling trains. The main ways to reduce and protect against noise is reducing squeak and suppression of vibration. For reducing squeak, it will be useful to remove the squeak caused by the "festivities" of metal panels of the car and / or its individual components during the trip. In the car bigger than the other decorative elements creaking doors and trunk. To get rid of squeaks apply the necessary porous sheets, which can reduce noise. Proofing material unique in that it does not skip the water and consists of "closed cells". Based on this particular squeak disappears. Noise isolation will