RISK ASSESSMENT OF NOISE EXPOSURE IN WOODEN FURNITURE MANUFACTURING INDUSTRY

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ABSTRACT

A cross-sectional study was conducted to investigate the noise exposure and noise induced hearing loss (NIHL) symptoms among workers in wooden furniture manufacturing industry. Environmental noise monitoring was carried out by using sound level meter (SLM) to assess the noise level in different workstations. Personal noise monitoring was conducted by using portable dosimeter to monitor personal noise exposed among workers. Questionnaire was developed to obtain demographic information, job profile and health history of respondents. Meanwhile, walk-through survey and interview was conducted to identify the sources of noise and other related factors. The area noise level measurements showed that the molding operation recorded the highest noise level in the industry compared to other operations. The respondents who work with machine were randomly chosen from the selected block and they were divided into high and low exposure group. Personal noise measurement shows that 60% of respondents exposed to low noise level (85-90 dBA) whereas 40% of respondents exposed to high noise level (> 90 dBA). There was a significant different ($t = -11.289$, $p = 0.001$) of personal noise level between low and high exposed group. Besides that, NIHL symptoms complaints among the exposed worker shows that prevalence of tinnitus among the highly exposed group was significantly higher than the low exposed group ($\chi 2 = 11.667$, $p = 0.001$). The factors such as personal noise level ($p = 0.026$) and employment period ($p = 0.010$) shows significant relationship with ear pain whereas only personal noise level ($p = 0.001$) shows significant relationship with tinnitus. This might due to bad work practices among workers who did not wearing appropriate PPE during performing their work as observed throughout the study period. Hence, the use of noise protection gadget among workers and other control measure within the wooden furniture industry is strongly recommended to ensure the workers' safety and health.

ABSTRAK

Satu kajian keratan rentas telah dijalankan untuk menyiasat pendedahan bunyi bising dan gejala kehilangan pendengaran akibat kebisingan (NIHL) di kalangan pekerja dalam industri pembuatan perabot kayu. Pemantauan bunyi alam sekitar telah dijalankan dengan menggunakan meter paras bunyi (SLM) untuk menilai tahap bunyi di tempat kerja yang berbeza. Pemantauan bunyi peribadi telah dijalankan dengan menggunakan pengukur Dosis mudah alih untuk memantau bunyi peribadi yang terdedah di kalangan pekerja. Soal selidik telah direka untuk mendapatkan maklumat demografi, profil pekerjaan dan rekod kesihatan responden. Sementara itu, berjalan-melalui kaji selidik dan temubual telah dijalankan untuk mengenal pasti punca bunyi dan factor-faktor lain yang berkaitan. Pengukuran tahap kebisingan kawasan menunjukkan bahawa operasi pengacuan mencapai tahap kebisingan yang tertinggi dalam industri berbanding dengan operasi yang lain. Responden yang bekerja dengan mesin telah dipilih secara rawak daripada blok yang dipilih dan mereka telah dibahagikan kepada kumpulan pendedahan tinggi dan rendah. Pengukuran bunyi peribadi menunjukkan bahawa 60% daripada responden telah terdedah kepada tahap bunyi yang rendah (85-90 dBA) manakala 40% daripada responden terdedah kepada tahap bunyi bising yang tinggi (> 90 dBA). Ini menunjukkan bahawa terdapat perbezaan yang signifikan (t = -11,289, p = 0.001) paras bunyi peribadi antara kumpulan rendah dan tinggi terdedah. Di samping itu, aduan gejala NIHL di kalangan pekerja yang terdedah menunjukkan bahawa kelaziman tinnitus di kalangan kumpulan yang amat terdedah adalah lebih tinggi berbanding dengan golongan yang berpendapatan rendah yang terdedah ($\chi 2$ = 11,667, p = 0.001). Faktor-faktor seperti tahap peribadi bunyi (p = 0.026) dan tempoh pekerjaan (p = 0.010) menunjukkan perkaitan penting dengan sakit telinga manakala tahap bunyi bising hanya peribadi (p = 0.001) menunjukkan perkaitan penting dengan tinnitus. Hal ini mungkin disebabkan oleh amalan kerja yang tidak baik di kalangan pekerja yang tidak memakai PPE yang sesuai semasa menjalankan tugas mereka sepanjang tempoh kajian. Oleh itu, penggunaan alat perlindungan bunyi di kalangan pekerja dan langkah kawalan lain di dalam industri perabot woodent adalah amat disyorkan untuk memastikan keselamatan dan kesihatan pekerja.

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LIST OF SYMBOLS

D	Noise dose
dB	Decibel
dBA	Decibel in A-Weighting Filter
Hz	Hertz
Khz	Kilohertz
L_{eq}	Equivalent continuous sound level
L_{max}	Maximum sound level
L_{min}	Minimum sound level
L_{peak}	Peak sound level
n	Number of samples
Pa	Pascal
W/m^2	Sound intensity

LIST OF ABBREVIATIONS

ANSI	American National Standard Institute
DOSH	Department of Occupational Safety and Health
FMA	Factory and Machinery Acts
ISO	International Standard Organization
MATRADE	Malaysia External Trade Development Corporation
NIHL	Noise-Induced Hearing Loss
OSHA 1994	Occupational Safety and Health Act 1994
OR	Odds ratio
SLM	Sound Level Meter
SOCSO	Social Security Organization
SPSS	Statistical Package for Social Science
SPL	Sound Pressure Level
TWA	Time Weighted Average

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

Chapter 1 introduces concept, purpose, objective and nature of the study. The introduction is given a description of the problem that addressed. This chapter provides a detail description on introduction, background of study, problem statement, objectives, research question, hypothesis, significance of study, scope of study, operational definition, and conceptual framework.

1.0 INTRODUCTION

The wooden furniture manufacturing industry is a fastest developing industry and has best known in the production of wood furniture in Malaysia (Ratnasingam et al., 2012). In year 2011, Malaysia External Trade Development Corporation (MATRADE) reported, Malaysia ranked as the eighth largest exporter of furniture in the world. The manufacturers produce a wide range of furniture product such as kitchen furniture, bedroom furniture, living room furniture and office furniture. Wooden furniture industry today has transformed from a cottage based and skill-dependent industry to a technological base and high number of worker industry (Ratnasingam et al., 2012). Shaikh (1998) claimed that, industry using high technology includes heavy machinery and power tool to lighten the workload of the workers, overcome the demand of the population and increase production. However, the existing technology produces high level of noise and high probability to cause hearing damage towards worker (Shaikh, 1998).

A sound brings delightful to some people, but at the same time can cause annoying and even physical or psychological illnesses (Marcos et al., 2009). The

severity effect of noise was caused by accumulation and lead to an obvious physical, psychic and social deterioration (Mohammadi, 2008). According to Medina-Tiencken (2013), when long term exposes to high level of noise generate from machinery, can cause dangerous on hearing ability. Robinowitz (2000) stated that, when a person exposes to high level of noise can impact on the hair cells of the cochlea membrane and lead to hearing loss. The noise level generated from the machine depending on various factors, including the type and power of engine, design solutions, and the type of work being done, whereas high fluctuation in the noise level can be identified during a specific type of work progress, which attributed to different rotational speed, engine load and operator skill (Perez et al., 2004). The way of workers exposes to the hazard can be an important input for a better understanding of hazard management to their safety.

In addition, there were some risk factors should be concerned, such as duration of exposure, intensity of noise and age of worker due to these can lead to hearing loss (Mndeme et al., 2012). In 2010, Razman founded that the prevalence of hearing loss and tinnitus increases with duration of occupational exposure of noise. When noise exposure over an 8 hour working day equals or exceeds 85 dBA, it can lead to hearing loss (Mndeme et al., 2012). Besides that, the old age population was greater probability to get noise-induced hearing loss (NIHL) compared to other population, although every age group significant to NIHL when exposed to noise (Medina-Tiencken, 2013). According to Sorainen et al. (2000), when compared with different kind of industry, the woodworking industry was the fourth highest prevalence of getting hearing impairment. Therefore, the assessment of noise exposure towards workers within the working environment of wooden furniture manufacturing workplace is an essential. This paper is to assess the risk of noise exposure towards worker in wood furniture manufacturing industry and factor of noise exposure and subsequent noise-induced hearing loss (NIHL) symptoms by workers.

1.1 BACKGROUND OF STUDY

Noise is a sound which is loud and unpleasant and cause disturbance and occupational disease (Hong et al., 2013). Wood furniture manufacturing industry was one of the noisiest environments to work. According to Ratnasingam et al. (2010) in comparison between Europe and Scandinavian countries, Malaysia wooden furniture industry worker exposed to a higher noise level than the permissible standards and less strict enforcement of the existing regulation in Malaysia. Therefore, noise compromised safety and health among worker in wood furniture manufacturing industry. Besides that, Ohlemiller (2008) claimed that, there were 10 million of people in the United State impacted by noise injury get from occupational setting. Noise able to cause psychological issues such as annoyance, cognitive failure, stress and interference concentration and if exposed to noise where over 85 dBA can develop noise-induced hearing loss (Mndeme et al., 2012). Besides that, tinnitus is a ringing sound in the ear and the main symptom to get NIHL (Rabinowitz, 2000).

Furthermore, due to low cost economy, most of the wooden furniture manufacturing industry not willing to put investment and budget on safety and health and always overlook about worker welfare, mainly focus on cost competitiveness (Medina-Tiencken, 2013). Ratnasingam et al. (2010) stated that, in the furniture manufacturing industry, workers exposed to high level of noise which emitted from many kinds of machinery and tools such as circular saws, planers, sanders, driller, structural vibration of machine frame, dust and wood chip extraction system, aerodynamic turbulence of the rotating tools and wood lathes. When long term exposed to high intensity of noise from the sources can lead to noise-induce hearing loss (NIHL) and other negative effects such as sleep disturbance, interference of speech and cognitive disorder (Picard et al., 2008). NIHL had reported the main cause was exposed to high level of noise (Rachiotis et al., 2006 and Hong et al., 2013) and it was a major health issue affecting million of people worldwide (Sliwinska-Kawalska et al., 2013).

There was a strong association between noise exposure and NIHL in industry had been found in numerous studies and the risk of hearing damage increase as the duration and dose of noise exposure increase (Celik et al., 1998; Pourbakht et al., 2003;

Rachiotis et al., 2006; Kim et al., 2011, Arezes et al., 2012 and Hong et al., 2013). Noise-induced hearing loss (NIHL) is a preventable disease if we notice it earlier and risk can minimized with application of noise control and hearing control device (Hong et al., 2013). The employer needs take responsibility about safety and health of workers as it can affect the productivity and company profitability. Therefore, in order to minimize this hazard, it is essential for employer and employees understand this hazard and conduct a series of control measure to overcome the risks of hearing damage in the workplace. Thus, this study carried out to assess the risk of noise exposure in the wood furniture manufacturing industry.

1.2 PROBLEM STATEMENTS

National Institute Occupational Safety and Health (NIOSH) had estimated over 30 million employees exposed to high noise level during performing their work (McReynolds, 2005). When exposed repeating to the high intensity of noise can bring impact on the structure of the inner ear (sensory hair cells and cochlea) and lead to hearing loss (Chao et al., 2013). NIHL is a primary hazard in many workplaces and in society (McReynolds, 2005). Rabinowitz (2000) found that, NIHL is dangerous due to its slowly happening and painless. Noise injury had been intensively studied for a long time, but the studies still cannot determine who was the most at risk in a noisy environment (Ohlemiller, 2008).

Besides that, Leather et al. (2003) claimed that, noise exposure in the workplace (L_{Aeq8hr} > 85 DBA) indicated a potential risk towards workers. When the worker exposed to high level of noise, it induced temporary or permanent hearing loss and led to loss of perception and concentration, fatigue, dizziness, recognition of speech, warning signals and quality of life (Picard et al., 2008). The cost of the negative effect of noise is large, the cost not only financial compensation or reduce the enjoyment of social life, but also reduces productivity, increased stress and risk of accident (Aurich et al., 2012). In Korea, the manufacturing sector accounted for over 80% of the 2324 workers who claimed occupational insurance compensations for NIHL and hearing disorders as the large proportion of diagnoses made by occupational medical checkups (Kim et al., 2011).

Furthermore, a statistic had adopted from Social Security Organization (SOCSO) showed a number of hearing loss cases between the years 1995 until 2009 caused by noise (DOSH). From the statistic, year 1995 until 2003, the number of cases was fluctuated but from year 2004 to 2007 was increasing gradually. In year 2008, the case of hearing loss slightly reduced. However, from year 2008 to 2009, the cases of hearing loss were dramatically increased and the number of cases was almost double up. It showed that the issue of hearing loss caused by noise was serious and should always be concerned and understood.

1.3 RESEARCH QUESTIONS

This study is conducted to answer the following questions:

i. What is the environmental noise level in different workstations of wooden furniture manufacturing industry?
ii. What is the level of personal noise exposure among the exposed group?
iii. What is the prevalence of NIHL symptoms among the exposed group?
iv. What are the factors influence noises induced hearing loss (NIHL) symptoms among the excessively exposed workers?

1.4 RESEARCH OBJECTIVES

1.4.1 Main Objective

To investigate the noise exposure and noise-induced hearing loss (NIHL) symptoms among workers in wooden furniture manufacturing industry.

1.4.2 Specific Objectives

i. To assess the environmental noise level in different workstations.
ii. To compare the personal noise exposure level between low exposed and high exposed group.
iii. To compare the prevalence of NIHL symptoms between low and high exposed workers.
iv. To investigate the factors that influence NIHL symptoms among the exposed group.

1.5 RESEARCH HYPOTHESIS

The research hypotheses are listed as below:

i. There is a significant difference of personal noise level between low exposed and high exposed group.

ii. The prevalence of NIHL symptoms among the highly exposed group is significantly higher than the low exposed group.

iii. Factors such as duration of employment and intensity of noise significantly influenced NIHL symptoms.

1.6 SIGNIFICANCE OF STUDY

This research focused on occupational noise exposure among wood furniture manufacturing industry workers. Therefore, this study determined the severity of noise exposure and factors could influence the hearing loss symptoms among employees throughout their employment period. This study can provide useful information since lack of publication related to personal and environmental noise exposure level and NIHL symptoms in the wooden furniture manufacturing industry. According to Sliwinska-kawalska et al. (2013), NIHL is a complex disease. Therefore, in order to develop new therapies used to prevent NIHL, more research should be conducted which aim to improve scientific knowledge on NIHL. As a result, this study is important to contribute more information regarding on the NIHL caused by high noise exposure.

Besides that, this study can provide a more detailed information and current status of noise level exposure in order to let employees to identify the hazard. This can let employees and employers to understand the danger and risk of noise exposure and enhance their safety awareness when conduct their work task in the furniture manufacturing process. Based on the noise mapping developed in the study, the employees and employers in the industry can identify the noise level of each working station and the sources of the noise. In addition, this study can be served as other sources of reference and baseline information for future research study on noise exposure in either similar or different industry. A significant discovery from study can help focusing at the remote facet of noise related injury and narrowly to further study that always is a mistake. The more research study can help to enhance the finding and this can be served as further sources and benefits to enhance the understanding regarding on noise and noise-induced hearing loss.

The instrument used to carry out noise monitoring is SLM and dosimeter. The SLM is used to monitor the environmental noise level and measured data is used to develop noise mapping, whereas dosimeter is used to monitor on personal noise exposure level. The distinct data collected from the monitoring brought back for further analysis.

1.8 DEFINITIONS OF VARIABLE

1. Noise
   - *Conceptual definition* - Noise is a sound that combination of loud, harsh and unwanted electronic signal in the air and cause harm the quality of health of people (Hong et al., 2013).
   - *Operational definition* - Noise is generating from machinery or power tool used and it is measured in dBA.

2. Noise-induced hearing loss (NIHL)
   - *Conceptual definition* - NIHL is hearing loss that develops slowly over a long period of time (several years) as the result of exposure to continuous or intermittent loud noise (McReynolds, 2005).
   - *Operational definition* – NIHL symptom include tinnitus, communication difficulty, and speech discrimination.

3. Factor of hearing damage
   - *Conceptual definition* - An element used to contribute hearing impairment of a person (Oxford Dictionaries, n.d).
   - *Operational definition* – Factor of hearing damage include duration of exposure and intensity of noise.

4. Personal noise exposure
   - *Conceptual definition* - Personal noise exposure refers to a particular person being exposed or contact with noise or unwanted sound (Oxford Dictionaries, n.d).
   - *Operational definition* – The personal noise exposure level is measured by a personal noise dosimeter and expressed in dBA

5. Environmental noise exposure

- *Conceptual definition* - Environmental noise exposure is contact or experience unwanted sound present in surrounding from human activity (Oxford Dictionaries, n.d).
- *Operational definition* – The environmental noise exposure level is measure by a sound level meter (SLM) and it provides measurement in dBA

1.9 CONCEPTUAL FRAMEWORK

Figure 1.1 shows that conceptual framework for thus research which intended to study the risk assessment of noise exposure in wooden furniture manufacturing industry. The main activity of the industry is produce wooden furniture or merchandise for use or sale by using labor, machinery, power tools, and chemical. The noise contour was developed and the noise exposed worker was separated into high and low exposed group based on the environmental noise measurement by using sound level meter (SLM) and personal noise measurement by using portable dosimeter.

Besides that, it contributed the idea on the factors which cause the auditory effect such as noise–induced hearing loss and non auditory effect such as headache, dizzy, sleep loss, stress, fatigue, and cognitive failure. The factor influencing associated to hearing damage were exposure time, noise level and age. Moreover, the noise-induced hearing loss symptoms such as ear pain, hearing difficulty and tinnitus were also assessed by using the questionnaire.

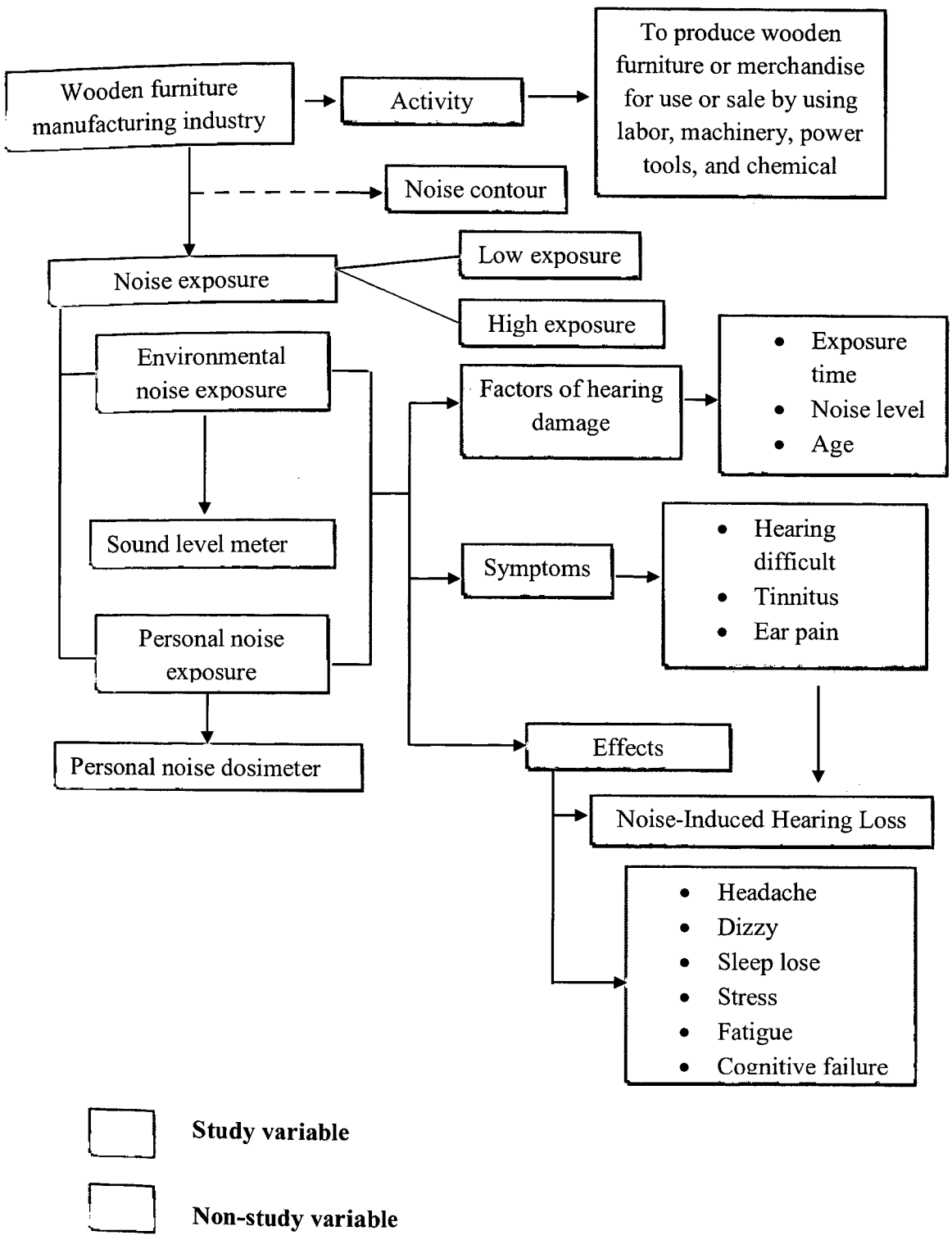

Figure 1.1: Variable associated of noise exposure in wooden furniture manufacturing industry

CHAPTER 2

LITERATURE REVIEW

This chapter discusses in detail about background of noise, the mechanism of the ear, risk factors of hearing damage, adverse effects of noise exposure, and noise exposure assessment from several sources including journals, books and theses.

2.0 INTRODUCTION

Noise is an unwanted sound which exposes by workers and most frequent risk factor at industrial settings. There was increasing of using technology, which reduces the physical burden of work, but these bring more safety and health issue to be concerned due to it was generated high level of noise (Mohammadi, 2008). Besides that, workers were suffering needless hearing impairment in the manufacturing industry due to expose high intensity of noise (Bates, 2001). Sorainen (2000) stated that, when compared between different fields of industry, the woodworking industry was the top four highest prevalence of hearing impairment. The main sound level exposed by workers in carpentry plants was more than 85 dBA and often 100 dBA (Sorainen, 2000). The workers who are frequently exposed to noise were bringing harmful to safety and health. Therefore, it is essential to focus on this issue due to this problem is an ongoing problem worldwide.

In the USA, there were over 5 million of industrial workers exposed to high noise level in excess of 85 dBA, which bring to hearing loss (Celik et al., 1998). The

2.1 BACKGROUND OF NOISE

2.1.1 Noise and Sound Pressure Level

Noise can be defined as any sound that is unwanted which can cause occupational health problem (Way et al., 2013). Noise also can be defined as by-product of many industrial processes (Mohammadi, 2008). Sound can be a source of information and which is essential component use in the workplace, but also can cause disturbances and adverse effect on people hearing when exposed to high intensity sound level. Sound pressure proportional to square of sound intensity (W/m2) is expressed in Pascal units (Pa) but the sound pressure level is expressed in decibel units (dB) (Muzet, 2007). A sound consists important moving series of pressure fluctuations and normal unit of pressure is the Pascal (Pa) but sound pressure lead to use of vast and unwieldy numbers, it is more practical to express acoustic parameters as a logarithmic ratio of the measured value called decibel, dB (South, 2004). The audible sound pressure range was from 20 x 10^{-6} Pa (the threshold of hearing) to 100 Pa (the threshold of pain) (Hj Ghazali, 2010).

According to Tomei et al. (2010), when exposed to a noise less than 35 dBA, it may not induce disturbance and not easy to cause health problems. A noise ranging from 35 to 65 dBA was tend to annoyance and increases the tendency of auditory effect. For noise level from 66 dBA to 85 dBA was cause fatigue and health problem. In addition, for 85 dBA to 115 dBA can lead to hearing damage and psychological effects. For the noise level, which above than 115 dBA can lead to the further hearing effect and damage on others biological and functional system. In addition, Tomei et al., (2010) claimed that, the people cannot be exposed to a noise which more than 130 dBA due to it can cause immediate of auditory damage, nausea and vertigo. In the large industrial of art woodworking, the noise level was more than 85 decibels (Figure 2.1) could be generated. Therefore, exposed to different level of noise can cause different negative effect to the people.