June 2015, vol 12, No. 1 : 117-120

Comparison Of Perception, Video Observation And Direct Measurement Methods On Musculoskeletal Disorders Physical Factors Among Electronics Workers

Roseni Abdul Aziz[1, 2], Aini Zuhra Abdul Kadir[2], Jafri Mohd. Rohani [2], Ademola James Adeyemi[2], Mat Rebi Abdul. Rani[2],

[1] *Ergonomics Excellence Centre, National Institute of Occupational Safety and Health (NIOSH)*

[2] *Departments of Materials, Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia*

Corresponding author. Tel.: +607-599 1200 ; fax: +607-598 0746 ; E-mail :roseni@niosh.com.my

Abstract

The increase in Musculoskeletal Disorders (MSDs) cases in the context of manufacturing industry in Malaysia in the recent years has become a national concern. Therefore, the study aims to compare the severity of the WMSDs cases involving electronic workers by using survey, interview, observation and experimental methods. The questionnaire was designed and distributed to 204 assembly workers performing printer and inserting semiconductor in the electronic sector. The ergonomic risk was assessed through direct observation of workers' posture at their workstation using WERA. In addition, Electromyogram (EMG) analysis was used to measure the muscle activity of workers. The result shows that standing workers are exposed to consistent MSD more than sitting workers in all body regions except for the upper back. According to WERA results, both postures contribute to high risk of MSD especially at wrist and leg regions. In conclusion, there is a significant correlation in the findings from the survey, observation and EMG analysis about the prevalence of MSDs among the workers, although the degree of prevalence differs in some body regions. Hence, there is a need to identify more interacting variables associated with the problem.

Keywords:Musculoskeletal Disorders (MSDs), Workplace Ergonomics Risk Assessment (WERA), Electromyogram

Introduction

Musculoskeletal disorders (MSDs) are a major health problem, resulting in loss of productivity in individuals and organisations. Hence, many organisations and governments have put in place numerous programmes to alleviate the effect of MSDs among their workforce. Researchers have been investigating the causes and associated factors of the various MSDs. These studies, due to the multidisciplinary nature of the problem and also the multifactorial risks associated with MSD, have been applying different methodologies to arrive at their recommendations to the problem. Most of these assessment methods are not well-defined and lack sufficient level of validation (James *et al*., 2012; Spielholz *et al*., 2001). However, self-reported questionnaires, observation tools and direct measuring instruments are the three general measurement tools used for analyzing physical exposure during work (Spielholz *et al*., 2001).

The objective of these methods differs, and a tool with sufficient reliability in assessing a particular risk may not be reliable for another (Ikuma *et al*., 2009). While direct measuring instruments are aimed at determining the maximum tissue tolerance, both the observation tools and questionnaires are aimed at identifying the acceptable limits of work (Fernandez and Marley, 2014). Hence, only direct measurement, mainly through experimental procedures, is acceptable for investigating causality because of its high reactivity and excellent variable control ability (Drury, 2005). However, direct measurements have low face validity and are associated with high cost and skills (James *et al*., 2012). Observation tools and questionnaires, on the other hand, have better face validity and are less expensive in terms of cost and skills. Since MSDs are also multidisciplinary and multifactorial in nature, a complementary design built on the strengths of the methods are desirable, because this will help in capturing the complexity and interactions associated with MSD studies (Eatough *et al*., 2012; James *et al*., 2012; Spielholz *et al*., 2001). Hence, the three methods are used in this study to complement one another, since none of them directly measures the risk factors, but only produces estimates (Spielholz *et al*., 2001).

Methodology

To ensure fair comparisons, samples were collected from the sample population in two electronics companies in Johor. The comparison was also limited to body regions captured in the three measuring instruments, namely, neck, shoulder, wrist, lower/upper back and the leg. The body map component of a validated

questionnaire (Cronbach alpha = 0.77 to 0.92), used in a previous study (Aziz *et al*., 2013), was adopted for this study. The participants were expected to identify body regions where they experienced pain. Using a Likert scale, they were expected to rate the frequency (how often they experience pain) and the intensity (how much pain). The ergonomic risk was assessed though direct observation of worker's posture at their workstation, using Workplace Ergonomic Risk Assessment (WERA) diagnostic tool. WERA is a screening tool that assesses biomechanical and postural loading on the whole body, particularly to the neck, trunk and the limbs. Every respondent was observed for at least 10 minutes throughout their working duration. Researchers informed the workers about the procedures and obtained their consent before the study was carried out. However, there were interactions with them during measurement to minimize disruption during work. To directly measure the effect of the work schedule on the workers' muscles, eleven of the workers, comprising six males and five females, signed the consent form to take part in an electromyography analysis. Five muscles on both sides of the participants were monitored continuously for one hour without interruption. They are the muscles on both sides of the neck, trapezius muscles on both sides of the upper back, the erector spinae muscles on both sides of the lower back, the calf muscles on both legs and the arm muscles on both hands. The protocols and data processing procedures were highlighted in a previous study (Aziz *et al*., 2014).

Statistical Analysis

All the data collected during the research was coded and analyzed using Statistical Package for Social Sciences (SPSS) Version 21.0. t-test analysis was carried out to identify significant difference between standing and sitting workers. Graphical plot was produced using SPSS.

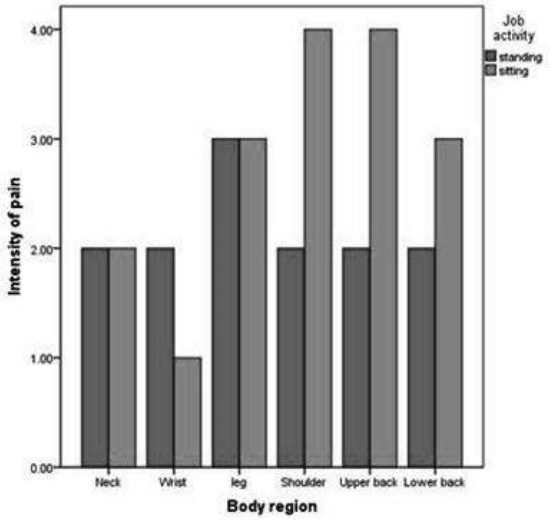


Figure 1: Reported Intensity of pain by survey

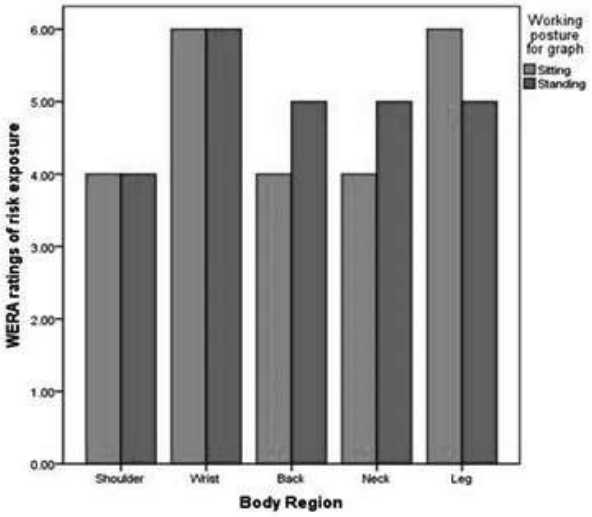


Figure 2: Observed intensity of pain by WERA

	Risk Exposure by WERA		Reported Pain		Significant difference btw standing and sitting			
	Sitting	Standing	Sitting	Standing	WERA	Survey	MPF	AEMG
Neck	Medium	High	Little	Little	Yes	None	Yes	Yes
Shoulder	Medium	Medium	Substantial	Little	Yes	Yes	No	Yes
Wrist	High	High	None	Little	None	None	Yes	Yes
Back	Medium	High	moderate	Little	Yes	Yes	Yes	No
Leg	High	High	moderate	Moderate	Yes	Yes	Yes	No

Table 1: Rating of observed and reported MSD prevalence and the level of significance among the three tools.

Results and discussion

Figure 1 and Figure 2 show perceived levels of pain experienced by the respondents and the expert risk exposure levels respectively. Standing workers reported higher MSD prevalence on the shoulder and the back regions than sitting workers while sitting workers reported higher prevalence at the wrist/hand region. The observed risk exposure was however contrary in most

of the regions, as sitting workers are believed to be more exposed to MSDs at the shoulder, back and the leg regions. Table 1 shows side-by-side comparisons of the tools rating the MSD occurrence.

Table 1 shows that the reported pain in different body regions is lower than the observed risk level associated with the region. Hence, standing workers demonstrated higher tolerance level than sitting workers because they reported little pain in the compared regions, despite the high risk level observed for these regions. The interaction of gender with posture, may also contribute to this, as most of the sitting workers are female, who are reported to experience and report higher pain level. The years of experience and job satisfaction may have also contributed to this observation.

The most diverse variation between observed risk and reported pain is at the wrist area. Despite a high risk level observed for both postures, workers actually complain of little or no pain. This variation further highlighted the reported difficulty in agreement between experts and workers on estimation of wrist flexion or extension in relation to MSD (Spielholz *et al*., 2001). Observation about the danger of under-reporting cannot be over-emphasized because flexion and extension of the wrist have been identified with disorders such as tenosynovitis and carpal tunnel syndrome, and reportedly promote the development of upper extremities disorders (Spielholz *et al*., 2001). Individual motivation, associated with workers satisfaction may account for the lower ratings in the self-reported questionnaires. The difference between reported and observed discomfort may have arisen because both employed the psychophysical approach in which they are aimed at empirically quantify the workers subjective tolerance to occupational stress (Fernandez and Marley, 2014). The lower rating of the questionnaires highlights the necessity for psychophysical adjustment to improve its accuracy (Spielholz *et al*., 2001). This could be achieved by moving the scales in the questionnaires by one level. However, both the WERA observation tool and the survey instrument identified the significant difference between standing and sitting workers, in the body regions compared, except on the neck area.

Conclusion

The study has shown that there is the need to use multiple methodologies to investigate work-related musculoskeletal disorder because a single method does not adequately report various attributes of the problem. The combination of at least, two methodologies will highlight some effects which can help to provide more comprehensive explanations to the factors causing the problems.

Acknowledgements

We would like to express our gratitude and thanks to National Institute of Occupational Safety and Health (NIOSH) Malaysia for funding this research study. A special acknowledgement is for the General Manager Operation of NIOSH, Mr Fadzil Osman for his encouragement, guidance and support, Manager of NIOSH Southern Regional Office, Mr Khairunnizam Mustapa for his motivation, Head of Ergonomics Excellence Centre (EEC), Mr Raemy Md Zein for tips, guidance and advices, and members of EEC and NIOSH for their support. Last but not least, special thanks also go to the respondents who participated in the sample collection exercise.

References

(1). Aziz, R.A., Rani, M.R.A., Rohani, J.M., Adeyemi, A.J., Omar, N., 2013. Relationships Between Working Postures and MSD in Different Body Regions Among Electronics Assembly Workers in Malaysia, in: Proceedings of the 2013 IEEE Industrial Engineering and Engineering Management Conference. IEEE, Bangkok, pp. 1–5.

(2). Drury, C.., 2005. Designing Ergonomics Studies, in: Wilson, J.R., Corlett, N. (Eds.), Evaluation of Human Work. CRC Press Inc, Boca Raton.

(3). Eatough, E.M., Way, J.D., Chang, C.-H., 2012. Understanding the link between psychosocial work stressors and work-related musculoskeletal complaints. Appl. Ergon. 43, 554–63.

(4). Fernandez, J.E., Marley, R.J., 2014. The development and application of psychophysical methods in upper-extremity work tasks and task elements. Int. J. Ind. Ergon. 44, 200–206.

(5). Ikuma, L.H., Nussbaum, M. a., Babski-Reeves, K.L., 2009. Reliability of physiological and subjective responses to physical and psychosocial exposures during a simulated manufacturing task. Int. J. Ind. Ergon. 39, 813–820.

(6). James, A.A., Rohani, J.M., Rani, M.R.A., 2012. Development of a holistic backpack-back pain model for school children. 2012 Southeast Asian Netw. Ergon. Soc. Conf. 1–5.

(7). Spielholz, P., Silverstein, B., Morgan, M., Checkoway, H., Kaufman, J., 2001. Comparison of self-report, video observation and direct measurement methods for upper extremity musculoskeletal disorder physical risk factors. Ergonomics 44, 588–613.

June 2015, vol 12, No. 1 : 121-124

RULA Mobile Android Application Software

Yusof Kadikon [1+], Imran Mohd Shafek [1] and M.Maarof Bahurdin [1]

[1] *Universiti Kuala Lumpur Malaysia France Institute, Seksyen 14, Jalan Teras Jernang, 43650 Bandar Baru Bangi, Malaysia*

Corresponding Author: Tel : +603-89132800; Fax : +603-89258845; Email :yusofk@unikl.edu.my

Abstract

In Malaysia, the number of Musculoskeletal Disorder (MSD) cases is increasing . Rapid Upper Limb Assessment (RULA) is carried out in a physical paper form which is cumbersome and based on the complex nature and it should consider human error. This project aims to create the RULA application for mobile devices featuring the android system for this move will cut down the process time by more than half, create a more structured system and eliminate human error wholly. The application will be designed on the App Inventor website which features a lot of handy tutorials and takes the initiative to create a RULA mobile app for Android phones. The RULA mobile app for Android phones is intended to make it easier and much more efficient to conduct a RULA analysis. Additionally, the analyses can be conducted by minimally trained users, eliminating the need for highly trained technicians. RULA test is performed to achieve accurate results and the mathematical processes will be programmed into the app so that the user will have a friendly interface and will only be asked to tick boxes.

Keywords:: Android apps, RULA

Introduction

The increasing number of MSD cases in Malaysia lately has our nation worried. It is because, from 2011 to 2012, there were 90% cases reported to SOCSO. The scope of this project covers the basics of ergonomics, the correct way in carrying out the RULA survey through the manual process, and converting it into a simple and understandable application which executes the objectives and accuracy of the RULA survey without fail. The correct way of programming the system on a software, downloading it into an android, and making sure that it runs smoothly without crashing will need to be addressed because those are the most important aspects of this project as differing results will surely lead to confusion and ultimately, the failure of this application.

Figure 1 shows the whole general idea of the flow of the project; a conversion from the current cumbersome paper form of RULA survey into an application through the application inventor by creating the right building blocks to make the application act the way we want it to before being transferred to an online android emulator. There are several emulators that can do the job but later on, this project will discuss which one is used and comparisons between the chosen emulator and other options will be made. An emulator basically functions to mimic the actions of a real android for testing before the application is downloaded into a real android for further testing

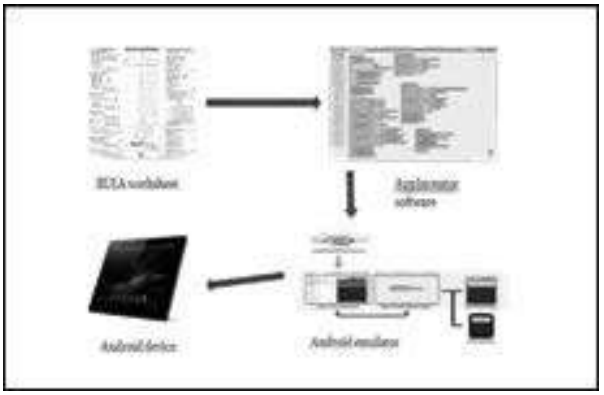


Figure 1 : General Scope of Apps. Development

Literature Review

RULA

The Rapid Upper Limb Assessment or more commonly known as the RULA survey was developed by Dr. E. Nigel Corlett and Dr. Lynn McAtamney of University of Nottingham's Institute for occupational Ergonomics. It was initially developed to "investigate the exposure of individual workers to risk factors associated with work-related upper limb disorders". It is a rather simple diagnostic tool that allows us to survey various tasks involving the upper limbs at work. It heavily focuses on use of arms, wrists, position of the head, and the posture of the upper body. RULA is a quick survey method for use in ergonomic investigations of workplaces where Musculoskeletal Disorders (MSDs) are reported. RULA is a screening tool that assesses biomechanical

and postural loading on the body and largely focuses on the neck, trunk and upper limbs, and is ideal for sedentary workers such as computer workplaces. It has been validated on groups of computer users and sewing machine operators and is quick and easy to complete.

RULA scores indicate the level of intervention required to reduce MSD risks and compliments other ergonomic methods (L. McAtamney and E.Nigel Corlett,2000). It ultimately gives a total job assessment that suggests directions for modifying body positions to reduce the possibility of hazards although it does not provide exact engineering controls or work activity changes.(M. Hargberg, 1987)

The RULA survey has a few steps in its procedure. It can be carried out on the jobsite in a matter of minutes with the correct order and participation from the subject the test is carried out on.

i. Record the position of the upper limbs and the head, trunk and legs with two separate number codes.

ii. The codes are entered into the relevant boxes.

iii. An initial score is found in the appropriate tables, A and B.

iv. The score is modified according to the use of the limbs

v. The final A and B scores are calculated.

vi. Using the final scores, a Grand Score, using table C, is determined.

In summary, RULA remains a useful tool, but only with proper training in its application and interpretation. It is best applied to jobs characterized by static postures with lower concern for force and repetition factors (E. N. Corlett and R P Bishop,1976) . Jobs that involve multiple postures will require additional analysis, time and effort if a complete risk analysis is desired. In such cases, the results of RULA are best considered along with the results of other evaluation tools and tempered with professional experience and knowledge. It is easy to overestimate the risk of a job with RULA if the analyst focuses only on extreme postures, especially if those extremes have short durations. In other cases, such as jobs involving forces, repetition and durations, RULA may underestimate risk. Careful consideration must be applied in the use and interpretation of RULA (Nexteer,2009). The RULA survey has been recognized to contain certain limitations that have caused its slow growth worldwide, and these are the real factors that an application would easily help address:

i. Cumbersome paperwork

ii. Requires big time and energy commitments

iii. Long study periods due to the longitudinal nature of the method itself

iv. Commitment from participants

v. Manual calculations which are error prone

Android

Android is an operating system based on the Linux kernel, designed primarily for touch screen mobile devices such as smart phones and tablet computers. The user interface of Android is based on direct manipulation, using touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching and reverse pinching to manipulate on-screen objects. Internal hardware such as accelerometers, gyroscopes and proximity sensors are used by some applications to respond to additional user actions, for example adjusting the screen from portrait to landscape depending on how the device is oriented. Android allows users to customize their 11 home screens with shortcuts to applications and widgets, which allow users to display live content, such as emails and weather information, directly on the home screen. Applications can further send notifications to the user to inform them of relevant information, such as new emails and text messages.

When it comes to major apps, the line between Android and iOS is starting to blur rapidly. Choosing a smartphone or tablet platform should be a well-considered decision because switching from iOS to Android or vice versa will require us to buy apps again in the Google Play (or Apple app) store. Android is now the world's most commonly used smartphone platform and is used by many different phone manufacturers. iOS is only used on Apple devices, such as the iPhone. This is a result after comparisons were made between deciding

	Android	iOS
Developer Google Inc. Apple Inc. components Very limited. Unless Developer Google Inc. Apple Inc.	Widgets Yes No Customizability A lot. Can almost change jailbroken. Widgets Yes No	Source model Open source Closed, with open source anything Media transfer Relatively easy Only with desktop application Source model Open source Closed, with open source

Figure 2 : Comparison of Androids and iOS

to use iOS or androids shown in figure 2 .

Apps Inventor

The app inventor software is divided into 2 parts to ease the programming process. This new method which features a very different way of programming through its visual 'building block' method programmed and created by Google engineers has been proven to be highly effective for students who are new in the app development scene.

- *The component designer*

This is the main window. Any main changes will be done on this window. It is used to create and select components for the app and specifying properties. The palette is divided into four sections according to the type of component. In the middle is the viewer which represents the screen of a phone and is used to layout the components. The components pane which lists the components placed on the viewer and the properties pane to edit and customize each component.

- *Building blocks*

Each component designer has its own set of blocks associated with the things it can do. There are several colored blocks that indicate different behaviours which can be assigned to other blocks to create our desired event.

i. Brown blocks - Control blocks

ii. Blue blocks - Action blocks

iii. Green blocks - Logic blocks

iv. Pink blocks - Text blocks

v. Grey blocks - Colours blocks

vi. Orange blocks - Variables blocks

vii. Purple blocks - Procedures blocks

Methodology

The app is divided into six sections, cut down to six major screens. These screens represent each screen in the viewer for arrangement purposes. The screens, although containing a few slides in it, is named after the first number of the screen. The six screens are:

i. Screen1

Features the opening screen of the app, with the app logo, name and a start button.

ii. Screen2

Features the definition of RULA and a start button to go straight into the assessment

iii. Screen3

Features 7 slides, slide 3 to slide 9, which covers upper arm, lower arm, wrist and wrist twist, posture A score, muscle use, forces and loads and wrists and arms score.

iv. Screen10

features 2 slides, slide 10 and slide 11, which covers neck and neck twist and side bend.

v. Screen12

Covers 7 slides, slide 12 to slide 18, which covers trunk, trunk twist and side bend, legs, posture B score, muscle use, forces and loads and neck trunk and leg score.

vi. Screen19

Covers the last slide, which gives us the score sheet and recommendation. Included is a 'home' button that takes us to the beginning of the app and an 'exit' button which exits the app.

Results

Experiment was conducted on two subjects doing two different kinds of work. The boxes related were checked and the scores were calculated by the blocks programmed in the app. The results were accurate as the same test done with paper produces the same results, only it took the app a mere few minutes to complete first

Figure 3: RULA apps.

test while the paper form took longer as the calculations are done manually and the constant need to refer to tables consumed most of the time. Figure 3, shows the complete result of RULA android apps after experiment.

Conclusion

Convert the RULA assessment, carried out in a physical paper form, into a mobile app. The objective is completed as the app is produced. This project revolves around mostly very technical angles, thus it would be very wise to do some research to prepare oneself instead of diving head on into the project and come up short later. The RULA test should be understood deeply from the

surface down to the details, how the calculations work, how to carry out the test, applying the tables correctly and how to interpret the data received so it can be used for research purposes.

References

(1). E. N. Corlett and R P Bishop (1976).'A technique for assessing postural discomfort', Taylor and Francis.

(2). E. R. Tichauer,(1978). 'Ergonomics sustains occupational safety and health' (1st edition). Wiley

(3). Lynn McAtamney and E. Nigel Corlett, (2000). 'RULA : A survey method for the investigation of work related upper limb disorders', Applied ergonomics,

(4). M. Hargberg, (1987) 'Occupational shoulder and neck disorders', 2nd edition,

(5). Nexteer Automotive Plant,(2009) 'Ergonomics Programme Improvement Initiatives',

June 2015, vol 12, No. 1 : 125-132

A Survey on Working Postures among Malaysian Industrial Workers

Raemy Md. Zein[1], Isa Halim[2], Noorul Azreen Azis[1], Adi Saptari[2] and Seri Rahayu Kamat[2]

[1]Ergonomics Excellence Centre, National Institute of Occupational Safety & Health (Southern Regional Office), No. 10, Persiaran Teknologi, Taman Teknologi Johor, 81400 Senai.

[2]Department of Manufacturing Management, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

Tel: +6019-6011072; E-mail: raemy@niosh.com.my

Abstract

Working in a safe working posture is a necessity to enhance occupational health of industrial workers. Poor working posture may lead to injuries, discomfort and fatigue to the workers. The objective of this study is to survey the postures practised by the Malaysian industrial workers. A questionnaire survey was performed among 282 Malaysian industrial workers in 10 different industries. From the answered questionnaire, it was observed that shoulder at chest level (30.1%), back in a bent forward (33.3%) and lifting heavy load (44.7%) are the major work postures practised by most of industrial workers. This survey identifies that working with shoulder and hand at chest level and back region moderately bent forward is the main working posture practice by worker. Workers also reported lifting load below 5 kg at the workstation. This survey recommended for industrial workers to be aware of the comfortable working posture to avoid injury.

Keywords: working posture, occupational injuries, questionnaire survey, ergonomics solutions

Introduction

In today's fast economic growth, occupational health plays an important role to boost competitiveness and productivity in Malaysian industries. Usually industrial workers perform their jobs in standing, sitting, and alternating sitting and standing positions. Standing position is the best choice when the jobs require frequent movements, a large degree of freedom, and handling heavy objects. However, standing in a long period of time could lead to discomfort and fatigue among industrial workers.

The Social Security Organization (SOCSO) of Malaysia reported the severity of injuries that can contribute to poor occupational health. In the SOCSO annual reports, it was stated that industrial workers suffered from injuries in the head, neck, shoulder and lower limb, upper back and lower back. In 2012, the numbers of injuries recorded were 9100 (fingers), 5683 (hands), 4750 (lower legs) and 2579 (shoulders) (SOCSO Annual report 2012). In addition to poor occupational health, unsafe working practices affect the psychology of workers. Workers who are out of work for too long may have lower self-esteem and morale due to loss of personal and professional relationship with peers or colleagues. In case the workers have exhausted their medical leave entitlement, they may need to take unpaid leave which will result in loss of income. Furthermore, the employers will also be affected as they need to take in temporary staff to replace the workers who have health problems. This could contribute to indirect costs which include expenses from lost days, production disruptions, increased premiums and cost to train new or replacement workers. Effective strategy to reduce the number of injuries should be developed to overcome this situation in the future.

In recognition of the importance of safe working practices, this study was performed to investigate the orientations of posture practised by the workers in Malaysian industries.

Literature Review

Working Posture

Working posture can be defined as the orientation of body parts in a work area while a worker is performing a task (Nico *et al*., 2004). Working posture is determined by the characteristics of the worker, the design of workstation and the process. Dimensions, spatial position, orientation and design of workstation must be suited with the physical of workers so that they can perform the task in a safe working posture. In general, workers can perform the jobs either in standing or sitting, and combination of both in their workplaces.

Occupational Injuries related to Working Posture

Occupational injuries associated with working posture refer to conditions where the workers experienced discomfort in one or various body parts such as neck, shoulder, back, elbow, hand, hip and knee, pain in the joints, tingling, and swelling. Performing jobs in prolonged standing can be linked to lower back

pain among industrial workers (Lafond *et al*., 2009). The cause of discomfort and whole body fatigue associated with prolonged standing is reduced blood circulation in the lower legs and localized muscle fatigue (Madeleine, 1998). Continuous standing for more than 4 hours in a day, potentially contribute to pain in the lower back and feet (William *et al*., 2000); (Messing and Kilbom, 2001).

Assessment of Working Posture

In advancement of research in occupational ergonomics, several methods and tools been developed to identify, assess, and analyze occupational injuries related to working posture. The methods can be categorized into subjective, semi qualitative, and direct technical measurement methods. Both techniques can be applied at industrial workplaces and/or laboratories. Subjective method is used to obtain psychological feedbacks from the respondents (workers) through personal interview and questionnaire survey. The Borg Scale (or called Rating Perceived Exertion, RPE), and the Visual Analogue Scale (VAS) are commonly used. The Borg Scale is used to measure perceived exertion experienced by the respondents (Borg, 1982). The VAS is a psychometric response scale which can help respondents to specify level of agreements (e.g. comfort, moderate comfort, discomfort) by indicating a position along a continuous line between two end-points. The Borg Scale was applied to classify posture comforts on the basis of maximum holding time (MHT). Comfort posture can be obtained when workers perform jobs at moderate working height (50%, 75%, 100%, 125% from shoulder height) and small working distance (25%, 50% from arm reach). The moderate comfort posture could be obtained if the work is performed at moderate working height (50%, 75%, 100%, 125% from shoulder height) and large working distance (75%, 100% from arm reach).

On the other hand, discomfort posture is recognized when the working height is too low or too high than 25% and 150% of shoulder height respectively (Miedema *et al*., 1997). A study applied rate of intensity of unpleasantness (scale of 0 to 10) to examine the differences between subjective, physiological and biomechanical responses among individuals exposed to prolonged standing. The study revealed a reduced subjective effect of the soft surface on the intensity of unpleasantness accompanied by low postural activity and no swelling of the shank (Madeleine, 1998). Besides Borg Scale and VAS, a survey form was also established to investigate discomfort and subjective fatigue due to standing at workplaces. Surveys using the Body Part Symptom form revealed that, all respondents who performed jobs in standing position experienced discomfort and pain, and the frequency and level of discomfort occurrence are greater at lower extremities (Ahmad *et al*., 2006); (Taha and Majid, 2008).

Through a semi qualitative method, working posture can be evaluated using Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993). The RULA produces a score to demonstrate the risk level of posture. Low scores of 1 or 2 indicate that the working posture is acceptable. Further investigation and changes are required for grand scores 3 or 4; prompt investigation and changes for grand scores of 5 or 6 and immediate investigations and changes for a grand score of 7. Besides RULA, the Rapid Entire Body Assessment (REBA) is a useful tool to assess working postures and movements corresponding to the tasks and workstations (Sue and Lynn, 2000). A coding system is used to generate an action list that indicates the level of intervention or modification of workstation required to reduce the risks of occupational injuries due to physical loading on the workers. Another tool is Workplace Ergonomic Risk Assessment (WERA). It was established to screen the task for exposure to the physical risk factor that can contribute to occupational injuries (Abdol Rahman *et al*., 2012). This tool consists of six physical risk factors: posture, repetition, forceful, vibration, contact stress and task duration and it involves the five main body regions (shoulder, wrist, back, neck and leg).

The direct technical measurement method measures and analyzes physiological and biomechanical responses of subjects. This method requires scientific technical tools which can produce specific quantities such as pressure, voltage and frequency. The application of direct technical measurement method is always linked to direct contact between subjects and the instruments. The advantage of utilizing direct technical measurement method is reliable data that could be acquired from the subjects to represent their actual condition during the experiments. The tools that are commonly used for the assessment of working posture are surface electromyography (sEMG) and body pressure measurement system. The sEMG has been considered a reliable tool to assess localized muscle fatigue (Kumar *et al*., 2004); (Luttmann *et al*., 2000) due to awkward working posture. It refers to non-invasive (on the skin surface) recordings of electrical signals which are generated by muscle contractions. Muscle fatigue can be quantified by observing the changes in amplitude and frequency of electromyogram signals over time (Reenen *et al*., 2009). When the signal amplitude increases and power spectrum shifts to lower frequency, it indicates that the muscles are in a fatigue condition (Luttmann et al., 2000); (Hostens and Ramon, 2005). Figure 1 shows the application of sEMG in measuring muscle activity of a worker while performing jobs in sitting position.

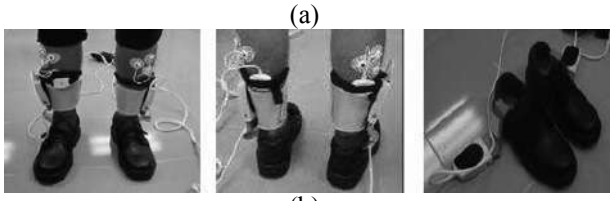
As for the body pressure measurement system, it is used to measure the distribution of pressure or force between human body and contact surface such as seat pan, back rest, shoe insole, and gloves. Figure 2 shows an example of body pressure measurement system in measuring pressure of back and buttock for sitting position (a) and pressure under the feet during the standing position (b).

Ergonomics Solutions for Working Posture

In occupational ergonomics, engineering controls

Figure 1: Muscle activity measurement using sEMG

(a)



(b)

Figure 2: Body pressure measurement system for buttock and back (a), and feet (b)

and administrative controls are methods to reduce the risk of occupational injuries due to unsafe working posture. Engineering controls refer to the use of engineering techniques to minimize the risk of occupational injuries. It includes application of floor mats and shoe insoles to release muscle fatigue in the feet due to floor condition at the workplace. Many researches revealed that floor mats and shoe insole are effective solutions to improve body comfort for standing jobs. King (2002) found that the floor mat, shoe insoles and combined conditions provide more comfort than standing on hard floor. However, floor mat and shoe insoles may have little effect on controlling leg oedema for industrial workers exposed to standing for more than 8 hour shifts (Zander *et al*., 2004). Muscle fatigue in the leg may not be relieved by using floor mats, which benefitted the back (Kim *et. al*., 1994). Sitting can be much less strenuous than standing because it requires fewer muscles to be contracted to stabilize the body. Furthemore the loading on upper limbs will be uniformly distributed through the seat pan (Kroemer et al., 1994), thus reducing the loading on the lower limbs. However, sitting in long periods of time is also not good for health. Alternating the standing and sitting positions using a sit-stand stool enables workers to perform the jobs in sitting and/ or standing. In addition, the sit-stand stool is equipped with foot rest that may provide comfort on workers' legs. Also, it can be rotated 360 degrees so that the workers can reach the materials without twisting their body and it enlarges the degree of freedom to do the jobs.

Administrative controls using work-rest scheduling is an alternative in cases where engineering controls are impossible to be implemented due to various constraints. Jaap and Huub (1998) proved that providing longer breaks would be more effective to minimize risk of leg swelling (Dieen and Vrielink, 1998). Konz (2006) proposed to have some sitting, some standing and some walking for a job and process in the manufacturing environment. If a job requires continuous standing throughout the working hours, job rotation within the shift is recommended (Konz, 1996).

Methodology

The study was carried out using a questionnaire designed to include personal factors, occupational factors and postural factors for investigation. Personal factors investigated were age, gender, ethnicity, citizenship, height, weight, marital status, and academic status

Occupational factors investigated included occupation and tasks, duration of work and rest, type of industries, frequency of physical and mental fatigue and work posture adopted. The types of industries were based on classification under schedule 1 of Occupational Safety & Health Act (1994).

Postural factors investigated were segmental posture adopted during work (neck, hand & shoulder, wrist, back and leg) involving manual handling activities. Each subject was asked to provide frequency of segmental posture adopted by him or her during work. Postural factors were based on WERA work posture classification (Nasrull, 2012) whereas the frequency of posture adoption was based on Dictionary of Occupational Titles, 1991

A total of 300 survey questionnaire were distributed amongst Malaysian Adult industrial workers attending National Conference of Occupational Safety & Health (COSH) organized by National Institute of Occupational Safety & Health (NIOSH), Malaysia on 25th to 27th August 2014. Out of these, 282 responded and filled the questionnaire (94%). All the 282 respondents completed the questionnaire

Results

The data was collected from various industrial workers in Malaysia. Table 1 shows the background information of the respondents during this study. The mean age of the industrial workers was 43.55+1.053 years, while the mean body height and the mean body weight were 166.9+10.425 cm and 73.33+14.02 kg, respectively. The average time for the workers to work is 9.24+1.304 hours. Based on the survey, 95% of the workers change their working position during working time, where 78% of them are working in standing and sitting positions. Mini break gives workers time to rest and relieve them from job monotony. Analysis of physical and mental fatigue shows that 77.1 % of employees

experienced physical fatigue and 62.1 % experienced mental fatigue while performing duties. Analysis of posture shows that most of the industrial workers used highly risk working posture when performing their work duties. Table 2 shows the distribution of body posture for neck, hands, back, wrist, leg and load for lifting among the industrial workers in Malaysia.

Of all 282 survey samples, it was identified that most frequent working posture for neck, shoulder, wrist and leg is in neutral position (40.8%, 33.3%, 40.4% and 42.2% respectively). The most working posture performed by industrial workers usually focus on back of the body and object lifting. Based on the survey, the frequent working postures for back is where the workers are moderately bent forward around 20o (33.3%) with load lifting under 5 kg (19.1%) and only 8.2% of workers are lifting the load more than 10 kg frequently (Table 2). Working in awkward conditions while lifting heavy load may induce musculoskeletal disorder diseases such as lower back pain. From the survey, it was identified that 33% of the working time of the workers was performing their tasks in awkward position with the body slightly bent forward.

Figure 1 shows findings from the survey of working posture among the industrial workers. Based on Figure 1, most of industrial workers practise moderately bent forward body posture during working time. Shoulder, back and load lifting shows higher tendency for musculoskeletal disorder to occur.

The frequency of extreme working postures for every body part is below than 30% (Figure 1) except for neck and back position. 47.2% of respondent are used to extremely bend the neck forward and backward when performing job task and 51.1% of respondents was reported to moderately bend forward their back position.

Discussion

Industrial workers are exposed to various physical and ergonomics hazards at the workplace. The main objective of this survey is to identify working posture among the industrial workers. This study observed various experience of industrial workers in vastly different industries. The analysis of the working postures shows that most of the workers employ inappropriate working postures while performing tasks. Working in awkward positions leads to the development of musculoskeletal disorder. From the survey, it was identified that working with the shoulder at chest level, back bent forward and lifting loads more than 5 kg were the most critical postures which will induce musculoskeletal disorder diseases. From the survey, it can be concluded that the shoulder and back regions are the common regions for musculoskeletal disorder among industrial workers. Workers must understand the principal of working in the neutral positions. Working in awkward position will increase the possibility for body to get injury. The most critical job that leads to poor working posture should be eliminated or reduced to minimize the risk of musculoskeletal disorder or back injury. Engineering control or redesigning employee job task (Lee and Han, 2013) is an example to reduce the risk due to injury.

Shoulder and back positions give the higher frequency to be performed by the workers due to forward and backward movements. Task requirement and workspace design are the contributing factors that lead to working posture. Some of industrial workplace is poorly designed, where workers need to adjust to the workspace design to complete the task given. Many studies have been performed to identify the working postures for specific job tasks (Lee and Han, 2013; Gangopadhyay et al. , 2010). However most of them are focusing on

Table 1: Background information of respondents

	Frequency	*Percent (%)*
Gender:		
o Male	212	75.2
o Female	70	24.8
Age:		
o 20 - 29 olds	49	17.4
o 30 – 39 olds	90	31.9
o 40 – 49 olds	93	33.0
o 50 – 59 olds	39	13.8
o 60 – 69 olds	11	3.9
Industry:		
o Manufacturing	78	27.7
o Mining and quarrying	9	3.2
o Construction	97	34.4
o Agriculture, forestry and fisheries	11	3.9
o Utility	26	9.2
o Transportation, storage and communication	20	7.1
o Wholesale and retail trade	1	0.4
o Hotel and restaurant	8	2.8
o Finance, insurance, real estate and services	15	5.3
o Public service and statutory	15	5.3

Table 2: Distribution of Frequent Work Posture among Industrial Workers

Body part	*Force/posture*	*Frequency (%)*
Neck	Neutral position	40.8
	Moderately bent forward	36.9
	Extremely bent forward	16.0
Hands/ shoulder	Waist level	33.3
	At the chest level	30.1
	Above chest level	15.6
Back	Neutral position	38.7
	Bent forward	33.3
	Extremely bent forward	18.1
Wrist	Neutral position	40.4
	Moderately bent up or bent down	40.1
	Bent up or bent down with twisting	28.4
Leg	Feet flat on floor/floor rest	42.2
	Feet bent forward on the floor	34.0
	Feet not touching the floor	25.2
Manual handling	Load 0 – 5 kg	19.1
	Load 5 – 10 kg	13.1
	> 10 kg	8.2

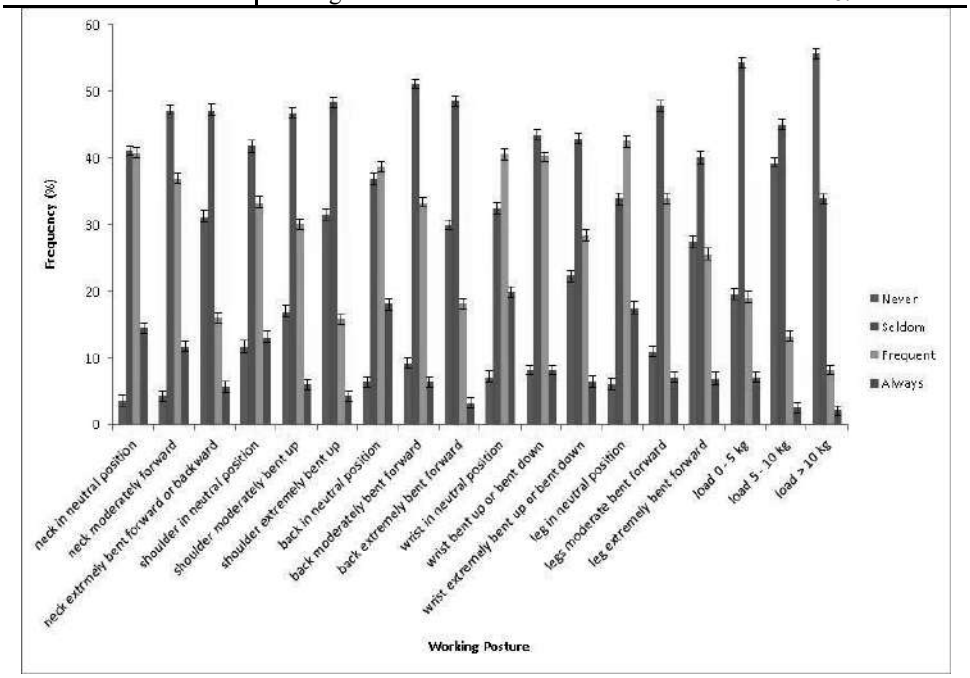


Figure 1: Frequency of Working Postures Based on Different Body Parts

the production area and certain industries only. This survey is one of the approaches to gather information on working posture practices among industrial workers. A good working posture can minimize the injury and increase the work performance (Rahman, 2012), while the lack of awareness on ergonomics risk factors contributes to developing workplace accidents. A good work posture will avoid strain and damage to body parts such as muscle, lower back and tendons. Most of the workers have the tendency to accept the work without realizing the stress that will be absorbed by the body. Some of the workers may not realize that their bodies are under strain until the they feel the real pain without understanding the causes. This study recommended the industrial workers to be aware of comfortable working postures during work. Training is required for employees to be aware of the importance of ergonomics risk factors at the workplace and its association with health.

Conclusion

Industrial workers give higher contribution in the development of industry in Malaysia. Industrial work is dynamic and more complicated than regular jobs. Different type of industries involves different type of working posture based on job tasks. This survey identifies that working with shoulder and hand at chest level and back region moderately bent forward is the main working posture practised by workers. Workers also reported lifting load below 5 kg at the workstation. This survey recommended for industrial workers to be aware of the comfortable working posture to avoid

injury. Musculoskeletal disease will affect the daily life of the workers and in some cases, it prevents workers from working due to back injury. A further study is necessary to identify job tasks with greater potentials to impact on working posture. The study should be focusing on the employees in the production area and the management level to reduce the error during data collection. Management teams shall provide training for employees to work in safe postures and implement safe work practices in workplace to prevent musculoskeletal disorder disease and injury.

Acknowledgements

The authors would like to acknowledge the National Institute of Safety and Health of Malaysia for funding this research (project no.: 06-01-01-SF0258), and the Universiti Teknikal Malaysia Melaka (UTeM) for providing facilities and assistance to prepare this paper.

References

(1). D. Lafond, A. Champagne, M. Descarreaux, J.-D. Dubois, J. M. Prado, and M. Duarte (2009), Postural control during prolonged standing in persons with chronic low back pain. Gait & Posture, vol. 29, pp. 421-427.

(2). P. Madeleine, M. Voigt, and L. Arendt-Nielsen (1998), "Subjective, physiological and biomechanical responses to prolonged manual work performed standing on hard and soft surfaces," European Journal of Applied Physiology and Occupational Physiology", vol. 77, pp. 1-9.

(3). J. K. William, S. V. Jeff, A. B. Jill, A. G. Lincoln, R. W. Paul, L. G. Ana, M. Z. Vladimir, D. Marcos, and A. R. Nicholas (2000). Influence of compression hosiery on physiological responses to standing fatigue in women. Medicine & Science in Sports & Exercise, pp. 1849-1858.

(4). K. Messing and A. Kilbom (2001), Standing and very slow walking: foot pain-pressure threshold, subjective pain experience and work activity. Applied Ergonomics, vol. 32, pp. 81-90..

(5). G. Borg (1982), Psychophysical bases of perceived exertion. Medicine & Science in Sports & Exercise, vol. 14, pp. 377-381.

(6). M. C. Miedema, M. Douwes, and J. Dul (1997), Recommended maximum holding times for prevention of discomfort of static standing postures. International Journal of Industrial Ergonomics, vol. 19, pp. 9-18.

(7). N. Ahmad, Z. Taha, and P. L. Eu (2006), "Energetic requirement, muscle fatigue, and musculoskeletal risk of prolonged standing on female Malaysian operators in the electronic industries: influence of age," Engineering e-Transaction", vol. 1, pp. 47-58.

(8). Z. Taha and S. A. Majid (2008), "Frequency and level of discomfort of male operators in standing work posture," in The 9th Asia Pacific Industrial Engineering & Management Systems Conference, Bali, Indonesia.

(9). S. Kumar, T. Amell, Y. Narayan, and N. Prasad (2004). Measurement of localized muscle fatigue in biceps brachii using objective and subjective measures in Muscle Strength, S. Kumar, Ed., ed New York: CRC Press, pp. 105-121.

(10). 10 A. Luttmann, M. Jager, and W. Laurig (2000). Electromyographical indication of muscular fatigue in occupational field studies. International Journal of Industrial Ergonomics, vol. 25, pp. 645-660.

(11). H. H. H.-v. Reenen, B. Visser, A. J. v. d. Beek, B. M. Blatter, J. H. v. Dieen, and W. v. Mechelen (2009). The effect of a resistance-training programme on muscle strength, physical workload, muscle fatigue and musculoskeletal discomfort: An experiment. Applied Ergonomics, vol. 40, pp. 1-8.

(12). I. Hostens and H. Ramon (2005) Assessment of muscle fatigue in low level monotonous task performance during car driving. Journal of Electromyography and Kinesiology, vol. 15, pp. 266-274.

(13). P. M. King (2002).A comparison of the effects of floor mats and shoe in-soles on standing fatigue, Applied Ergonomics, vol. 33, pp. 477-484.

(14). 14 J. E. Zander, P. M. King, and B. N. Ezenwa (2004). Influence of flooring conditions on lower leg volume following prolonged standing. International Journal of Industrial Ergonomics, vol. 34, pp. 279-288.

(15). J. Y. Kim, C. S. Buttle, and W. S. Marras (1994). The effects of mats on back and leg fatigue, Applied Ergonomics, vol. 25, pp. 29-34.

(16). K. Kroemer, H. Kroemer, and K. Kroemer-Elbert (1994). Ergonomics - How to Design for Ease and Efficiency. New Jersey: Prentice Hall International Inc.

(17). J. H. V. Dieen and H. H. E. O. Vrielink (1998). Evaluation of work-rest schedules with respect to the effects of postural workload in standing work, Ergonomics, vol. 41, pp. 1832-1844..

(18). S. Konz (2006) Standing work, in "International Encyclopedia of Ergonomics and Human Factors" vol. 1, W. Karwowski, Ed., Second Edition ed. New

York: Taylor & Francis, pp. 929-932.

(19). Nico J. Delleman, Christine M. Haslegrave, Don B. Chaffin (2004). Working postures and movements: tools for evaluation and engineering, CRC Press, Boca Raton, Florida.

(20). McAtamney, L. and Corlett, E. N. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. Applied Ergonomics 24 (2), p. 91-99.

(21). Hignett, S. and McAtamney, L. (2000), Rapid Entire Body Assessment (REBA). Applied Ergonomics, 31, p. 201-205.

(22). Mohd Nasrull Abdol Rahman, Mat Rebi Abdul Rani and Jafri Mohd Rohani. Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management Istanbul, Turkey, July 3–6, 2012.

(23). Social Security Organization Annual Report 2012, The Ministry of Human Resource of Malaysia.

(24). Chowdury M.L. Rahman (2014). Study and Analysis of Work Postures of Workers Working in a Ceramic Industry Through Rapid Upper Limb Assessment (RULA). International Journal of Engineering and Applied Sciences. Vol. 5. No. 3.

(25). Gongapadhyay S., Ghosh T., Ghosal G. and Das B. (2010). Effect of Working Posture on Occurrence of Musculoskeletal Disorders among the Sand Core Making Workers of West Bengal. Cent Eur J Public Health; Vol.: 18 (1) Page: 38–42.

(26). Tzu-Hsien Lee and Chia-Shan Han (2013). Analysis of Working Postures at a Construction Site Using the OWAS Method. International Journal of Occupational Safety and Ergonomics (JOSE), Vol. 19, No. 2, Page: 245–250.

June 2015, vol 12, No. 1 : 133-136

Comparison and Prevalence of Work-related Musculoskeletal Disorders among Workforce in Malaysia

M.A.M.Rebi [1], R.M.Zein [1], R.A.Aziz [1], H.K.Tamilselvan [1], A.J. Adeyemi [2], N.A Azis [1] and M.N Mali [1]

[1] *Ergonomics Excellence Centre, National Institute of Occupational Safety and Health (NIOSH)*

[2] *Faculty of Mechanical, Universiti Teknologi Malaysia*

Abstract

This study is carried out to establish the prevalence of Work-related Musculoskeletal Disorders (MSD) among the Malaysian workforce population in order to propose some measures to benefit the people at large. Secondary data from three studies among drivers, clerical workers using visual display terminals (VDT) and fabrication workers were used to report the prevalence of MSDs and the associated risk factors. The study identified high prevalence of MSDs in multiple body regions. The MSD occurrence was also significantly associated with psychosocial factors. There is need for organisations to consider such factors in work design, which will reduce the high prevalence and high financial implications associated with MSDs among workers.

Keywords: Work-Related Musculoskeletal, Financial Impact and Medical

Introduction

In today's fast economic growth, occupational heWork-related Musculoskeletal Disorders (MSD) is an occupational disease that many workers in Malaysia have been reporting to SOCSO for claimable cases. MSD, which is reportedly on the increase, involve many people, across the ages of population, and can be considered to constitute the leading percentage of all told or untold complaints among people. A study by the Medical Journal The Lancet found that the MSD condition were the second greatest disability in the world affecting 1.7 billion people worldwide (http: //www.bbc.com/news/ business). The impacts of MSDs need to be established because their severity encompasses all sectors in society for full-time, part-time and self-employment. The impact could be observed among individuals, families, organizations and country. The individual may have to endure the pains and discomforts, the family needs to face the nursing of the sufferers, organization may have to bear the losses while the nation may lag in productivity.

Further impacts of MSD have been shown to reverberate into the quality of working life and work productivity where the total ergonomics (macro and micro) seemed to provide some remedial measures. The medical costs, the loss of productivity and the sufferings have all been associated with WMSDs.

Apart from the effect on individuals and organisations, MSDs are also responsible for huge financial loss to governments. The cost of MSD conditions was USD$149.4 billion in 1992, of which 48% was due to direct medical care cost and the reminder was due to indirect costs resulting from wage losses (Yelin and Callahan,1995). In the UK, almost 31 million days of work had been lost due to back, neck and muscle problems (Labor Force survey, 2014). It had also being established that sitting in the office had become the primary cause of absenteeism and the highest record in Europe. According to the Work Foundation, it was estimated that employees suffering from bone and joint pains, resulting from sedentary work and chronic keyboard, would cost the European Union (EU) economies about €240 billion (£200) each year. U.S. Bureau of Labor Statistics reports 650,000 work-related musculoskeletal disorders (WRMSDs), resulting in costs to employers of over 20 billion dollars. These costs include Worker's Compensation and medical expenses, the latter of which are increasing 2.5 times faster than benefit costs. $1 of every $3 of Worker's Compensation costs are spent on occupational musculoskeletal disorders (MSDs). Employers pay $15-20 billion per year in Worker's Compensation costs for lost workdays. Mean costs per case of upper extremity MSD are $8,070 versus a mean cost of $4,075 per case for all types of work-related injury. Worker's Compensation claims per injury equal $29,000 - $32,000 per year. Medical bills for the average shoulder injury (excluding surgery) are $20,000 per year.

Prof Anthony Woolf, a rheumatologist at the Royal Cornwall Hospital stated that around 30% of all disability in the UK was due to those conditions.

The cost of MSDs is different through occupations and industries and could persist in three (3) categories (Waehrer *et al*, 2005). These are : Direct Cost (payments for hospitals and medical cares, nursing, rehabilitation, etc), Indirect Cost (losses due to wage, productivity, absenteeism, workplace, and etc.) and Quality-of-Life Cost (value attributed to pain and suffering by victims and families). Indirect costs are 3 to 5 times higher, reaching approximately $150 billion per year. These

include absenteeism, staff replacement and retraining, productivity, and/or quality. In sonography alone, the costs are significant.

In Malaysia, Social Security Organization (SOCSO) provided the statistics as shown in Table 1.1 which shows the number of accidents and benefits paid according to the location of injuries for both male and female workers in 2011.

Furthermore, the costs of MSD may be staggering, bad enough that unavailable information on such may be inadequate to provide the right picture of the problems. The study covers the impact, causes and cost of MSD among the population of Malaysia where the current scenario of problems to describe situations that would include the frequency and trends, financial implications and establishing the ergonomic risk factors that would cause the MSD. This study uses secondary data from three previous researches to enumerate the present

Table 1.1(d) : Number of Accidents and Benefit Paid According to Location of Injury (and for both male and female workers) for various parts of body, 2011.

No.	Location of Injury	Accident Reported	TD Paid	PD Paid	DB Paid
1.	Neck (including throat and cervical vertebrae)	235	208	45	6
2.	Back	1,510	1,349	468	4
3.	Chest	693	557	105	31
4.	Abdomen	187	132	24	17
5.	Pelvis	296	283	81	-
6.	Trunk, multiple locations	713	644	238	77
7.	Trunk, unspecified location	161	135	30	1
8.	Shoulder	2,744	2,741	831	1
9.	Upper arm	403	92	20	-
10.	Elbow	423	321	92	1
11.	Forearm	190	473	96	-
12.	Dislocations	1,327	1,080	233	4
13.	Sprain and strains	4,709	4,508	1,055	25
TOTAL		**13,591**	**12,523**	**3,318**	**167**

The increase in MSDs in industry has resulted in research into the causes and in legislation in the U.S. regulating the design of office furniture and duration of video terminal work. Appropriate ergonomic adaptations have been found to effectively reduce the risk of MSD symptoms. Adapting a workstation to each person and his/her work requirements ensures that it functions as intended. Productivity is increased if employees' work areas are arranged to suit them and the type of work being done.

Dollars spent on improving the ergonomic design of the workstation have an excellent return on investment. This investment leads to improved performance of workers and improved employee wellbeing. Ergonomics provides the foundation for effective management and well-trained workers to perform at their best level, thus increasing productivity and profits.

The causes of MSD are plentiful that need to be ranked that may vary between sectors of societies. level of MSD prevalence among Malaysia workers. The comparison is important has most studies normally investigated MSDs among single work group. This comparison will be useful in estimating the cost of MSD among difference work force.

Methodology

Secondary data from three different workers were used to determine the prevalence of MSDs at different body regions. The data were collected from 94 drivers (Kartini, 2010), 132 fabrication workers (Emily, 2014) and 76 workers using video display terminals (VDTs) at their workplace (Shahab, 2014). Since these studies were independently conducted, the prevalence reported were limited to identical body regions investigated in the three studies. For the VDT where left and right body regions are separately measured, the higher value was adapted. Also, the prevalence for the general population was computed instead of the gender-based prevalence reported in the VDT study. Percentage value of MSD prevalence was used in the analysis to effective

comparison. All statistical analysis was carried out using SPSS at 0.05 significance level.

Results

The results from the three studies show that the prevalence of MSDs among Malaysian workers is still high. Table 2a to 2c shows the ranking of the reported cases based on body region in decreasing order. The Tables show that low back pain and Neck pain are the most prevalent MSDs among the respondents. Figure 1 shows that larger percentage of bus drivers experienced MSD in most of the body region and fabrications happened to report the least pain among the three group of works.

Discussion

The studies revealed the high prevalence of MSDs in different body regions among all the workers involved in the study. The highest prevalence of low back pain among the workers is in line with local and international trends which have identified low back pain as the MSDs with the highest prevalence and its associated cost (Tissot *et al.*, 2009). This high occurrence is independent of the working posture as shown by the large prevalence percentage among the three workers. It is therefore expected to be responsible for the largest cost to employees, employers and the country at large. This is because Table 1 shows that compensation is a function of the number of cases. The same effect can be observed about neck and shoulder pains. The occurrence

Table 2a: The number of cases of MSDs at different body regions among VDTs workers (N=76)

Parts of Body	No of cases	Percentage cases
Neck	44	57.9
Lower back	39	51.3
Shoulder	38	50
Knee	35	46.1
Upper back	25	32.9
Hip	20	26.3
Wrist	14	18.4
Ankle	12	15.8
Elbow	6	7.9

Table 2b: The number of cases of MSDs at different body regions among drivers (N=94)

Parts of Body	No of cases	Percentage cases
Lower back	71	76
Neck	68	72
Hip	58	62
Ankle	58	61
Calf	54	58
Upper back	50	53
Shoulder	48	51
Knee	41	43
Wrist/hand	32	34
Elbow	31	33
Head	29	31
Lower front	22	23
Upper front	13	14

Table 2c: The number of cases of MSDs at different body regions among fabrication workers (N=132)

Parts of Body	No of cases	Percentage cases
Low back	55	41.7
Shoulder	25	18.9
Neck	22	16.7
Wrist/hands	15	11.4
Ankle/feet	10	7.6
Knee	9	6.8
Upper back	5	3.8
Thigh/hips	4	3.0
Elbow	1	0.8

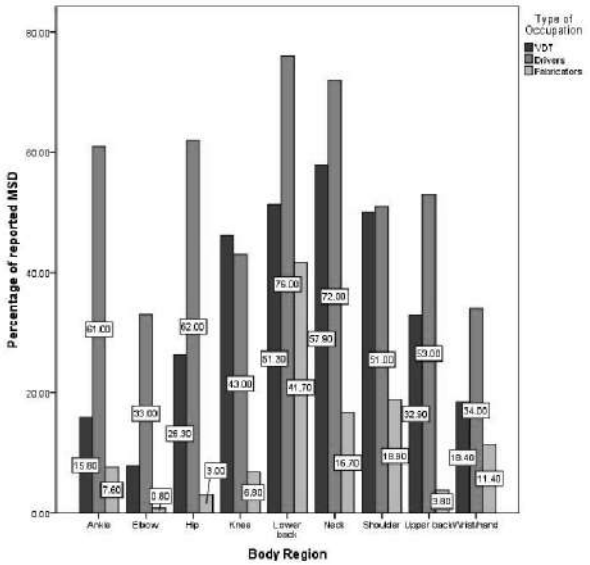


Figure 1: Percentage of reported cases of MSDs at different body regions among the workers

of multiple MSDs, greater than half, among the sedentary and driving populations, calls for serious concern since provisions are reportedly made for support and rest. This will lead to high cost and lost of job hours associated with low productivity level.

All the studies identified the significant role of psychosocial factors in the occurrence of MSDs. Factors, such as job demands, role expectations, control at work and social interactions with supervisors/leadership and others workers, have been reported to play critical roles in the workers' attitudes to MSDs. These factors were reported to be associated with work stress and job satisfaction. The findings in these studies have highlighted the interactions among physical, mental and socio-psychological capacities of workers, as it affects their general well-being and job satisfaction. The comprehensive design of suitable working environment will therefore contribute to the effective reduction in MSD cases, which will consequently lead to reduction of the cost associated with them.

Conclusion

The prevalence of Work-related musculoskeletal disorders is still high among Malaysian workers. The high prevalence in multiple body regions have serious financial implications for the workers, the employers and the government agencies, such as SOSCO, which is expected to pay compensations for such health problems. Therefore, there is a need to pay more attention to the design of the working environment since psychosocial factors are reported to interact with the workers physiology in the occurrence of such disorders. Finally, it is expected to reduce the prevalence of MSDs and the associated financial implications.

References

(1). Kartini (2010) Musculoskeletal Disorders Among Drivers. MEng Thesis UTM

(2). Ch'ng (2010) Musculoskeletal Disorders Among Fabrication Workers. MEng Thesis UTM

(3). Shahab (2014) Musculoskeletal Disorders Among Video Display Terminal Users. MEng Thesis UTM

June 2015, vol 12, No. 1 : 137-140

Comparison Of Direct Method And Indirect Methods For Sampling And Analysis Of Airborne Respirable Crystaline Silica By X-Ray Difractometer

Suhaily Amran [1], Mohd Talib Latif [2], Abdul Mutalib Leman[3], Shoffian Amin Jaafar [1], Ahmad Sayuti Zainal Abidin[1]

[1] Laboratory Division, Consultation Research and Development Department, National Institute of Occupational Safety and Health (NIOSH), Lot 1, Jln 15/1, Section 15, 43650 Bandar Baru Bangi Tel: 03 013 3687119, email: suhaily@niosh.com.my, ahmad.sayuti@niosh.com.my, shoffian.amin.jaafar@gmail.com

[2] School of Environmental and Natural Resources Science, Faculty of Science and Technology, Universiti Kebangsaan Malaysia (UKM), 43650 Bandar Baru Bangi, Selangor Tel: 03 89213822, email: talib@ukm.edu.my

[3] Department of Mechanical Engineering Technology, Faculty of Engineering Technology. Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Parit Raja, Batu Pahat. Johor. Tel: , email: mutallib@uthm.edu.my

Abstract

There are several alternative sampling and analytical methods available for the determination of respirable crystalline silica exposure among workers. The commonly used ones are, (1) NIOSH Manual Analytical Method No.7500(NMAM 7500) which is Silica, crystalline, by X-ray difractometer via filter deposition(NIOSH 2003), and (2) MDHS 101 (Methods for the Determination of Hazardous Substances (MDHS) Guidance No.101: Respirable crystalline silica in respirable airborne dust). The aim of this study is to compare applicability of respirable crystalline silica sampling and analysis between method MDHS 101 and NMAM 7500. Laboratory procedures will be performed strictly based on MDHS 101 and NMAM 7500. Both methods apply X-ray diffraction as analytical technique with many variations on sampling techniques and laboratory preparations. Quality assurance values such as detection limits, accuracy and precision are derived from both data and will be compared to determine which of the method establishes better quality assurance. The method which establishes better quality assurance will be recommend to be used in Malaysian respirable crystalline silica monitoring programme. The strength of this research lies on its potential to provide local capabilities in analysis of respirable crystalline silica in Malaysian setting.

Keywords: Quartz, NMAM 7500, MDHS 101, Granite, Quarry

Introduction

Respirable crystalline silica exposures are determined from exposure monitoring data. The data gathered from this monitoring are compared with occupational exposure standard (OES) recommended or enforced by various agencies or authorities. OES is implemented with the main intention to prevent respirable crystalline silica exposure which may lead to lung diseases such as silicosis and lung cancer. Exposure data in respirable crystalline silica in Malaysia are either unavailable or questionable due to limited Malaysian laboratories capabilities to perform specific analysis for crystalline silica. These scenarios highlight the need for local laboratories to establish accurate techniques in qualitative and quantitative measurement for respirable crystalline silica. Only with accurate measurement techniques, the compliance status among Malaysian workers can be established, evaluated and appropriately controlled.

There are several monitoring methods used by industrial hygienists in the determination of respirable cristalline silica exposure. Among the commonly used ones are, (1) NIOSH Manual Analytical Method No.7500(NMAM 7500) which is Silica, crystalline, by X-ray difractometer via filter deposition(NIOSH 2003), (2) NIOSH Manual Analytical Method No.7602 (NMAM 7602) which is silica, crystalline by infrared (KBr pellet) (NIOSH 2003), (3) Methods for the Determination of Hazardous Substance Guidance No.101(MDHS 101) which is Respirable crystalline silica in Respirable Airborne Dust) (HSE 2005), (4) OSHA ID 142 which is Quartz And Cristobalite In Workplace Atmospheres) (OSHA 1996) and (5) MSHA P2 which is X-ray Diffraction Determination of Quartz and Crystobalite In respirable Mine Dust (MSHA 2013). All of these methods apply X-ray diffraction or Infrared as their analytical techniques. Sampling techniques among these methods are similar but the analytical procedures are apparently different among them.

In Malaysia, Crystalline Silica exposure is managed by two specified regulations, namely Occupational Safety and Health (Use and Standard of Exposure of Chemical Hazardous to Health) Regulations 2000 or in short USECHH Regulation 2000; and Factory and Machinery (Mineral Dust) Regulation 1989 or in short FM (Mineral Dust) Regulation 1989. Both regulations stipulate permissible exposure limit (PEL) for crystalline

silica but enforcement activities will follow USECHH Regulations 2000 due to it being more stringent and its more current PEL (DOSH 1989, 2000). USECHH Regulations 2000 detail out the PEL for crystalline silica as 3 mg/m^3 for respirable dust; 10 mg/m^3 for total dust; 0.1 mg/m^3 for quartz; 0.05 mg/m^3 for cristobalite; 0.1 mg/m^3 for tripoli and 0.05 mg/m^3 for tridymite(DOSH 2000). This regulation also specifies that dust which contains more than 1% cytalline silica must be monitored as crystalline silica instead of general total dust or respirable dust (DOSH 2000).

In the United State of America, OES for crystalline silica was recommended by 3 agencies namely Occupational Safety and Health Administration of United State of America (OSHA), National Institute of Occupational Safety And Health (NIOSH) and American Conference of Governmental Industrial Hygiene (ACGIH). OSHA set PEL at 10mg/m^3/(%silica+2) for quartz while for tridamite and cristobalite at 5 mg/m^3/(%silica+2). NIOSH established PEL at 0.05mg/m^3 for all types of crystalline silica while ACGIH established different threshold limit values (TLV) for respirable quartz, tridamite and crystobalite at 0.01mg/m^3, 0.05mg/m^3, 0.05mg/m^3 respectively (NIOSH 2003). In the United Kingdoms, Health and Safety Executive recommended workplace exposure limit (WEL) at 0.01mg/m^3 for all types of crystalline silica (HSE 2011). National Occupational Health and Safety Commission of Australia set national exposure standards of 0.1 mg/m^3 for quartz, cristobalite and tridymite. These countries implement the long term exposure standards of eight hour time weighted average (8HrTWA) for respirable crystalline silica.

The aim of this study is to compare applicability of respirable crystalline silica sampling and analysis between MDHS 101 and NMAM 7500 methods. Laboratory procedures will be performed strictly based on MDHS 101 and NMAM 7500. Both methods apply X-ray diffraction as analytical techniques with many variations on sampling techniques and laboratory procedures.

Method For Crystalline Silica Analysis

According to Madsen *et al*. (1995), analysis of Crystalline silica can be performed by various techniques including thermal analysis, calometric, X-ray diffraction or infrared. Calometric method preparation is very complex and involving the use of very hazardous chemicals such as hydrofluoric acid, while thermal analysis technique requires high sample amounts which make it unsuitable for airborne samples (Madsen *et al.* 1995). The most common analytical techniques used to analyze RCS are via infrared (IR) and X-ray diffraction (Key-Schwartz et al. 2003; Madsen *et al*. 1995; Miller 2014).

X-ray diffraction is a technique that measures crystalline material. It is less influenced by interference, and it can distinguish between different types of crystalline silica such as quartz, cristobalite and tridamite. The basic principle of quantification with X-ray diffraction is based on measurement of intensity of crystalline characteristic of a substance. The diffracted intensity is directly proportional to mass of quartz/crytobalite on the filter (HSE 2005). The diffraction effect is dependent on the nature of crystalline structure of the phase resulting in diffraction pattern which is distinctive (Smith 1992). Calibration standards can be prepared by known amounts of pure standard weights. Weights of unknown samples can be established by comparing intensity of the samples with calibration curve derived from the standards. The X-ray diffraction method is suitable for the determination of quartz and crystobalite in respirable dust samples weighing up to 2 mg on a filter (HSE 2005). Linear relationship between diffracted intensity and mass may not hold when the dust is very low, or close to origin. Calibration line may not necessary pass though zero and this will contribute to uncertainty of analysis (HSE 2005). X-ray diffraction intensity may vary according to particle size. Smaller particles (0.2 to 2.0 um) shows lower intensities (Key-Schwartz *et al*. 2003). In this case, the particle size of the airborne crystalline silica may affect the intensity of the results.

Analysis of crystalline silica by X-ray diffraction may be performed by direct or indirect methods. Direct and indirect methods are often in competition in industrial hygiene to measure the airborne concentration of a pollutant in work places (Kaufer *et al*. 2005). 'Direct' means that the sample filter can be analyzed by X-ray diffraction without any pre-treatment procedures. Direct analytical method keep samples handling operation to a minimum, but the standard must be prepared under the same conditions as samples (Kaufer *et al*. 2005). An example of a direct method is method MDHS 101. To stimulate the same conditions as samples, standard filters can be produced in an exposure chamber as described in MDHS 101 (HSE 2005). For a direct X-ray diffraction analysis, each filter is placed directly against a 25mm zinc or Aluminum plate holder. The plates serve as a reflecting material during an analysis of X-ray diffraction. Crystalline free silica contents are determined by directly measuring the centre of the filter by using the X–ray diffraction technique. Indeed, if all collected respirable dusts are uniformly deposited on the filter, the result obtained from the X-ray diffraction method would be representative to the silica content collected on the filter (Chen *et al*. 2010). In direct method, since there is no pre-treatment of the filters, there is a possibility that the dusts are not uniformly distributed on the filter. To improve X-ray diffraction measurement, MDHS 101 recommended that filters are positioned on sample spinner auto sampler during analysis (HSE 2005).

Indirect methods apply pre-treatment of the filter membrane. NMAM 7500 is one of examples of indirect method by X-ray diffraction. Apart from NMAM 7500, another indirect method is described in NMAM 7602

but the analysis is performed by FTIR (NIOSH 2003). This discussion however will only focus on indirect method by X-ray diffraction. NMAM 7500 recommends silver membrane as the substrate of the base background correction. However the silver membrane have a great variability due to different factory batches (Kuo *et al*. 2010). The indirect method introduces additional sample handling operations with the higher risk of loss of material and it is time consuming (Kaufer *et al*. 2005). Besides, silver membrane is very expensive (Kuo et al. 2010; Yabuta & Ohta 2003). The analysis cost of indirect method is expensive due to the cost of silver membrane. Among the advantages, filtration procedure on the silver membrane will initiate uniform distribution of particles on the filter, which may reduce error in XRD measurements.

The purpose of quality assurance programme in industrial hygiene analytical procedures is to ensure the reliability of reported data (Paik&Levine 1997). In other words, quality assurance will ensure that the tests performed are meeting the objective of sampling. Quality assurance procedure will ensure results obtained in analysis are realistic and representative. In general, performance characteristic for a method development and validation will include applicability, selectivity, calibration and linearity, linearity intercept, trueness, precisions recovery, range, detection limit, sensitivity, ruggedness, fitness for purpose, matrix variation and measurement uncertainty (Peter, 2007,Thompson, 2002).

Selectivity is the degree to which a method can quantify the analyte accurately in the presence of interference (Thompson *et al*. 2002). Analysis of crystalline silica with X-Ray diffraction will much depend on crystalline characteristic of the substances. Based on NMAM 7500, analysis of crystalline silica such as quartz, crystobalite and tridamite will have interference from other mineral such as barite, mica, potash, feldspars and many other minerals. Besides, the diffraction patterns for aluminum phosphates are practically identical with crystalline silica. If calcite is present, loss of quartz may occur during sample treatment. NMAM7500 specified special treatment process if calcite is present in the sample. In case of ambiguity due to interference, analysis may use different, less sensitive peak in the crystalline diffraction characteristic (NIOSH 2003).

Trueness is the closest of agreement between a test result and the acceptable reference value (Thompson et al. 2002). A typical trueness experiment generates a mean response to certified reference material (CRM). Certified reference materials are traceable to international standards with known uncertainty values (Thompson et al. 2002). NMAM 7500 recommends the use of the NIST SRM 1878a for quartz identification (NIOSH 2003). MDHS 101 recommends the use of the NIST SRM 1878a by US National Institute of Standard and Technology (NIST), or Sikron F600(HSE standard A9950) by Health and Safety Laboratory (HSL), United Kingdom. Alternatively, MDHS 101 permits the use of any other documented standard which has been compared to primary standards (HSE 2005). The selected CRM will be used for filters for standard calibration. Result of samples will be based on calibration linearity obtained from the filters that are traceable to CRM. Jim Chisholm in 2005 conducted a comparison study between HSE A9950 (Sikron F 600) and NIST SRM 1878. The findings showed that there was no significant difference in the diffraction peak position, or peak area intensity between the two standards. However, the Sikron F600 peak areas are significantly higher than NIST SRM 1878 (Chisholm 2005).

Precision is the closeness of agreement between independent test results obtained under stipulated conditions. It is usually specified in term of standard deviation or relative standard deviation (Thompson *et al*. 2002, Peter, 2007). Precision may be considered at three levels: repeatability, intermediate precision and reproducibility (Peter *et al*. 2007). Precision data for quartz analysis by X-ray diffraction was reported by various validated data which are quite different. The precision data are generally based on coefficient of variance (CV.); NMAM 7500 indicates precision values at 8%, 10.6% ,10%, 5% for NMAM 7500, OSHA ID 142, MSHA P-2, MDHS 101 respectively (Key-Schwartz *et al*. 2003).Besides, different methods also indicate various range and limits of detection. The range of validation studies are 20-2000,50-160, 20-500,50-2000 for NMAM 7500, OSHA ID 142, MSHA P-2, MDHS 101 respectively (Key-Schwartz, 2003). The limits of detection (LOD) are declared as 5 µg , 10 µg, 5µg and 3µg of quartz for NMAM 7500, OSHA ID 142, MSHA P-2, MDHS 101, respectivey (Key-Schwartz, 2003).

Methodology

This study is based on laboratory experiment performed in industrial hygiene analytical laboratory of NIOSH Malaysia. The design which applies for this study is based on experimental study. Procedures for sampling and analysis of each method are performed strictly accordingly to the designated methods. To reduce bias of the findings, this study will control certain confounding factors such as type of filter, selective device and sampling pumps. Environmental factors such as humidity and temperature will be measured and will be used to calculate sampling volume correction if required. Laboratory procedure starts with the development of standard range filters from bulk standard. For the purpose of this study, JAWE standard 461(quartz) supplied by Japan Association for Working Environment Measurement was used. Standard range filter was prepared separately based on MDHS 101 and NMAM 7500. MDHS 101 will represent `direct` method, while NMAM 7500 will represent `indirect` method.

In MDHS 101, the standard filter was generated in a plastic glass chamber. The chamber is made from a transparent plastic material consisting of an enclosed tower chamber. The design of the chamber is quite

similar with design of borosilicate chamber proposed by MDHS101. There is a small opening on the top of the chamber which is designed to place in a filter media into a chamber. Standard preparations start by generating quartz cloud in the chamber. A few milligram of JAWE 461 are placed at the base of the chamber. Airstream is supplied by a compressor via a piping system. Airstream is blown to the mass of standard to generate quartz cloud. From the top opening, 25mm open face filter cassettes are inserted into the chamber. Prior to that, the filters are weighed to determine the filters weights before impaction. The filter cassette is connected to a standard flow sampling pump. The flow rate of the sampling pump is set at medium flow within 1 to 2 l/min. Different range of standard weight is generated by adjusting the pump running time. Actual standard weight of each filter will be determined by the differences between post and pre weight. Six standards filters are generated within range of 10 µg to 500 µg.

In NMAM 7500, standard filters are generated from vacuum filtration assembly systems. The vacuum filtration assembly systems are attached to a side arm of vacuum flasks with 25mm filter holders. Standard preparation starts by weighing 10 mg and 50 mg of JAWE 461. Each preparation will be transferred to a volumetric flask and diluted with one liter of 2-propanol to make preparations of 10mg/L and 50 mg/L stock solution. The stock solution will be ultrasonic treated for 20 minutes to generate suspended solid. The solution is then immediately transferred to a magnetic stirrer and stirring bars are placed into the solution. The solution is kept for stirring continuously until the subsequent process. From the 10 mg/L stock, two standard ranges of 10 µg/L and 20 µg/L are produced. While, from the 50 mg/L stock, four standard ranges of 50 µg/L, 100 µg/L, 250 µg/L and 250 µg/L are produced. The related procedures are described in Table 1.

Based on the information in Table 1, a total of 6 ranges of standards within 10-500µg standard concentrations will be generated. Each stock volume of each standard is transferred to a vacuum filtration funnel. The filter apparatus are pre mounted with 25mm silver membrane. The solution is allowed for suspension for few minutes prior to vacuuming. After vacuuming, the filter area is dried and ready for X-ray diffraction analysis.

Both sets of the 6 ranges of standards filter generated from NMAM 7500 and MDHS 101 are sent for analysis by X-ray diffraction analysis. Calibrations curved are derived by comparing the known weights of the filters and the intensity of the deposited quartz. Regression value, range, and lowest detected standard are determined from the calibration curves. The validation process will be done following the procedures to obtain quality assurance data. Based on the calibration curves, 10 duplicates are reproduced from the lowest standard range. Each article is prepared and analyzed independently. The standard deviation of each set will be established to determine the limit of detection (LOD) and limit of quantification (LOQ). LOD will be established by multiplying SD value with 3. LOQ will be established by multiplying SD value with 10.

Recovery data is established by preparing several spike samples. Spike samples for NMAM 7500 are generated from vacuum filtrations system while NIST traceable ready-made filter are used to represent MDHS 101 spike samples. Besides, recovery, repeatability and reproducibility data was established by repeating analysis of the known QC samples. Bulk samples of quarry dust are collected from a quarry. The bulk sample was grinded to generate homogenous fine particles. Qualitative analyses of the quarry dust are performed to find out whether there is any presence of interference such as calcite and barite. Few filters are generated from actual quarry dust. The filters are generated with exposure chamber or vacuuming filtration system. The purposes of this procedure are to check whether this method can really be applied for real samples.

Quality assurance values such as detection limits, accuracy and precision are derived from both data and will be compared to determine which of the methods establishes better quality. The method which establishes better quality will be recommended to be used in the next phase of this study. In addition, the method will be recommended to be included in the Malaysian respirable crystalline silica monitoring programme.

Conclusion

The study will compare MDHS 101 and NMAM 7500 capabilities to be used in local setting. The strength of this research lies on its potential to provide reliable analysis techniques of respirable crystalline silica in Malaysian setting.

Table 1: Standard Range Preparation

Standard ID	1	2	3	4	5	6
Standard weight concentration (µg/ sample)	10	20	50	100	250	500
stock	10000ug/l= 10ug/ml		50000ug/l=	50ug/ml		
Stock volume (ml)	1	2	1	2	5	10

References

(1). MSHA, 2013. X -Ray Determination of Quartz And Crystobalite in Respirable Mine Dust. Pittsburgh, department of labour: 1-21.

(2). Chen, C.-H., Tsaia, P.-J., Lai, C.-Y., Peng, Y.-L., Soo, J.-C., Chen, C.-Y. & Shih, T.-S. 2010. Effects of Uniformities of Deposition of Respirable Particles on Filters on Determining Their Quartz Contents by Using the Direct on-Filter X-Ray Diffraction (Dof Xrd) Method. Journal of Hazardous Materials 176(389–394.

(3). Chisholm, J. 2005. Comparison of Quartz Standard for X-Ray Diffraction Analysis: Hse A9950 (Sikron F600) and Nist Srm 1878. Ann Occupational Hygiene 49(4): 351-358.

(4). DOSH. 1989. Factory and Machinery (Mineral Dust) Regulation 1989. Health

(5). DOSH. 2000. Occupational Safety and Health (Use and Standard of Exposure Chemical Hazardous to Health) Regulations 2000. Health, Kuala Lumpur.

(6). HSE. 2005. Methods for the Determination of Hazardous Substances (Mdhs) Guidance No.101: Respirable Crystalline Silicain Respirable Airborne Dust, Health and Safety Executive: 1-16

(7). HSE. 2011. Eh40/2005 Workplace Exposure Limits. Executive,

(8). Kaufer, E., Masson, A., Moulut, J. C., Lecaque, T. & Protois, J. C. 2005. Comparison of Direct (X-Ray Difraction and Infrared Spectophotometry) and Indiect (Infrared Spectrometry) Methods for the Analysis of A-Quartz in Airborne Dust. Ann. Occupational Hygiene 49(661-671.

(9). Key-Schwartz, R. J., Baron, P. A., Bartley, D. L. & L.Rice, F. 2003. Determination of Airborne Crystalline Silica Dlm. (pnyt.). Hazard Review: Health Effect of Occupational Exposure to Respirable Crystalline Silica, hlm. 260-280.

(10). Kuo, C.-T., Uang, S.-N. & Huang, H.-T. 2010. Application of X-Ray Diffractometry on Analysis Crystalline Free Silica in Foundries. Departmrnt of Public Health, C. M. U. 30 November 2010.

(11). Madsen, F. A., Rose, M. C. & Cee, R. 1995. Review of Quartz Analytical Methodologies: Present and Future Needs. Applied Occupational and Environmental Hygiene 10(12): 991-1002.

(12). Miller, A. 2014. In Pursuit of a Direct on Filter Method for Measuring Silica in Filter Samples of Airborne Dust. Colloqium Mechanical Engineering, hlm.

(13). Miller, A. L., Drake, P. L., Murphy, N. C., Noll, J. D. & Volkwein, J. C. 2012. Evaluating Portable Infrared Spectrometers for Measuring the Silica Content of Coal Dust. Journal Environmental Monitoring 14(1): 48-55.

(14). NIOSH. 2003. Niosh Manual Analytical Method No 7500: Silica, Crystalline, by X-Ray Difractometer (Xrd) Via Filter Deposition: 1-9.

(15). OSHA. 1996. Osha Id-142: Quartz and Cristobalite in Workplace Atmosphere. Salt Lake City, Utah: 1-24.

(16). Paik, N. W. & Levine, S. P. 1997. Quality Control for Industrial Hygiene Laboratory. World health Forum 18(359-362

(17). Peter, F. T., Drummer, O. H. & Musshoff, F. 2007. Validation for New Method. Forensic Science International 165(216-224.

(18). Smith, D. K. 1992. Issue and Controversy: The Measurement of Crystalline Silica. International Symposium.

(19). Thompson, M., Ellison, S. L. R. & Wood, R. 2002. Harmonized Guidelines for Singgle Laboratory Validation of Method of Analysis (Iupac Tecnical Report). Pure Applied Chemistry 74(5): 835-855.

(20). Yabuta, J. & Ohta, H. 2003. Determination of Free Silica in Dust Particles: Effect of Particle Size for the X-Ray Diffraction and Phosphoric Acid Methods. Industrial Health , 41(249–259).

June 2015, vol 12, No. 1 : 143-144

Overview Of A Comparative Study On Isolation Techniques For Legionella Species In Water

Nurzuhairah Jamil[1]; Rafiza Shaharudin[2]; Suhaily Amran[1]; Mohd Norhafsam Maghpor[1]; Ahmad Sayuti Zainal Abidin[1]; Naemah Tajol Arus[1]; Rochi Bakel[1]; Shoffian Amin Jaafar[1]

[1]Laboratory Divison, Consultation, Research and Development Department, National Institute of Occupational Safety and Health (NIOSH), Lot 1, Jln 15/1, Seksyen 15, 43650 Bandar Baru Bangi, Selangor, Malaysia Tel: 03-87692274 Faks : 03-87692100 Email : nurzuhairah@niosh.com.my

[2]Occupational Health Unit, Environmental Health Research Centre (EHRC), Institute for Medical Research (IMR), Jalan Pahang, 50588, Kuala Lumpur, Malaysia

Abstract

Legionellosis is a respiratory infection caused by gram-negative bacteria known as Legionella. Although there are many species of Legionella, the majority of all reported cases of legionellosis were caused by Legionella pneumophila. Investigations of Legionella outbreaks comprised sampling building water systems for the presence of Legionella. The aim of this study is to determine the isolation techniques with the most optimal yield for detection of Legionella based on the Australian/New Zealand Standard Waters –Examination for Legionella (AS/NZS 3896:2008). This is an experimental research, in which, Legionella species will be spiked in a bottle of water and various isolation techniques will be conducted. As most cases of Legionellosis are caused by Legionella pneumophila group, this group of species will be used.

Keywords: Legionella, Legionellosis, Australian/New Zealand Standard Method

Introduction

In 1976 a severe outbreak of Legionnaires' disease occurred in Philadelphia, USA. There were a total of 239 cases of pneumonia with 34 deaths. According to Fraser (2005), the bacterium was only isolated later and named as *Legionella pneumophila*. Since then, over 50 species of Legionella have been described, in which at least 21 species are associated with human infections (Coscolla & Gonzalez-Candelas 2007). Legionella spp. are weakly gram-negative bacteria living primarily around fresh aquatic environments such as lakes and streams (Fields et al., 2002; Hsu *et al*., 2009).

According to Borella *et al*. (2005) and Rota *et al*. (2003), Legionella spp. is an omnipresent microorganism which can grow at temperatures of 25°C to 42 °C in natural and artificial aquatic environments. Usually, the Legionella-related diseases are associated directly with bacteria found in man-made aquatic environment where warm water and biofilms support the growth and survival of Legionella spp. (Steinert *et al*., 2002; Napoli *et al.*, 2009). Many factors, such as temperature, hardness and chemical element concentration of the water, flow rate, type of surface, concentration of nutrients and disinfectants, can influence the accumulation of bacteria on pipeline surfaces and biofilm formation (Borella *et al.* 2004 and Borella *et al.* 2005).

Fields *et al.* (2002) reported Legionella spp. as an important waterborne bacterium that poses a significant health risk to people exposed to the organism in aerosolized water droplets from contaminated water systems. Although Legionella bacteria are widely found in low levels in natural bodies of water (Fliermans *et al*. 1981) it is also viable in potable and non-potable building water systems (Fields *et al*. 2002). The transmission is via inhalation or aspiration of aerosols contaminated with legionellae and it is mostly from water cooling towers and other man-made water systems (CDC 2007; Neil & Berkelman 2008; Ricketts *et al.* 2008).

Effects of climate change and global warming have affected ventilation and cooling of the built environment. Legionella is foreseen to be increased in Indoor Air Quality (IAQ) concern. Periodic environmental monitoring of critical points would be the best strategy for Legionellosis prevention. Currently there are no standards of testing for Legionella in Malaysia. Different testing methods are used by different laboratories. This study aims to determine the best isolation technique for Legionella species of those described by the Australian/New Zealand Standard Waters – Examination for Legionella (AS/NZS 3896:2008).

Methodology

Isolation techniques

This study will be conducted in NIOSH Bandar Baru Bangi, Selangor microbiology laboratory. Legionella pneumophilla (serogroup 1)

reference strain will be provided by Bacteriology Unit, Institute of Medical Research (IMR) Kuala Lumpur. The Legionella species obtained will be spiked into 1 liter schott bottle containing sterile water. The sample will then, be analyzed within 48 hours and sterile materials will be used throughout the analysis. 200 ml will be extracted from 1 liter sample and centrifuged. Then, 10ml of it will undergo three different isolation techniques which are heat, acid, and direct treatments. For heat treatment, 5 ml of untreated sample will be heated at 50°C for 30 minutes. Then 100 ul of the sample will be inoculated onto BCYE (Buffered Charcoal Yeast Extract) BCYE-GVPC

(Buffered Charcoal Yeast Extract with Glycine Vancomycin Polymyxin Cyclohexamide) agar. Meanwhile for the acid treatment technique, 1 ml of spiked sample will be transferred into 9ml of HCI-KCl acid buffer (pH 2.2). The solution will be mixed well and left for 5 minutes at room temperature. Similar amount of sample and inoculation as the heat treated technique will be applied. For direct treatment technique, no treatment of spiked sample is done prior to inoculation.

Screening suspected Legionella species

After the incubation period at 37ºC for up to 14 days in 5% CO2, glassy-looking colonies suspected to be Legionella will be selected and sub cultured on to BA (Blood Agar) and BCYE-GVPC media. Colonies growing on BCYE-GVPC agar but not on BA were presumptively identified as Legionella-like organisms. Latex agglutination test will be used as the confirmation test for the presence of Legionella species.

The number of suspected Legionella colonies on each BCYE and BCYE-GVPC agar count and CFU/ml is calculated by multiplying the total number of colonies by the dilution factor and dividing by the volume of inoculum.

Conclusion

The information from this study is expected to be useful for the development of a Malaysia standard in Legionella testing and analysis.

Acknowledgements

We would like to thank Institute of Medical Research (IMR) Kuala Lumpur especially Environment Health Research Centre (EHRC) for being fully supportive and for their encouragement in terms of technical expertise in carrying out this research.

References

(1). Coscolla, M. & Gonzalez-Candelas, F. 2007 Population structure and recombination in environmental isolates of Legionella pneumophila. Environ. Microbiol. 9, 643–656.

(2). Fields, B.S., Benson, R.F., Besser, R.E., 2002. Legionella and Legionnaires' disease: 25 years of investigation. Clin. Microbiol. Rev. 15, 506e526.

(3). Fraser, D. W. 2005 Historical review: the challenges were legion. Lancet Infect. Dis. 5, 237– 241.

(4). Hsu, B.M., Ma, P.H., Liou, T.S., Chen, J.S., Shih, F.C., 2009. Identification of 18S ribosomal DNA genotype of Acanthamoeba from hot spring recreation areas in the central range, Taiwan. J. Hydrol. 367, 249–254.

(5). Fliermans, C.B., Cherry, W.B., Orrison, L.H., Smith, S.J., Tison, D.L.,Pope, D.H., 1981. Ecological distribution of Legionella pneumophila. Appl. Environ. Microbiol. 41 (1), 9e16.

(6). P. Borella, M.T. Montagna, V. Romano-Spica, S. Stampi, G. Stancanelli, M. Triassi, R. Neglia, I. Marchesi, G. Fantuzzi, D. Tatò, C. Napoli, G. Quaranta, P. Laurenti, E. Leoni, G. De Luca, C. Ossi, M. Moro, G. Ribera D'Alcalà. Legionella infection risk from domestic hot water. Emerg. Infect. Dis., 10 (2004), pp. 457–464

(7). P. Borella, M.T. Montagna, S. Stampi, G. Stancanelli, V. Romano-Spica, M. Triassi, I. Marchesi, A. Bargellini, D. Tatò, C. Napoli, F. Zanetti, E. Leoni, M. Moro, S. Scaltriti, G. Ribera D'Alcalà, R. Santarpia, S. Boccia. Legionella contamination in hot water of Italian hotels. Appl. Environ. Microbiol., 71 (2005), pp. 5805–5813

(8). P. Borella, M.T. Montagna, S. Stampi, M. Triassi. Environmental diffusion of Legionella spp. and legionellosisfrequency among patients with pneumonia. Preliminary results of a multicentric Italian survey. Ann. Ig., 15 (2003), pp. 493–503

(9). Neil, K. & Berkelman, R. 2008 Increasing incidence of legionellosis in the United States, 1990–2005: changing epidemiologic trends. Clin. Infect. Dis. 47, 591–599.

(10). Steinert, M., Hentschel, U., Hacker, J., 2002. Legionella pneumophila: an aquatic microbe goes astray. FEMS Microbiol. Rev. 26, 149–162

(11). Napoli, C., Iatta, R., Fasano, F., Marsico, T., Montagna, M.T., 2009. Variable bacterial load of Legionella spp. in a hospital water system. Sci. Total. Environ. 408, 242–244.

June 2015, vol 12, No. 1 : 145-150

trans,trans-Muconic Acid As The Biomarker for Benzene Exposure Among Oil and Gas Petrol Tanker Drivers

Mohd Norhafsam Maghpor[1]; Suhaily Amran[1]; Ahmad Sayuti Zainal Abidin[1]; Naemah Tajol Arus[1]; Nurzuhairah Jamil[1]; Nor Husna Mat Hussin[1]

[1]Laboratory Division, Consultation, Research, and Development Department, National Institute of Occupational Safety and Health, Lot 1, Jalan 15/1, Seksyen 15, 43650 Bandar Baru Bangi, Selangor, Malaysia

Corresponding Author: Tel : +603-87692274; Fax : +603-89269842; Email :mohd.norhafsam@niosh.com.my

Abstract

A study has been conducted on *trans,trans*-muconic acid (*t,t-MA*) as the biomarker for benzene exposure among oil and gas petrol tanker drivers. The objectives of this study are to determine the significant difference and the correlation between Benzene personal exposure and urinary *t,t-MA* among exposed and non-exposed workers. A total of 92 questionnaires were distributed to obtain demographic and descriptive data. Benzene personal exposure was sampled using SKC passive samplers and the data was analyzed using GC-FID. Urinary *t,t-MA* was collected at end of work shift and analyzed using HPLC-UV detector. A total of 30 non-exposed workers were also sampled. The averages of urinary *t,t-MA* were 96.65 ug/g creatinine for exposed workers and 0.51 ug/g creatinine for non-exposed workers. Meanwhile, the averages of Benzene personal exposure were 0.37 mg/m^3 and 0.01 mg/m^3 for exposed workers and non-exposed workers respectively. No significant correlation was found between exposure to benzene with excreted urinary *t,t-MA* of workers occupationally exposed (p-value > 0.05) as well as to workers non-exposed to benzene (p-value > 0.05). In conclusion, there is no significant correlation found between Benzene personal exposure and urinary *t,t-MA* among exposed and non-exposed workers. Applicability of using *t,t-MA* as the biomarker of benzene exposure shall be further discussed with all the other confounding factors to be taken into account.

Keywords: trans,trans-muconic acid, Benzene, oil and gas, tanker driver

Introduction

Benzene, which has been used widely as a major industrial chemical is a normal constituent in petrol used by road vehicles (Richard J, 2010, Clifford P, 2010, and Paola Manini, 2006). Benzene is present in crude oil, and its concentration increases during refining. Being a component which cannot be eliminated, exposure control for Benzene is focused much more on engineering control, administrative control and personal protection.

Benzene exposure is always related to chronic diseases such as cancer as reported by International Agency for Research on Cancer (IARC, 1989). Authorities and research organization conduct a lot of research and data collection on Benzene, Benzene derivatives; its biotransformation in body and its effects to human. Data gathered from these studies was analyzed and interpreted to establish permissible exposure limit (PEL). PEL is used as a compliance level to guide employers to control Benzene exposure among their workers. Exceeding PEL simply means noncompliance to regulation and a possibility of chemical accumulation in workers' body. In Malaysia, PEL for Benzene are established by the Department of Occupational Safety and Health (DOSH). According to Occupational Safety and Health (Use and Standard of Exposure Chemical Hazardous to Health) Regulation 2000, PEL for Benzene can be classified into two.

The PEL are (1) eight hour time weighted average (8hrTWA) for long term exposure; and (2) Maximum Exposure Limit (MEL) for short term exposure. The PEL is widely applied by Malaysian employers to determine personal chemical exposure among their workers. The exposure level will be determined during chemical monitoring conducted by DOSH registered Hygiene Technician.

Besides PEL, DOSH has also published Guidelines of Medical Surveillance in 2001. The guidelines establish permissible level for biological monitoring known as Biological Exposure Indices (BEI). In these guidelines three (3) parameters are listed as biomarkers of Benzene. The Biomarkers are (1) urinary Phenol, (2) urinary S-Phenyl Mercapturic Acid (s-PMA); and (3) urinary *trans,trans*-Muconic Acid. During Benzene related medical surveillance programmes, the Malaysian Occupational Health Doctor (OHD) usually collect worker's urine to determine the concentration of these biomarkers in the body. If the level of biomarkers in urine is found to be more than BEI, the doctor will come out with further recommendation in order to reduce workers' exposure. Since the guidelines do not specify which one among the three (3) biomarkers is to be used for specific situations, the OHD will simply choose one of those three based on available cost and resources.

Literature Review

Based on samples received in NIOSH laboratory since 2008 to 2009 (IHAL, 2009), it is clear that most of registered OHD's prefer to select *t,t-MA* as Benzene biomarkers compared with phenol and S-PMA. Considering that Malaysian PEL and BEI are adopted from foreign countries, there is no specific data supporting that *t,t-MA* is a good indicator to be applied among Malaysian population. In addition, *t,t-MA* is not a specific marker of exposure to Benzene, since it is also a metabolite of sorbic acid, an anti-mycotic commonly added to foods (Ruppert *et al*., 1997). Besides, the level of contaminant absorbed, bio-transformed and excreted is much more related to individual factors such as dietary intake, genetic, smoking habit and preexistent disease. Daily diet can be a major confounding factor when *t,t-MA* is used for biological monitoring of Benzene at concentrations as low as 0.1–0.5ppm (Ruppert *et al*., 1997), which means that its use as a biomarker may have to be limited (Pezzagno and Maestri, 1997; Renner *et al*., 1999; Weaver *et al*., 2000). Several literature studies revealed no significant correlation found between exposure to benzene and *t,t-MA* excretion data (Mariella *et al*., 2006 and Gobba *et al*., 1997). This led to the need for further study especially for local worker's population.

t,t-MA acid has been widely used by registered Malaysian Occupational Health Doctor as the biomarker for Benzene exposure. Previous studies indicated that there is no difference in urinary *t,t-MA* in Benzene for exposed and non-exposed workers (Gobba.F, 1997). The applicability of using *t,t-MA* as the biomarker for Benzene exposure among exposed and non-exposed workers is not well defined although it is widely used as an indicator during medical surveillance programmes. Besides, studies of *t,t-MA* as a biomarker for Benzene exposure have not been extensively done in Malaysia. This study is needed to establish national data among Malaysian workers' population.

The objectives of this study are to determine whether there is a significant difference of urinary *t,t-MA* concentration between exposed and non-exposed workers and to determine the correlation between Benzene personal exposure with urinary *t,t-MA* among exposed and non-exposed groups.

Methodology

Study Sample

A total of 92 oil and gas tanker drivers were selected as samples for this study. The drivers are consistently exposed to Benzene during their fuel filling activities at the depots and also at the petrol stations. The degree of exposure much relies on fuel composition, volume pumping, and number of trips performed daily. Other sources of Benzene exposure include vapours from vehicle fuel tanks, fuel-soaked rags or accidentally soiled clothing, exhaust gases from tankers delivering fuel, and vehicles moving within the gas filling-station area. Meanwhile, a total of 30 unexposed workers as a control group were also sampled. They were with office work background, occupationally-free from exposure to Benzene. Selection of workers to be sampled was based on their exposure to Benzene and they were divided into two groups; exposed and non-exposed.

Benzene Personal Exposure Monitoring

A total of 122 questionnaires were distributed among workers for descriptive and demographic data such as age and sex; and smoking habit. Following the method used by Jorunn Kirkeleit (2006), Benzene personal exposure was sampled using passive samplers; 575 Series SKC was attached to driver's collar near to breathing zone (Jorunn Kirkeleit, 2006) and analyzed using GC-FID based on OSHA 1005 method and according to manufacturer procedure; SKC 37009 (www.skcinc.com). The device is very light and does not cause any interruption to workers' activities. The passive sampler was removed from the sealed pouch and the sample was identified according to individual driver. Start time was recorded and the passive sampler was attached to the driver. After sampling, sampler was capped and stop time was recorded. In the laboratory, the tube was cut with a razor blade or a sharp knife. Samples were extracted with carbon disulfide and digested for 1 hour followed with analysis by Agilent gas chromatography using flame ionization detection (GC-FID).

Biological Monitoring of Urinary t,t-MA

Urine *t,t-MA* was collected before the drivers ended their shift-work. Each of the drivers was given a 20ml urine container for urine collection. The urine samples were collected at the end of shifts as per Guideline on Medical Surveillance (2001) published by Malaysian Department of Occupational Safety and Health, DOSH. A total of approximately ten (10) millilitres of the urine samples was collected in a sterile container, sealed and stored at −4◦C until analysis. Prior to analysis, the urine samples were thawed. One (1) millilitre of the urine sample was pipetted into a 15 ml conical tube, after which, 1 millilitre of methanol was added. The urine sample was later centrifuged at 3000 rpm. Urinary *t,t-MA* analysis was performed by HPLC–UV detector method at 264 nm. All passive samplers and urine samples were sent to Industrial Hygiene Analytical laboratory (IHAL), NIOSH Malaysia for analysis.

Statistical Analysis

Data was analyzed by using the Statistical Package for Social Sciences (SPSS) version. Test of the normality of data was conducted, followed by Wilcoxon-Signed Ranks Test (significant difference test) and Spearman correlation test. Only p-value <0.05 will be considered as significant.

Results

Urine and personal exposure monitoring samples were collected, a total of 122, comprising 92 exposed petrol tanker drivers and 30 unexposed personnel with office work background as a control group. Duration of working hours varied from 8 hours to more than 12 hours.

Discussion

This study was conducted to achieve two objectives. The first objective is to determine significant difference of urinary t,t-muconic acid concentration between exposed and non-exposed workers. The second objective is to investigate the correlation between benzene personal exposure with urinary t,t-muconic acid.

Benzene Personal Exposure

Table 1 shows that average benzene concentration in the breathing zone of the exposed petrol tanker drivers was 0.37mg/m^3 ranging from non-detectable to 3.70mg/m3. Meanwhile, the average benzene concentration of the unexposed control group was 0.01mg/m^3 ranging from non-detectable to 0.05mg/m^3. Small amounts of benzene normally occur in the environment. Giorgio Marrubini *et.al* (2001) estimates that 0.02 and 0.015 ug/day are the human daily intakes of benzene from food and water respectively. Besides, emission from vehicle exhausts and environmental tobacco smoke (ETS) have been identified as one of the major sources for environmental benzene exposure (Eric S, 2007).

Biological Monitoring of Urinary t,t-MA

The average urinary *trans,trans*-muconic acid was 96.65 µg/g creatinine ranging from non-detectable to 4550.83 µg/g creatinine for petrol tanker drivers. Besides, the average of urinary *trans,trans*-muconic acid was 0.51 µg/g creatinine ranging from non-detectable to 8.70 µg/g creatinine for unexposed control group. All

Table 1: Descriptive data

Description	Personal Benzene, mg/m^3		Urinary t,tma, ug/g creatinine	
	Petrol Tanker Driver	Non-exposed Group	Petrol Tanker Driver	Non-exposed Group
n	92	30	92	30
Age	24 – 52	22 - 39	24 - 52	22 - 39
Mean	0.37	0.01	96.65	0.51
Range	ND – 3.70	ND – 0.05	ND – 4550.83	ND – 8.70
Smoking habit	58%	50%	58%	50%
Compliance to PEL	98%	100%	-	-
Compliance to BEI	-	-	98%	100%

Remarks : PEL (Permissible Exposure Limit) for Benzene = 1.6 mg/m^3 (USECHH Reg. 2000)
BEI (Biological Exposure Indices) for *t,t*-ma = 500 ug/g creatinine (Guideline on Medical Surveillance, 2005)
ND = Non-detectable

Table 2: Significant difference test (Wilcoxon-Signed Ranks Test)

Test Variable	p-value	Conclusion
Petrol tanker driver vs non-exposed group **(Personal benzene)**	0.000	**Significant** p-value < 0.05
Petrol tanker driver vs non-exposed group **(urinary *t,t*-ma)**	0.465	**Not significant** p-value > 0.05

Table 3: Correlation test (Spearman Test)

Test Variable	p-value	Conclusion
Personal Benzene vs *t,t*-ma **(Petrol tanker driver)**	0.088	**Not significant** p-value > 0.05
Personal Benzene vs *t,t*-ma **(non-exposed group)**	0.452	**Not significant** p-value > 0.05

urinary *t,t*-muconic acids were found non-detectable in all samples except for two samples. Some HPLC analysis method suggested that matrix interference may cause poor separation of the *t,t*-muconic acid (Giorgio Marubini *et.al* (2001)) as well.

Significant difference test of Benzene Personal Exposure and Urinary trans, trans–muconic acid

In order to investigate hypothesis 1 of this study, significant difference test was conducted using Wilcoxon-Signed Ranks Test as in Table 2. It was concluded that there is significant difference of personal air benzene between petrol tanker drivers when compared with non-exposed group with p-value of 0.000 (p-value <0.05). This confirmed the occupational benzene exposure of the petrol tanker drivers. Meanwhile, it was found that there is no significant difference of urinary *trans,trans*-muconic acid between petrol tanker drivers compared with unexposed group with p-value of 0.465 (p-value > 0.05).

Even though benzene exposure results show a significant difference between exposed (petrol tanker driver) and unexposed groups, there no significant difference was found on urinary *t,t*-muconic acid, thus suggesting that there might be no correlation between the two parameters. *trans,trans*-muconic acid might not be the best or the most suitable biomarker for benzene exposure.

Correlation between Benzene Personal Exposure with Urinary trans,trans-muconic acid

Results from correlation test showed that p value is more than 0.05 (p>0.05) using Spearman test as shown in Table 3. This indicates that there is no significant correlation between benzene personal exposure with urinary *t,t*-muconic acid for both occupationally exposed and non-exposed group with both p-values > 0.05. This also suggests that, high exposure to benzene does not really give an impact to the elevation of urinary *t,t*-muconic acid results. There were two (2) tests used in this study to evaluate the reliability of the *t,t*-muconic acid as the biomarker for benzene exposure. Significant difference test was done using Wilcoxon-Signed Ranks Test which showed significant difference and no significant difference in personal benzene exposure and urinary *t,t*-muconic acid respectively. A further test conducted was a correlation test using Spearman Test which found no significant correlation between personal benzene exposure with urinary *t,t*-muconic acid for both exposed (petrol tanker driver) and unexposed groups.

Based on this study, there is no positive evidence to prove that urinary trans, trans-muconic acid is a reliable biomarker for benzene exposure among exposed workers. Thus, the use of this biomarker shall be further discussed. Other biomarkers such as phenol and s-phenyl mercapturic acid as stated in Guideline on Medical Surveillance, 2001 shall be chosen as an alternative.

Findings of this study suggest that several modifications may be required in order to improve the sensitiveness of the benzene personal and urinary *t,t*-muconic acid. A number of other studies also suggested that analyzing urinary *t,t*-muconic acid may be improved by reanalysis using high performance liquid chromatography, HPLC under improved chromatographic conditions such as application of a more specific detector, for instance diode array detector, DAD besides reconfirming results by gas chromatography, GC especially GC-MS (Giorgio M, 2001). Environmental tobacco smoke, ETS is one of the factors which also can contribute to the indoor benzene concentration of the control group (Eric S, 2007).

Applicability of using *t,t-MA* as the biomarker for benzene exposure shall be further discussed with all the other confounding factors such as smoking habits, life-style and ingestion of dietary sorbic acid, to be taken into account (Gerrard Scherer, 1998).

Conclusion

The results indicate that there is no significant correlation between benzene personal exposure and urinary *trans,trans*-muconic acid and that no significant difference was found. Urinary *trans,trans*-muconic acid was also found non-detectable on all the petrol tanker drivers and control group population except for two samples.

Acknowledgements

The authors wish to thank all personnel especially from Laboratory Division involved in this study as well as National Institute of Occupational Safety and Health Malaysia for the grant.

References

(1). Rupert, T., Scherer., G., Tricker, A.R., Adlkofer, F., 1997. trans,trans- Muconic acid as a biomarker of non-occupational environmental exposure to benzene. Int. Arch. Occup. Environ. Health 69, 247–251.

(2). Mariella C., Enrico B., Maria L.S., Isabella M., Giovanna T., Paolo F., Enrico P., Giovanni B.B., Comparison of exposure assessment methods in occupational exposure to benzene in gasoline filling-station attendants Toxicology Letters 162 (2006) 146–152

(3). Eric S.J., Sverre L., Yu-Sheng Lin, A critique of benzene exposure in the general population, Science of the Total Environment 374 (2007) 183–198

(4). Richard J. Albertini., Stephen A. Judice., Leslie Recio, Vernon E. Walker, Hprt mutant frequency and p53 gene status in mice chronically exposed by inhalation to benzene, Chemico-Biological

Interactions 184 (2010) 77–85

(5). Giorgio Marrubini, Teresa Coccini, Luigi Manzo, Direct analysis of urinary trans,trans-muconic acid by coupled column liquid chromatography and spectrophotometric ultraviolet detection: method applicability to human urine, Journal of Chromatography B, 758 (2001) 295–303

(6). Gerhard Scherer, Thomas Renner, Michael Meger, Analysis and evaluation of trans,trans-muconic acid as a biomarker for benzene exposure, Journal of Chromatography B, 717 (1998) 179–199

(7). IARC. Monographs on the evaluation of the carcinogenic risk of chemicals to humans. Benzene, vol. 45. Lyon, France: International Agency for Research on Cancer; 1989.

(8). Department of Occupational Safety and Health Malaysia, Guidelines On Medical Surveillance 2001, 37-40

(9). Carrieri M, Comparison of exposure assessment methods in occupational exposure to benzene in gasoline filling-station attendants, Toxicology Letters 162 (2006) 146–152

(10). Eric S. Johnson, Review: A critique of benzene exposure in the general population, Science of the Total Environment 374 (2007) 183–198

(11). Richard J. Albertini, Hprt mutant frequency and p53 gene status in mice chronically exposed by inhalation to benzene, Chemico-Biological Interactions 184 (2010) 77–85

(12). Helen J. Badham, In utero and in vitro effects of benzene and its metabolites on erythroid differentiation and the role of reactive oxygen species, Toxicology and Applied Pharmacology 244 (2010) 273–279

(13). Clifford P. Weisel, Benzene exposure: An overview of monitoring methods and their findings, Chemico-Biological Interactions 184 (2010) 58–66

(14). Jorunn Kirkeleit, Biological monitoring of benzene exposure during maintenance work in crude oil cargo tanks, Chemico-Biological Interactions 164 (2006) 60–67

(15). Paola Manini, Biological monitoring of low benzene exposure in Italian traffic policemen, Toxicology Letters 181 (2008) 25–30

(16). Gobba F, Inter-individual variability of benzene metabolism to trans,trans-muconic acid and its implications in the biological monitoring of occupational exposure, The Science of the Total Environment 199 (1997) 41-48

June 2015, vol 12, No. 1 : 151-154

In-Vitro Indoor Fungal Treatment On Wood By Using Potassium Sorbate As Biocide

U.K. Parjo[1], N. M. Sunar[1], A.M. Leman[1], P.Gani[2], Q. Emparan [2], E.C.Ming[2]

[1]Faculty of Engineering Technology (FTK), Universiti Tun Hussein Onn Malaysia (UTHM), 86400, Parit Raja, Batu Pahat, Johor, Malaysia

[2]Faculty of Civil and Environmental Engineering, Universiti Tun Hussien Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor.

Email : [1]*umi5506@yahoo.com, [1]shuhaila@uthm.edu.my,[1]mutalib@uthm.edu.my, [2]parancgat@yahoo.com, [2]quinston89@gmail.com, [2]erchinming@hotmail.com,

Abstract

The indoor air contaminations in the buildings are normally contributed by causes from humans, animals and air borne fungi. These factors greatly cause the problem of sick building syndrome and indoor air pollutant. This study was undertaken to discover the potential efficiency of biocide potassium sorbate to remediate the indoor air fungal especially on wood material. Samples of fungal were collected according to NIOSH Method (NMAM 0800). The total amount of fungi and bacteria were enumerated at 806 cfu/m^3 and 280 cfu/m^3, respectively in a lecturer's room. The study also revealed that the growth of fungi was at the minimum when incorporated with a biocide treatment according to ASTM D559000 standard. This biocide has been proven to be effective and able to reduce the growth rate of indoor fungi. Overall results showed that this type of biocide is effective to overcome the fungal problem on wood material in the buildings.

Keywords:Indoor air quality, biocide, human health

Introduction

In recent years, a number of construction materials have been found to be sensitive to the growth of mould as well as being influenced by temperature, relative humidity and other parameters in all climates during all seasons of the year in Malaysia. The presence of mould can cause occupational diseases to building occupants. Previous studies have been conducted to determine the level of indoor air quality that can be affected by the mould growth. Ibrahim *et al*., 2011 mentioned about the effects of relative humidity and temperature on the growth of fungi. Spengler *et al*., 2000 also found that the parameter data such as carbon dioxide, temperature and relative humidity have significant negative impacts on ventilation and environmental conditions. Similarly, Shelton *et al*., 2002 found the environmental factors such as high temperature and relative humidity to contribute to the higher occurrences of indoor fungi. On the other hand, various factors have been found to affect mould surface such as the fungal species (Górny *et al.*, 2001); (Kildesø *et al*., 2003), the air velocity over the surface (Pasanen *et al*., 2012);(Madsen, 2012) and construction buildings (Gorny *et al*., 2001).

Lee and Chang (1999) showed that other air pollutants such as sulfur dioxide (SO_2), temperature, relative humidity, bacteria, formaldehyde (HCHO), nitric oxide(NO), carbon dioxide(CO_2) and nitrogen dioxide (NO_2) are also used as parameters in air quality monitoring. The high concentration airborne microbe in indoor air environment can cause health problems such as wheezing, eye irritation and shortness, asthma and rhinitis (Mandal and Brand, 2011). In addition, the growth of fungi on building surfaces can cause health risks and should not be tolerated in indoor environment (Lights, 2012). Safe workplaces should be provided by design and care about the importance of the microbiological air quality (Mandal and Brand, 2011). In Malaysia, Department of Occupational Safety and Health, Industrial Code of Practices for Indoor Air Quality has proposed the limits for the microbe concentration in buildings.

There have been relatively few recent studies on bio-resistance coating for indoor fungal treatment. A research by Belloti *et al.*, 2012 showed that, antimicrobial coatings can create healthy environment because it can prevent and protect the bio-deterioration of the substrates in buildings such as microbial repelling, biocide releasing and contact killing. The type of coatings and building material should be environmental friendly compounds, non-toxic for human and green chemical in controlling microbial growth.

Concerning this problem, this study aimed to find out if there exists a possibility for improving the method to remediate the growth of indoor fungal after incorporation with biocides. Also, there would be a further study to evaluate the efficiency of biocides to

treat indoor fungal with the utilization of a coating for coating-bio resistance. A newly constructed building was selected for this study. This study will discover a new potential of biocide effectiveness to treat the indoor fungal in the building with wood material.

Literature review

Fungi

Species of fungi can grow easily on the surface materials. They use compound such as nutrients and energy sources to produce spores as dispersal and survival units. Discolouration could happen when the fungi is present in the outdoor environment, which could affect the indoor environment such as unpleasant odours. In addition, the presence of nutrients, heat and moisture also causes the growth of fungi. Commonly, water in the material is considered as an important element for the fungi growth either in outdoor or indoor of buildings.

Previous Research

Although there have been many researchers who investigate about indoor air quality, few of them focus on remediation for fungal growth. So it is necessary to study on remediation of fungal growth on material construction by using biocide that is proven to reduce the fungal growth. Bellotti *et al*., (2013) identified the application of bioactive compounds from food industry which was able to control mould growth in indoor waterborne coatings. In addition biocides such as zinc salicylate, zinc benzoate, calcium benzoate and potassium sorbate have been used to treat *Chaetomium globosum and Alternaria* alternate and the bioassays revealed that zinc benzoate and zinc salicylate proved to be active against both fungi.

In addition, in a study by Vacher *et al*., (2010), it was analyzed that there was partial resistance to fungal growth on biodegradable materials when Dibromo-3-Nitrilopropionamide was used as a biocide to treat Penicillium or Aspergillus, Chaetomium, Ulocladium, Stachybotrys and Cladosporium. For biocides nano zinc oxide and anatase titanium dioxide used by Hochmannova & Vytrasova (2010) on photocatalytic and antimicrobial effects of interior paints, nano-form of ZnO was found to be the best photocatalytic agent and also the best broadest spectrum antimicrobial agent for these interior paints to treat *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, fungi Aspergillus niger and Penicillium chrysogenum.*

In 2009, Stanojevic *et al*., concluded that the biocide application such as sodium benzoate, sodium nitrite and potassium sorbate was able to treat *Bacillus subtilis, Bacillus mycoides, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Aspergillus flavus, Fusarium oxysporum, Candida albicans, Trichoderma harsianum and Penicillium italicum* and Escherichia coli manifested the greatest sensitivity to the combined action of preservatives, with Aspergillus flavus having the greatest resistance. The study was carried out by Smilanick *et al*., (2008) to treat *Penicillium digitatum* using potassium sorbate, imazalil (imz), thiabendazole (tbz), pyrimethanil, and fludioxonil. Potassium sorbate was compatible with these fungicides and consistently improved their performance more effectively when heated. According to Clausen & Yang (2003), the potential of potassium sorbate in test fungi was able to inhibit 5% of a number of fungus such as *Aspergillus niger, Penicillium chrysogenum, and Trichoderma viride.*

Methodology

Collection sampling site

This study was carried out in a new institutional building located in Batu Pahat. Air monitoring was conducted in the building to isolate the indoor fungal prior to in-vitro of biocidal study in the laboratory.

Collection and sampling of airborne fungi method

Three indoor samples were collected in the rooms, while outdoor samples were collected outside the main entrance at the ground floor. Airborne microbes' concentrations were determined using an Anderson single stage impactor, operated at a flow rate of 28.3 L/min as per requirement of National Institute of Occupational Safety And Health (NIOSH) and following the method in NIOSH Manual Analytical Method (NMAM 0800). The impactor was located at the centre of the sampling location at a height of 1.0 to 1.5 meter above the floor. The samples were taken below a 5-minute period to prevent over loading of the substrate. Malt extract agar (MEA) was used for sampling airborne fungi and trypcase soy agar (TSA) for airborne bacteria. Each sample was plated in triplicate. The samples were immediately sealed and kept in a disinfected cool box to inhibit any contamination. Counted microbe was calculated as colonies forming unit per cubic meter of air (CFU/m^3). The fungal samples were incubated at 25°C and the counting was done after a lapse of 5 days. The total bacteria count was done after incubating the samples at 37°C for 2 days (Belloti *et al*., 2013).

Antimicrobial test method

The indoor fungi isolated from airborne fungi sampling was selected into a new medium using streak plating method which steps were referred to Mckerrell (2004). The new isolation was incubated after 5 days for growth (Bellotti *et al*., 2013). The spore solution containing 100 ml of distilled water mixed with approximately 0.85 grams natrium chloride (NaCl) and 0.005 ml Tween 20 were used to prepare the fungal spore suspension (Bellotti *et al*., 2013). By using neubauer chamber improved, the spore concentration was adjusted to $1.0x10^6$ spores/ml. The antimicrobial coatings bio-resistance test was done to study the effectiveness of

antimicrobial agent which was potassium sorbate to prevent fungi growth on wood. Samples of wall finishing in this study was prepared in two conditions, control and biocide treatment sample.

Coatings bio-resistance test

Currently the materials used in construction include wood. Wood can be sensitive to the growth of fungi in extreme conditions. For sample preparation, the steps were referred to Vacher *et al* (2010) and Bellotti *et al*., (2013). The wood was cut to 5cm x 5cm size each. Each of the sample surface was washed with 70% ethanol and allowed to dry for 24 hours before used. An amount of 0.03grams of potassium sorbate biocide was used for treatment samples and applied on wood support. The same procedures were carried out with control wood support. All samples were left dried in laboratory conditions for 24 hours before inoculation with fungal spores. The wood was irradiated with UV-light for 40 minutes to avoid contamination. On the surface wood substrate, a 50 µl aliquot of the spore suspension was placed and distributed homogeneously. During incubation, contamination must be avoided. All the samples, placed in agar plates were incubated at 37°C and the growth was recorded.

Results and discussion

The analyses relied on effectiveness of biocides used in this study. Table 1 shows the total fungi and bacteria count measured in the affected rooms. The total fungi count in the building approached the maximum exposure limit of 1000cfu/m^3 set by DOSH, Malaysia (ICOP, 2010), excluded relative humidity. The high microbe count may be because of centralized air-conditioning system in the building, where it was assumed that the microbe spores would spread to help the microbial growth and this caused the indoor microbial to reach the ASTM standard scale. Figure 1 shows the representatives of fungal and bacterial colonies growth on agar plates. These colonies were isolated and continued the antimicrobial activity by using biocides.

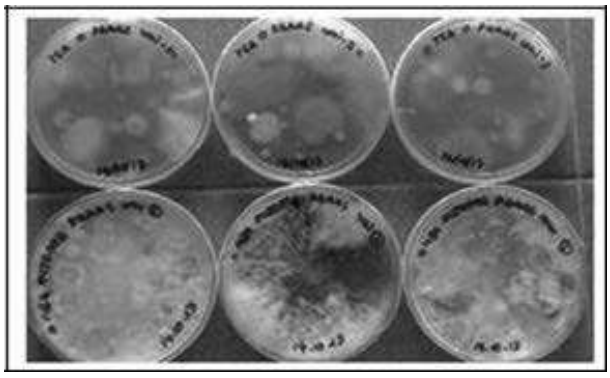
Table 1: Total fungal count in affected rooms

Location	Total fungi (CFU/m^3)	Total bacteria (CFU/m^3)
Acceptable range by ICOPIAQ (2010)	1000	500
Affected Room M146 (FKAAS) (n=3)	806	156

Antimicrobial activity

The result of antimicrobial activity is shown in Figure 2, after 15 days of being incubated. No growth of fungi was observed during the period of day 1 until day 5. Only on day 6, fungi growth was observed on the

Figure 1: Fungal and bacterial colonies growth from affected rooms



surface of the untreated wood, at the recorded scale rating of 1 according ASTM D5590-00 standard specification. Differently with the treated wood with biocide, there was still no growth of fungi observed. On day 9 until day 15, the rating scale remained the same at the rating scale of 2 for the untreated wood. The scale is lower for treated wood than that for untreated wood. Thus, from this test we know that the treated wood can reduce the fungal growth compared to untreated wood which caused to increase the total fungal growth. The ability of wood treated after being added with biocide is proven. From this study, it shows that some fungi can be inhibited, evident from the treated wood sample which supported no growth. This indicates that potassium sorbate is effective in reducing the rate of fungal colony growth.

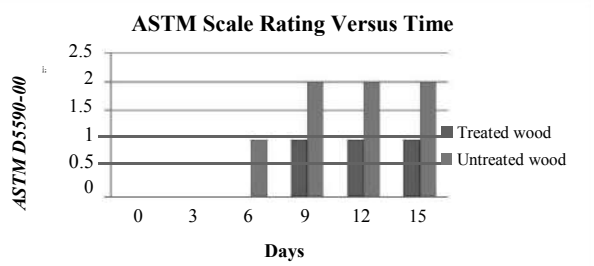


Figure 2: Level of indoor fungal growth for biocide-free wood and biocide-treated wood after 15 days. The observed growth on specimens indicated has been rated as 0,1,2,3, and 4

Conclusion

This study has shown that the application of the biocide is able to reduce the growth of indoor fungal on wood support. Fungi growth is slower after 10 days being incubated. Therefore in the long term, the method should be designed to treat indoor fungal. This is necessary since indoor fungal is a major issue that can cause occupational human disease. A high relative humidity could affect the untreated wood, so substrate with biocide is recommended to support fungal infestation. Thus, it is highly recommended to treat indoor fungal in the affected building by using potassium sorbate to reduce the cost of maintenance. Nevertheless, some improvements are

needed for fully optimization of biocide in the future.

Acknowledgements

The authors wish thanks to MyBrain15 and FRGS (Vote: 1479) for sponsorship of this research.

References

(1). American Society for Testing and Materials (2010). Standard Test Method for Determining the Resistance of Paint films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay. United States: ASTM D5590-00

(2). Bellotti, N., Salvatore, L., Deya, C., Panno, M.T.D., Amo, B.D., & Romagnoli,R. (2013). The Application of Bioactive Compounds from the Food

(3). Clausen, A.C. & Yang, V.W. (2003). Mould Inhibition on Unseasoned Southern Pine.

(4). Brisbane, Australia: USDA Forest Service Forest Products Laboratory One Gifford Pinchot Drive Madison, Wisconsin 53726 USA.

(5). DOSH, (2010). Industry Code of Practice on Indoor Air Quality, Ministry of Human Resources, Malaysia.

(6). Górny, R. L., Reponen, T., Grinshpun, S. A., Willeke, K., (2001). Source strength of fungal spore aerosolization from mouldy building material. Atmospheric Environment 35: 4853-4862.

(7). Industry to Control Mould Growth in Indoor Waterborne Coatings. Journal of Colloids and Surfaces B: Biointerfaces, pp. 140-144. Microbiology, 68, 1743–1753.

(8). Hochmannovaa, L. & Vytrasova, J. (2010). Photocatalytic And Antimicrobial Effects of Interior paints. Elsevier, Progress in Organic Coatings , 1-5.

(9). Kildesø, J., Würtz, H., Nielsen, K. F., Kruse, p., Willeke, K., Thrane, U., Gravesen, S., Nielsen, P. A., Schneider, T., (2003). Determination of fungal spore released from wet building materials. Indoor Air 13(2): 148-155.

(10). Lee, S. C.,&Chang, M. (1999). Indoor air quality investigations in five classrooms. Indoor Air, 9, 134–138.

(11). Mandal, J., And Brandl, H., (2011).Bioaerosol in indoor environment – A review with special reference to residential and occupational locations. Environmental & Biological Monitoring.4,83-96

(12). Mariz, I.D.F.A., Millichamp, I.S., Cal, J.C.D.L. & Leiza, J.R. (2010). High Performance Water-Borne Paints With High Volume Solids Based on Bimodal Latexes. Elsevier, Science Direct, Progress in Organic Coatings, 225–233

(13). McKerrell, M. (2004). Biotechnology: Unit 2 – Microbiological Techniques – Student Materials. Retrieved December 01, 2013, from Learning and Teaching

(14). National Institute of Occupational Safety & Health (2010). Recommendations for the Cleaning and Remediation of Flood-Contaminated HVAC Systems: A Guide for Building Owners and Managers. Retrieved from 9 June, 2013 from: http://www.cdc.gov/niosh/topics/emres/Cleaning-Flood-HVAC.html

(15). Pasanen, A-L., Korpi, A., Kasanen, J.P., Pasanen, P., (1999). Can microbial volatile matabolites cause irritation at indoor air concentrations? Pp 60-65 in (Johanning. ed.)

(16). Bioaerosols, fungi and mycotoxins: health effects, assessment, prevention, and control. ©Eastern New York Occupation and Environmental Health Center, Albany, NY.

(17). Pagliaro, M. & Rossi, M. (2008). The Future of Glycerol: New Uses of a Versatile Raw Material. Retrieved December 10, 2013, from Springer, Organic Chemistry, Future of Glycerol:http://www.springer.com/chemistry/organic+chemistry/book/978-0-85404-124-4 Shelton, B. G., Kirkland, K. H., Flanders, W. D., & Morris, G. K.(2002). Profiles of Airborne Fungi in buildings and outdoor environments in the United States. Applied and Environmental

(18). Spengler, J. D., Samet, J. M., & McCarthy, J. F. (2000). Indoor air quality handbook. In H. A. Burge (Ed.), The fungi (p.45.16). NY: McGraw-Hill Companies.

(19). Smilanick, J.L., Mansour, M.F., Gabler, F.M. & Sorenson, D. (2008). Control of Citrus Postharvest Green Mould And Sour Rot By Potassium Sorbate Combined With Heat And Fungicides. Elsevier, Science Direct, Postharvest Biology and Technology , 226–238.

(20). Stanojevic, L.D., Stefanovic, O.C. & Sukdolak, S.S. (2009). Antimicrobial Effects of Sodium Benzoate, Sodium Nitrite and Potassium Sorbate and Their Synergistic Action In Vitro. Bulgarian Journal of Agricultural Science , 307-311.

(21). Vacher, S., Hernandez, C., Bartschi, C., Poussereau, N., (2010). Impact of Paint and Wall-Paper on Mould Growth on Plasterboards and Aluminum, Elsevier, Building and Environment, pp. 916-92

June 2015, vol 12, No. 1 : 155-160

Web-Based Interactive Accident Cost Calculator For Manufacturing Industry

Jafri Mohd Rohani[1], Hood Atan[1], Wan Harun Wan Hamid[1], Mohamed Fitri Johari[1], Wan Lokman Wan Bedurdin[2], Hafizah Ithnin[2]

[1]Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81300 Skudai, Johor

[2]Innovation and Commercialization Centre (ICC), Industry Centre, Technovation Park, Universiti Teknologi Malaysia, 81300 Skudai, Johor

Corresponding Author: Tel : +607-5534568; Email : jafri@fkm.utm.my

Abstract

Currently accident cost calculations involve lengthy process of data collection procedures. Accident cost calculations can be categorized into direct and indirect costs. Many manufacturing industries are having difficulties in identifying and quantifying the accident cost category. Besides, it involves manual data collection which is time consuming and has high tendency to make errors throughout the process. The data collection process also involves various parties. For example, getting direct cost data from human resource department while indirect cost data need to be obtained from manufacturing and safety department. The objective of this study is to propose Web-Based interactive Accident Cost Calculator (WBACC) for manufacturing industries. This WBACC has two options; option 1: calculations based on input data at the time of accident. Option 2: calculations based on historical data such as previous accident records. Option 1 is much simpler because it only requires accident demographic data while option 2 is much more complex. However, option 2 is more accurate compared to option 1. This proposed WBACC can be used by safety and health practitioners to convince their top management in making decisions especially on safety budget allocation.

Keywords:Web-based accident cost calculator, direct cost, indirect cost, direct-indirect cost ratio, accident-prevention cost ratio.

Introduction

The main objective of this study is to increase awareness and motivation to Safety and Health Officer (SHO) on the importance of total occupational accident costs in manufacturing industry. Another objective is to provide easy to use interactive web-based accident cost calculator system that is reliable and credible to be used by SHO for decision making process and to convince the top management to invest in safety related programmes or activities. Preventing workplace accident would seem to be an effective means of reducing costs due to poor working condition and to convince top management to invest in prevention, the impact of occupational accident must be expressed in terms understood by managers, that is dollars and cents.

Literature Review

The research on accident cost has already begun since 1920s and was pioneered by Heinrich (1959). The study was based on 75,000 cases on occupational accidents. He was quoted as saying that the indirect cost components can exceed as much as four times of direct costs (Head and Harcourt, 1997) and most of work accident costs are hidden and cannot be identified easily.

His direct cost includes hospital and medical cost, cost of lost work time except when it is being paid by the employer without reimbursement, insurance premium and compensation claims. Otherwise, hidden cost that are taken into account are time of injured employee, the other employees who stop work or who are upset; time of foremen, supervisors or other executives who give attention to the injury; time spent by first-aid attendants and hospital department staff when not paid for by the insurance carrier; damage to any machines, equipment and other properties, and interference with the site's production; costs to the employer of welfare and benefit systems and continuing the full wages of the employee after returning to work who are not fully recovered; loss of profit on the injured person's production, on idle machines; overhead (e.g., lights, heat) when the employee is away or not fully productive.

Heinrich claimed that there is linear correlation between direct and indirect cost. This ratio (1:4) has been widely used in safety management since the last five decades due to its simplicity. Besides, safety practitioners have long used this ratio to inform the management on total accident costs (Manuelle, 2011). Then, conclusion made by Heinrich was extended further by Bird (1974) by representing this finding into graphical form which is easier to understand and also known as Accident Cost Iceberg.

The indirect cost proportion is much larger than the cost directly related to an accident. He added that direct cost can be estimated based on the nature of accident while indirect costs still remain a major obstacle to

determine for each cost component.

However, Simonds and Grimaldi (1956) argued that many cost components included in Heinrich's study can be termed as direct cost in the sense of appearing as distinct monetary outlays in a firms financial accounts. Therefore, they proposed an alternative terminology of direct and indirect cost based on insurance coverage. Cost that is covered by insurance is regarded as direct cost while indirect is a cost which is not insured by insurance body. This study has prompted many researchers to redefine their definition of direct and indirect costs.

In separate issue, Manuele (2011) claimed that the ratios that have been determined by Heinrich (1931), Grimaldi and Simmonds (1989) are invalid although the elements of direct and indirect cost categories are differed from those studies. The basis of this statement is direct cost of accident has increased in the past 15 years at greater pace than indirect cost.

Study done by Head and Harcourt (1997) also depicted different conclusion when they established ratio direct to indirect cost of 2.9:1. Laufer (1987a,1987b) cost assessment indicated that insured to uninsured cost ratio stood at 3:1. Thus, it is hard to generalize the ratio obtained by different researchers since each of them has different interpretation of direct and indirect components whereas each study would include different cost components in its study. In addition, it is not accurate to say indirect cost will always be more than direct cost since opposite findings have already been demonstrated in previous studies.

In fact, the study done by Heinrich was conducted back in 1920s. The validity of the ratio calculated at that time is something that can be questionable due to enormous change in business and industry since past decades. Besides, structural change in compensation system and work practice will definitely influence the ratio between direct and indirect costs.

The variation of direct and indirect cost ratios is affected by several factors. The factors identified are type of process, criticality of the workstation where the accident happened and severity of accident (Everett & Frank, 1996). In addition the ratio can vary between 1:1 to 20:1 and largely depending on cost calculation methodology adopted by the researchers and type of industry sector (Dorman, 2000).

Despite of those arguments on ratio calculations, the classification of workplace accident cost used still maintains its relevance and has staying power. Jallon *et. al* (2011) found that most researchers separate workplace accident cost into two categories which are direct and indirect costs. Direct cost is regarded as visible components which is easily identifiable by the employers and they are already aware of its existence in the event of accident. On the other hand, indirect cost is also known as invisible cost, which is hidden and poses more difficulties in cost quantification. Employers always tend to underestimate this type of cost.

Nevertheless, there is no consensus on the definitions of these cost types but this kind of distinction of direct/ indirect cost is often used in scientific literature. Common cost components that are always being included in direct cost category are cost of hospitalization and ambulance service, cost of accident victim's compensation and cost of medical expenses and rehabilitation cost (Neville, 1998; Hinze, 1991; Leigh *et.al*, 2004; LaBelle, 2000, Heinrich, 1959, Brody *et. al*, 1990a,1990b).

Generally, direct cost is covered by government compensation body or private insurance company. These two entities would compensate the victims and cover hospitalization and injury treatment costs. Besides, employers are obliged to pay annual premium for this accident coverage and the fees are reflected in risks posed by organization activities.

In contrast, Sun *et. al*. (2006) categorized indirect cost components into four groups which are:

- Legal and administrative cost: resources that need to be allocated by the employers in terms of manpower or financial aspects. The resources are utilized to do data entry in the accident registry, issue accident notification report, compile accident statistics and monitor the file

- Productivity costs: when accident occurs, the company may need to shut down its plant with directive from DOSH. This will require overtime when the plant is set to resume its operation in order to fulfil customer demand and cause production delay at the same time

- Replacement costs: any injured or dead workers need to be replaced to maintain production output. An additional worker would incur hiring cost and cost that is associated with staff training.

- Cost of investigation: internal and external investigation team will be dispatched to the accident location once workplace accident happens. This team will assess the cause of accident before taking any further actions. Deployment of this investigation team involves certain cost since they need to spend their time to focus on this accident rather than doing their normal job.

System design

Accident Cost Calculator software development project was launched by Universiti Teknologi Malaysia in 2014. The objective was to produce web-based accident cost calculator system to predict costs of any occurrence of worker-related accident(s) at the workplace. Figure 1 shows web-based interactive accident costs system including user module for administrator, private and

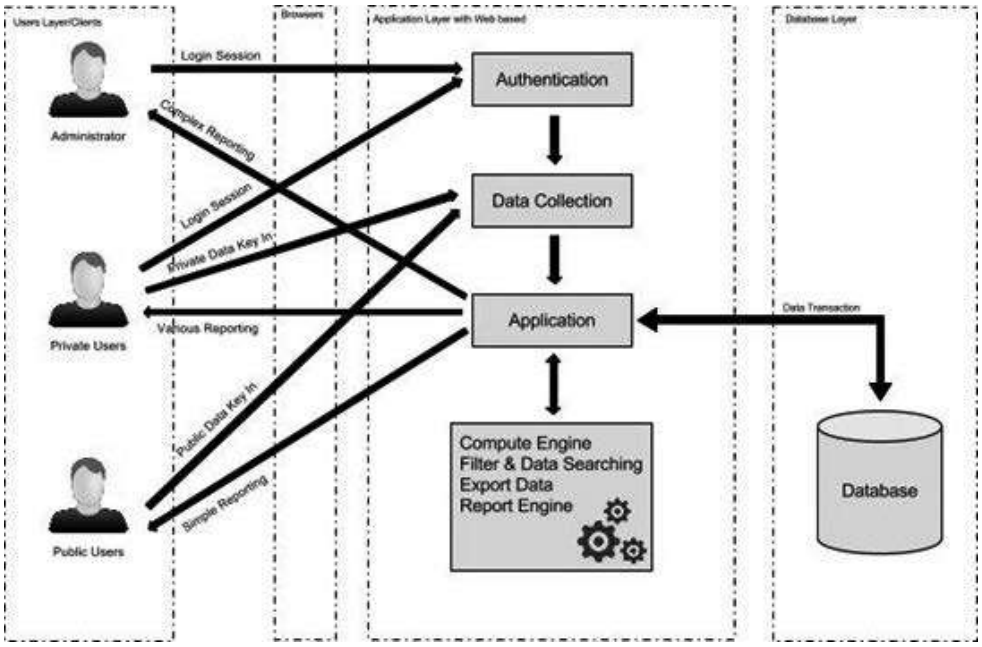


Figure 1: System design of Accident Cost Calculator

public user. Initial application of the software is for the manufacturing sector, which would later be extended but not limited to; construction, agriculture, utility and public sectors. Each sector differs on parameter and coefficient in its accident cost calculation thus each would have its own module. This software also includes three modules which are user module for administrator, module for private user and module for public user. Administrator module has access to data collection generated from software for private and public users. Accident statistics, direct and indirect accident costs, etc. can be collected and further analysed through this system. With aid of these data, common cause for workplace accidents can be identified and safety measures can be proposed.

Private users have access to the system and are able to retrieve their recorded data and generate simple analysis. Public users are encouraged to use the system to gauge their accident costs without data retention. This web-based application software is accessible through multiple platforms of various operating systems such as Windows, Macintosh, Linux, etc. It is also able to support various internet browsers such as Internet Explorer, Mozilla Firefox, Google Chrome and many more.

Accident Cost Calculator

- *Web-based Interactive Accident Cost Calculator For Manufacturing Sector*

Web-based Interactive Accident Cost Calculator will be hosted at ICC-UTM . The target users are manufacturing companies which need to estimate occupational accident costs at workplace. The system can be extended further for other industries or services as well for example construction, utilities, agriculture, public sector in the future. There are three options available for different types of users; administrator, private user and public user. As for public user, there is no login required and the user can estimate the total accident cost based on demographic data. No information will be captured by the system when the public user logout from the calculator. If the user opts to calculate the total accident costs and other statistics, the user will require to login and the confidentiality of the data will be preserved.

- *Input required to use accident cost calculator*

  i. Demographic profile of the victim: name, age, gender, citizenship, etc.

  ii. Company profile: name, address, sector, types of industry, number of workers (Malaysia and non-Malaysia)

  iii. Accident profile: location of accident, types of severity (temporary disability (HUS), permanent disability (HUK) and fatal (FOT) cases,), cause of accident, location of body injury, type of injury, number of medical leave.

  iv. Accident cost information: direct cost, indirect cost, prevention cost and personal cost

- *Overview of the system*

  - Welcoming page of Accident Cost Calculator
  - Input your information (fill-up information as required):
    - Fill-up required information on demographic profile as in part i
    - Fill-up required information on company profile as in part ii
    - Fill-up required information on accident

profile as in part iii

- After the user fills up required information in part i, part ii and part iii, the user can now estimate roughly the direct cost, indirect cost and total cost of accident. This method is called Option 1 in our accident cost calculator.

- If the user is interested to calculate the true cost of accident, the ratio prevention cost to total cost of accident and personal cost, the user can proceed to fill-up the required information in part iv. This method is called Option 2.

▪ Perform calculation (predict the cost of accident)

- Predict the accident cost:

- Yes (do calculation) or No (Cancel)

▪ Output of the accident cost calculator

i. All input in part i, part ii, part iii and part iv.

ii. Total accident cost

iii. Total direct cost

iv. Total indirect cost

v. Total personal cost

vi. Total prevention cost based on HIRARC Principle; Elimination and Substitution, Engineering Control, Administrative Control and Personal Protective equipment

▪ Reporting

- Print

- Save (PDF file)

- Email to (PDF File)

Conclusion

This study has proposed two options for accident cost calculation; Option 1: To predict rough estimation of total accident cost based on demographic data. Thus, the user only requires data related to the accident such as number of medical leave, types of industry, number of non-Malaysian workers and nationality of the workers. After that, the predicted direct cost of the accident can be estimated. Then ratio default value will be used to estimate indirect cost. The ratio default value is based on the range of predicted direct cost. For Option 2: To calculate the actual accident cost based on previous accident records. The input data requires calculations of each cost component for direct cost and indirect cost. In order to calculate direct cost the user requires input on medical cost, rehabilitation cost, compensation cost and funeral cost. As for indirect cost, the user requires input about productivity loss, worker replacement cost, legal and administration cost, investigation cost, machine and equipment damage cost, product cost, fine or penalty and other costs. Option 2 is much more detailed compared to Option 1. However, Option 2 will give more accurate results compared to Option 1. Therefore, the SHO has two options for calculating total accident cost.

Acknowledgements

We wish to express warm appreciation to the management of Department of Occupational Safety and Health (DOSH) Headquarters office for providing the funding for this study. We would also like to thank DOSH state offices (Penang, Pahang, Kedah, Johor, Selangor and Sarawak) for their cooperation throughout this study.

References

(1). Bird, F. (1974).Management Guide to Loss Control. Atlanta, GA: Institute Press.

(2). Brody, B., Létourneau, Y., & Poirier, A. (1990a). Le coût des accidents de travail: État des connaissances. Relations Industrielles, 45(1), 94–116.

(3). Brody, B., Létourneau, Y., & Poirier, A. (1990b). Les coûts Indirects des accidents du travail. Rapport de recherche R-044.. Montréal, QC: IRSST

(4). Dorman, P. (2000). The economics of Safety, Health and Well being at work. Geneva: International Labour Organization.

(5). Everett, J. G., & Frank, P. B., Jr. (1996). Costs of Accidents and Injuries to the Construction Industry. Journal of Construction Engineering and Management, 122(2), 158–164.

(6). Head, L., & Harcourt, M. (1997). The direct and indirect costs of Worplace Accidents in New Zealand. Proceedings of the 11th AIRAANZ Conference, January 30 – February 1, 1997, Brisbane, Australia.

(7). Heinrich, H. W. (1959).Industrial accident prevention: A scientific approach (1931 for the 1st ed.; 1941 for the 2nd ed.). (4th ed.). New York, NY: McGraw Hill.

(8). Hinze, J. (1991).Indirect costs of construction accidents. The construction Industry Institute (CII), Source document 67, Austin, TX.

(9). LaBelle, J. E. (2000). What do accidents truly cost? Determining Total Incident Costs. Professional Safety, 45(4), 38–42.

(10). Laufer, A. (1987a). Construction accident cost and management safety motivation. Journal of Occupational Accidents, 8(4), 295–315.

(11). Laufer, A. (1987b). Construction safety: economics, information and management involvement. Construction Management and Economics, 5,73–90

(12). Leigh, J. P., Waehrer, G., Miller, T. R., & Keenan, C. (2004). Costs of occupational injury and illness across industries. Scandinavian Journal of Work Environment and Health, 30(3), 199–205.

(13). Manuele, F. (2011). Accident costs. Rethinking ratios of indirect to direct costs. Professional Safety,(Jan 2011), 39–47.

(14). Neville, H. (1998). Workplace accidents: they cost more than you might think. Industrial Management (Norcross, Georgia), 40(1), 7–9.

(15). Simonds, R. and Grimaldi, J., 1963, Safety Management; Accident Cost and Control (Homewood, IL: Richard D. Irwin, Inc.).

(16). Sun, L., Paez, O., Lee, D., Salem, S., & Daraiseh, N. (2006). Estimating the uninsured costs of work-related accidents, part I: a systematic review. Theoretical Issues in Ergonomics Science, 7(3), 227–245.

June 2015, vol 12, No. 1

June 2015, vol 12, No. 1 : 161-164

Statistical Analysis of Metalworking Accidents within Small and Medium Enterprises (SMEs) in Malaysia

Kamarizan Kidam[a*], Hairozie Asri[b] , Zainazrin Zainal Abidin[a], Zulkifly Sulaiman[b], Mimi Haryani Hashim[a], Adnan Ripin[a], Mohammed Wijayanuddin Ali[a], Hazlee M Safuan[a], Saharudin Haron[a], Norasikin Othman[a] , Zaki Yamani Zakaria[a], Mohamad Fazli Masri[b], Syed Abdul Hamid Syed Hassan[b], Nazruddin Mat Ali[b], and Azman Ahmad[b]

[a] *Department of Chemical Engineering / Institute of Hydrogen Economy, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Malaysia.*

[b] *Department of Occupational Safety and Health, Aras 2, 3 & 4, Blok D3, Kompleks D,Pusat Pentadbiran Kerajaan Persekutuan 62530 W. P. Putrajaya, Malaysia.*

Corresponding Author: Tel : +607-5535519; Fax : +607-5588166; Email : kamarizan@cheme.utm.my

Abstract

Small and Medium Enterprises (SMEs) are known to be one of the major contributors to the national economy. However, in terms of Occupational Safety and Health (OSH) implementation and performance, these SMEs, especially in the metalworking sector have yet to meet the necessary standard. This paper discusses the statistical analysis of accidents in metalworking industry by using accident reports submitted to the Department of Safety and Health (DOSH) which involved 740 accident cases. The main objective is to identify the real causes of accidents and recommend an appropriate action plan for accidents prevention at the workplace.

Keywords:Metalworking Industry; SMEs; Accident Analysis; Accident Causes; Machine.

Introduction

SME refers to small and medium enterprises. In Malaysia, SMEs are one of the sectors that drive the growth of the economy. However, OSH issues in the SMEs have become a major concern due to the fact that about 80% of total accidents in Malaysia are from this sector (Surienty, 2012). Moreover, the accident rate at SMEs showed 30% to 50% higher than larger companies. Compared to multi-national companies (MNCs) in Malaysia, they are adhering well to the philosophy of self-regulation for people at work to enhance the OSH compliance.

According to DOSH Malaysia annual report (DOSH, 2014) the level of SMEs employers' compliance with the Occupational Safety and Health Act (OSHA) 1994 and its regulations is still not up to the standard and needs further improvement. It is been claimed that the common reasons that led to poor levels of OSH performance in SMEs are due to factors such as lack of expertise, resources or manpower (Surienty, 2012). Common problems such as lack of capital and qualified manpower have always been highlighted as excuses for the unacceptable level of occupational safety and health in SMEs.

To overcome such problems, the government, through specific agencies such as Malaysia's Small Medium Industries Development Corporation (SMIDEC), have provided various incentives including grants for skill training and allocations for quality and productivity improvement. However, the same problems remain and are continuously being brought up by the SMEs when issues on occupational safety and health are discussed.

In this paper, the actual causes of the problems in the SMEs are explored through a detailed study on accident reports available from DOSH databases. Besides, researching and discovering the factors that lead to low compliance of OSH among the SMEs, the data will be used in this study to formulate more effective approaches for accident prevention in SMEs. The ultimate goal is to recommend appropriate and practical action plan for improving and upgrading OSH in SME sector.

Methodology

Accident analysis is chosen as the research methodology of the paper. Accident analysis is a method that involves the collecting and analysing of accident data from selected data sources by frequency analysis. In this research, accident data involving both local and foreign workers will be used. A total of 740 accidents data have been collected from DOSH Malaysia. The analysis of statistical accident data in this research involves three states of Malaysia which are Johor, Melaka and Selangor. The data extracted from the accident reports are being properly analysed and presented in the form of frequency and accident ranking. By studying these accident reports, the real causes of accidents can be identified.

Results And Discussion

Statistical analysis of 740 accident cases has been carried out by using accident analysis methodology. The focus of the paper is to identify the basic and root causes of accidents as well as the most risky machineries that are commonly involved in accidents within the metalworking sector.

Basic Causes of Accident

The pie chart in Figure 1 illustrates the basic causes of accidents related to metalworking industries of SMEs. The basic causes of accidents can be divided into four major categories which are organizational failure, human failure, machine failure and work surroundings. From the pie chart, Organizational failure, which is 47% from a total of 740 reported cases, is the highest factor that contributed to accident followed by human failure which is 36%, machines failure 11% and last but not least work station factor which is 6%.

In the organizational aspect of OSH, the common problems are related to poor OSH commitment by the employer and OSH implementation on site. The factory owner failed to capture the spirit of self-regulation and as low as reasonably practicable (ALARP) in risk management as gazetted in OSHA 1994. Due to this limitation, their awareness and commitment towards OSH are seriously "*corroded or compromised"* in terms of quality and productivity of the operation.

According to the accident report analysis, human failure is the second highest cause of accident due to manual or semi-automatic operation of most machines in the SMEs. This type of operation requires major human involvement. The need of humans to run these machines is necessary since majority of the metal work is routine, simple and obvious. In this case, the employees "*mine-set or perception"* on occupational hazard is low (i.e. take it easy or normal) and at the same time, majority of them *"accepted"* the hazard related to their work. The machine operator believes that the design of the "*machine is error-free"* and "*nothing"* can be done to control the machine hazard. Due to these conditions, accidents naturally occur in accordance to Normal Accident Theory (NAT) proposed by Perrow (2001).

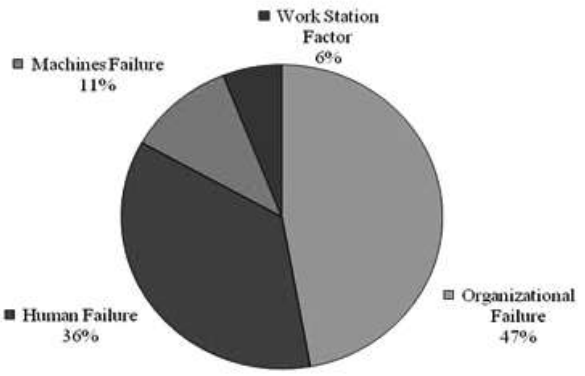


Figure 1: Basic causes of accident based on the data recorded by the Department of Occupational Safety and Health (DOSH) databases

In addition, machine failure caused 11% of the total 740 cases of accidents. It is usually caused by lack of safety measures such as no machine guarding or easily open guard. Machines such as forming roll, roller and power press can cause danger to the workers and guarding is an important measure to protect the workers from possible hazards. Aging equipment also leads to the prevalence of accidents in metalworking industry. Moreover, the technology of the machines itself such as no and inadequate sensor as well as no interlock system also caused accidents in the metalworking industry.

Workstation factors for instance inadequate lighting, noise, improper plant layout, crowded space, lack of accessibility, humidity and heat contributed to 6% of the total accidents reported. However, lighting and noise are not really contributing to the accidents since the occurrence of the accidents caused by lighting and noises are really low. Moreover, these unsafe conditions support the other basic factors of accident, in particular human errors.

Root Causes of Accidents

A root cause of accidents that is divided in detail from the basic causes of accidents (from Figure 1) is presented in Figure 2. From the chart, lack of supervision (18%) is the highest root cause of accidents. Mistakes and lack of procedure are recorded second and third with a percentage of 16% and 12% respectively, followed by violation (11%).

The common issues on the organizational failure are related to lack of supervision which recorded the highest root cause of accident (18%), inadequate or no OSH documentation such as Standard Operating Procedure (SOP), lack of OSH management and safety committee as well as lack of training. The findings are as expected because of the characteristics of metalworking industries within SMEs. They are usually small scale companies with lack of workers and financial resources which contributed to the lack of management supervision and accidents. However, these companies are still subjected to the employers' responsibility as required in Section 15 (2) of OSHA 1994. Basic OSH requirement still needs to be fulfilled for safe operation.

Mistakes by humans while operating the machine recorded as the second highest because humans make errors or mistakes in their actions and judgments due to poor reasoning, carelessness and insufficient knowledge and training. Humans also tend to make mistakes when they are tired as they become exhausted due to long working period.

Lack of procedure caused 12% out of the 740 accidents. Lack of procedure in an organization can reduce the understanding of the workers towards the

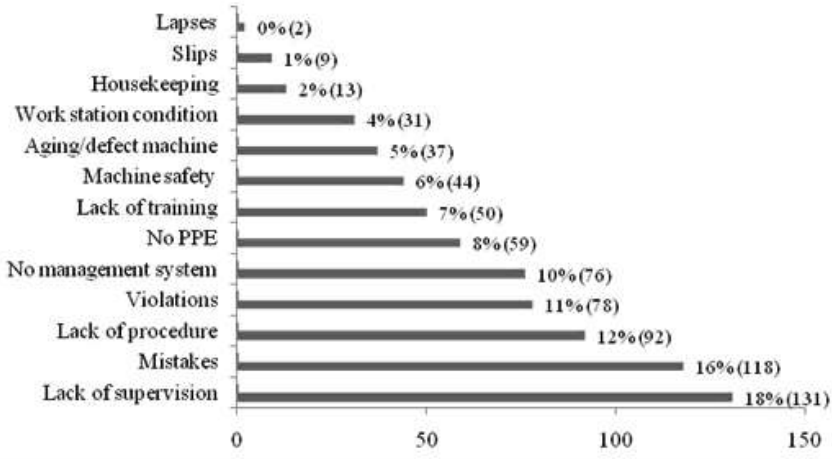


Figure 2: Root causes of accident according to data analysis from the DOSH databases

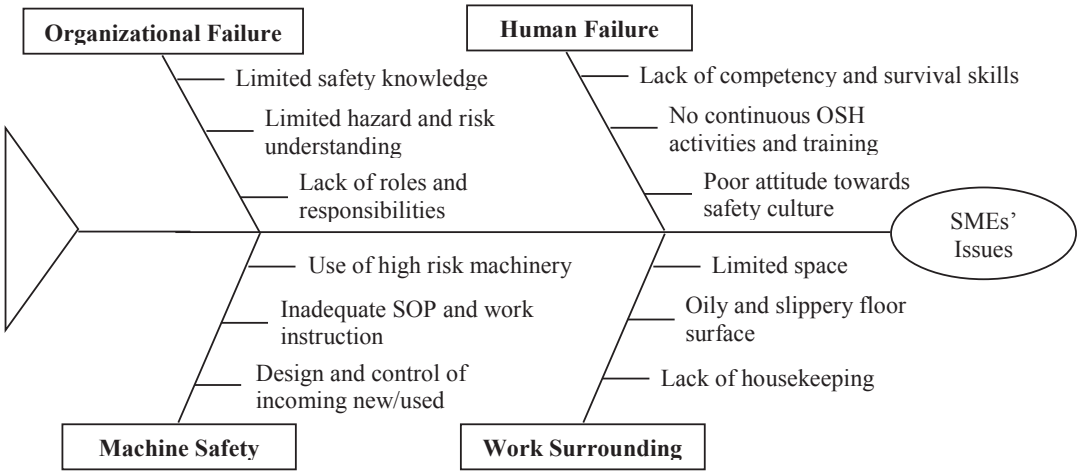


Figure 4: SMEs' Issues

task they are performing which can lead to accidents. The organization needs to provide a complete and proper standard operating procedure in order to avoid accidents caused by lack of procedure. Violation is another common root cause of accidents in the metalworking industry which caused 11% of the accidents followed by no management system (10%) and no PPE (8%). Violation and no PPE occurred due to human factor while performing job with the machines. This usually happens if employees are not aware of the possible hazards and risks that might occur if they violate the machines working procedures and ignore proper PPE provided by the management.

Conclusion

Based on the findings from this research, it is clear that there are many OSH related issues and problems associated with SMEs. These issues are being grouped into four distinct OSH elements as systematically illustrated in a fish-bone diagram in Figure 4.

Statistically, the basic causes of accidents based on the data recorded can be divided into four major categories, which are organizational failure, human failure, machine failure and workstation factor. In the analysis, organizational and human failures are among dominant factors to cause accidents due to lack of supervision and low safety management system implemented in SMEs. Human mistakes also play an important role in causing accidents to happen mostly due to the lack of workers' training and knowledge.

To improve this situation, suitable action plans at different levels of OSH implementation could be done in Malaysia which includes in the area of enforcement, experience feedback system, safety management system, and safety culture. Focus will be given to prevent accidents from design, technical, organizational and human aspects by utilizing layer of protection concept such as inherently safer, passive engineered, active engineered and procedural. A balanced approach in risk management should be emphasized for effective accident

prevention at the workplace. Basically, improving the readiness of factory, machineries, work station and people on OSH aspects will lead to increasing OSH awareness and implementation within the SMEs. By acting upon these overall and balanced OSH action plans, it is believed that OSH compliance level can be significantly increased and accidents at the workplace can be reduced.

References

(1). DOSH (2013). Annual Report 2013, Department of Occupational Safety and Health, Malaysia, available for download at www.dosh.gov.my

(2). SOCSO (2013). Annual Report 2013, Social Security Organization, Malaysia, available for download atwww.perkeso.gov.my/en/report/annual-reports.html

(3). Surienty, L. (2012). Management practices and OSH implementation in SMEs in Malaysia. Universiti Sains Malaysia. Retrieved October 1, 2013, available for download at http://ilera2012.wharton.upenn.edu/refereedpapers/surientylilisilera.pdf

(4). Perrow, C (2001). Normal Accidents: Living with High-Risk Technologies, Nasic Books, New York.

June 2015, vol 12, No. 1 : 165-170

Analysis Of The Perception Of Occupational Accidents In Mining And Quarrying Sector Towards A Safe And Healthy Working Environment

***Nur Azlina Abd Rahman[1], Muhamad Arifpin Mansor[1], Ahmad Rasdan Ismail[2]**

[1] Faculty of Technology, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia

[2]Faculty of Creative Technology and Heritage Universiti Malaysia Kelantan Beg Berkunci 01, 16300 Bachok, Kelantan, Malaysia

Corresponding Author: Tel : +6013-2979770; Fax : +609-5492147; Email :nazarlin2519@gmail.com

Abstract

The occurrences of occupational accidents and incidents are increasing in parallel with the growth of industries such as mining and quarrying. The main objective of this study was to analyze data on the perception of occupational accidents in the mining and quarrying sector in Malaysia. The data was collected and examined based on the questionnaires on the level of perception of accident investigation in mining and quarrying sector. Statistical data reported by the Department of Occupational Safety and Health (DOSH) was also reviewed. The findings of this study prove that the level of perception of workers towards occupational accident issues in mining and quarrying sector is still in the moderate level with the mean value of 3.28. The findings show that 51.7% of the workers agree while 25.9% totally agree to the accident occurrence. Only 1.7% of the workers are not aware of accident occurrence at the workplace. Employers and employees must carry out their responsibilities to prevent accidents by adhering to health and safety practices at the workplace.

Keywords:Occupational accident; Accident prevention; Safety; Mining; Quarry.

Introduction

Accidents at the workplace occur every day and the situations become worst by day, causing major concerns to almost all types of industry. In Malaysia, each sector has its own occurrence of accidents involving fatalities and injuries which include permanent disabilities and non-permanent disabilities. Most sectors such as manufacturing, construction, and agricultural industry are reported to have the highest recorded number of accidents. A lot of previous studies have highlighted the characteristics (1,2), causes (3,4) and the rates of accidents in those sectors (5) but there have been a lack of studies in other sectors such as mining and quarrying.

In Malaysia, the number of occupational accident occurrences in mining and quarrying sector is low and not too serious when compared to that of other sectors such as manufacturing, agricultural, forestry and construction which have been recorded to have the highest number of occupational accidents in year 2013. However, occupational accident statistics (6) by the Department of Occupational Safety and Health (DOSH), Malaysia (Table 1), clearly shows that manufacturing, construction, agricultural, forestry, logging and fishing sectors are the biggest sectors which contributed to the largest economic growth rates with the highest number of accidents involving death, non-permanent disability and permanent disability cases Many studies have highlighted these three sectors with regards to the statistical occupational accidents. However, there is a lack of studies in mining and quarrying sectors which, in fact, are the much bigger sectors that provide larger income and economic growth despite the risks in this industry.

Mining and quarrying industry has its own laws and policies enacted by the government as initiatives, an example of which is the introduction new mining and quarrying laws. The laws and policies in mining and quarrying activities are enacted by the Mineral Development Act 1994, the State Mineral Enactment, the Mineral Development Act 525 of 1994 and the Quarrying Rules under the National Land Code. The Mineral Development Act 525 of 1994, defines the power of the Federal Government for inspection and regulation of mineral exploration and mining and other related issues.

Mining and quarrying are not a highly ranked sector but are always known to be the main contributor to the accident rates in the industry and they remains as one of the most hazardous occupations. A study by Lirong. W. *et al*. (7) briefly describes the overview on the safety record of the mining industry. There was a decreasing trend in the fatalities rate from 90 cases in 1999 to 53 cases in 2008. However, this is not an indication of safety improvements in this industry since the decrease in fatalities is only temporary. There are high possibilities that accidents will occur because of the high risk nature of the industry. The analytical study of occupational accident is the initial key for illustrating and evaluating the evolutions of the rules and regulations in the mining and quarrying sector particularly pertaining to the

Table 1 : Occupational Accident Statistics by Sector

Occupational Sectors	Number of victims		
	Death (D)	Non Permanent Disability (NPD)	Permanent Disability (PD)
Manufacturing	47	1007	93
Mining and Quarrying	1	17	0
Construction	36	55	9
Agricultural, Forestry, Logging and Fishing	26	286	9
Utility	0	65	0
Transport, storage and Communication	7	54	1
Wholesale and Retail Trade	3	54	5
Hotel and Restaurant	0	7	1
Financial, insurance, Real Estate and Business Services	0	48	1
Public Services and Statutory Bodies	0	50	0

Sources: Department of Occupational Safety and Health (DOSH), Malaysia

implementation and prevention rules. As mentioned before, preventive measures could be applied based on the analysis of occupational accidents. Therefore, the main objective of this study was to analyze data on the perception of occupational accidents in mining and quarrying industry in Pahang, by obtaining clues that support the strategies for the accident prevention towards a safe and healthy working environment.

Materials and Methods

In the descriptive study, occupational accident is defined as an unexpected and unplanned occurrence, including acts of violence arising out of or in connection with work which results in one or more workers incurring a personal injury, disease or death (8). The aim of this paper was to determine the perception among the workers on the accident investigation in mining and quarrying industry.

Questionnaires were used as a method for the data collection. The questionnaires consist of four parts presenting the level of safety practices that have been implemented in the quarry and mining industry. Part A comprises questions regarding the level of safety awareness at quarry and mines, while part B comprises questions on the level of perception of workers knowledge on safety and health at workplace. Part C is about perception of carrying out safety and health programme by workers at the workplace, and part D is about accident investigation at the workplace.

A total of 58 samples' questionnaires was distributed to the quarry and mining companies throughout the East Coast of Malaysia. So far, this study method has been applied by using a set of Likert –type scales multiple choice items (9). The questionnaires were distributed to the subjects individually. Each company was given 50 questionnaires, collected after 5 working days.

The awareness, knowledge and compliance of safety among workers in mining and quarrying industry will indicate the level of safety practice. The data was analyzed by computing the mean of each answered question. The computed mean from respondent's answer was categorized into the categorizing framework as Table 2. The range of mean that form the categorizing framework was calculated based on mid – point method

Table 2 : Range of mean for safety and health practice

Scale	Lower range	Upper range	Range of mean	Level of practice
1	0	— + 1 = 1.5	0 – 1.5	Very low
2	— - 2 = 1.5	— + 2 =2.5	1.6 – 2.5	Low
3	— - 3 = 2.5	— + 3 = 3.5	2.6 – 3.5	Moderate
4	— - 4 = 3.5	— + 4 = 4.5	3.6 – 4.5	High
5	— - 5 = 4.5	5	4.6 – 5.0	Very high

(10). Statistical analysis was done using SPSS software (version 20.0).

Results and Discussions

Reliability measure: Questionnaire reliability was tested using Cronbach alpha (α) as shown in Table 3. Rodeghier (9) found that Cronbach alpha (α) is derived from the average correlations of all items on the scale. Meanwhile, the reliability test shown in the Table 4 indicates that out of 5 reliabilities measured, 3 had reliability above 0.7. One item had reliability measure of at least 0.506. The result indicates that the reliability measures are high for the safety perception in mining and quarrying industry.

Table 5 shows the means of safety and health practices in mining and quarrying. Based on Table 5, the overall safety awareness among quarry and mines workers is 3.37 which are still below the satisfaction level. Lack of safety awareness among quarry and mines workers can cause many problems (11). This result further explains the fact that safety awareness is very important in any work since lack of safety awareness may cause accidents at the workplace.

Based on Table 5, the safety knowledge of quarry and mines workers is 3.31 which is also below the satisfaction level. Safety knowledge is very important in order to create a safe working environment and increase the awareness of safety. Lack of knowledge in safety will cause accidents as said by Joy (12), "many accidents occur at mines because the mineworkers are unaware of the rules, aware but do not understand the rules, mistakenly applied the rules, ignored the rules and poorly trained or lacked sufficient educational background". Another study from Neal *et al*.(13) believed that safety knowledge is the mediating factor which contributes in creating good safety environment at the workplace.

Meanwhile for the safety implementation, the mean is 3.18 which shows that they have implemented the element compulsory in Occupational Safety and Health Act (OSHA) 1994. These results reflect their level of compliance towards OSHA 1994 since the questions asked in section of implementation were referred to OSHA 1994. Mekos (14) in his study in Thessaloniki stated that lack of rules and regulations keep contributing to causes of accidents at the workplace. Besides, good safety implementation starts with complying with acts and regulations (15).

Table 3: Characteristic of the sample

Characteristics	Category	Frequency	Percentage (%)	Mean±SD
Gender	Male	42	72.4	1.28±0.451
	Female	16	27.6	
Age	< 20	1	1.7	31.78±9.030
	20 - 29	30	51.7	
	30 - 39	14	24.1	
	40 - 49	11	18.97	
	>50	2	3.4	
Education	SPM	28	48.3	2.24±1.315
	Certificate	4	6.9	
	Diploma	10	17.2	
	Bachelor Degree	16	27.6	
Position	Employer	16	27.6	1.72±0.451
	Employee	42	72.4	

Table 4: Reliability measures using Cronbach's α for tested factors

Tested factors	Cronbach alpha (α)
The level of safety awareness at mining and Quarrying	0.829
The perception of workers' knowledge on safety and health at workplace	0.506
The perception of carrying out safety and health programme by workers at workplace	0.892
The level of perception of occupational accidents in mining and quarrying	0.748

Table 5 : Means of all parts of the questions

Questions	Means
Awareness	3.37
Knowledge	3.31
Safety implementation	3.18
Occupational Accidents	3.28

The occupational accidents have the mean value of 3.28 which is in the moderate level. This result shows that the workers in mining and quarrying have a moderate level of knowledge and perception towards the occupational accident issues at their workplace. Previous studies claimed that employees and employers must have sufficient knowledge and awareness about safety to avoid any occupational accidents (16). Furthermore, occupational accident cases may be higher if there is low awareness, knowledge and safety implementation at the

Table 6 : The percentage respondents' distribution on occupational accident of the workers at their workplace

	n	TD (%)	D (%)	NS (%)	A (%)	TA(%)	Mean	SD
I am aware of any accident occurrence at my workplace	58	1.7	3.4	17.2	51.7	25.9	3.97	0.858
I have experienced minor and major injuries at my workplace within these three months	58	44.8	22.4	17.2	12.1	3.4	2.07	1.197
There are procedures to explain on where and whom to report to if any accident occurs	58	13.8	12.1	17.2	41.4	15.5	3.33	1.276
Any incident and accident which occurred at my workplace was reported to the top Management	58	1.7	1.7	12.1	44.8	39.7	4.19	0.847
Any incident and accident which occurred was reported to the Department of Occupational Safety and Health (DOSH)	58	12.1	5.2	15.5	44.8	22.4	3.60	1.242
The top management at my workplace always announces accidents to all workers as "lesson learned"'	58	1.7	15.5	17.2	44.8	20.7	3.67	1.033
There are first aider teams in my workplace to assist during any emergency/ accident	58	12.1	19.0	22.4	34.5	12.1	3.16	1.225
There are safety campaigns conducted by this company to give awareness on accident prevention at the workplace	58	15.5	24.1	25.9	29.3	5.2	2.84	1.167

workplace.

Table 6 shows the analysis made on the perception towards occupational accident at their workplace. Most of them (51.7%) agreed on any accident occurrence at workplace and 25.9% totally agreed. Only 1.7% were not aware on any accident occurrence at workplace. For the next questions, 44.8% never experienced any minor and major injury and only 12.1% agreed that they had experienced injuries during work. However, these injuries were of minor types which did not require any medical leave. From the distribution of the questionnaires, it was shown that, 41.4% of the respondents agree on the availability of the procedures to explain where and whom to report if any accident happens and only 13.8 % show that they are not aware of the procedures. When an accident occurs, about 44.8% of the workers report the accidents to the top management, while 1.7% do not report to the top management. This is because the accident was just a minor accident.

The result also shows that, 44.8% agree to report any accident occurrence to the Department of Occupational Safety and Health (DOSH), while 5.2% disagree on the questions. Some 44.8% of the respondents agree that the top management at workplace always announces accidents to all workers as "lesson learned". Meanwhile, 34.5% agree that there are first aider teams at their workplace during any emergency and accident. Other than that, about 29.3% agree that their company conducts safety campaigns to give awareness on the accident prevention at workplace and 15.5% do not agree on that statement. This study concludes that most of the respondents realize on the issues of occupational accident at their workplace as the mean of all questions shows moderate values.

Conclusion

Occupational accident in mining and quarrying sector is in moderate level, meaning that it can be prevented. Therefore, most of the common occupational accidents can be prevented with the cooperation of both employers and employees who will consider that it is their responsibility to prevent accidents at workplace. Employers are required to perform risk assessment for possible accidents that can occur and adapt necessary method to prevent accidents based on the health and safety procedures practised by them. Employees then must strictly follow the health and safety measures adopted by their employers to avoid accidents at workplace and to ensure that they can run the operation effectively and efficiently.

Acknowledgement

The authors would like to express their gratitude to the Department of Occupational Safety and Health, Malaysia (DOSH) and Social Security Organization (SOCSO) for sharing some information and to the Universiti Malaysia Pahang (UMP) for funding this research.

References

(1). L. Song, X.Q. He. and C. W. Li. Longitudinal relationship between economic development and occupational accidents in China. Accident Analysis and Prevention. 2011; 43: 82-86.

(2). S. M. Said, Z. A. Halim, F. Said. Workplace Injuries in Malaysian Manufacturing Industries. Scientific Conference on Occupational Safety and Health (SCI-COSH) .2011.

(3). Abdelhamid, T.S. and Everett, J.G. Identifying of root causes of construction accidents. Journal of Construction Engineering and Management, ASCE. 2000; 52-60

(4). Zakaria. N.H., Mansor. N, Abdullah. Z. Workplace Accidents in Malaysia: Most Common Causes and Solutions. Business and Management Review. 2012: 2(5): 75-88

(5). D. N. M. A. Abdullah and G.C.M. Wern. An Analysis of Accident Statistics in Malaysian Construction Sector. International Conference on E-business, ,Management and Economics IPEDR. 2011; 3

(6). Department of Occupational Safety and Health. Occupational accidents statistics by sector until August 2013, Retrieved November 22, 2013. http://www.dosh.gov.my/index.php?option=com_content&view=article&id=843&Itemid=545&lang=en

(7). Lirong. W., Zhongan. J., Weimin. C., Xiuwei. Z., Dawei. L., and Yujing.Y. Major accident analysis and prevention of coal mines in China from the year of 1949 to 2009. Mining, Science and Technology. 2011: 21:693-699

(8). Raouf, A. Accident prevention. Encyclopedia of Occupational Health and Safety.2011;56.

(9). Rodeghier, M., 1996. Survey with Confidence: A Practical Guide to Survey Research Using SPSS. 1st Edn., SPSS Inc., Chicago, IL., pp: 178

(10). Zhuang, Z., and Groce, D.W., 1995, "The national occupational health survey of mining: magnitude of potential exposures to musculoskeletal overload conditions," in Advances in Industrial Ergonomics and Safety VII, A.C. Bittner and P.C. Champney, eds., Taylor & Francis, pp. 273-280.

(11). Guo Wei-ci & Wu Chao, 2011. Comparative Study on Coal Mine Safety between China and the US from a Safety Sociology Perspective

(12). Neal, A., Griffin, M.A., Hart, P.M., 2000. The impact of organizational climate on safety climate and individual behavior. Safety Science 34, 99–109.

(13). Joy, J., 1999. Learning from mistakes in mining. Australian Journal of Mining, June. Retrieved from http://www.qrc.org.au/_files/docs/conferences/OHS_1999/Safety_Joy.doc

(14). Mekos, K. Z.,2010. Complaint reports for violations of health and safety legislation in the area of Thessaloniki (Greece). Safety Science, 48(2), 209–214.

(15). James K.C., Chen & Dulamjav Z., 2013. Managing occupational health and safety in the mining industry.

(16). M. Kamalinia, H. Mohammadi, M. H. Mohrz, M. Arassi, M. A. Faghih and M. Mirzajani. Investigation of occupational accident induce sever injury in Fars, Iran from 2005- 2007 Open Journal of Safety Science and Technology. 2012; 2:113-118.

June 2015, vol 12, No. 1 : 171-178

An Examination Of Commuting Accident In Malaysia

Mohd Nasir Selamat [1] and Lilis Surienty[2]

[1]*Universiti Kebangsaan Malaysia, Selangor, Malaysia*

[2]*Universiti Sains Malaysia, Penang, Malaysia*

Corresponding Author: Tel : +6012-3628941; Email :nasiry0809@gmail.com

Abstract

Recent statistics from the Social Security Organization (SOCSO) of Malaysia shows Commuting Accident (CA) increased consistently by 1500 cases per year from 2008 to 2012. This has resulted in the rising of fatality rate, extensive claims of compensation payment and not to mention loss of valuable talents. However, little is known about the contributing factors to the occurrences of CA in Malaysia because CA is never considered to be work related before. This study aims to explore work related factors with occurrence of CA using 5-year statistical data from SOCSO, Malaysia. Moreover, we also reviewed studies published between 1990s and 2014 to support the statistical findings. Motorbike is found as the most common vehicle used which involved in CA. Individual factors concerning workers behaviour is a main risk factor of CA. Family related factors (parenting responsibility), work burden, workplace support as well as environmental factors such as bad weather and bad road conditions are also significant contributions of CA. It is very important to develop behavioural intervention strategies and provide proper training. Hence, more attention should be directed to young individual workers in balancing them with capabilities and organization performance demand. This may lead to the elimination of the other causes of CA. In conclusion, solutions to this problem involve not only a particular party to ensure the wellbeing of workers in Malaysia, but all authorities should play roles in enhancing safety and health matter of workers especially on the occurrence of accident.

Keywords:Commuting Accidents, Work-Related Factor, Intervention

Introduction

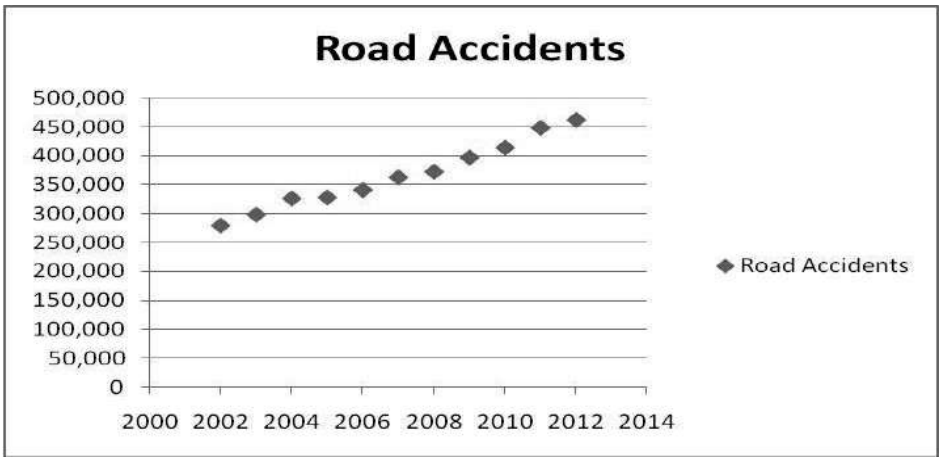
Globally, road traffic injuries become a major cause of death, with approximately 1.2 million mortalities and the number of injuries could be as high as 50 million worldwide annually (Peden *et al.* 2004). Road traffic injuries is the eighth leading cause of death throughout the world and the leading cause of death for young people aged between 15 to 29 years old as reported by global status report on road safety (2013). It is becoming a major concern when the road accident involving people while they are working in an organization. For example, accident can happen on the route between a worker's residence and his work site, from the work site to other places as well as the route between work sites to worker's residence. This refers to Commuting Accident (CA).

In Malaysia, the latest statistics of road accidents is 462,423 cases in which 6,917 cases of fatalities and were dramatically increased from 2011 with 13,383 cases difference (Road Safety Department of Malaysia, 2012). Referring to Histogram 1, the rate of deaths of road accidents was rising beginning from 2005 to 2012 (approximately 7000 death cases in 2012) whereby at least 10% of them happened because of commuting accidents. In other words, it translates into 18 to 20 people killed every day. Motorcyclists and pillion riders formed most of the fatality cases which made up about 60% of the fatalities.

In the same way, the number of CA occurrence is increasing every year and it makes a major problem among the organizations as well as the government. From 2010 to 2011, the CA cases were increasing dramatically to almost 2700 cases. Additionally, referring to Table 1 the total rate of cases had been increasing until 2012, which shows 26,256 cases than 22,036 in 2010. This eventually related with the total number of industrial accidents in Malaysia rising by 2.76% in 2012. Thus, it is becoming crucial to many parties and more effort is needed to avert this problem because it reflects to the persons involved as well as for the economy of organizations. Importantly it affects the cost of compensations, loss of workdays, as well as reduces organization productivity. It can be said that the impact of commuting accidents is greater than industrial accidents as it normally involves multiple injuries.

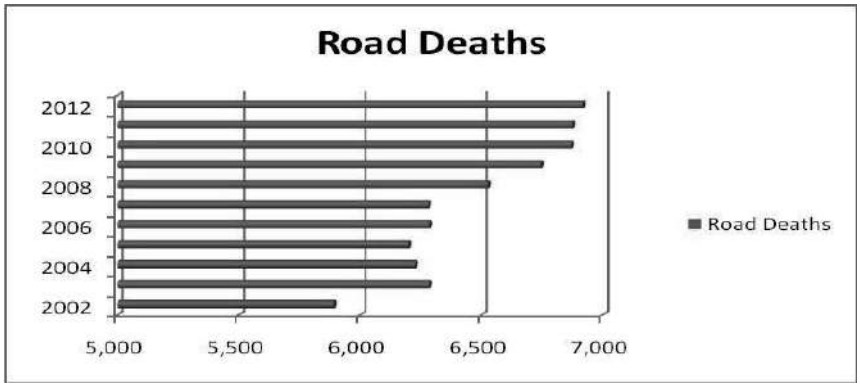
The value of compensation payment from SOCSO to accident victims had increased to almost RM80 million (until June 2012 from RM320 million in 2011). This value came from compensations of numerous cases of accidents in Malaysia. Hence, this paper is conducted to analyze the causes of CA occurrences amongst workers in Malaysia as well to propose suggestions in preventing the problem.

Histogram 1 :
The Number of Road Accidents and Road Fatalities in Malaysia from 2002 to 2012.



Note; Taken from Statistics of Road Accidents in Malaysia, (Road Safety Department of Malaysia, 2012).

Histogram 2 :
The Number of Road Deaths in Malaysia from 2002 to 2012.



Note; Taken from Statistics of Road Accidents in Malaysia, (Road Safety Department of Malaysia, 2012).

Table 1 :
Relative Frequency of Accidents at Work Reported from 2008-2012

Items/Years	2008	2009	2010	2011	2012
Number of accident reported	54,133	55,186	57,639	59,897	61,552
Number of industrial accidents reported	35,092	34,376	35,603	35,088	35,296
Number of commuting accidents reported	19,041	20,810	22,036	24,809	26,256
Accident Rate per 10,000 workers	95	104	104	104	105
Commuting accident rate per 10,00 workers	34	39	40	43	45

Note; *Taken from Schedule of Statistics of Accidents in Malaysia, SOCSO, (2008-2012)*

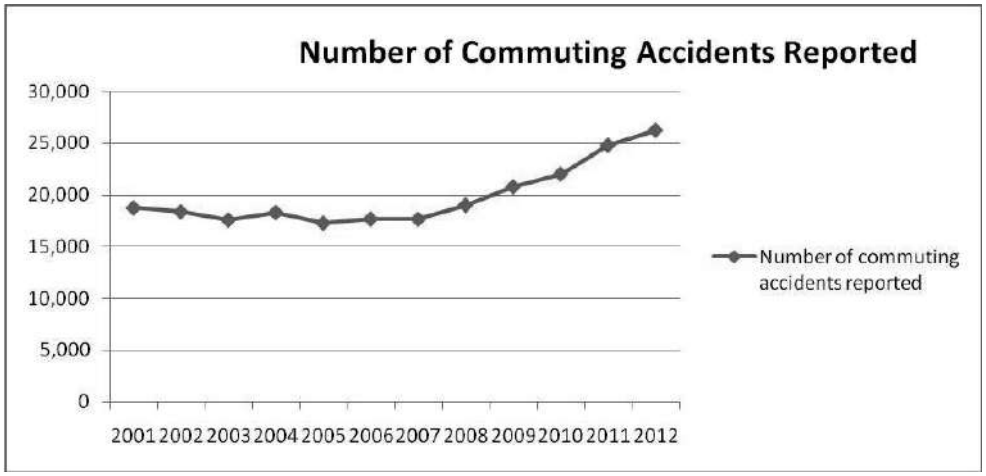
Commuting Accident

One major concern of organization is to protect the workers from risks and health problems while enhancing the well-being and security of workers at work. Due to this concern, occurrence of accidents at work is the most important issue to be given attention. Two types of work-related accidents include commuting accident and accident occurring during the course of work or occupational accident. In Malaysia, more than 40 per cent of work-related accidents are due to commuting accidents (SOCSO, 2012).

CA is defined as accident happening on the route between the worker's residence and the work site as well as on the route from the work site to his residence (Herdiansah, 2013). Occupational accident refers to unplanned and unexpected events, which invariably proceeded by an unsafe act or unsafe condition or a combination or both (DiBerardinis, 1999; Kohn, Friend, & Winterberger, 1996). According to the European Union (2001), an occupational accident can be defined as a discrete occurrence in the course of work, which leads to physical or mental harm.

In Malaysia, occurrence of accident becomes a major

Histogram 3 :
The Number of Commuting Accidents in Malaysia from 2001 to 2012



Note: *Taken from Schedule of Statistics of Accidents in Malaysia, Annual Report SOCSO, (2001-2012)*

concern with the increase of cases every year especially on the CA (as refers in Table 1). CA refers to accidents including from/to place of work, any authorised recess and other work related accidents. CA is generally similar to road traffic accident since both happen on the road. Both types of accidents become major serious problems in which the World Health Organisation (WHO) has arranged a consultation meeting since 2001 and prepared a 5-year WHO strategy for road traffic prevention (Adnan *et al*., 2012). This is because studies found that road traffic injuries are a major cause of death in many countries, with approximately 1.2 million mortalities, and the number of injured people could be as high as 50 million worldwide annually (Peden *et al*., 2004). As reported from SOCSO Malaysia, in 2011 there were 3 cases of work related death happening every day in which 2 cases were concerning CA. Reports also have shown that manufacturing and public service sector contributed higher number of CA that is 50% from the total occupational accidents reported. Furthermore, WHO has reported on related death rates, which the WHO African Region had the highest mortality rate in 2002, at 28.3 per 100,000 populations, followed closely by the low-income and middle-income countries of the WHO Eastern Mediterranean Region, at 26.4 per 100,000 populations (Peden *et al*., 2004).

The occurrence of CA will lead to several impact such as increasing the cost to cover the problems. Study by Joris (2010) about the cyclist accidents on the road has found that seven types of costs need to be covered. These include; (1) direct medical costs, (2) direct non-medical costs, (3) productivity loss, (4) leisure time loss, (5) costs related to permanent invalidity, (6) costs related to pain and (7) costs related to negative psychological consequences. Moreover, it reflects to organization when the accident involves assets and products of organization such as company cars. Individuals will suffer from the accident, which gives temporary or permanent impact on their bodies. A study in 2010 in Malaysia revealed that the percentage of body part injuries showed hand (19.76%) getting more impact than other body parts like head (4.42%), limbs (8.0%) and shoulder (7.73%). It is becoming crucial when victims of CA are diagnosed as disabled or they died.

Methodology

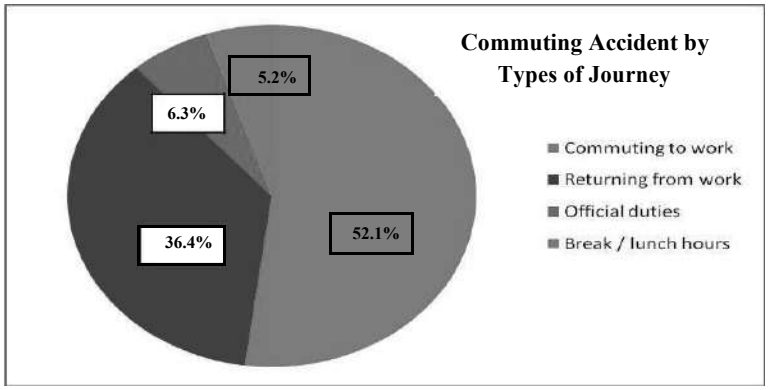
The statistical data from annual reports of SOCSO from 2008 to 2012 were used in this study. These data provide information on the number CA cases amongst workers. Moreover, references were made on related studies since 1980, which present issues indicating the significance of CA at the workplace. Hence, these include several research studies from abroad and local through manual search. Electronic bibliographic databases, conference proceedings, and reference lists were systematically searched for relevant documents.

We first review the conceptual basis of the CA including the definition from experts and others studies. Comparing several definitions will provide an operational definition, which is appropriate to the present study. Moreover, major concern in this study is on the main causes of CA occurrence. The review and comparison of several studies are important to get more inputs with regard to the study aims. Therefore, further explanations are discussed below. Hence, following the discussion, several negative impacts of CA on the workers as well as the organizations will be explained. Finally, it is the utmost intention of the current study to reveal the importance of employers to provide a better safety and health matters to the workers in performing their work.

Major Cause of Commuting Accident Occurrence

Based on several literatures concerning CA, this study finds four major categories of factors that contribute to occurrence of CA. These include individual, workload demand factors, physical environment and

Histogram 4 :
Commuting Accident by Types of Journey 2010.



social environment. Recently, NIOSH, Malaysia has mentioned that there are other underlying factors primarily speeding, reckless driving, hand phone texting and lack of focus which can influence workers to getting involved on CA (NIOSH News, 2013). Traditionally, studies had classified the causes into three major factors: human, vehicle and environmental factors. These factors are commonly referred to as the Haddon Matrix, in recognition of Haddon, Jr (1980). Another study made by Odero *et al*., (2003) found that human factors, including road user behaviour and incapacitation were the most common factors which accounted for more than 85% of all traffic crashes.

Human and Individual Factor

Individual factor is found as a major cause of CA occurrence in Malaysia. Most CAs occurred due to human factors, such as bad attitudes or driving habits, level of age and health as well as behavioural problems of workers.

Some younger workers especially those who are working at fast food restaurants like McDonald, Kentucky Fried Chicken (KFC), have a driving license for less than one year, and thus, not having much experience in handling their motorbikes and other transportations. Moreover, other delivery companies have also seemed to contribute to more occurrence of CA. Serani *et al*., (2011) have also found that younger groups show high proportion of fatality and serious injuries in Malaysia and most of the victims involved in accidents were males. Some riders have been disqualified from handling transportations, but cases of this nature are limited. However, they may put other road users at risks.

Discipline of workers is identified as one of the reasons they are getting involved in accidents. Ignorance of traffic rules such as speeding over the speed limit allowed is a major concern in CA. Not wearing proper helmets, modification of vehicles such as adjusting signal lamp could affect driving performance. For example, a study has reported that some people do not wear proper helmets while riding on residential streets and rural road than riding on the highways and expressways (Kulanthayan *et al*., 2000). This is due to their worry of being detected by the police for non-helmet use on these types of roads, as well as different risks and speed limits on both types of roads.

Other studies identified over speeding while driving contributes to at least 75% of fatal traffic crashes in South Africa (Satchwell, 2002), as well as more than 25 per cent of all traffic accidents in Tanzania between 1999 and 2001 (Barengo, Mkamba, Mshana, & Miettola, 2006). In Malaysia, study found that the locations of accidents from workplace are mostly those who are used to travel between 1km to 5km from their workplace (31%). It seems that delivery workers at fast food restaurants have high possibility contributing to this statistics. For a long journey travel (more than 10km) and short distance (less than 1km) reported 22 percent and 23 percent respectively.

Moreover, texting massages and talking through hand phone while driving have contributed to CA (Oxley *et al*., 2013). Other studies also found that the possibility to increase the high risk and occurrence of accident on the road is due to less concentration because using hand phone while driving and riding (Stutts, Reinfurt & Rodgman, 2001; Regan, Lee & Young, 2008). As mentioned early, the younger male drivers were found consistently involving in this problem.

Study in Iran by Fareshteh *et al*., (2009) with regard to the accident-related risk behaviours associated with motivations for motorcycle users found that there are seven accident-related risk behaviours. These include (1) performing stunts, (2) disobeying traffic rules, (3) driving while under the influence of drugs or alcohol, (4) riding without proper skills or qualifications, (5) illegally transporting passengers, (6) illegally transporting cargo, and (7) not wearing a helmet. These behaviours correspond with four main motivational themes which refer to (1) convenient commuting, (2) occupational transportation, (3) recreation and sensation seeking and (4) criminal activity. Thus, individual factor among workers is one of the factors that is contributing to the occurrence of CA.

Workload Demand Factors

Study was done by Oxley *et al.*, (2013) investigating between two groups; those who are working on shift and do not. They found that, people who are working on shift have a higher possibility to be involved in CA than those who do not work on shift. Study found that morning shift contributed higher number of victim up to 68.8% than evening shift and night shift with 14.6% and 16.6 % respectively (SOCSO, 2010).

Additionally, factor of working overtime with extra workload which burdens the workers will affect their physical and emotional health. This happens when the workers do an extra work. For example, they use their energy more than their capability. This makes them to easily feel tired before going back home. Therefore, the possibility of them to be involved in CA is higher.

Besides, some workers will be rushing while giving service to customers. Limited time and getting stuck on the road develop bad feelings in the workers as they cannot fulfil the customer service well, and therefore some of them may involve in an accident. Fast food restaurants like Pizza Hut, McDonald's, and KFC offer delivery services within 10 minutes upon orders. Thus, limited time to send the orders forces workers to ride as fast as they can, which eventually sometimes cause them to involve in an accident. SOCSO (2012) has reported that 70% of the occurrences of CA were due to these matters. In addition, those who travel on long distances (more than 200km and above on a weekly basis) will experience tiredness that may affect their driving concentration, which eventually could lead them to accidents (Oxley *et al*., 2013).

Physical Environment and Vehicles Factors

Road and environmental condition is one of the factors that contributes to the occurrence of CA. Poor road condition and dangerous road location can easily cause workers to involve in accidents. Due to slippery, traffic jam, as well as hazardous road conditions, the workers do not have any option but still performing their tasks. In this situation, the possibility of them getting into accidents is high, especially when the urgency to complete the task and it is most critical to all the workers. Other studies have also found that weather condition, types of road, time of day and visibility contribute to CA (Golob & Recker, 2003; Jung, Qin & Noyce, 2012; Wang, Quddus & Ison, 2013).

Most motorcyclists in Malaysia are found to easily involve in accidents due to the environmental condition (Ramli, 2013; Serani *et al*., 2011). Study mentioned that the motorcycle-related trauma contributes significantly to road deaths and injuries in Malaysia and this is drawing more concerns. In 2010 alone, 6,872 people died on Malaysian roads and close to 26,000 were injured, and approximately 60 percent of these deaths were motorcyclists (despite contributing to approximately 50 percent of the vehicle fleet) (Malaysian Institute of Road Safety Research [MIROS], 2011).

With regard to the importance of motor vehicles in Malaysia as well as other Asian countries as daily transportation and is mainly used for commuting and running daily errands, a survey in Malaysia was done by Radin-Umar (2006). The survey on motorcyclists' receptiveness on transport and vehicle policies revealed that many Malaysian road users still favour motorcycles as a mode of transportation despite recent Government increment in motorcycle insurance premium. Another study reported that in Singapore crash statistics from 2001 to 2006, motorcyclist fatality and injury rates per registered vehicle were higher than those of other motor vehicles by 13 and 7 times, respectively. (Haque, Chin & Huang, 2009).

Those who travel for a long distance are facing higher possibility of CA incidence. Especially during the night shift, they can be tired and sleepy easily while driving. Bus drivers, lorry drivers and those who use big transportations for long distance travel and work more hours are easily feeling burdened and tired. The concentration to drive is disturbed and this may cause accident. Many cases happened recently in Malaysia concerning bus drivers who were involved in accidents while travelling long distances and putting many passengers at the risk of fatality as well as serious injuries. A study found that 99 commercial drivers including bus and truck drivers confirmed that they have eyesight and eyesight related problems while driving especially at night (Adeoti, 2007). It reported that a lower level of eyesight relates to a higher level of traffic collisions. It becomes crucial with bad weather while driving and this increases the possibility of involving in accidents. Therefore, several aspects need to be taken into consideration in preventing the occurrence of accidents, which can avoid any negative implication on the workers and organizations.

Implication of Findings

It is important to focus on having better solutions in preventing CA from becoming a major problem in Malaysia. Based on the human factor analysis, certain betterment measures include enhancing the safety policy of user road, making effort to change negative behaviours like giving them safety driving and riding training. It is essential to reduce the risks of riding behaviours such as speeding, overtaking, turning safely, and keeping adequate distance between vehicles (Oxley *et al*., 2013). Hence, the findings of this study will help to develop more targeted counter measures to improve cost-effective safety awareness programmes to all workers.

Furthermore, in order to enhance the awareness of OSHA at work, the Malaysian government has taken the responsibility in promoting OSH through Master Plan 2015 (OSH-MP 15). The main aim of the OSH-MP 15 is to build a safe, healthy, and productive pool of human

capital by creating, cultivating, and sustaining a safe and healthy work culture in all organizations throughout Malaysia. Besides, as spelled under Section 15 (2) (c) of the

Occupation Safety and Health Act (OSHA) 1994, it is the duty of all employers to ensure that their workers were not only safe at their workplace, but also while on their journey to and from home.

In order to take care of these matters, workers must understand occupational risks and dangers. CA can be prevented by the changes of human attitude. Awareness and self encouragement would be the best action that need to be taken by individuals while controlling the CA. The roles of human resource management in organization is to enforce OSH aspects including safety-driving training and improving safety culture (awareness). Safety-driving training enables workers to change their behaviour and perform their duties, to be able to protect their lives and health. As mentioned by the Chairman of NIOSH Malaysia, Tan Sri Lee Lam Thye "Employers and employees have to collaborate and be committed to help reduce commuting accidents on our roads", (BULETIN NIOSH, 2013). Moreover, workers' awareness and responsibility towards the organization while working will increase and make workers feel more comfortable in doing their work. Hence, the implementation of several actions while preventing the occurrence of CA can also be altered to impart knowledge that is more practical rather than merely increasing awareness of OSH aspects.

Conclusion

It is found that a significant number of CA are due to individual factors such as terrible behaviour while driving (talking to phone, texting massages, speeding, disobeying traffic rules and others), excessive workloads, and less attention from the employers on the employees' welfare and needs, weather as well as road conditions.

With respect to occupational accident research, there are significant challenges and scope for future researchers. It could be good in the future to gather all the empirical studies in Malaysia and among the Asian countries by looking at the implication of increasing occurrence of CA in terms of economic and values of the company as well as on the workers themselves. It could gain more understanding and cooperation between countries that can develop network and knowledge sharing in resolving safety and health related problems. Additionally, future studies could also focus on closer analyses on behavioural risk factors of CA, for example experienced workload, working climate, as well as the originality rules of workers.

Finally, such comprehensive information could not be gathered in the present study and must be considered as a limitation, with this information being necessary for designing more effective interventional strategies in order to reduce the risk of CA. At the end, this move will enhance the efficiency of OSHA at work, Safety Road Policy and relevance for decision makers, give a significant meaning to improve the competitiveness of employees' productivity, as well as improving the well-being of industry employees in Malaysia and other countries.

References

(1). Adeoti, C. O., Ubah, J. N., Isawumi, M. A., Ashaye, A. O., Oluwatimilehin, I. O., Raji, R. A. (2007). Visual standards in commercial driving. Niger Postgrad Medicine Journal, 14(3), 199-203.

(2). Adnan, A. H., & David, B. (2012). Road safety in 10 countries: A global opportunity Traffic Injury Prevention, 13(1), 1-2.

(3). Barengo, N. C., Mkamba, M., Mshana S. M. & Miettola, (2006). Journal road traffic accidents in Dar-es-Salaam, Tanzania during 1999 and 2001. International Journal of Injury Control and Safety Promotion, 13 (1).

(4). Fereshteh, Z. A., Shamsaddin, N., Mohsen, B., Eesa, M., Ali, M., Fazlollah, A., & Fazlollah G. (2009). Accident-related risk behaviors associated with motivations for motorcycle use in Iran: A country with very high traffic deaths. Traffic Injury Prevention, 10, 237-242.

(5). Golob, T. and Recker, W. (2003). Relationships Among Urban Freeway Accidents, Traffic Flow, Weather, and Lighting Conditions. Journal Transportation Engineering, 129(4), 342-353.

(6). Haddon, W. Jr. (1980). Advances in the epidemiology of injuries as a basis for public policy. Public Health Rep. 95 (5), 411-21.

(7). Haque, M. M., Chin, H. C. & Huang, H. (2009). Modeling fault among motorcyclists involved in crashes. Accident Analysis & Prevention. 41(2), 327-35.

(8). Joris, A., Bas, G., Grégory, V., Bart, D., Steven, B., Leo-De, N., Inge, L., Inge, M., Romain, M., Isabelle, T., Rudi, T., Hanny, & W., Luc, I. P. (2010). Commuting by bike in Belgium, the costs of minor accidents. Accident Analysis and Prevention, 42, 2149-2157.

(9). Jung, S., Qin, X., and Noyce, D. (2012). Injury severity of multivehicle crash in rainy weather. Journal of Transportation Engineering, 138(1), 50-59.

(10). Khon, J. P., Friend, M. A., & Winterberger, C. A. (1996). Fundamental of occupational safety and health. Industrial Technology Department, East

Carolina University, Greenville, North Carolina.

(11). Kulanthayan, S., Radin-Umar, R. S., et al. (2000). Compliance of proper safety helmet usage in motorcyclists. Medical Journal of Malaysia. 55(1), 40-44.

(12). Malaysian Institute of Road Safety Research. M-Roads Crash Database. Kajang, Kuala Lumpur, 2011. Odero, W., Khayesi, M. & Heda, P.M. (2003). Road traffic injuries in Kenya: Magnitude, causes and status of intervention. Injury Control and Safety Promotion. 10 (1–2), 53-61.

(13). Oxley, J. Deepa, R. M., Yuen, J., Hoareau, E. & Hizal-Hanis, H. (2013). Identifying contributing factors to fatal and serious injury motorcycle collisions involving children in Malaysia. 57th AAAM Annual Conference Annals of Advances in Automotive Medicine September 22-25, 2013.

(14). Oxley, J. Deepa, R. M., Yuen, J., Hoareau, E., Mohammed-Azman, A.M., Harun, B., Saraswathy, V., & Prame, K. N. (2013). Commuter motorcycle crashes in Malaysia: An understanding of contributing factors. 57th AAAM Annual Conference Annals of Advances in Automotive Medicine September 22-25, 2013.

(15). Pang T. Yen, Radin-Umar, R. S., Azhar, A. A., Harwant-Singh., Shahrom,A.W., Abdul-HalimM., Zahari, N., & Mohd-Shafie, O. (1999). Fatal injuries in Malaysia motorcyclists. International Medical Research Journal, 3(2), 115-119.

(16). Radin-Umar, R. S. (2006). Motorcycle safety programmes in Malaysia: how effective are they? International Journal of Injury Control and Safety Promotion, 13(2), 71-9.

(17). Ramli, R. (2013). Effectiveness of motorcycle helmets for preventing head and facial injuries. Unpublished PhD Thesis, Monash University.

(18). Regan, M., Lee, J., & Young, K. (2008). Driver distraction: Theory, effects and mitigation. CRC Press, New York, USA. 2008.

(19). Road Safety Department of Malaysia. Malaysia: JKJR, 2012. http://www.jkjr.gov.my/statistics.html (Accessed 15 February 2011). Statistics on road accident. Available online at . http://www.jkjr.gov.my/statistics.html Statistics on road accident.

(20). Road Safety Department of Malaysia. Malaysia: JKJR, 2008. http://www.jkjr.gov.my/statistics.html Statistics on road accident.

(21). Road Safety Department of Malaysia, 2012. Malaysia: JKJR, 2008. http://www.jkjr.gov.my/statistics.html Statistics on road accident.

(22). Social Security Organisation (SOCSO). Statistical Report. 2009. Department of Social Security, Malaysian Ministry of Human Resources, Kuala Lumpur, Malaysia.

(23). Social Security Organisation (SOCSO). Statistical Report. 2010. Department of Social Security, Malaysian Ministry of Human Resources, Kuala Lumpur, Malaysia.

(24). Social Security Organisation (SOCSO). Statistical Report. 2011. Department of Social Security, Malaysian Ministry of Human Resources, Kuala Lumpur, Malaysia.

(25). Social Security Organisation (SOCSO). Statistical Report. 2012. Department of Social Security, Malaysian Ministry of Human Resources, Kuala Lumpur, Malaysia.

(26). Stutts, J., Reinfurt, D., & Rodgman, E. (2001). The role of driver distraction in traffic crashes: an analysis of 1995-1999 crash worthiness data system data. Proceedings, 45th Annual Meeting, Association for the Advancement of Automotive Medicine, 287-301. Des Plains, Illinois, USA.

(27). Wang, C., Quddus, M., & Ison, S. (2013). The effect of traffic and road characteristics on road safety: A revive and future research direction. Safety Science, 57, 264-275.

(28). World Health Organisation [WHO] (2009). Regional Report on Status of Road Safety: the South-East Asia Region. Genève, Switzerland: The World Health Organisation.

(29). World Health Organisation [WHO]. (2004) World Report on Road Traffic Injury Prevention. Genève, Switzerland: The World Health Organisation.

June 2015, vol 12, No. 1 : 179-182

An Overview of Industrial Dust Explosion Incidents and The Best Mitigation Practices in Malaysia

Mohd Azimie Bin Ahmad [1], Norazura Binti Ismail [2] and Mohamad Rizza Bin Othman[3 1]

[1]University Malaysia Pahang, Faculty of Engineering Technology

[2] University Malaysia Pahang, Faculty of Engineering Technology

[3] University Malaysia Pahang, Faculty of Chemical Engineering & Natural Resources

Abstract

The trends of safety incident process have been put in the statistical research and development in order to prevent and mitigate the phenomenon. One of the incidents is known as dust explosion. It represents a constant hazard to industries which includes any manufacturing using and handling combustible dust materials. Lack of sharing and know-how on best practices in managing the workplace must be avoided throughout the industries. The severity and the consequences of not taking the safety precautions at workplace have not been foreseen by the process team. This present paper discusses the best practices in managing the hazards from the catastrophes to happen again. In addition, the mitigation response has also been explored thoroughly through database of best practices.

Keywords:Process Safety Incident, Dust explosion, best practices, database, mitigation

Introduction

An increasing number of accidents related to dust explosion has been recorded and discussed since 1785 worldwide with many new cases leading to significant problems of injuries, fatalities, destruction of equipment and property loss. These events may still occur in various industries handling particulate organic and inorganic powders and dust. Those industries include grain and food, metal and metal finish products, power generation, textile manufacturing, coal mining and also chemical manufacturing.

The incidents normally happen in the unit operations such as grinders, silo, mills, dust collectors, bucket elevators, conveyors, and other modes of transportation. Abbasi and Abbasi found from the record of dust explosion incidents that on average, one dust explosion occurs in each industrialized country every day (Abbasi and Abbasi, 2007). Unfortunately, there is still lack of publications whether printed or soft copies present in developing countries that provides details information on dust explosions.

Even though no coal mining industry is commercialized in Malaysia, there is a risk of having coal dust explosion due to transportation, storage and use of coal in power generation industry, cement industry and other manufacturing industry. Although coal dust is commonly difficult to ignite and hard to explode, it can pose hazards when it explodes (Continillo *et. al*., 1991).

Literature Review

Mechanism of Dust Explosion

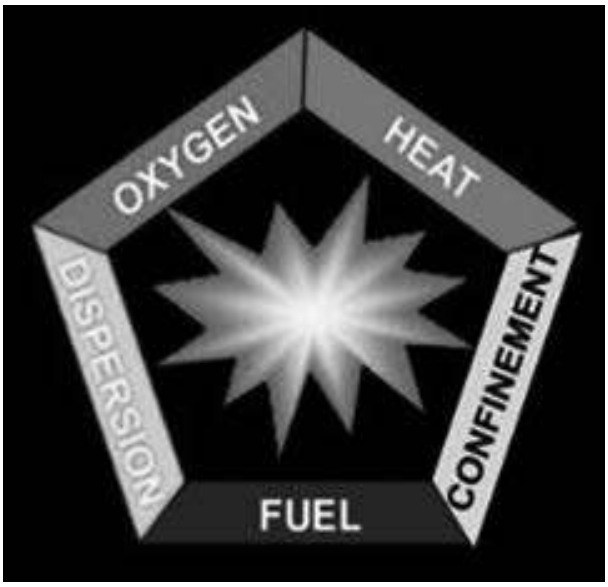


Figure 1: Dust Explosion Pentagon (cited from DOSH website)

Dust explosion may occur with the existence of five (5) elements, namely, oxygen, heat, confinement, fuel and dispersion.

Dust Explosion Cases in Malaysia

There were several cases which happened in Mac 2008 in Lumut, Perak, reported on the website of Department of Safety and Health. The incidents took

Year	Case	Process Safety Management (PSM) Elements		
		Process Hazard Analysis	Training of Manpower	Emergency Preparedness & Response
2008	Perak	√	√	√
2010	Penang	√	√	√
2013	Penang	√	√	√
2014	Pahang	√	√	

Table 1: Checklist of PSM Elements that may be lacking in term of implementation in fieldwork resulting with accident occurrences

place at a flour factory. The incident was triggered by the hot work activity (welding) in the confined space area filled in with the corn starch dust. The explosion covered the whole tunnel and its impact affected a jetty, a conveyor system while it also destroyed the installation in the tunnel, causing four (4) deaths.

Meanwhile, in an incident which happened in Nov 2010 in Penang, a rim manufacturing factory was burned down due to combustible dust explosion from polishing activities. The incident started from the fire that caused an explosion in the ducting system which transported aluminium dust to the tower duct collector. The impact during the incident caused some injuries to eight (8) workers while three (3) factory areas were destroyed.

Another incident took place at a herb factory in August 2013 in Penang. The explosion started from the oven that was used to heat the herb dust. The local exhaust ventilation, ducting system and tower dust collector were affected in this explosion. No injuries were reported.

The most recent incident took place in at a wood chip manufacturing factory in Gebeng, Pahang in August 2014. A dust collector was found to be in fire and it exploded. There were no fatalities reported. There was a possibility of spark on the conveyor system but the official report was yet to be confirmed by the relevant authority.

Development of Lesson Learning in Managing Process Safety Incident

An increasing number of accidents at workplace keeps the society questioning why these accidents have not been eliminated. It really depends on the effectiveness of lessons learned from the reported incidents. (Jacobsson, Ek, and Akselsson, 2011) proposed a six-step method for evaluating learning from incidents.

The effectiveness of learning from incidents can often be questioned. In many cases, the learning process stops at the reporting step. The analysis of the incident reports and the following implementation of appropriate measures and improvements are often ineffective and therefore full lessons are seldom learned (Jacobsson *et al*., 2011). For example, on 23 March 2005, the isomerization unit at the BP Texas City refinery exploded. Fifteen workers were killed and more than 170 people were injured. The investigation of the BP US Refineries Independent Safety Review Panel (the so-called Baker Panel) found that potential weaknesses in safety process had been highlighted in numerous reports prior to accidents that had occurred previously. According to the Baker Panel, BP had not learned those lessons because of organizational "learning disability" associated with issues regarding safety management, cost cutting, reward structure, decentralization and leadership (Hopkins, 2008).

By learning from past incidents, operating companies can improve reliability, reduce risk and improve financial performance. In the spirit of 'safety is not proprietary', the authors here once again ask the chemical companies and relevant government agencies to share their accident reports. In order for this to work effectively, operating agencies must be willing to share experience by reporting accidents and near misses to the chemical process safety community at large.

One of the obstacles to an effective and proactive lesson learning effort is the lack of public access to accident investigation reports. While public awareness of industrial accidents is available from various government sources, the information disclosed about the accident is superficial. Moreover, finding accidents involving specific substances, processes or equipment is an additional challenge. To help address these challenges, the authors will present in this paper an overview of lesson learned in Malaysia and identify the areas in need of further research and improvement.

These incidents will be effectively shared throughout the industries by the development of the database that will be the medium of best practices and the mitigation plans are kept and discussed by the relevant industries.

Recommendation

In reality, to set compliance with legal frameworks such as the Process Safety Management standards requires substantial resources and is complex to implement although it will bring a lot of improvements in SME operations in Malaysia.

According to the statistics noted above, the real

cases may be more than reported but still there are three main causes to be looked into details, namely, inadequate process hazard analysis, training and emergency response planning. These are the major contributors to the incident cases which take place in Malaysia.

Thus, the following recommendations are given to the SMEs and the government agencies that intend to help SMEs in accident prevention.

Establishing the relationships between local authorities and relevant SMEs

The relationship between stakeholders in SMEs is a must to improve their understanding on the risk mitigation and control. A simple step by step methodology addressing PSM elements targeting SMEs needs to be established. The local authorities should review the SMEs operating procedures and discuss the process hazard analysis, training and emergency response planning.

To coordinate PSM related activities between SMEs, industrial park administration, local authorities, research centre, universities and communities should work together on the assessment and improvement of their operating procedures to reduce risks. It depends on a strategic approach to prepare and respond to emergency events with community involvement. This collaboration will have further guidance for learning lessons and developing operation sustainability.

Investigation on root causes into PSM system level

The root cause analysis usually is a weak point in accident investigations. As such, the effectiveness of lesson learning is often questioned. Accident investigations often stop at the events close to the accident, usually concerned only about the behaviour of the hardware and the operators carrying out the activities.

Changing the hardware or disciplining the operators will not systematically eradicate the root causes that exist in the safety management system. With bad performance of the hardware or the operators, similar accidents will inevitably occur again. Therefore a causal analysis should be sufficiently robust such that it does not stop at the technical causes (e.g., equipment failure, human error). Instead, it should eventually determine what failure(s) occurred in the process safety management (PSM)'s system that created the conditions for the technical failures to occur. Root causes on PSM elements should be examined and reported thoroughly and systematically.

Disclosure information to public

More information about chemical accident risks and accidents need to be shared with the public, particularly in areas where a significant lack of information has made citizens distrust local agencies. Information also needs to be shared on the causes and lessons learned so that government and industry experts can improve their accident prevention, preparedness and response programmes and procedures. In this regard, the government should establish information systems and requirements that can achieve these goals.

There should be information available for the public on accidents in a region, on sites where potential accidents can occur, and what to do in case of a major accident on one of these sites. When people are treated with fairness and honesty, and the right to take their own decisions is respected, they are less likely to overestimate small hazards and will support the government and companies actively.

Building dedicated website for lesson learning

Government and industry also need additional knowledge about causes and lessons learned from accidents that can be used to update their standards, systems and procedures to support accident prevention, preparedness and response. The government should therefore create a common register specifically for reporting causes and lessons learned from investigations of major chemical accidents directly by industry or by government on the basis of its own or industry investigations. Full accident reports should be published in a dedicated website that is publicly accessible so that other operators and industries can learn from these accidents. Examples of such websites can be found in Europe (e- Mars) and US (CSB).

Establishing lesson sharing mechanism for the industry

This paper is mostly directed to the role of government while safety is, in the end, at the hands of industry. The chemical process industries must take a leading role in preventing accidents with big companies in particular, investing resources to build industry-wide awareness and capacity. In particular, the industry should establish mechanisms to voluntarily share lessons learned with each other, by expanding existing industry and professional associations to support forums, publications, workshops and training events on risk management and lessons learning. The establishment of the Malaysia equivalents to the Center for Chemical Process Safety (CCPS) and Chemical Safety Board (CSB) of the United States should also be considered.

That is where the University Malaysia Pahang stands as a pioneer in developing such environment to the related industries in Malaysia. Building up expertise and total understanding in PSM criteria will help fasten the preparation of Malaysia towards process safety incidents.

Conclusion

Lesson learning is not only difficult for SMEs that have limited human resources and expertise, but also for large multinational corporations. Incident investigation

is regulated under Malaysian laws. However, how to effectively and systematically learn the lessons from incident investigation reports has not been specified by the standards. Lesson learning does not only require high quality investigation reports, but also a high self-learning capability. A continuous learning organization has been recognized as one of the ten attributes that is important to create a best-in-class safety culture (Mannan, Mentzer, & Zhang, 2013).

Learning is not completed until a relatively permanent change of behaviour including process design or procedure is verified. Lesson learning should not be constrained within one organization only. It should be encouraged and facilitated across industries and countries as a long term process. Priorities for Malaysia SMEs should be put on improving their capabilities in process hazard analysis and emergency preparedness and providing all necessary trainings to their employees. In order for an effective uptake of these practices, the Malaysian approaches introduced in this paper can provide easily applicable methodologies for SMEs with limited resources to coordinate their PSM activities. Improving chemical process safety management and emergency preparedness supports sustainable industrial development.

Acknowledgements

The first author of this paper gratefully acknowledges financial supports from the University Malaysia Pahang. Finally, we appreciate the reviewers of this paper for their detailed recommendations.

References

(1). Abbasi, T. and Abbasi, S. A. (2007). Dust Explosions- Cases, Causes, Consequences, and Control. Journal of Hazardous Materials, 140: 7-44.

(2). Continillo, G., Crescitelli, S., Fumo, E., Napolitano, F. and Russo G. (1991). Coal Dust Explosions in a Spherical Bomb. Journal of Loss Prevention in the Process Industries, 4: 223-229.

(3). Hopkins, A. (2008). Failure to learn. The BP Texas city refinery disaster. CCH Australia Limited.

(4). Jacobsson, A., Ek, A., & Akselsson, R. (2011). Method for evaluating learning from incidents using the idea of "Level of Learning". Journal of Loss Prevention in the Process Industries, 24, 333-343.

(5). Jacobsson, A., Sales, J., & Muthtaq, F. (2009). A sequential method to identify underlying causes from industrial accidents reported to the MA database. Journal of Loss Prevention in the Process Industries, 22, 197-203.

(6). Mannan, S., Mentzer, R., & Zhang, J. (2013). Framework for creating a best-in-class safety culture. Journal of Loss Prevention in the Process Industries, 26(6), 1423-1432.

June 2015, vol 12, No. 1 : 183-186

Research and Design of Ergonomics Rostrum

[1]Mohamad Norashraf Mohd Noh, [1] Hari Krishnan, [1] Roseni Abd Aziz, [1]Raemy Md Zein, [1] Noorul Azreen Azis

[1]Ergonomics Excellence Centre, National Institute of Occupational Safety and Health, SRO Johor Bahru, Johor, Malaysia

Abstract

This invention is more on ergonomics scope. This ergonomics rostrum fulfills the ergonomics criteria especially when used while standing. The important parts in this invention are rostrum head and platform. The rostrum head is adjustable so the users can set the height of rostrum head for their suitability and comfort. Another important part in this invention is platform. The purpose of the platform is to help users reach the rostrum head. The platform can flip into the rostrum body. This invention can be used by anyone especially for Malaysian people because its designed was based on the Malaysian height.

Keywords:Ergonomics Rostrum, Design Rostrum, Anthropometry.

Introduction

Rostrums are usually used by leaders, speakers and celebrities to convey messages and to speak formally to the audience, during formal ceremonies such as meetings, award giving ceremonies, political campaign and others. Rostrums are always overlooked as something less than important. Using rostrums is one of the effective ways to give out information to the audience. The audience would listen to the speaker once the speaker is on the podium. The design of the rostrum must be attractive with aesthetic values to attract the audience to focus on the speaker when he or she conveys the message or information. The currently available rostrums in Malaysian market usually have fixed height position. In this study, the height of Malaysian citizens is taken into consideration, with anthropometric data collected by Ergonomics Excellence Centre (EEC). The designing process applies mechanical method and ergonomics element to make sure that this project follows Malaysian standard heights.

Methodology

Maximum (cm)	Minimum (cm)	Human Body Part
267.0	118.0	Vertical Grip Reach
203.0	143.5	Stature
174.4	125.4	Eye Height
158.7	115.9	Shoulder Height
140.9	110.0	Armpit Height
117.7	83.8	Elbow Height

Table 1 : Anthropometry Statistic Data

Anthropometry statistic data is very important before a designer designs the adjustable rostrum because from this data, the designer will know the minimum and maximum heights that the rostrum head can reach. This data was collected by Ergonomics Excellence Centre to know the height of Malaysians. This data can also be used for other projects because it fulfills the Malaysian standard heights.

Product Design Specification (PDS)

A product Design Specification (PDS) is a structured description of the purpose, functions, characteristics and other kinds of information that describe the design problems. Developing the proper PDS is the essential first step in any design process, because a good design will define a product that satisfies all the objectives of the project in a balanced way. And there is no way to know how to balance all the different factors that can influence a product success without first understanding the nature and requirements of the design problems.

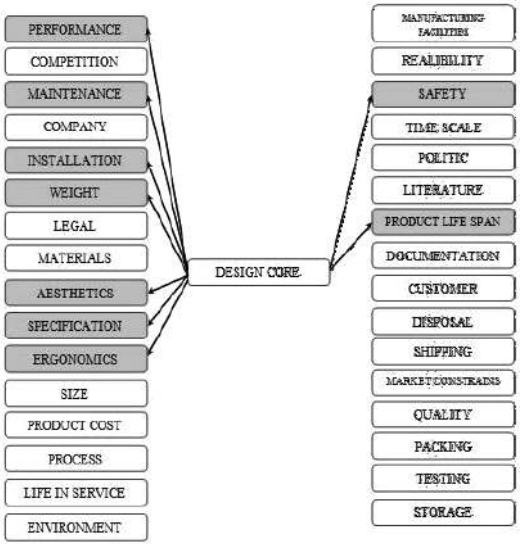


Figure 1: Selective PDS adjustable rostrum

NO.	CRITERIA	COMMENT
1	Performance	The performance mechanism should not to slow or to fast while lifting or lowering the rostrum head.
2	Maintenance	Wherefore the mechanism is electro-mechanical the mechanism must be easy for maintenance.
3	Installation	There are various size and shape for every mechanism, the mechanism should easy to install on rostrum.
4	Weight	Load carried by mechanism can support the rostrum while lifting or lowering the adjustable rostrum.
5	Aesthetic	The rostrum must have aesthetic criteria and look not like common design in the market.
6	Specification	Specification electro-mechanical must suitable with Malaysia standard such as voltage electric supply.
7	Ergonomics	The rostrum must fulfill the ergonomics criteria while users standing.
8	Safety	Electro-mechanical mechanism not hazardous to users
9	Product life span	The adjustable mechanism can be used in long life expectancy.

Table 2: PDS Criteria of adjustable rostrum

Final Design & Specifications

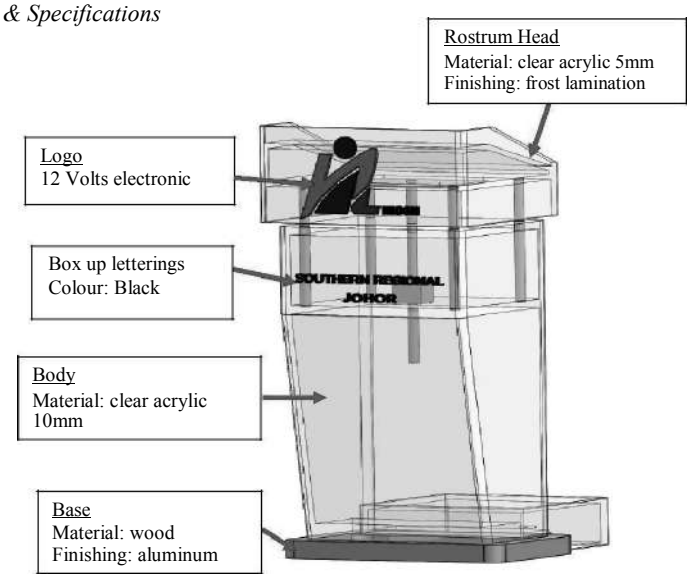


Figure 2: Final Design & Specification for Adjustable Rostrum

Platform Analysis

First Design

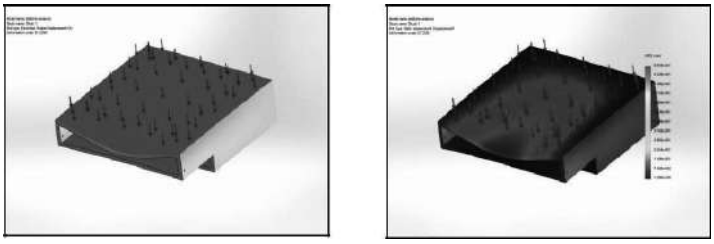


Figure 3: Platform analysis for first design

Figure 3 shows stress analysis for rostrum platform. The force applied on this design is 1000N. Software used for this analysis is SolidWorks. Material for this design is acrylic. Red area marks the critical area for the platform when load is applied and the platform will be broken. It is because the platform has no support at the front.

Second Design

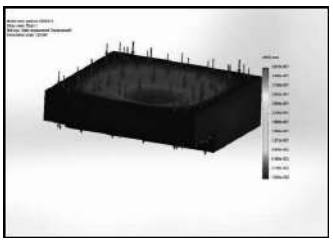


Figure 4: Platform analysis for second design

Figure 1.15 shows stress analysis for Design 2 rostrum platform. The force applied on top of the platform is 1000N. Material applied for this design is acrylic. The platform will break at the centre of rostrum because it is fully acrylic without frame support.

Third Design

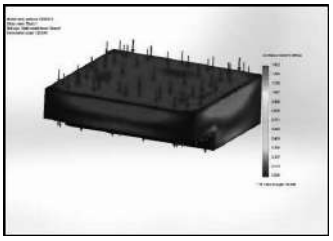


Figure 5: Platform analysis for third design

Figure 1.16 shows stress analysis using SolidWorks software. This design can support load of 1000N because the platform has a frame. The material of platform is acrylic. This is the best result among the three designs.

Ergonomics View

Normal height

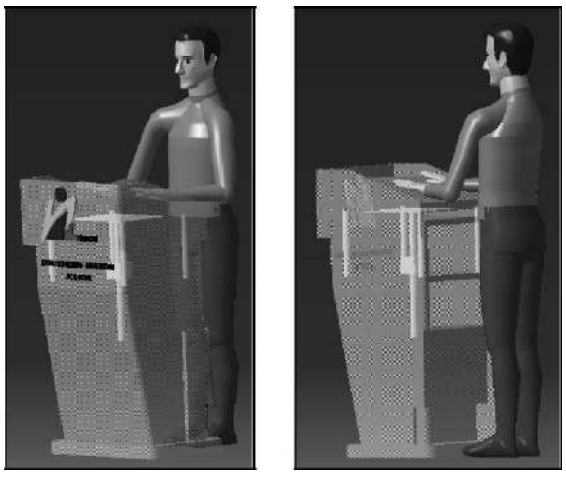


Figure 6: Adjustable Rostrum for normal height

Figure 6 shows normal heights when users use the adjustable rostrum. The users use the adjustable rostrum without bending their body to read text. This height is a normal height for Malaysian populations.

Minimum height

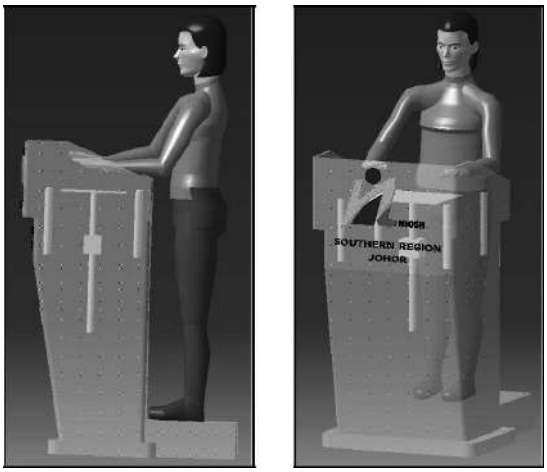


Figure 7: Adjustable Rostrum for minimum height

Figure 7 shows the minimum height that rostrum head can reach. The users set the rostrum head to a minimum height and pull down the rostrum platform before standing on the platform when using it. The minimum height of Malaysians who can use this adjustable rostrum is 1435mm and the elbow height from platform is 838 mm.

Design Criteria

Ergonomics is one of the design criteria. To fulfill this criteria, the rostrum top must be adjustable so that the users can adjust the rostrum top to suit the elbow height without the users having to bend their back. Another important criterion is safety. The platform can be flipped inside to rostrum body if not in use. Other than that, the adjustable rostrum must be easy to maintain and the cost of maintenance must be low. The last important design criterion in this design is product life span. The rostrum body and the mechanism can be used in long life expectancy.

Advantages

An advantage of this design is that the height of the rostrum top will be adjusted following the user's height and comfort. Other than that, this adjustable rostrum has a platform to help the users reach the rostrum top. Another advantage is the use of acrylic as the construction material to make the rostrum more attractive. The NIOSH logo also is complete with LED.

Conclusion

Ergonomics aspect is not so popular in Malaysia and the application to household products or furniture is low. Anthropometric data helps designers to design ergonomics products based on Malaysian population. The designer also must do research about design criteria and characteristics, do force analysis and select the best material applicable to the design. The designer should test if the design is practicable among Malaysians using Delmia software.

References

(1). AmpliVOx Company . (n.d.). Retrieved March 25, 2014, from AmpliVox Web site: http://www.ampli.com/lecterns-and-podiums/3540-Clear-Acrylic-and-Wood-Floor-Lectern.aspx

(2). Discounts Display. (n.d.). Retrieved March 23, 2014, from Discount Display Web site: http://www.discountdisplays.co.uk/html/metal-pulpit.html

(3). Guangzhou Yimaijia Metal Product Co., Ltd. (n.d.). Retrieved March 25, 2014, from http://yimaijia.en.made-in-china.com/product/PoZxTEJVOqrB/China-Rostrum-Podium-Aluminum-Platform-ISO.html

(4). Guangzhou Yimaijia Metal Product Co., Ltd. (n.d.). Retrieved March 20, 2014, from http://yimaijia.en.made-in-china.com/product/PqwmTrJHYoUF/China-Rostrum-B-25-Podium-Lectern-Wooden-Platform.html

(5). Oriental Motor Company. (n.d.). Retrieved April 7, 2014, from Oriental Motor Web site: http://www.orientalmotor.com.my/products/ac/list/detail/?brand_tbl_code=AC

June 2015, vol 12, No. 1 : 187-190

Kajian Rintis Beban Kerja Fizikal KeAtas Pemandu Bas Bandar

Wan Amirul Wan Abdul Manan[1], Azlis-Sani Jalil[1], Roseni Abdul Aziz[2], S.M. Sabri S.M. Ismail[3] dan Noor Aqilah Ahmad Tajedi[3]

[1] Fakulti Kejuruteraan Mekanikal dan Pembuatan, Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Batu Pahat, Johor

[2] Ergonomics Excellence Centre, NIOSH Southern Regional Office (Johor Bahru), No 10, Jalan Persiaran Teknologi, Taman Teknologi Johor, 81400 Senai, Johor.

[3] Research & Development, Project Development Division, Prasarana Malaysia Berhad, Level 6, Wisma Monorail, Jalan Tebing, Brickfields, 50470 Kuala Lumpur.

Corresponding Author: Tel : +607-4537347; Email :azlis@uthm.edu.my

Abstrak

Peningkatan masalah *muskulosketal* di kalangan pemandu bas henti-henti akibat beban kerja fizikal semakin menjadi perhatian. Oleh itu, tujuan kajian ini adalah untuk mengenalpasti jenis beban kerja fizikal yang dihadapi oleh pemandu bas henti-henti di Kuala Lumpur dan kesannya terhadap prestasi fizikal mereka. Dalam kajian ini, kaedah rakaman video digunakan untuk melihat dan merakamkan setiap beban kerja fizikal yang dihadapi oleh mereka semasa memandu dan satu simulasi dibuat untuk melihat kesan beban kerja tersebut terhadap prestasi kerja mereka. Keseluruhan hasil kajian menunjukkan beberapa jenis beban kerja fizikal yang telah dikenalpasti iaitu seperti menekan butang suis pada panel kawalan, memberi tiket kepada penumpang, memandang cermin sisi sambil memasukkan wang ke dalam tabung, menoleh untuk menjawab pertanyaan penumpang dan membelok sambil menarik tombol isyarat. Demi kesinambungan kajian ini, satu kajian terhadap beban kerja mental perlu dibuat untuk mengetahui secara menyeluruh beban kerja yang dihadapi oleh pemandu bas.

Keywords:beban kerja fizikal, pemandu bas, ergonomik, pengangkutan awam

Pendahuluan

Penggunaan bas henti-henti sebagai pengangkutan awam adalah sangat penting dan utama di bandar – bandar besar di Malaysia. Pertambahan tugas telah menyebabkan ramai pemandu bas terpaksa menghadapi beban kerja yang berlebihan semasa menjalankan tugas. Antara beban kerja yang biasa dihadapi oleh pemandu bas henti-henti adalah beban kerja fizikal kerana banyak melakukan pergerakan semasa memandu. Variasi jenis beban kerja fizikal yang dihadapi oleh pemandu bas boleh menyebabkan kesan buruk terhadap prestasi kerja dan kesihatan mereka dalam jangka masa yang panjang. Penurunan prestasi pemanduan pula boleh menyebabkan kualiti perkhidmatan syarikat menurun dan penyumbang kearah peningkatan kemalangan.

Untuk mengatasi masalah ini, pihak atau syarikat pengendali perkhidmatan bas henti-henti di Malaysia perlu bertindak mengenalpasti jenis beban kerja fizikal yang sering dihadapi oleh pemandu bas dan kesan beban kerja tersebut kepada pretasi fizikal mereka. Langkah ini membolehkan syarikat tersebut menyediakan satu situasi yang lebih selesa untuk memastikan beban kerja fizikal keatas pemandu bas dapat dikurangkan. Ini akan memberi kesan yang baik terhadap kesihatan pemandu bas dan dapat memastikan kelangsungan perjalanan bas henti-henti di Malaysia.

Kajian Literatur

Beban kerja fizikal

Beban kerja menjadi topik yang semakin penting dalam masyarakat kita. Kajian beban kerja bukanlah sesuatu yang baru; ia telah dibincangkan dan dikaji sejak manusia mula menggunakan pelbagai peralatan dalam industri. Kebanyakan pihak industri hanya memikirkan bagaimana untuk memaksimumkan keuntungan, namun mereka perlu memberi tumpuan untuk mengurangkan beban kerja yang dihadapi oleh pekerja mereka. Penyelesaian kepada isu ini adalah dengan menentukan satu cara untuk mengukur beban kerja dengan tepat dan menentukan tahap-tahap beban kerja yang berlebihan yang dihadapi oleh pekerja. Ketika konsep beban kerja pertama kali diperkenalkan, penumpuan kajian lebih terarah kepada beban kerja fizikal. Namun peningkatan teknologi yang pesat telah membuatkan kerja-kerja fizikal banyak dilakukan oleh mesin. Oleh itu, kajian pada masa kini telah memberi tumpuan lebih kepada jenis-jenis beban kerja iaitu dari sudut psikomotor, penglihatan dan komunikasi semasa melakukan kerja (Wierwille, 1985). Kerja memandu pula adalah gabungan banyak jenis beban kerja, namun yang paling penting adalah dari sudut mental dan fizikal.

Penyelidikan sebelum ini menunjukkan bahawa memandu bas adalah pekerjaan yang memberi tekanan dan dikaitkan dengan peningkatan risiko kesihatan.

Sebagai contoh, kajian epidemiologi telah mendapati bahawa pekerjaan pemandu bas adalah berisiko tinggi untuk mendapat penyakit seperti *kardiovaskular, gastrousus* dan masalah *muskuloskeletal* (Winkleby, Ragland, Fisher, & Syme, 1988). Terdapat juga bukti tahap tekanan darah yang tinggi di kalangan pemandu bas (Evans, Johansson, & Rydstedt, 1999) dan kenaikan hormon yang berkaitan dengan tekanan dikalangan pemandu bas semasa bekerja seperti *adrenalin* dan *kortisol* (Aronsson & Rissler, 1998; Carrere, Evans, Palsane, & Rivas, 1991).

Jenis beban kerja fizikal

Antara jenis beban kerja fizikal yang sering dihadapi oleh pemandu bas semasa memandu adalah seperti menyentuh sesuatu suis pada panel kawalan dan membuat pergerakan badan. Situasi ini akan mengurangkan tumpuan iaitu maklumat visual dan pengendalian stereng oleh pemandu bas ketika memandu. Ini menunjukkan bahawa, beban kerja fizikal ini berupaya menukar parameter pemanduan iaitu daripada memandu kepada dipandu. Ini akan membuatkan pemandu mudah hilang fokus kepada pemanduan dan boleh menyebabkan kemalangan.

Selain itu, terdapat pelbagai tugas yang terpaksa dilakukan oleh pemandu seperti menjangkau tangan mereka kepada sasaran. Proses ini akan menyebabkan pengendalian kawalan bas menjadi kurang cekap kerana fokus pemandu tertumpu kepada sasaran yang ingin dicapai. Sasaran beban kerja fizikal diklasifikasikan sebagai jarak dari kedudukan asal pemandu kepada sasaran. Antara sasaran yang sentiasa dicapai oleh pemandu adalah seperti suis penekan, cermin pandang sisi dan panel kawalan.

Sebaliknya, terdapat tiga strategi beban kerja fizikal semasa memandu iaitu yang pertama mata dan badan dimana dengan cara regangan tangan mereka kepada sasaran dengan melihat sasaran. Kedua ialah hanya menggunakan mata iaitu dengan cara hanya mengerling ke arah sasaran. Seterusnya yang ketiga ialah hanya menggunakan badan dengan cara meregang tangan mereka kepada sasaran tanpa melihat objek yang disasarkan. Oleh itu, terdapat sembilan beban kerja fizikal tugas hasil gabungan tiga sasaran dan tiga strategi.

Kesan beban kerja fizikal

Hasil kajian sebelum ini, terdapat kira-kira 20% daripada kesemua tuntutan pampasan mencatatkan daripada kecederaan belakang akibat kerja yang berkaitan beban kerja fizikal dan telah menanggung 33% kos pampasan daripada kesemua pekerja di Amerika Syarikat (Andersson *et al*., 1991). Selain itu, kos yang berkaitan dengan kecederaan belakang ketika bekerja di Amerika Syarikat telah mencatatkan jumlah yang besar iaitu sebanyak 49000000000 USD pada tahun 1992 (Leigh *et al*., 1997). Setelah itu, pencegahan kecederaan belakang dan yang berkaitan seperti hilang keupayaan telah menjadi satu cabaran besar bagi majikan, pihak insurans, dan pakar-pakar kesihatan pekerjaan untuk memastikan masalah itu berkurangan.

Beberapa faktor kerja fizikal dan psikososial telah banyak dikaitkan dengan penyumbangan masalah sakit belakang akibat pekerjaan dalam kajian sebelum ini. Faktor biomekanik iaitu penggunaan fizikal untuk mengendalikan pekerjaan berat secara manual seperti mengangkat dengan kerap, menarik atau menolak, duduk dan berdiri berpanjangan, getaran seluruh badan, dan memandu kenderaan motor adalah antara penyumbang sakit belakang (Pope *et al*, 1991.; Bernard, 1997; Krause *et al*, 2001.; National Research Council, 2001). Selain itu, berdasarkan satu kajian yang telah dibuat menunjukkan beban kerja fizikal dan masalah ergonomik yang sering dilaporkan adalah berkaitan dengan masalah sakit belakang dan sakit leher dikalangan pemandu bas (Krause *et al*., 2001).

Metodologi

Kaedah pemerhatian

Pemerhatian dalam kajian ini terbahagi daripada dua kaedah iaitu dengan mengambil rakaman video dan mengambil gambar dengan menggunakan model kamera SJ4000. Kaedah ini digunakan untuk merakam segala tindakan dan pergerakan pemandu bas semasa memandu untuk tujuan analisis. Kaedah ini sangat penting kerana melalui analisis ini beban kerja fizikal dapat diperhatikan dan dianalisa dengan baik dan berkesan. Setelah rakaman video dan gambar diambil, satu proses melihat kembali rakaman video dan gambar untuk melihat segala tindakan pemandu bas semasa memandu bagi tujuan menganalisa beban kerja fizikal yang dihadapinya. Panjang rakaman video yang mengikut masa tertentu yang ditetapkan.

Kaedah pengukuran

Pengukuran yang dibuat di lokasi untuk mendapatkan ukuran asal untuk dianalisis adakah kawasan kajian iaitu sekitar ruang tempat pemandu bas termasuk tempat duduk, kawasan kawalan, dan papan pemuka memberikan impak beban kerja fizikal semasa memandu. Ukuran yang dibuat dengan menggunakan pita pengukur untuk mengukur panjang dan lebar dan ketinggian tempat duduk, kawasan kawalan dan panel kawalan. Setiap ukuran yang diambil diterjemahkan dalam lakaran dan dimasukkan dalam perisian simulasi.

Keputusan

Berdasarkan pemerhatian sebenar daripada rakaman video yang dibuat telah menunjukkan terdapat beberapa bentuk beban fizikal yang biasa dihadapi oleh pemandu bas henti-henti diantaranya ialah menekan butang suis pada panel kawalan, memberi tiket kepada penumpang, memandang cermin sisi sambil memasukkan wang ke dalam tabung, menoleh untuk menjawab pertanyaan penumpang dan membelok sambil menarik tombol isyarat.

Gambarajah 1: Menekan Butang Suis Pada Panel Kawalan

Gambarajah 2: Memberi Tiket Kepada Penumpang

Gambarajah 3: Memandang Cermin Sisi Sambil Memasukkan Wang Ke Dalam Tabung

Gambarajah 4: Menoleh Untuk Menjawab Pertanyaan Penumpang

Gambarajah 5: Membelok Sambil Menarik Tombol Isyarat

Gambarajah menunjukkan situasi sebenar bagaimana pemandu bas henti-henti menangani beban kerja fizikal yang dihadapi oleh mereka.

Daripada pemerhatian ini dapat diketahui secara jelas beberapa jenis beban kerja fizikal yang terpaksa ditanggung oleh pemandu bas henti-henti semasa memandu. Hal ini akan mengganggu prestasi pemanduan mereka sekiranya beban yang terpaksa ditanggung itu berterusan dan kian bertambah. Masalah ini akan memberi kesan kepada kesihatan fizikal pemandu bas dan boleh membahayakan penumpang sekiranya mereka gagal menghadapi beban kerja tersebut secara berterusan.

Perbincangan

Hasil daripada kajian ini menunjukkan bahawa beban kerja fizikal boleh diklasifikasikan dalam pelbagai keadaan. Keadaan yang dimaksudkan sama ada ketika berdepan dengan penumpang ataupun ketika melakukan pengawalan bas. Oleh itu, setiap syarikat yang menyediakan perkhidmatan bas perlu mencari jalan penyelesaian untuk mengurangkanbeban kerja fizikal yang dihadapi oleh pemandu bas. Ia adalah penting agar prestasi pemanduan mereka sentiasa pada tahap maksimum bagi menjamin perkhidmatan yang berkualiti dan keselamatan penumpang.

Selepas itu jangkaan keputusan berikutnya yang akan diperolehi diakhir kajian nanti adalah mengetahui kesan beban kerja fizikal terhadap anggota badan pemandu bas apabila kaedah simulasi dengan menggunakan analisis *Rapid Upper Limb Assessment* (RULA) di dalam perisian Delmia.

Kesimpulan

Pelbagai cara telah dilakukan oleh industri bagi mengurangkan masalah yang dihadapi oleh pemandu bas semasa bekerja. Namun begitu, masih banyak yang perlu dilihat secara terperinci akan masalah-masalah tersebut terutamanya berkenaan beban kerja fizikal. Antara objektif kajian ini yang pertama adalah mengkaji jenis beban kerja fizikal yang dihadapi oleh pemandu bas. Kaedah pemerhatian telah digunakan untuk memastikan objektif ini tercapai dengan memasang rakaman video

untuk melihat setiap pergerakan pemandu bas semasa memandu. Daripada kaedah ini, kita dapat mengenalpasti jenis beban kerja fizikal yang dihadapi oleh pemandu bas.

Objektif yang seterusnya adalah untuk mengetahui kesan beban kerja fizikal terhadap anggota badan pemandu bas. Kaedah simulasi digunakan untuk mencapai objektif tersebut dimana simulasi setiap pergerakan asal dibuat menggunakan perisian Delmia dan analisinya menggunakan *Rapid Upper Limb Assessment* (RULA) untuk mengetahui anggota badan mana yang terkesan. Hasil daripada pemerhatian yang dibuat, pelbagai jenis beban kerja fizikal yang terpaksa dihadapi oleh pemandu bas seperti mana yang telah tersenarai.

Langkah kajian seterusnya masih dalam perlaksanaan dan kajian sebelum data sebenar diperolehi.

Penghargaan

Penulis amat berterima kasih atas sokongan data dan kerjasama yang diberikan oleh pihak Prasarana Malaysia Berhad.

Rujukan

(1). Andersson GBJ, Pope MH, Frymoyer JW, Snook SH. 1991. Epidemiology and cost. In: Pope MH, Andersson GBJ, Frymoyer JW, Chaffin DB editors. Occupational low back pain: Assessment, treatment, and prevention. St. Louis: Mosby Year Book. pp 95–113.

(2). Aronsson, G., & Rissler, A. (1998). Psychophysiological stress reactions in female and male urban bus drivers. Journal of Occupational Health Psychology, 3(2), 122-129.

(3). Bernard BP, editor. 1997. Musculoskeletal disorders and workplace factors. Cincinnati:

(4). ‘‘U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health’’. ‘‘U.S. Department of Health and Human Services PHS, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health’’, editor. DHHS (NIOSH) Publication No. 97–141.

(5). Carrere, S., Evans, G. W., Palsane, M. N., & Rivas, M. (1991). Job strain and occupational stress among urban public transit operators. Journal of Occupational Psychology, 64, 305

(6). Evans, G. W., Johansson, G., & Rystedt, L. (1999). Hassles on the job: A study of a job intervention with urban bus drivers. Journal of Organizational Behavior, 20, 199-208.

(7). Krause N, Frank JW, Dasinger LK, Sullivan TJ, Sinclair SJ. 2001. Determinants of duration of disability and return to work after workrelated injury and illness: Challenges for future research. Am J Ind Med 40:464–484.

(8). Leigh JP, Markowitz SB, Fahs M, Shin C, Landrigan PJ. 1997. Occupational injury and illness in the United States. Estimates of costs, morbidity, and mortality. Arch Intern Med 157(14):1557–1568.

(9). National Research Council. 2001. National Research Council. Institute of Medicine. Panel on Musculoskeletal Disorders and the Workplace. Commission on Behavioral and Social Sciences and Education. Musculoskeletal disorders and the workplace: low back and upper extremities. Washington, DC: National Academy Press.

(10). Wierwille, W. W., Eggemeier, F.T. (1993). Recommendations for mental workload measurement in a test and evaluation environment. Human Factors, 35(2), 263-281.

(11). Winkleby, M. A., Ragland, D. R., Fisher, J. M., & Syme, S. L. (1988). Excess risk of sickness and disease in bus drivers: A review and synthesis of epidemiological studies. International Journal of Epidemiology, 17, 255-262.

June 2015, vol 12, No. 1 : 191-196

Hand Arm Vibration Assessment among Hand Held Grass Cutter Workers: A Case Study in Malaysia

M.H, Ali [1], N.A., Azmir [2], M.I., Ghazali [2] and M.N., Yahya [2]

[1] OSH Management Division, Consultation, Research & Development Department, National Institute of Occupational Safety & Health (NIOSH), 43650 Bandar Baru Bangi, Selangor

[2] Department of Engineering Mechanics, Faculty of Mechanical & Manufacturing, Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Parit Raja, Batu Pahat, Johor.

Abstract

The objective of this research is to analyze and evaluate the hand arm vibration exposure of hand held grass cutter machines during their normal operation time. On-site field measurement for five different types of hand held grass cutter machines. In this research, the hand arm vibration exposure levels of different machines were measured at practical cutting condition in accordance to guidelines on occupational vibration which are presented in the occupational safety and health standard manual. The hand arm vibration level on the worker's both right and left handles of the grass cutter machine were measured and analyzed, respectively. The vibration frequency weighting acceleration was calculated by using h-weighting. The hand arm vibration acceleration value was expressed in the root-mean-square (rms) combination of all three major axis (a_{hwx}, a_{hwy} & a_{hwz}). The estimated daily vibration exposure, A(8) were differ between 2.1 to 20.7 ms^{-2} for right hand while 2.7 to 29.1 ms^{-2} for left hand. In short, worker will induce fingers blanching in 10% of the exposed person after less than 3.7 years exposed to hand arm vibration.

Keywords:Hand Arm Vibration, Hand Held Grass Cutter Machine & Fingers Blanching

Introduction

The model of hand held grass cutter machine is widely applied in various tropical countries for maintaining grass landscape. A typical public open grass compound needs monthly grass cutting operation either at highway or facilities location. It produces a service industry with a large number of workers involved using the hand held grass cutter to maintain grass growth. The workers involved in these duties are generally contract workers with less awareness related to occupational safety and health such as hand arm vibration syndrome[1] and noise induced hearing loss[2]. Statistics of occupational accidents by sector, which caused death, permanent disability and non-permanent disability, have been widely investigated and represented a significant problem to the Malaysian industry. Hand held grass cutter workers were investigated under the agricultural sector which reported the second highest cause of non-permanent disability behind industrial sector[3]. In depth, there are 161 compensation claims under musculoskeletal disorders [4] in 2009. In spite of the facts, health surveillance in occupational vibration was sustained. However, there is lack of effective management of agriculture service activities suggesting for worker shift scheduling by following guideline proposed by Department of Occupational Safety and Health (DOSH), Malaysia.

This work shares the findings from onsite hand arm vibration measurement study of five different hand held grass cutter machines which are normally used by workers in the agriculture sector. The objective of this study is to acquire and evaluate the hand arm vibration characteristics of hand held grass cutter machine according to established safety standard and guidelines.

Literature Review

Hand held vibrating tools are used in various works and inducement to hand arm vibration may cause various signs, including neurological and vascular disturbances as well as muscle and joint disorder [5]. These are commonly known as Hand Arm Vibration Syndrome (HAVS). Symptoms of HAVS are numbness, tingling, loss of grip strength force and incapacity of work process. Prolonged vibration transmitted to hand caused vibration induced white fingers or finger blanching due to poor blood supply. The severity of hand arm vibration exposure is based on the total magnitude, m/s^2 of vibration produced by the machine and duration of routine operation.

Guidelines Concerning Hand Arm Vibration

The DOSH Malaysia establishes the minimum health and safety requirements regarding the occupational vibration of workers involved in vibrating tools, and states that the vibration transmitted to the hand arm system is to be measured in accordance with the International Standard [6]. Furthermore, American Conference of Governmental Industrial Hygienists (ACGIH) specifies the threshold limit value and duration of exposure to be followed for the purpose of mitigating

HAVS [7]. Besides, European Directive has established the regulation to protect workers from vibration hazard [8]. Although there are several detail safety descriptions related to human response to vibration, hand arm vibration disease has gradually reduced after implementing the Directive 2002/44/EC in Great Britain [9].

For hand arm vibration assessment, article 3 of Directive 2002/44/EC establishes the following safety limits for A(8): i. Exposure Limit Value (ELV) = 5 m/s^2, ii. Exposure Action Value (EAV) = 2.5 m/s^2. The ELV is the maximum amount of hand arm vibration a worker may be exposed to in any single day. It indicates a potential high risk above which the worker should not be exposed. The EAV is the daily amount of hand arm vibration exposure which employers are required to take acceptable and suitable control measures to mitigate exposure or to provide periodically health surveillances for the workers involved. In Malaysia, Appendix B of guidelines on occupational vibration [10] was used as reference for workers involved in hand arm vibration. In this particular guideline, established Threshold Limit Value (TLV) and exposure duration for vibration transmitted to hand arm in A(8): i. 4 hours and less than 8 hours = 4 m/s^2, ii. 2 hours and less than 4 hours = 6 m/s^2, iii. 1 hour and less than 2 hours = 8 m/s^2, iv. Less than 1 hour = 12 m/s^2. The TLV is vibration acceleration component levels and the duration of exposure for hand arm vibration. The values shall be used as a basis for the control measure of hand arm vibration exposure.

Table 1. Frequency, mean height, mean weight and mean working experience of hand held grass cutter workers participated in the survey for each type of grass cutter machines

	Hand held grass cutter workers			
	Frequency	Mean Height (m)	Mean Weight (kg)	Mean Working Experience (months)
Type A	47	1.62 ± 0.13	60.35 ± 20.10	44
Type B	49	1.62 ± 0.15	60.13 ± 25.75	40
Type C	23	1.64 ± 0.13	57.86 ± 13.90	32
Type D	23	1.67 ± 0.13	65.50 ± 21.45	19
Type E	26	1.55 ± 0.14	57.97 ± 16.45	35

Table 2. The technical specification of the hand held grass cutter machines survey

Specification	Type A	Type B	Type C	Type D	Type E
Model	TU33	TB33 / TL33	KNC 3340	TB43	BG328
Discharge capacity (cc)	32.6	32.8	33	43	30.5 – 32.8
Net weight (kg)	9	9.5 – 9.8	9.7	8 – 9.4	7.8 – 10.5
Standard power (kW)	0.97	0.9	1.26	1.25 – 1.57	0.81 – 0.85
Max output (rpm)	6500	6500	6500	7000	6000 - 7500

Methodology

This work is part of a much wider research (168 workers come from maintenance grass and turf operation personal company) conducted to gather data relating to 5 different types of hand held grass cutter machine hazard, such as hand arm vibration and occupational health. Every worker was interviewed about the machine that they usually use, and the hand arm vibration exposure was also measured while performing their routine tasks. Hand arm vibration measurement was performed for both handles per machine. The orientation of the vibration measurement followed the biodynamic and basicentric coordinate system. These systems measure the hand by using tri-axial accelerometer propose in ISO 5349. The accelerometer was connected by using the wire cable to the analyzer. The frequency of each type of hand held grass cutter machine for which hand arm vibration measurement is depicted in Table 1, as well as the mean height, mean weight and mean working experience for each machine. The five different types of hand held grass cutter machines were identified as given in Table 2. It was found that, the hand held grass cutter machines were different in structural component design and grip handle as well. However, the same engine model that generates power (source of vibration and noise) for cutting purpose makes the best indication to differ the types of machines used by hand held grass cutter workers.

The analysis of hand arm vibration exposure in compliance with ISO 5439 is based on vibration quantity that combines all three axes. This hand arm vibration total value, ahv is defined as the root mean square or equivalent vibration transmitted to hand of three axes values shall be obtained by using Equation (1).

$$a_{eq} = a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2} \quad (1) \text{ ; total vibration value}$$

where; a_{hwx}, a_{hwy} and a_{hwz} are the frequency of hand arm vibration measurement proposed in ISO 5439 (h-weighted) acceleration values for each axis which contain amplitude and time exposure. The hand arm vibration exposure depends on the magnitude of the total value of vibration and the duration of exposure. Daily vibration duration is the total time which the hands are exposed to vibration during a working day. It is very important to estimate the total daily vibration exposure since hand held grass cutter workers do not operate

the machine for 8 hours per day. An average time of workers operating the machine is about 5.46 hours per day. According to ISO 5439, the daily vibration exposure shall be stated in terms of the 8 hours energy equivalent frequency h-weighted vibration total values as A(8). The daily vibration exposure, A(8) under normal operating condition shall be obtained using Equation (2).

$$A(8) = a_{hv}\sqrt{\frac{T}{T_0}} \quad . \qquad (2)$$

where; a_{hv} is the vibration total value for the hand held grass cutter machine, T is the duration of operating the machine and To is the reference time (8 hours). From the measured A(8) values, the maximum daily usage time of the hand held grass cutter will be known and then used to determine the extent of compliance with the regulation or guidelines. Equation (3) is used to estimate 10% of hand held grass cutter workers exposed to a risk of fingers colour change so called vibration-induced white finger.

$$D_y = 3.18(A(8))^{-1.06} \quad . \qquad (3)$$

where; *A(8)* is the daily vibration exposure (m/s^2), *Dy* is the group mean of exposure time of hand arm vibration (year).

Figure 1 shows a schematic and set up of hand arm vibration and noise data collection process. Hand held grass cutter workers work as subcontractors of highway and facilities grass maintenance was selected as subject in this study. Blaze software version 6.1.1 for Larson Davis human vibration metre (HVM 100, PCB Piezotronic, 00496) was used to analyse hand arm vibration exposures following ISO 5349. *Raw, h*-weighted tri-axial hand arm vibration measurements were collected using ICP accelerometer mounted on both left and right handles of hand held grass cutter machine, respectively. The tri-axial piezoelectric accelerometer handle mounted adapter was inserted between the worker's fingers and the handle and fixed on the handle by tape [11][2]. The right hand was used for operating the speed cutting control. Each handle was measured one time with sampling rate of 1 second period for 4 minutes. However, to produce a statistical significant of vibration data, at least 60 seconds should be enough for vibration data collection[12].

Results and Discussion

Magnitude of vibration level depends on the operating system of the hand held grass cutter machines. The worker exposes the hand arm vibration in his hands at the left and right grip of handle. It was observed that the rms vibration acceleration values for left hand are higher compared to right hand (Figure 2). In addition to vibration, the landscape working areas such as drain and slope are the other difficulty for the workers to carry out during their routine operation activities. The a_{hv} acceleration values for each measurement axes for the five different types of hand held grass cutter machines are given for left and right hand of workers in Figures 2a and b, respectively. The a_{hwy} (parallel to the longitudinal direction of handle) contributes high vibration magnitude for left hand while a_{hwx} (perpendicular to the longitudinal direction of handle) contributes high vibration magnitude for the right hand. The a_{hv} acceleration values vary between 3.33 to 33.6 m/s^2 for left hand and 2.48 to 23.9 m/s^2 for right hand. The maximum vibration magnitude on the left hand in the y direction of machine type E was measured as 26.5 m/s^2. The cutting tool rotation movement of the grass cutter shaft is in the *y* direction. On the other side, minimum vibration magnitude value was determined as 0.93 m/s^2 on the left hand in the *z* direction of machine type C. It is a great evidence that the acceleration values of *x* and *y* direction of the left and right hand give significant contribution in increasing the total vibration value. The type C machine shows less vibration transmitted to both hand compared to the other types of hand held grass cutter machines. A strong correlation is obtained between total vibration magnitude levels for both hand (Spearman correlation coefficient 0.778, $\rho<0.05$), and hence a clear conclusion can be stated that the hand arm vibration of left hand is associated with vibration transmitted to the right hand.

Daily exposure value of A(8) in m/s^2 is calculated from a_{hv} and the mean daily time of operation vary from 2.7 to 29.1 m/s^2 (mean 8.81 and S.D 5.02 m/s^2) for the left hand while 2.1 to 20.7 m/s^2 (mean 6.13 and S.D 3.01 m/s^2) for the right hand. A box plot graph showing spread of A(8) according to the machine type is presented in Figure 3. More detailed data, statistical data for daily vibration exposure, A(8) for left and right hand by the types of hand held grass cutter machines are presented in

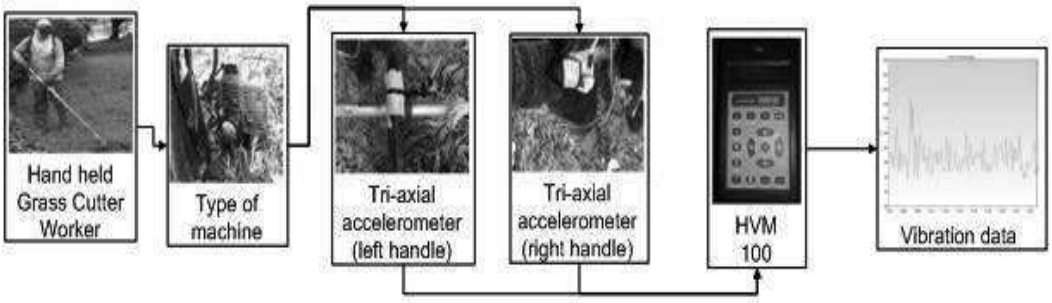


Figure 1: Schematics of hand arm vibration assessment data collection process

June 2015, vol 12, No. 1

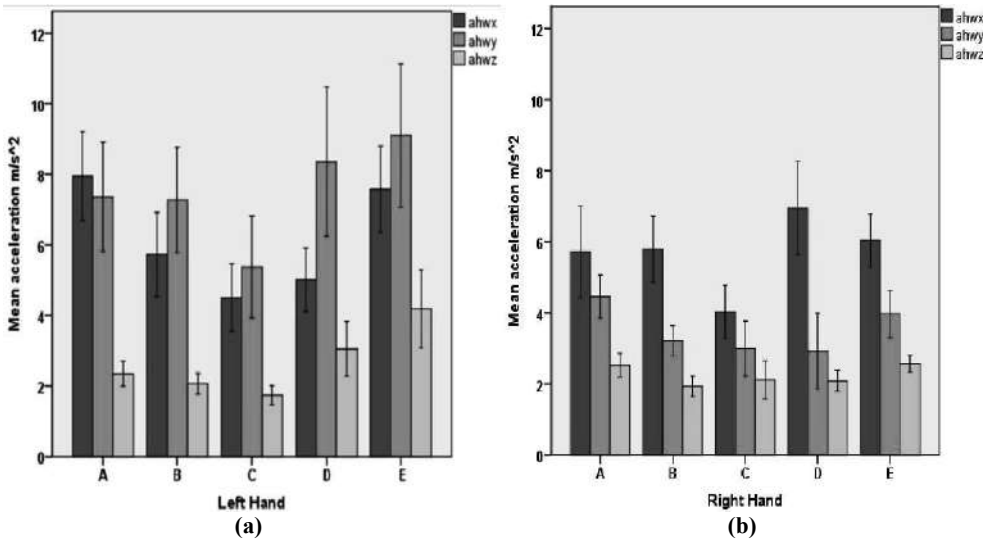


Figure 2. The rms (a_{hw}) acceleration values and standard deviation of hand held grass cutter machine for left and right hand in three axes.

Table 3. Both left and right hand vibration measurement exceed the EAV value for the mean A(8) for each type of machines. Control measures were not implemented in reducing the vibration levels such as handle vibration damper or anti vibration glove. The outliers or extreme values shown in Figure 3 reveal that the workers have high possibility of exposure to impulsive force due to impact between dynamic rotation of cutting blade with stone, wood, etc. By referring to guidelines on occupational vibration, hand held grass cutter workers should operate the machine maximum 2 hours per daily to protect them from HAVS diseases. Thus, risks of HAVS have to be observed not only in the form of high vibration magnitude exposed but also with the duration of operating the machine itself. As seen in Table 3, the A(8) values are almost similar for all of the machines except for machine type C which shows less vibration magnitude for both left and right hand. However, the A(8) value has exceeded the ELV for left hand and below EAV for right hand. This will be good perception for hand held grass cutter machine selection management proposed.

Daily vibration exposure values were also calculated with the mean total exposure duration in years which may be expected to produce episodes of fingers blanching for each type of machines. The machine type C reveals the maximum duration for the left hand which is 5.7 years while the right hand is 7.3 years. The minimum duration is 3.7 years for workers induced to left hand colour change which used machine type E.

Conclusion

The vibration values that were measured in this study show that worker's hands will be predicted to induce fingers blanching in 10% of the exposed person after less than 3.7 years for machine type E. Therefore, it is compulsory for employers to take responsibility in terms of occupational safety and health. Employers should provide provision of such information, instruction, training and supervision as it is necessary to ensure, so far as is practicable, to mitigate the hand arm vibration risk. Hence, a proper work schedule should be arranged to protect workers from HAVS. The type C machine provides the most comfort operating

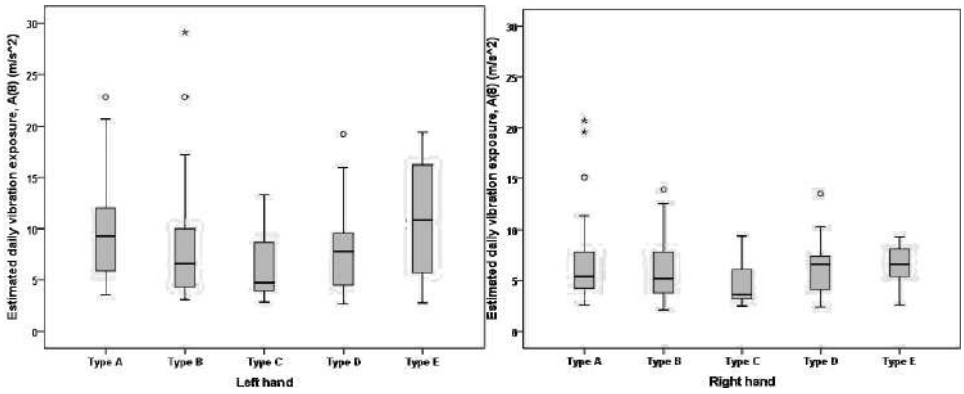


Figure 3: Box-plot graph showing spreads of daily exposure values A(8) (for the left and right hand that gave the highest value) for each type of hand held grass cutter machines.

Table 3: Statistical data for daily vibration exposure, A(8) for left and right hand by type of hand held grass cutter machine

Type of hand held grass cutter	Mean operating hours in a day	Left hand, A(8) (m/s^2)		Right hand, A(8) (m/s^2)	
		Mean (S.D)	Range	Mean (S.D)	Range
A	5.57	9.92 (4.92)	3.6 – 22.8	6.73 (3.94)	2.6 – 20.7
B	5.40	8.13 (5.27)	3.1 – 29.1	5.91 (2.70)	2.1 – 13.9
C	5.96	6.30 (3.34)	2.9 – 13.3	4.77 (2.27)	2.5 – 9.40
D	4.70	8.23 (4.60)	2.7 – 19.2	6.25 (2.84)	2.4 – 13.5
E	5.62	10.82 (3.94)	2.6 – 20.7	6.57 (1.96)	2.6 – 9.30

S.D, standard deviation; Range, minimum – maximum

condition for workers when compared with type A, B, D and E machines. Therefore, type C machine could be recommended machine for grass cutting operation.

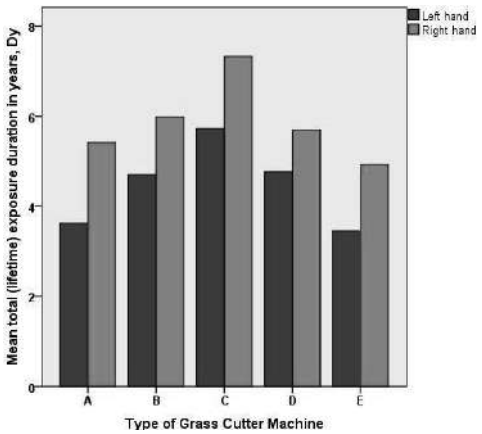


Figure 4 : Mean total (lifetime) exposure duration in years which may be expected to produce episodes of finger blanching (vibration-induce white fingers)

Acknowledgement

The authors would like to express special thanks to the Universiti Tun Hussein Onn Malaysia, Leading Highway Maintenance Company in Malaysia and NIOSH, Malaysia for their assistance and support throughout this research.

References

(1). Y. H. Ko, O. L. Ean, and Z. M. Ripin, ―The design and development of suspended handles for reducing hand-arm vibration in petrol driven grass trimmer,‖ Int. J. Ind. Ergon., vol. 41, no. 5, pp. 459–470, Sep. 2011.

(2). N. A. Azmir, M. I. Ghazali, and M. N. Yahya, ― Hand Arm Vibration And Personal Noise Exposure Characteristics Of Hand Held Grass Cutter Machines,‖ in The 21st International Congress on Sound and Vibration, 2014.

(3). Department of Occupational Safety & Health, ―Occupational Accident Statistics By Sector,‖ [Online], 2013. [Online].Available:http://www.dosh.gov.my/index.php?option=com_ content&view=article&id=843&Itemid=545&lang-en.

(4). Social Security Organization, ―Statistik Penyakit Muskuloskeletal Pekerjaan 1995-2009,‖ [Online], 2009. [Online]. Available: http://www.dosh.gov.my/index.php?option=com_docman&task=doc_download&gid=330&Itemid=496.

(5). M. J. Griffin, Handbook of human vibration. Academic press, 1990.

(6). BS EN ISO 5349-1, ―Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration - Part 1: General requirements.‖ British Standards, 2001.

(7). C. A. Janicak, ―Preventing HAVS in the Workplace,‖ Prof. Saf., vol. 49, no. 1, pp. 35–40, 2004.

(8). ―Directive 2002/44/EC of the European Parliament and of the Council of 25th June 2002 on the minimum health and safety requirements regarding the exposure to workers to the risks arising from physical agents (vibration), Off. J. Eur. Communities, vol. 45, no. EC, pp. 13–19, 2002.

(9). P. Brereton, ―Impact of european directive 2002/44/ec on the risk of developing hand-arm vibration syndrome in Great Britain,‖ in Canadian Acoustics, 2011, 2nd ed., vol. 39, pp. 108–109.

(10). Department of Occupational Safety and Health, Ministry of Human Resources, Malaysia on Guidelines On Occupational Vibration. Malaysia: JKKP, 2003.

(11). K. N. Dewangan and V. K. Tewari, ―Characteristics of hand-transmitted vibration of a hand tractor used in three operational modes,‖ Int. J. Ind. Ergon., vol. 39, no. 1, pp. 239–245, Jan. 2009.

(12). J. F. Wasserman, D. E. Wasserman, and D. Wilder, ―Occupational Vibration: A Concise Perspective,‖ in Handbook of Human Factors and Ergonomics Methods, CRC Press LLC, 2005, pp. 73–1.

June 2015, vol 12, No. 1 : 197-202

Perception Study On Ergonomics Practices In Malaysian Quarry And Mining Industry

***Norhidayah Mat Sout, [2]Ahmad Rasdan Ismail, [1]Muhamad Arifpin Mansor**

[1]Faculty of Technology, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia

[2]Faculty of Creative Technology and Heritage Universiti Malaysia Kelantan Beg Berkunci 01, 16300 Bachok, Kelantan, Malaysia

Corresponding Author: Tel : +6013-5929101; Fax : +609-5492147 ; Email :hidayahsout@gmail.com

Abstract

Ergonomics can be viewed as an approach to reduce injury and illness rates to improve the overall working conditions for employees by addressing risk factor exposure that may occur during manual tasks. The objective of this research was to analyze ergonomics risk factors by associating the perception of employer and employees towards their workplace condition in quarry and mining industry. A Questionnaire on Ergonomics Risk Assessment was used to determine the comparison level awareness and perception analysis among quarry and mining industry in Malaysia. The findings of this research prove that the exposure of ergonomics risk factors towards the workers is in a moderate level with a mean of 3.59 for the overall respondent review about the ergonomics risk among workers at their workplace. Besides, the most concern in ergonomics is about the awkward posture at work. Some 8.8% of them agreed and 6.6% of them totally agreed that they were in awkward posture while doing their work. As a conclusion, assessment of ergonomics in quarry and mining industry will be a platform to provide a safe and healthy working environment.

Keywords:ergonomics, risk factor, quarry and mining

Introduction

Over the past century, there has been a rapid development in every country around the world for the government to increase the quality, health, and safety requirements in several occupations. In the new global economy, Occupational Safety and Health has become a central issue for quarry and mining industry in Malaysia. Recent evidences show that Malaysia's identified mineral resources were barite, bauxite, clay, coal, copper, gold, ilmenite, iron ore, monazite, natural gas, petroleum, silica, silver, struverite (tantalum), tin, and zircon. During the 20th century, mineral production played an important role in Malaysia's national economy, after many years of exploitation. Minerals such as barite, bauxite, copper, ilmenite, iron ore, and tin were either depleted or the capacities to produce them had decreased significantly in recent years. In terms of its contribution to the country's economy, the mining and quarrying sector accounted for 7.0% of the Gross Domestic Product in 2010 compared to the mining and quarrying sector in 2009 (1).

The quarry and mining industry play a very important and necessary role in the development of the country. The industry guarantees adequate and continuous supply of raw materials to the construction, building and manufacturing sectors for the economic development of the country. The Environmental and social impact of quarrying and mining activities may be felt both on and off for a longer period of time. The physical impacts are on land, water, air, wildlife, vegetation, economic, supply and demand, revenues, employment and others. There are also health and safety implications for both individuals and communities. Mining and Quarrying Safety and Health Act 1999(2) stated that quarry is a place on land where operations are carried out continuously or from time to time to produce construction or road building material. Meanwhile the meaning of mine is any of the following places: a place where operations are carried out continuously or from time to time within the boundaries of land the subject of a mining tenure, a place where operations are carried out continuously or from time to time on land adjoining, adjacent to, or contiguous with, the boundaries of land the subject of a mining tenure and within which is a place mentioned in paragraph, a place where operations are carried out continuously or from time to time unlawfully because land at the place is not the subject of a mining tenure, a place that was a mine while works are done to secure it after its abandonment, a place where tourism, education or research related to mining happens that is declared under a regulation to be a mine.

Literature Review

Ergonomics are generally known to be related to humans and their jobs. Te-hsin and Kleiner (3) defined ergonomics as a combination of the words "ergo", a Greek word meaning "work" and "nomics", meaning "study"-the study of work. It also means an applied science that coordinates the design of devices, systems and physical working conditions with the capacities and requirements of the workers. According to the

International Ergonomics Association (4), ergonomics is concerned with understanding interactions among people and other elements of a system to optimize their wellbeing and overall system performance. In other words, ergonomics examines human behavioural, psychological and physiological capabilities and limitations.

In mining industry, the Implementation Guide and Tools from the Department of Health and Human Services (5) state that ergonomic is the scientific discipline concerned with the understanding of interactions among people and other elements of a system to optimize their well-being and overall system performance. The guidelines state that applying ergonomics principle to the design and evaluation of manual tasks involving lifting, pushing, carrying, moving, manipulating, holding, pounding or restraining a person, animal or item. In addition, the other ergonomic principle is related to jobs, products, environment and systems, ensuring that they meet the needs, capabilities and limitations of people. From the whole perspectives, ergonomics can be a third leg of a three pronged risk management approach to reduce musculoskeletal disorder (MSD) rates.

Jaafar N. *et al*.(6) stated that ergonomics is a broad science with a wide variety of working conditions that can affect workers' comfort and health, including factors such as lighting, noise, temperature, vibration, heavy lifting, repetitive motion, workstation design, tool design, machine design, chair design, footwear, etc. NIOSH (7) points out that the risk of musculoskeletal disorder is determined by various physical factors but most notable ones are frequency, duration, and intensity of work activities. International Labour Organization (ILO) (8) claimed that two million workers died every year because of occupational injuries and accidents. In the early 1900's, as many as 3,000 underground coal mine workers died every year. However, there has been a decreasing trend in mine worker fatalities. This trend may be due to the fact that advanced technologies have provided a safer work environment, hence a decrease in the number of workers required to perform tasks (9).

Recently, researchers who have shown increasing interests in new technologies in quarry and mining stated that although new technologies in mining industry may have positively affected workers' tasks and the efficiency of extracting coal, they may not reduce cumulative injuries. Many jobs still expose mine workers to musculoskeletal disorders such as awkward posture, exposure to whole body vibration, forceful exertions and repetitive motions (10). Therefore, the cumulative injuries in underground mining may still be present. Thus, to reduce cumulative injuries, it would be necessary to have a force towards the design of task, equipment and tools. However, the National Institute of Occupational Safety and Health (7) which interacts with mining companies has indicated that many have chosen not to entrust their resources because a clear cost/ benefit has not yet been shown.

Methodology

The aim of this paper was to determine the perception among the workers in mining and quarrying industry. A total of 91 sample questionnaires were distributed among the quarry and mining companies throughout East Coast of Malaysia. The study method was by the use of a set of Likert –type scales multiple choice items (11). The questionnaires were distributed to the subjects individually. Data collection for this study would be obtained from questionnaires to study the level of safety practices in the quarry. Each company was given 50 questionnaires, collected after 3 working days.

The questionnaires consisted of four parts which represented the levels of safety practices implemented in the quarry and mining industry; Part A comprising questions regarding the level of safety awareness in the quarry and mining industry, Part B comprising questions regarding the perception of workers' knowledge on safety and health at workplace, Part C about the perception of carrying out safety and health programme by workers at the workplace, and part D about the ergonomic risk of the workers at the workplace.

The awareness, knowledge and compliance of safety among workers in mining and quarrying industry would indicate the level of safety practices. The data was analyzed by computing the mean of each question answered. The computed mean from the respondents' answer was categorized into the categorizing framework as in Table 1. The range of mean that form the categorizing framework was calculated based on mid – point method (12).

Table 1 : Range of means for safety and health practice

Scale	Lower range	Upper range	Range of mean	Level of practice
1	0	— + 1 = 1.5	0 – 1.5	Very low
2	— - 2 = 1.5	— + 2 =2.5	1.6 – 2.5	Low
3	— - 3 = 2.5	— + 3 = 3.5	2.6 – 3.5	Moderate
4	— - 4 = 3.5	— + 4 = 4.5	3.6 – 4.5	High
5	— - 5 = 4.5	5	4.6 – 5.0	Very high

Results and Discussion

Table 2 explains the characteristic of samples taken among the quarry and mining workers. Reliability measures: Questionnaire reliability was tested using Cronbach alpha (α). Rodeghier (11) found that Cronbach alpha (α) was derived from the average correlations of all the items on the scale. Meanwhile, the reliability test is shown in the Table 3. Out of the total 5 reliability measures done, 3 of them have reliability above 0.7. One item has reliability measure at least 0.506. The result indicates that the reliability measures are high for the safety perception among the quarry and mining industry.

The mean value for safety implementation in this industry is 3.22. This shows that they have implemented the element compulsory in OSHA 1994. These results reflect their level of compliance towards OSHA 1994 since the questions asked in the implementation section referred to OSHA 1994. Mekos (16) in his study in Thessaloniki stated that insufficient rules and regulations keep contributing towards accidents at workplace. Besides, good safety implementation starts with complying with acts and regulations (17).

Moreover, Table 4 also shows that the perception of workers at quarry and mining sector towards ergonomics

Table 2 : Characteristic of the samples

Characteristics	Category	Frequency	Percentage (%)	Mean±SD
Gender	Male	69	75.8	1.24±0.431
	Female	22	24.2	
Age	< 20	1	1.1	33.77±10.359
	20 - 29	41	45.1	
	30 - 39	22	24.2	
	40 - 49	20	21.9	
	>50	7	7.7	
Education	SPM	55	60.4	1.91±1.226
	Certificate	6	6.6	
	Diploma	13	14.3	
	Bachelor degree	17	18.7	
Position	Employer	23	25.3	1.75±0.437
	employee	68	74.7	

Table 4 shows the means for safety and health practices in quarry and mining industry. Based on Table 4, the overall safety awareness among quarry and mines workers is 3.71, which is at the moderate level. This shows that the safety awareness in this industry still has not achieved the satisfaction level. Lack of safety awareness among the quarry and mines workers can cause large disaster to occur (13). This result proves that safety awareness is very important in any job or occupation. Lack of safety awareness may cause accidents at workplace.

Based on Table 4, safety knowledge among quarry and safety workers is 3.38, below the satisfactory level. Safety knowledge is very important in order to create a safe working environment, thus increasing the safety awareness. Lack of knowledge will cause accidents, as stated by Joy (15). Many accidents occur at mines sites either because the mineworkers are unaware of the rules, or they are aware of the rules but do not understand them, or they mistakenly apply the rules, or ignore them, or they are poorly trained or they lack sufficient educational background. Another study by Neal et al. (14) found that safety knowledge is the mediating factor which contributes in creating good safety environment at workplace.

is moderate with the value of 3.53. A previous study claimed that many jobs still expose mine workers to musculoskeletal disorder such as awkward posture, exposure to whole body vibration, forceful exertions and repetition (10). Therefore, high cumulative injuries in underground mining may still be present. Thus, to reduce cumulative injuries it would be necessary to have a force towards the design of task, equipment and tools. However, the National Institute of Occupational Safety and Health (7) which interacts with mining companies has indicated that many have chosen not to entrust their resources because a clear cost/ benefit has not yet been shown.

Table 5 highlights the analysis made on the perception towards ergonomics risk at their workplace with 44.0% of them agreeing and 35.2% totally agreeing with the range of movement at their workspace. The next question on the respondents' hands and arms free of the pressure of sharp edge on work surface shows that 41.8% of them agreed and 28.6% totally agreed with the statement. There were 39.6% respondents who agreed and 27.5% of them who totally agreed with the easily adjustable chair and stool suited to the task. The most important element in ergonomics is the body posture while working. A total of 67.0% agreed while 20.9 %

Table 3 : Reliability measures using Cronbach's α for tested factors

Tested factors	Cronbach alpha (α)
The level of safety awareness at the quarry and mining sites	0.829
The perception of workers knowledge on safety and health at workplace	0.506
The perception of carrying out safety and health programme by workers at workplace	0.892
The ergonomic risk of the workers at workplace	0.791

Table 4 : Mean of all parts of the questions

Questions	Mean
Awareness	3.71
Knowledge	3.38
Safety implementation	3.22
Ergonomic	3.53

totally agreed that they could change body posture while working. Almost half of the respondents (48.4%) agreed that all requirements of the task could be reviewed from a comfortable position while 18.7% of them totally agreed with it. Meanwhile, the main concern in ergonomics is awkward posture. There were 8.8% of the respondents who agreed and 6.6% who totally agreed that they were in awkward posture while doing their work. Table 5 shows that the external factors in ergonomics such as thermal comfort, noise and vibration do not affect their body and there were 28.6% of them who agreed and 9.9% who totally agreed with the statement. Findings from this study show that, most of the respondents realized that they were actually exposed to ergonomics risks. Recent evidences indicated that workplace environment is one of the factors affecting job satisfaction (18).

Conclusion

Industrial development seems to be moving toward further globalization, with a rapid growth of quarry and mining industry, an increased flexibility of production and a continuous progress in the future. It is always related to applied ergonomics research projects, addressing specific work problems with researchers or consultants providing information with little control or influence over how to control the ergonomics risk and how to implement the risk control of the ergonomics factors among workers. Other than that, it is such a useful finding for intervention programme on reducing ergonomics hazard in the quarry and mining industry. Hence, the companies must have an important role to play in establishing a balance between ergonomics risk factors and working method and the protection of employees' health and safety.

Acknowledgement

This study was funded by the Faculty of Technology Universiti Malaysia Pahang and the author would like to express gratitude to the Occupational Safety and Health Management Office, Universiti Malaysia Pahang for funding to this research.

Table 5 : The percentage of respondents' distribution on ergonomics risk.

	n	TD (%)	D (%)	NS (%)	A (%)	TA (%)	Mean	SD
I can move in the range of movement in my work space.	91	0.0	0.0	20.9	44.0	35.2	4.14	0.739
My hands and arms are free of the pressure of sharp edges on work surface.	91	2.2	3.3	24.2	41.8	28.6	3.91	0.927
Chair or stool that I use is easily adjustable and suited to the task.	91	1.1	0.0	31.9	39.6	27.5	3.92	0.833
I can change the body posture while working	91	0.0	1.1	11.0	67.0	20.9	4.08	0.601
All requirements of the task can be viewed from a comfortable position.	91	0.0	2.2	30.8	48.4	18.7	3.84	0.749
I work in awkward postures.	91	28.6	30.8	25.3	8.8	6.6	2.34	1.176
External factors such as thermal comfort, noise and vibration Do not affect my body.	91	11.0	19.8	30.8	28.6	9.9	3.07	1.153

TD: Totally disagree; D: Disagree; NS: Not sure; A: Agree; TA: Totally agree

References

(1). Department of statistics, 2011, yearbook of statistics Malaysia 2010: Kuala Lumpur, Malaysia, Department of statistics, June, 367 p.

(2). Mining and Quarrying Safety and Health Act 1999. (2012), (January).

(3). Te-Hsin,P&Kleiner,B.H. (2001). New developments concerning the occupational safety and health act. Journal of Managerial Law. Volume 43,No.1/2,138-146.

(4). International Ergonomics Association (2000); http://www.iea.cc/

(5). Guide, I. (2009). Ergonomics Processes Implementation Guide and Tools for the Mining Industry.

(6). Jaffar, N., & Lop, N. S. (2011). Procedia Engineering The 2nd International Building Control Conference 2011 A Literature Review of Ergonomics Risk Factors in Construction Industry, 00. doi:10.1016/j.proeng.2011.11.142

(7). NIOSH, 1997. Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back. NIOSH Publication No. 97B141, US Department of Health and Human Services, National Institute for Occupational Safety and Health, Cincinnati, OH.

(8). International Labour Organization (ILO):Chemical Safety in Asia: Law and Practice,2000: (online), available from http://www.ilo.org./public/english/protection/safework/papers/asiachem/ch1.html

(9). Moore, S. M., Bauer, E. R., & Steiner, L. J. (2008). P e r s Prevalence and cost of cumulative injuries over two decades of technological advances : a look at underground coal mining in the U .S ., (January).

(10). Zhuang, Z., and Groce, D.W., 1995, "The national occupational health survey of mining: magnitude of potential exposures to musculoskeletal overload conditions," in Advances in Industrial Ergonomics and Safety VII, A.C. Bittner and P.C. Champney, eds., Taylor & Francis, pp. 273-280.

(11). Rodeghier, M., 1996. Survey with Confidence: A Practical Guide to Survey Research Using SPSS. 1st Edn., SPSS Inc., Chicago, IL., pp: 178

(12). Teh, K.S. and Tan, A.G. 2003. STPM Mathematics. Malaysia :Pelangi

(13). Guo Wei-ci & Wu Chao, 2011. Comparative Study on Coal Mine Safety between China and the US from a Safety Sociology Perspective

(14). Neal, A., Griffin, M.A., Hart, P.M., 2000. The impact of organizational climate on safety climate and individual behaviour. Safety Science 34, 99–109.

(15). Joy, J., 1999. Learning from mistakes in mining. Australian Journal of Mining, June. Retrieved from http://www.qrc.org.au/_files/docs/ conferences/ OHS_1999/Safety_Joy.doc

(16). Mekos, K. Z.,2010. Complaint reports for violations of health and safety legislation in the area of Thessaloniki (Greece). Safety Science, 48(2), 209–214.

(17). James K.C., Chen & Dulamjav Z., 2013. Managing occupational health and safety in the mining industry.

(18). Shikdar, A.A. and N.M. Sawaqed, 2003. Worker productivity and occupational health and safety issues in selected industries. Comput. Ind. Eng., 45: 563-572. DOI: 10.1016/S0360-8352(03)00074-3

June 2015, vol 12, No. 1 : 203-208

Air Filtration Study to Improve Indoor Air Quality: A Proposed Study

M.D Amir Abdullah [1+], A.M Leman[2] and A.H Abdullah [1]

[1] *Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia*
[2] *Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia*
Corresponding Author: Tel : +6016-6573835; Email :gf130162@siswa.uthm.edu.my

Abstract

Indoor air quality has been a major public concern recently. Several health effects are related to this problem. Findings from several studies have shown MVAC system as the main contributor for IAQ problem. Good practice of maintenance and servicing is important to maintain MVAC system, especially the filter. Good air filtration for MVAC system is needed to make sure adequate air is received by the occupants. This paper illustrated a recent study of air filtration for MVAC system especially for several industries that used MVAC system in their premises. This paper also proposed an air filtration study for a better air quality. Several Acts and Regulations related to Safety and Health were identified to create the framework for the proposed study. Air filtration technique was used in this preliminary study to set up guidelines to create safe and clean indoor spaces for workers and occupants.

Keywords:IAQ, Filter, MVAC, Safety and Health

Introduction

People spend more than 90% of their time indoor. Therefore, indoor air quality (IAQ) has become a public concern. Mechanical ventilation and air conditioning (MVAC) system is used for climate control in certain area of buildings. This automated system for climate control is also important to provide a comfortable and safe working environment (Li, Wall, & Platt, 2010).

MVAC system usually consists of several parts and equipment to deliver air to the occupants. Meanwhile, ventilation is used to exchange the air in the enclosed spaces. Mechanical ventilation and natural ventilation are the common types of ventilation method used in commercial buildings. Air filtration has a significant role in order to create clean indoor air (Sublett *et al*., 2010). Air filter is also an important equipment used to prevent MVAC equipment such as air handling unit (AHU) and duct from becoming dirty, thus ensuring a good air quality (Hyttinen M. *et. al*., 2007; Lin & Chen, 2014).

Several health problems are also associated with poor IAQ such as, eye incitement, asthma, allergic dermatitis, pneumonia, and even death (DOSH, 2010; Sekhar & Goh, 2011). Air-filtration and air-cleaning systems can remove a variety of contaminants from a building's airborne environment (Azimi & Stephens, 2013; Möritz, Peters, Nipko, & Rüden, 2001). Air filter will be used as a sampling mechanism to evaluate contaminants that exist in certain MVAC systems (Noris, Siegel, & Kinney, 2011).The main reasons to install filters in MVAC system are as follows:

i. To maintain a clean environment for the comfort of the occupants

ii. To protect the décor of occupied spaces by removing the staining portion of airborne dust

iii. To protect the mechanical parts of the HVAC system

iv. To reduce particulates that are potentially harmful to occupants

v. To remove odours.

The effects of dust in HVAC system are commonly depending on the size of the dust particles. Usually, bigger-size dust will stick to the MVAC system and components (E.Mull, 1998). Thus, good air filtration is needed to protect MVAC system and to have better air quality for the occupants (Bluyssen, P.M *et. al.*, 2003).

Related Works

In recent years, air conditioning has been widely used in all buildings. The use of air conditioning could not be avoided since the outdoor temperature has increased. Air conditioning should not only promise a good energy consumption, but also guarantee a clean and safe air (Wan & Kong, 2008). Thus, to ensure a good air quality, air filters are used in MVAC system. Air filters perform as a primary defence against particles, pollutants and contaminants (Fedel, 2012).

Air Filtration Techniques

There are four methods of filtration: straining, impingement, interception, and diffusion. These four methods are used in capturing particles to filter media as shown in figure 1 (Fedel, 2012; Matela, 2008).

a. Straining: Straining occurs when the smallest dimension of a particle is greater than the

distance between adjoining filter-media fibres.

b. Impingement: High density particles are captured as they resist change in airflow direction around filter-media fibres and collide with the fibres.

c. Interception: Particles are captured based on forces of attraction as they come into direct contact with filter-media fibres.

d. Diffusion: Very small particles are captured at lower air velocities due to Brownian motion, which increases the probability that particles will come in contact with fibres and stay attached to them.

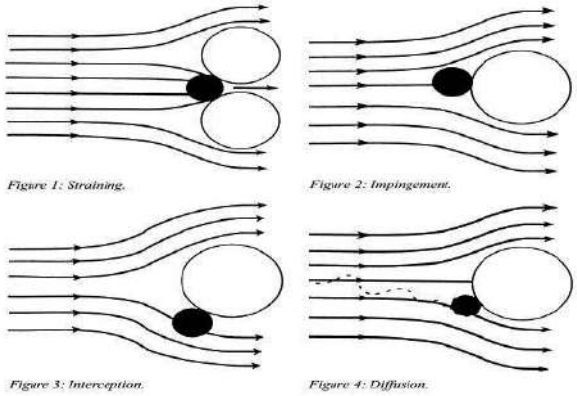


Figure 1 : Filtration methods

Filter Type

The effectiveness of a particular filter design or air-cleaning media will depend upon the nature of the contaminant, size of the particles, combination with the type of filter used and MVAC operating conditions (ASHRAE Fundamentals, 2009). Filters can be classified into four groups (E.Mull, 1998; Robinson & Ouellet, 1999):

i. Low efficiency filter

This filter is usually known as panel filter. It is typically flat panels, and mounted perpendicular to the direction of air flow. This type of filter has an efficiency below than 30%, making it low pressure drop, low cost, and good on lint. This kind of filters will be used as pre filters that will be installed upstream of higher efficiency filters.

ii. Medium efficiency filter

Medium efficiency filters are usually designed as bag type or box type filters. The average ASHRAE efficiency for medium efficiency filter is between 40%-60%. This filter is used as a second stage filter and is very effective to block 10-3µm of dust.

iii. High efficiency filter

This type of filters is usually come as bag or box type filters with average ASHRAE efficiency of 80%-90%. Usually, this filter is used as the final stage filter in commercial and public buildings. High efficiency filters are usually recognized as pleated media panel type of bag type.

iv. HEPA type filter

High efficiency particulate air (HEPA) and ultra-low penetration air (ULPA) are among the best types of filters. HEPA has 99.97% efficiency for dust greater than 0.3µm in diameter, while ULPA filter has 99.999% efficiency for dust particles greater than 0.12µm diameter. This kind of filters is frequently used in critical applications such as hospital operating rooms, cleaning rooms, pharmaceutical laboratories and precision manufacturing operations.

Some air filters are designed to be reused. The usage of the air filter depends on the application of MVAC system itself (Hall, 2009). The technology of air filter is developed to make sure that buildings get optimum air quality. Filters that are made from synthetic polymer fibres are commonly used instead of fibre glass filters which are typically used in recent years (Raynor *et. al*., 2008). The media is usually coarse (15µm to 60µm diameter) glass fibres, synthetic fibres, vegetable fibres, metallic wools, expanded metals and foils, crimped screens, random-matted wire, and synthetic open-cell foams (E.Mull, 1998). Meanwhile, I.S.H Buchanan *et. al*. conducted a research to gather information on whether air filter materials affected the building related syndrome (BRS). A high correlation is found between the use of polyester-synthetic filters and it increases the perception of BRS. (Buchanan, Mendell, Mirer, & Apte, 2008).

Air contaminant

There are many contaminants that are living in MVAC system such as particle, dust, fungi and bacteria. Usually, these microorganism and particles will stick in filtration system and other MVAC equipment. Z.Lu *et. al*. (2009) measured and analyzed the microorganism and particles in 10 AHU system of public buildings in China. The availability of this microorganism including fungi was very clear and the AHU system may transfer poor IAQ to the indoor (Lu, Lu, Zhang, & Sun, 2009). The availability of microorganism and particles in hospitals has also been discussed by P.C Raynor *et. al*. in their research. The biological and non-biological particles were measured for 13 weeks in operating systems of hospitals (Raynor *et. al*., 2008). Air and water are the major transportation medium to transmit particulate contaminants. During air filtration, the contaminants are complex mixtures of particles (Barhate & Ramakrishna, 2007).

Air contaminant

The most common air contaminant is dust. The size of less than 100µm is defined as dust. It is solid

granular particles and fibre. The mixture of granular particles, fibres, smoke, mist, and gases is referred as aerosol. There are three classifications of aerosol: coarse particles, fine particles and nuclei (E.Mull, 1998). The size range of particles in loading depends on whether the building is residential or commercial. (Waring & Siegel, 2008). The outdoor air intake should be a major factor that contributes to the presence of particles and dust in indoor spaces.

Methodology

There are several methods to evaluate the performance of air filter in MVAC system. This preliminary study can classify the filters from the samples and references are made to the Acts and Regulations associated with the IAQ parameters.

Minimum Efficiency Reporting Value (MERV)

Minimum Efficiency Reporting Value (MERV) is the scale to measure air filtration effectiveness. The scale was developed by American Society of Heating Refrigeration Association Engineer (ASHRAE). Table 1 shows the filter efficiency scale based on MERV minimum particle size that can be filtered, contaminant, and the application of the filter. The greater the rating, the better is the performance of the filter to capture the contaminant (ASHRAE Fundamentals, 2009; Fedel, 2012). Table 1 shows the MERV or filter classes and the contaminants that the filter can control.

In common commercial buildings, MERV 1 to MERV 5 filters are used to protect MVAC equipment. Meanwhile, MERV 6 to MERV 16 are used not only to protect equipment but also building occupants (Charles Seyfeer, 2008). Higher MERV values show better performance of the filters. In this study, the filter will be measured and classified with the building application and the MERV of the filter.

Data Collection

The aim of this study is to evaluate the performance of the filter. There are three components that need to be considered (E.Mull, 1998; Robinson & Ouellet, 1999):

a. Efficiency

b. Dust holding capacity

c. Resistance

This study will select several commercial building in order to gather information of their filter classes. The filter will have to be tested to evaluate their performance.

- *Arrestance Test*

The arrestance test is a standard synthetic dust test. During the process, dust is fed into the air stream,

Table 1 : Filter efficiency class and their contaminants

MERV	Min. particle size	Typically controlled contaminant	Typical Application
1–4	> 10.0 µm	Pollen, dust mites, cockroach debris, sanding dust, spray paint dust, textile fibres, carpet fibres	Residential window AC units
5–8	10.0–3.0 µm	Mold, spores, dust mite debris, cat and dog dander, hair spray, fabric protector, dusting aids, pudding mix	Better residential, general commercial, industrial workspaces
9–12	3.0–1.0 µm	Legionella, Humidifier dust, Lead dust, Milled flour, Auto emission particulates, Nebulizer droplets	Superior residential, better commercial, hospital laboratories
13–16	1.0–0.3 µm	Bacteria, droplet nuclei (sneeze), cooking oil, most smoke and insecticide dust, most face powder, most paint pigments	hospital & general surgery
17–20	< 0.3 µm	Virus, carbon dust, sea salt, smoke	Electronics & pharmaceutical manufacturing cleanrooms

passing through an air cleaner, and the weight fraction of the dust removed by the filter is measured. The dust weight is measured after the filter identified its increased weight. The weight percentage of the dust removed by the filter is then calculated based on the original total weight of the test dust. This test is usually to test low efficiency filters (E.Mull, 1998). Filter performance uses the ASHRAE 52.2-2007 standard.

- *Filter Dust Holding*

Dust holding capacity is defined as the amount of dust the filter will hold before being changed (Robinson & Ouellet, 1999). Therefore, the resistance (pressure drop) of the filter to the flow of air is measured as the dust fed into the airstream. The test will be considered completed when the filter reaches its limit or maximum allowable resistance set by the filter manufacturer (E.Mull, 1998). Filter lifetime expectancy varies greatly between filters as it has strong functions of dust holding capacity with a high degree of variability (Montgomery, Green, Rogak, & Bartlett, 2012).

Expected Results

From this study, the result is expected to determine the filtration efficiency class. From the data collected within target areas, this study identifies the source of the pollutant, thus improving the indoor air quality of the spaces. This study is also expected to identify material used for the filter in MVAC system.

References

(1). Azimi, P., & Stephens, B. (2013). HVAC Filtration for controlling infectious airborne disease transmission in indoor environments: Predicting risk reductions and operational costs. Building and Environment, 70, 150–160. doi:10.1016/j.buildenv.2013.08.025

(2). Barhate, R., & Ramakrishna, S. (2007). Nanofibrous filtering media: Filtration problems and solutions from tiny materials. Journal of Membrane Science, 296(1-2), 1–8. doi:10.1016/j.memsci.2007.03.038

(3). Bluyssen, P. M., Cox, C., Seppanen, O., & Oliveira, E. De. (2003). Why , when and how do HVAC-systems pollute the indoor environment and what to do about it ? the European AIRLESS project, 38, 209–225.

(4). Buchanan, I. S. H., Mendell, M. J., Mirer, a G., & Apte, M. G. (2008). Air filter materials, outdoor ozone and building-related symptoms in the BASE study. Indoor Air, 18(2), 144–55. doi:10.1111/j.1600-0668.2008.00519.x

(5). Charles Seyfeer. (2008). Updated Standard for Air-Filter Testing. HPAC Engineering Journal, (August), 45–49.

(6). DOSH. (2010). INDUSTRY CODE OF PRACTICE ON INDOOR AIR QUALITY, JKKP DP(S).

(7). E.Mull, T. (1998). HVAC Principles and Applications Manual. In McGraw Hill ISBN 0-07-044451-x.

(8). Fedel, T. (2012). Air Filters, An Inside Look. HPAC Engineering Journal, (November), 20– 23.

(9). Hall, R. (2009). Air filtration: Is air filter recycling for you? Filtration & Separation, 46(4), 34–36. doi:10.1016/S0015-1882(09)70160-0

(10). Hyttinen, M., Pasanen, P., Björkroth, M., & Kalliokoski, P. (2007). Odors and volatile organic compounds released from ventilation filters. Atmospheric Environment, 41(19), 4029–4039. doi:10.1016/j.atmosenv.2007.01.029

(11). Li, J., Wall, J., & Platt, G. (2010). Indoor Air Quality Control of HVAC System. In Proceedings of the 2010 International Conference on Modelling, Identification and Control (pp. 756–761).

(12). Lin, C., & Chen, H. (2014). Impact of HVAC filter on indoor air quality in terms of ozone removal and carbonyls generation, 89, 29–34.

(13). Lu, Z., Lu, W. Z., Zhang, J. L., & Sun, D. X. (2009). Microorganisms and particles in AHU systems: Measurement and analysis. Building and Environment, 44(4), 694–698. doi:10.1016/j.buildenv.2008.05.014

(14). Matela, D. (2008). Air-Filter Selection. HPAC Engineering Journal, (June).

(15). Montgomery, J. F., Green, S. I., Rogak, S. N., & Bartlett, K. (2012). Predicting the energy use and operation cost of HVAC air filters. Energy and Buildings, 47, 643–650. doi:10.1016/j.enbuild.2012.01.001

(16). Möritz, M., Peters, H., Nipko, B., & Rüden, H. (2001). Capability of air filters to retain airborne bacteria and molds in heating, ventilating and air-conditioning (HVAC) systems. International Journal of Hygiene and Environmental Health, 203(5-6), 401–9. doi:10.1078/1438-4639-00054

(17). Noris, F., Siegel, J. a., & Kinney, K. a. (2011). Evaluation of HVAC filters as a sampling mechanism for indoor microbial communities. Atmospheric Environment, 45(2), 338– 346. doi:10.1016/j.atmosenv.2010.10.017

(18). Raynor, P. C., Kim, B. G., Ramachandran, G., Strommen, M. R., Horns, J. H., & Streifel, a J. (2008). Collection of biological and non-biological

particles by new and used filters made from glass and electrostatically charged synthetic fibres. Indoor Air, 18(1), 51–62. doi:10.1111/j.1600-0668.2007.00504.x

(19). Robinson, T. J., & Ouellet, A. E. (1999). Filters and filtration. ASHRAE Journal, (April 1999), 58–63.

(20). Sekhar, S. C., & Goh, S. E. (2011). Thermal comfort and IAQ characteristics of naturally/mechanically ventilated and air-conditioned bedrooms in a hot and humid climate. Building and Environment, 46(10), 1905–1916. doi:10.1016/j.buildenv.2011.03.012

(21). Sublett, J. L., Seltzer, J., Burkhead, R., Williams, P. B., Wedner, H. J., & Phipatanakul, W. (2010). Air filters and air cleaners: rostrum by the American Academy of Allergy, Asthma & Immunology Indoor Allergen Committee. The Journal of Allergy and Clinical Immunology, 125(1), 32–8. doi:10.1016/j.jaci.2009.08.036

(22). Wan, R., & Kong, D. (2008). Analysis on Influencing Factors of Indoor Air Quality and Measures of Improvement on Modern Buildings. In 2nd International Conference on Bioinformatics and Biomedical Engineering (pp. 3959–3962). Ieee. doi:10.1109/ICBBE.2008.492

(23). Waring, M. S., & Siegel, J. a. (2008). Particle loading rates for HVAC filters, heat exchangers, and ducts. Indoor Air, 18(3), 209–24. doi:10.1111/j.1600-0668.2008.00518.x

June 2015, vol 12, No. 1 : 209-214

Indoor Air Quality of Museum Building Environment in a Tropical Climate: Proposed Study

S. N. Mohd Dzulkifli [1 *], A. H. Abdullah [1] and A. M. Leman [2]

[1] Fakulti Kejuruteraan Awam dan Alam Sekitar, Universiti Tun Hussein Onn Malaysia

[2] Fakulti Teknologi Kejuruteraan, Universiti Tun Hussein Onn Malaysia

Corresponding Author: Tel : +6013-4309514; Fax : +609-5492147 ; Email :shahrulniezam87@yahoo.com

Abstract

Indoor air pollution is rapidly becoming a major health issue worldwide. The quality of indoor air inside building is important not only for occupants' comfort but also for their health. Although researches are still under way to better define the nature and extent of the health implications for the general population, recent studies have shown significant amounts of harmful pollutants in the indoor environment. Poor indoor air quality (IAQ) has been tied to symptoms like headaches, fatigue, trouble concentrating and irritation of the eyes, nose, throat and lungs. In this study, occupants' comfort satisfaction on IAQ of a museum building environment in a tropical climate will be studied. IAQ aspects which will be considered as parameters are chemical contaminants, gaseous pollutant and comfort factors (temperature, humidity and air movement). Museum, archives, library, heritage building and gallery are the types of buildings that can be considered as heritage building environment. At the initial stage, a pilot study will be conducted to identify the current IAQ conditions inside those selected buildings.

Keywords:IAQ, Occupant Satisfaction, Heritage Building Environment

Introduction

Indoor air pollution is rapidly becoming a major health issue worldwide. Although researches are still under way to better define the nature and extent of the health implications for the general population, recent studies have shown significant amounts of harmful pollutants in the indoor environment. The serious concern over pollutants in indoor air is due largely to the fact that indoor pollutants are not easily dispersed or diluted as are outdoor pollutants. Thus, indoor pollutant levels are frequently higher than those of outdoors, particularly where buildings are tightly constructed to save energy.

Since most people spend almost 90% of their time indoors, many may be exposed to unhealthy concentrations of pollutants. These indoor environments include such places as homes, offices, stores, restaurants, warehouses, factories, government buildings, public buildings and even vehicles. In these environments, people are exposed to pollutants emanating from a wide array of sources.

Museums are one of niche products of Malaysia cultural heritage tourism attractions that could spur the growth of the tourism industry in this country (Ahmad & Badarulzaman, 2005). The museums need to focus on visitors' satisfaction so as to be able to have returning visitors in order to compete in the highly competitive world of leisure and tourist attractions. Basically, there are several issues affected by the poor indoor environment quality such as health problem, country reputation and productivity of workers in the heritage museum (Shuang, *et al.*, 2014).

Related Works

Indoor Air Quality

There are many factors in the environment inside a building which affect the occupants. While most of the current media attention is focused on air quality specifically, other factors either cause totally independent problems or act synergistically to worsen existing IAQ problems. These building environmental factors consist of noise, odours, lighting, comfort level and social conditions in the workplace. When these areas become problematic, they add to the perceived problem factors including ventilation or carbon dioxide level, draftiness, temperature and humidity, and gaseous and particulate contaminants. Problems can also be caused by contaminants which are totally unnoticed by the occupants.

According to the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) Standard 62-1989, acceptable air quality is when air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority of the people exposed do not express dissatisfaction. This definition implies compliance is required with both objective criteria to prevent illness and subjective criteria such as individual perceptions and comfort.

Table 1: Comparison guidelines of IAQ between Malaysia and Singapore

Indoor Air Contaminants	Malaysia	Singapore
	Eight hour time weighted average airborne concentration	
Carbon dioxide (CO_2)	C1000 ppm	1000 ppm
Carbon monoxide (CO)	10 ppm	9 ppm
Formaldehyde (HCHO)	0.1 ppm	0.1 ppm
Total volatile organic compound (TVOC)	3 ppm	3 ppm
Respirable particulate	0.15 mg/m^3	0.15 mg/m^3
Ozone (O^3)	0.05 ppm	0.05 ppm
Total bacteria counts	*500 cfu/m^3	500 cfu/m^3
Total fungal counts	*1000 cfu/m^3	500 cfu/m^3

Notes:

- For chemical contaminants, the limits are eight-hour time-weighted average airborne concentrations.
- mg/m^3 is milligrams per cubic meter of air at 25° Celsius and one atmospheric pressure.
- ppm is parts of vapour or gas per million parts of contaminated air by volume.
- cfu/m^3 is colony forming units per cubic meter.
- C is the ceiling limit that shall not be exceeded at any time. Readings above 1000 ppm are indication of inadequate ventilation.
- * excess of bacterial counts does not necessarily imply health risk but serve as an indicator for further investigation.

Table 2: Factors affecting occupant perceptions of building environment

Factors Directly Affecting Air Quality	Factors Affecting Other Perceptions
Temperature	Lighting
Temperature variations	Noise
Wet surfaces	Furnishings and surroundings
Air movement, draftiness and stuffiness	Social interaction
Humidity and moisture	Building vibration or movement
Gaseous and particulate contaminants	Crowding and personal space
Entrained dust and dirt	Odours from personal products
	Building functional byproducts

Not all occupants perceive, observe or react to environmental conditions in the same manner. Even serious conditions such as disease produced by microbial contamination is likely to affect only a small percentage of the occupants. Comparison guidelines of IAQ between Malaysia and Singapore are shown in Table 1. For IAQ, usually the important factors to be considered are air exchange rates, building design and ventilation characteristics, indoor contaminant sources, air movement and mixing, temperature, relative humidity and outdoor contaminant concentrations and meteorological conditions, as shown in Table 2.

According to O'Reilly and others (1998), there are three major factors that could affect IAQ, namely, source from chemical contaminants, biological or microbial contaminants and gaseous pollutants. However, there are also other factors that can be considered as major factors affecting IAQ such as particulate matter and thermal environment.

Thermal environment is a combination of temperature, relative humidity and the air movement in the building. Each occupant in a building will perceive the thermal environment differently. Temperature and relative humidity are general building conditions that are indicators of thermal comfort which can also provide indirect indications for potential organic and biological compound contaminations. Comfortable temperature levels are considered to be between 23°C to 26°C. Recommended humidity levels range from 40 to 70 percent, and higher humidity levels can be amplifiers for contamination. Variations over a measured period of time can also indicate the Heating Ventilation and Air-

Table 3: Acceptable range for specific physical parameters
(Source: Department of Occupational Safety and Health (DOSH) Malaysia)

Parameter	Acceptable range
Air temperature	23 – 26 ^{o}C
Relative humidity	40 – 70%
Air movement	0.15 – 0.50 m/s

Conditioning (HVAC) system problems. Table 3 shows an acceptable range for specific physical parameters in buildings.

Chemical contaminants can originate anywhere in a facility if someone uses, spills or disposes of some chemical in the wrong way or in excess of recommended amounts. Volatile Organic Compounds (VOC), formaldehyde, pesticide, Environmental Tobacco Smoke (ETS) and radon are contaminants that can be classified as chemical contaminants. Biological or microbial contaminants arise when there is sufficient moisture and a source of nutrient for microscopically small, biological elements to grow. Fungi, dust mites and bacteria are contaminants that can be classified as biological contaminants (O'Reilly *et al*., 1998).

Occupant Responses

- *Stresses*

The fundamental objectives of environmental control are to provide occupant comfort and prevent exposure to unhealthy contaminants. Occupant complaints do not necessarily arise from intense exposure to one specific contaminant but from more gradual or subtle exposures to a combination of conditions in the building. Occupant complaints about building conditions generally fall into the following three classes:

- Perceived conditions causing real physiological strains. These include stressors such as warm or cold drafts, odours, environmental tobacco smoke, improper lighting and noise.

- Conditions not perceived by the occupants which cause physiological strain. These stressors include odourless gases and vapours, particulates below the human detection level and gaseous compounds below the odour threshold.

- Conditions which are perceived to be problems but which would not normally cause physiological stress. Examples include the work or management climate and job satisfaction. Some real physical conditions issues, such as low noise level or variations in lighting, can also fit into this category when they occur in combination with other conditions.

- *Comfort Demand*

Comfort demands are based on meeting the needs and expectation of the occupants of the building. The occupants use normal human sensory inputs (sight, sound, smell, touch and even occasionally, taste) to determine their own perceptions of their environment. Most of the environmental factors we consider to be components of IAQ problems are sensed by touch and smell. Other stressors such as excessive or insufficient lighting or high noise levels, affect those respective sensory organs.

Museum Environment

Museum is one of the popular destinations among the tourists in Malaysia with an average of over three million visitors per year (Jabatan Muzium Malaysia, 2012). Since the year 2005, Malaysia has been moving away from constructing new buildings in favour of refurbishing historic and old ones (Kamaruzzaman, *et al*., 2010).

To date, Malaysia has about 150 historical museum buildings which managed by several departments such as the Department of Museums, Malaysia, or J*abatan Muzium Malaysia* (JMM), state governments, private sectors or private organizations (Mohd Darif, 2008). Under JMM, there are about 21 museum buildings that managed by this national organization while the balance from the overall total of 150 museum buildings are managed by other organizations. According to Raha (2011), there are about 56 historical museum buildings which were originally built not to be museum buildings. Few studies have been done so far on the quality of their indoor environment.

In Malaysia, previous researchers focused more on the contaminants based on the thermal environment in the museum environment only. Just few studies have been conducted on the chemical contaminants, microbial contaminant and gaseous pollutants. Most of the studies focus on the occupant satisfaction towards indoor environment. In general, when discussion about an indoor environment aspect is made, factors of thermal environment, aesthetic, visual or lighting, acoustics and indoor air are highlighted. Discussion about particulate matter aspect seems to be new in Malaysia compared to Singapore. In Singapore, they are focusing deeper on fine particulates effects and its contribution but in Malaysia, the main focus is still on total suspended particulates (Hanapi & Din, 2012). Although many

museums have been widely investigated in Europe, the effects of particulates matter and gaseous pollutants in museums under tropical and subtropical climates and with different economic realities are still unclear (Godoi *et al*., 2013)

The visitor satisfaction depends on the total experience of the visitors during their first visit to the museums (Rowley, 1999). The most important thing is to understand how the environment affects the visitors, the public and the workers (National Park Service, 1999). Discussion about the occupant satisfaction should consider gender differences. Usually, females are significantly more likely to complain about the indoor environment quality factors than their male counterparts (Kim, *et al*., 2013).

Methodology

At the initial stage, a pilot study will be conducted to identify the current IAQ conditions inside those selected buildings. This study proposed to use a quantitative method using the questionnaire survey. One of the methods used is by post occupancy evaluation, one of the best ways to define the user's need and demand on indoor environment quality of historical museums (Shuang, *et al*., 2014). They also suggested that this technique include the measurement and analytical study to correlate and to identify occupant satisfaction level with the actual level of indoor museum environment served. Table 4 shows IAQ Complaints and Investigation Process by Department of Occupational Safety and Health (DOSH) Malaysia.

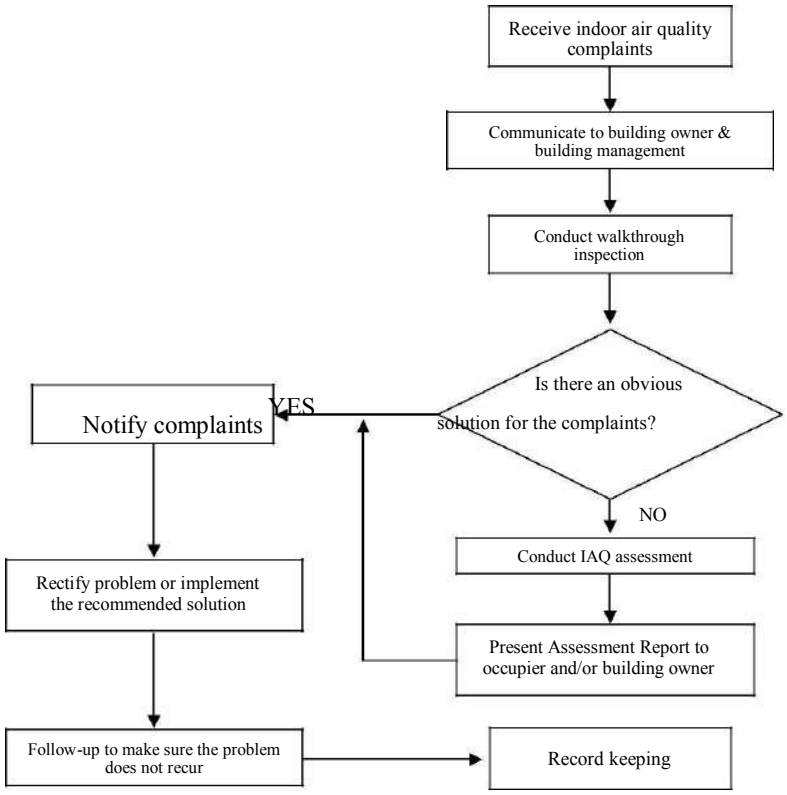
Expected Result

The aim of this study is to provide benefits to occupants, namely the visitors and staffs. The visitors may visit the museums as frequently as they wish to gain knowledge, while for the staff, their work productivity may be improved, without affecting their health while being inside the buildings. The study shows that, the benefits will also go to the customer, the government and the private sectors. Customers can gain better health during their visit to museum, beside gaining new knowledge from the information provided. For government and the private sectors, the benefits come from financial gains from increased visitors to the museums.

Acknowledgements

The author would like to express his gratitude especially to Associate Professor Dr. Abd. Halid bin Abdullah and Associate Professor Engr. Dr. Abdul Mutalib bin Leman for their guidance in the preparation of this paper.

Table 4: IAQ Complaints and Investigation Process
(Source: Industry Code of Practice on Indoor Air Quality 2010)



References

(1). Ahmad, A. & Badarulzaman, N. (2005). Conservation of Heritage Sites for Tourism Development in Malaysia. International Conference on Tourism Development: Vehicle for Development. Penang, Malaysia.

(2). ASHRAE Standard 62-1989 (1989). Ventilation for Acceptable Indoor Air Quality. Atlanta: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

(3). Godoi, R. H. M., Carneiro, B. H. B., Paralovo, S. L., Campos, V. P., Tavares, T. M.,

(4). Evangelista, H., Godoi, A. F. L. (2013). Indoor air quality of a museum in a subtropical climate: the Oscar Niemeyer museum in Curitiba, Brazil. The Science of the total environment, 452-453, 314–20. doi:10.1016/j.scitotenv.2013.02.070

(5). Hanapi, N., & Din, S. A. M. (2012). A Study on the Airborne Particulates Matter in Selected Museums of Peninsular Malaysia. Procedia - Social and Behavioural Sciences, 50, 602– 613. doi:10.1016/j.sbspro.2012.08.063

(6). Indoor Air Quality: A Systems Approach (1998). Third Edition. Virginia: Sheet Metal and Air Conditioning Contractors National Association, Inc.

(7). Industry Code of Practice on Indoor Air Quality 2010. Department of Occupational Safety and Health: Ministry of Human Resource Malaysia

(8). Jabatan Muzium Malaysia (2012). Laporan Tahunan 2012: Jabatan Muzium Malaysia. Kamaruzzaman, S. N., Zawawi, M. A. E., Pitt, M., & Don, Z. M. (2010). Occupant feedback on indoor environmental quality in refurbished historic buildings, 5(March), 192 –199.

(9). Kim, J., de Dear, R., Candido, C., Zhang, H., & Arens, E. (2013). Gender differences in office occupant perception of indoor environmental quality (IEQ).

(10). Mohd Darif, I. L. (2008). Rencana Utama: Kurang Sambutan Belia. Kosmo Online. Retrieved on 26 May 2008 from http://www.kosmo.com.my/kosmo/content.asp?y=2008&dt=0526&pub=Kosmo&sec=Rencana_Utama&pg=ru_01.htm

(11). National Park Service, N. (1999). US Museum Handbook Part I.

(12). O'Reilly J. T., Hagan P., Gots R. & Hedge A. (1998). Keeping Buildings Healthy: How to

(13). Monitor and Prevent Indoor Environment Problems. New York: John Wiley & Sons Inc.

(14). Rowley, J. (1999). Measuring Total Customer Experience in Museums. International Journal of Contemporary Hospitality Management, 11 (6), pp. 303 – 308.

(15). Shuang, G. W., Kamaruzzaman, S. N., & Zulkifli, N. (2014). Occupant's Perception on Indoor Performance of Historical Museum : A Case Study of National Museum and Perak Museum, Malaysia.

(16). Sulaiman, R., Kamaruzzaman, S. N., Salleh, N. & Mahbob, N. S. (2011). Can We Achieve A Balance Indoor Environmental Quality (IEQ) in Malaysian Historical Museum Building?. International Conference on Environmental Science and Technology, pp. 402 – 406.

June 2015, vol 12, No. 1 : 215-220

Monitoring of Indoor Plants Application for Indoor Air Quality Improvement: Proposed Study

Mohd Mahathir Suhaimi Shamsuri [1+], A.M.Leman [2], M.Sabree A.R[3] and Haryati Shafii[4]

[1-3] Faculty of Engineering Technology, [4] Faculty of Technology Management and Business Universiti Tun Hussein Onn Malaysia

Corresponding author. Tel.: + 6017-7338894 E-mail address: mohd_mahathir@rocketmail.com

Abstract

Indoor Air Quality (IAQ) is a subset of Indoor Environmental Quality (IEQ), where IAQ is about what we breath. Poor indoor air quality (IAQ) can cause health problems to the residents. Air conditions in the shelter must be preserved, in order to ensure the safety and health of the residents. Certain indoor plants can filter out toxin found in the air. Other than that, indoor plants can help clean the air. In this study, seven types of indoor plants that can live in equatorial climate like Malaysian environment will be selected. At the initial stage, planting of all types of indoor plants will be done, from sowing seed until all plants grow up. In the next stage, all plants will be tested to determine their effectiveness to improve indoor air quality. The comparison of data before and after installation of indoor plants is made. To gain the benefits of indoor plants, detailed study should be done in terms of response and monitoring of indoor air. The reason of this study is to provide benefits to building occupants. Besides, having the interior plants as part of decoration items may improve workers' productivity and reduce stress.

Keywords:IAQ, IEQ, Indoor Plants, Safety and Health

Introduction

Indoor environmental quality (IEQ) is the most important thing to the rating of buildings. Based on a study done by Fisk (2000), IEQ has relationships with communicable respiratory illness, allergy and asthma symptoms, sick building symptoms (SBS), and workers' performance. IEQ also takes human health and performance, thermal comfort, lighting, visual quality, and indoor air quality (IAQ) into account (Carazo Fernández *et. al.*, 2013).

According to Aydogan *et.al*, (2011), poor IAQ had steadily increased since early 1950's when it was found out about the relationships between indoor air, allergies, and other chronic illnesses. Other than that, poor indoor air can affect our residents with various diseases like upper respiratory infection (includes the mouth, nose, throat, voice box, and windpipe), otitis media (middle ear inflammation), asthma, eye irritation and cataract (Bruce *et.al*, 2002).

Many factors contribute to poor IAQ such as airtight buildings, changes in building materials and consumer products, poor ventilation and poor moisture control (Aydogan *et.al*, 2011). In addition, Sarigiannis *et. al.* (2011) stated that, the deterioration of IAQ is due to its containing chemical molecule gas in indoor air. Important categories of chemical which occur in indoor air are volatile organic compounds (VOC) and carbonyls. VOC is material easy to be volatile at room temperature, and examples of VOC materials are benzene, toluene, xylenes, styrene, and limonene, while examples of carbonyls material are formaldehyde and acetaldehyde. Building materials, furnishings, paints, office equipment and consumer products are significant sources of volatile organic compounds (VOCs) in buildings (Philomena *et. al*, 1997)

Indoor air must be preserved to maintain occupants' health. Apart from that, clean indoor air will ensure the safe and healthy conditions of residents who live in the buildings. It is absolutely necessary to give attention to the community, since nearly 80% of human life is spent indoors (Haryati Shafii, 2012).

Modern buildings mostly use HVAC (ventilation and air conditioning) system, to maintain a comfortable temperature, and also to provide clean indoor air. Reliable and optimal monitoring and control of ventilation system are essential for a HVAC system to maintain adequate indoor air quality with a least energy consumption (Li *et. al*., 2010). Indoor environment which is good for living is to provide comfort. As such the consumption of energy also must be determined to make it sustainable (Nicol & Humphreys, 2002).

In this project, the researcher will study about the benefits of indoor plants where one of their functions is to clean indoor air for a safer and healthier living. Indoor plants can filter out certain VOC and carbonyls available in indoor air. Based on previous researches such as those by Aydogan *et. al*., (2011), Raza *et. al*., (1995), Soreanu *et. al*., (2013), Torpy *et. al.*, (2014), and Wang *et. al.,* (2014), there is a positive implication on indoor plant as an air filter. However, indoor plants which will be used in this research must be able to live in equatorial climate such as in Malaysia.

Table 1: Pollution which occurs in indoor air

No.	Name of pollution	Characteristics	Effects
1.	Carbon monoxide (CO)	→ Colourless and odourless gas produced by the incomplete burning of material containing carbon. → Common sources of CO are leaking vented combustion appliances, automobile exhaust, parking garages, etc.	→ CO poisoning can cause brain damage and death. → Low levels of CO may feel sick with headache and nausea.
2.	Carbon dioxide (CO_2)	→ Colourless, odourless, and tasteless gas. → It is a product of completed carbon combustion and the by-product of biological respiration.	→ Lost focus on the mind → Headache → Unconsciousness
3.	Pesticides	→ Substances or mixture of substances used for preventing, destroying, repelling, or mitigating any pest.	→ Headache, tears in the eyes, vomiting, sweating, and general weakness. → Exposure to high doses may cause seizures and death.
4.	Radon	→ Colourless, odourless, and tasteless radioactive gaseous. → It comes from the natural decay of uranium and some other radionuclides that are present in soil.	→ Exposure to radon may cause lung cancer in humans.
5.	Biological Contaminants	→ Come from animal, plants, and microbes (dander animal, pollens from plants, and microbes).	→ Allergies to human if inhaled.
6.	Volatile Organic Compounds (VOCs)	→ Have significant vapour pressures. → Emitted as vapours from certain solids or liquids, and include a variety of chemicals. → Include benzene, formaldehyde, methylene chloride, trichloroethylene, and tetra-chloroethylene	→ Exposure to VOCs can result in both acute and chronic health effects, depending on many factors such as the level of exposure and the length of exposure.

Source: Yu (1998), Irigaray et al. (2007), and OSHA (2011)

Literature Review

IAQ is a major concern to businesses, schools, building managers, renters, and workers because it can impact the health, comfort, well-being, and productivity of the building occupants. However, in an effort to reduce total energy consumption in buildings, it has led to increasingly closed inner space. Reducing leakage and ventilation will reduce energy consumption for treating air into the building. Looking at the areas with extreme climate (temperature and humidity), the outdoor air and indoor air are very different. Some experts believe that more people may suffer from the effects of indoor air pollution rather than outdoor air pollution (OSHA, 2011). Other than that, reduction in fresh air intake can also cause the accumulation of gaseous contaminants within the indoor environment (Llewellyn & Dixon, 2011). Table 1 shows the pollution which occurs in indoor air.

Indoor plants are one of the solutions to prevent poor IAQ. By exploiting the physical properties of living plants, it possible to reduce our reliance on energy engineered and enhances indoor air quality (Freeman, 2008). Indoor plants are capable to reduce contamination of indoor air such as those caused by benzene, trichloroethylene, and formaldehyde (B.C. Wolverton, 1989).

Removable contamination in indoor air using indoor plants

The possibility of indoor plants to clean indoor air in residential area is high. This plant system is one of the most promising means of alleviating the sick building syndrome associated with many new, energy efficient buildings. The finding was proven by B.C. Wolverton in 1989. He did an experiment in a glass chamber at a temperature of 30°C ± 1°C and lighting intensity of 125 foot-candle ± 5. In the study, low-light-requiring

Table 2: Results from a study by B. C. Wolverton (1989)

Chemical gas / Plants	Formaldehyde			Benzene			Trichloroethylene		
	Initial (ppm)	Final (ppm)	Per cent removed	Initial (ppm)	Final (ppm)	Per cent removed	Initial (ppm)	Final (ppm)	Per cent removed
Mass cane	20	6	70	14	11	21.4	16	14	12.5
Pot mum	18	7	61	58	27	53	17	10	41.2
Gerbera daisy	16	8	50	65	21	67.7	20	13	35
Warneckei	8	4	50	27	13	52	20	18	10
Ficus	19	10	47.4	20	14	30	19	17	10.5

*ppm= part per million

Table 3 shows the other researchers' findings from studies involving removal of toxin in the air using indoor plants. The results of their experiments proved that indoor plants have the abilities to clean indoor air.

Table 3: The other researchers' findings from studies involving removal of toxin

Name of researcher	Indoor plant	Toxin	Method	Results
Irga *et. al.* (2013)	→Syngonium podophyllum	→VOC (benzene) → CO_2	→Experiment in glass chamber →Growth plant in two type of medium (conventional potting mix and hydroculture)	→ Reduction CO_2 from test chamber with a moderate increase in indoor light intensity, removing up to 61% ± 2.2 of 1000 ppmv over a 40 min period. →The hydroculture as a medium for growing plant is better than conventional potting mix for removing CO_2. → The rate of VOC (benzene) removal was slightly lower for hydroculture grown plants than those grown in potting mix, both removed 25 ppmv from the test chambers within 7 days.
Aydogan & Montoya, (2011)	→Hedera helix (English ivy) →Chrysanthemum morifolium (pot mum) →Dieffenbachia compacta (dump cane) →Epipremnum aureum (golden pathos)	→Formaldehyde	→Experiment in a glass chamber → Plant grown in three types of medium (growstone, expanded clay, and activated carbon)	→ The four plant species studied demonstrated similar abilities to remove formaldehyde (around 90%) for a 24 hours period. →Chrysanthemum morifolium can heal 2/3 of formaldehyde in a glass chamber in just 23 minute. →The all four plants are quicker to dilute toxin in dark condition compared to lighting condition.
Raza *et al*., (1995)	→Apicra deltoidea, →Sedum pachyphyllum →Bryophyllum pinnata →B. calycinum	CO_2	→Experiment in glass chamber and simulation hospital room.	→Apicra deltoidea seems to be a very useful succulent plant in removing almost 80% of the accumulated CO_2 (in chamber, in a dark condition). →Mixed succulent plants like Apicra deltoidea, Sedum pachyphyllum and Bryophyllum pinnata in a hospital room were observed to remove considerable amounts of CO_2. →In summer, all mixed succulent plants operate as the best part to remove CO_2 compared to winter and rainy seasons (in a hospital room, in lighting and dark conditions).

Wang *et al*., (2014)	→Golden Pothos (Epipremnum aureum)	→Formaldehyde	→ Formaldehyde removal by potted plant without air passing through the root. → Formaldehyde removal by microbial community with air flow passing through. → Formaldehyde removal by a dynamic botanical air filtration system (DBAF).	→ For static potted plants (without air passing through the root) as normally placed in rooms, the clean air delivery rate (CADR), which is often used to quantify the air cleaning ability of portable air cleaners, was only 5.1 m^3/h per m^2. → If the cross-section of the bed was taken into account, the CADR for microbial community with 0.25 m/s air flow would be 1050 m3/h per m2 bed. → The whole DBAF has a clean air delivery rate of 233 m^3/h per m^2 bed area.

house plants, along with activated carbon plant filters, demonstrated the potential for improving pollutants from the air in energy-efficient indoor buildings. Table 2 shows the results of his study in a period of 24 hours.

Proposed indoor plants

Manuscript Location of studies to be implemented is in the areas with high temperature and humidity (Batu Pahat, Johor). Based on Malaysian Meteorological Department (2013) mean of temperature and humidity at Batu Pahat from year 2011 to 2013 is 27°C and 85% humidity. Based on the research performed by Harimi *et. al.* (2007), indoor temperature is varied from 25.17°C to 30.31°C with an average value of 27.94°C.

However in this study, the researcher proposed that some of the indoor plants were able to be found in equatorial climate such as in Malaysia. Seven types of indoor plants used by the researcher were Areca Palm (Chrysalidocarpus lutescens), Kimberley Queen (Nephorolepis obliterata), Dumb Cane (Dieffenbachia), Snake Plant (Sansevieria trifasciata), Aloe Vera (Aloe barbadensis), Anthurium (Anthurium Alabama), and Syngonium (Syngonium podophyllum).

Methodology

Before all plants were used in real situations to monitor for IAQ enhancement, they must be examined to confirm their efficiency. In addition, the research about indoor plants was done outside from equatorial zone to ensure that the indoor plants selected will perform in the climate condition. So, plant test in a chamber is required to resolve this problem.

Seven plants species were used in these experiments (Areca Palm, Kimberley Queen, Dumb Cane, Snake Plant, Aloe Vera, Anthurium, and Syngonium). At an early stage, planting of all types of the indoor plants was done right from sowing the seeds until all plants grew up. These species were selected because they are common indoor plants available in Malaysia, and have the potential to reduce chemical vapour according to Wolverton (1996).

Test chamber

All indoor plants were placed into a clear glass chamber during this project. The purpose is to monitor the condition when experiment is conducted. Top covers were made from plastic will be used since it is easy to make a channel hole to insert the toxins used in this study. Adhesive also was used to provide airtight seal on the top (between top cover and glass chamber). A small fan 12DC was used to evenly spread toxins in the chamber.

Toxins uptake by plants

For these experiments, plants were located in glass chamber for 12 hours cycle of day and night. Toxins were injected into the chamber and concentration level was controlled through the toxins monitor. The concentration level of toxins was determined before and after toxins were injected since indoor plants were located in the chamber. This method is very similar to that by other researchers, Aydogan, (2011) and Irga *et. al*. (2013).

Expected results

In this project, all seven indoor plants are expected to remove toxin from the air, although from the previous studies by Irga *et. al.* (2013), Aydogan (2011), and others, the climate situation (temperature and humidity) is different from that in this research. So, the possibility of the plant to heal the air from toxin should be identified.

Table 4: All four criteria of indoor plants

Name	Light	Temperature	Actions on indoor air environment	Rating given for removable of chemical vapour
Areca Palm (Chrysalidocarpus lutescens)	Semi-sun	18^0C -24^0C	Releases copious amounts of moisture into air, and removes chemical toxins	8/10
Kimberley Queen (Nephrolepis obliterata)	Semi-sun to semi-shade	18^0C -24^0C	Highly effective for the removable of harmful atmospheric pollution, especially formaldehyde and alcohols	9/10
Dumb Cane (Dieffenbachia)	Semi-sun to semi-shade	16^0C -27^0C	Its large leaf surface helps to make it an effective plant for removing indoor air contaminants	7/10
Snake Plant (Sansevieria trifasciata)	Semi-sun, semi-shade to shade	18^0C -27^0C	It differs from most houseplants in that it produces oxygen and removes carbon dioxide at night.	3/10
Aloe Vera (Aloe barbadensis)	Full sun to semi-sun	18^0C-24^0C	Like snake plant, it produces oxygen and removes carbon dioxide at night.	2/10
Anthurium (Anthurium Alabama)	Semi-sun	18^0C -24^0C	Able to remove formaldehyde, xylene, toluene, and ammonia	3/10
Syngonium (Syngonium podophyllum)	Semi-sun to shade	16^0C -24^0C	Reduces high levels of CO2	4/10

Source: Wolverton (1996), and Irga *et al.* (2013).

References

(1). Aydogan, A., & Montoya, L. D. (2011). -Formaldehyde removal by common indoor plant species and various growing media. Atmospheric Environment, 45(16), 2675–2682. doi:10.1016/j.atmosenv.2011.02.062

(2). B.C. Wolverton. (1989). Interior Landscape Plants For Indoor Air Pollution Abatement (pp. 1–18). Washington.

(3). Bruce, N., Smith, K., Ezzati, M., & Lvovsky, K. (2002). Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor : Implications for Policy

(4). Action. In Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor: Implications for Policy Action and Intervention Measures (pp. 5– 21). Washington: World Health Organization. Retrieved from http://www.who.int/mediacentre/events/H%26SD_Plaq_no9.pdf

(5). Carazo Fernández, L., Fernández Alvarez, R., González-Barcala, F. J., & Rodríguez Portal, J. A. (2013). -Indoor Air Contaminants and Their Impact on Respiratory Pathologies. Archivos de Bronconeumología (English Edition), 49(1), 22–27. doi:10.1016/j.arbr.2012.11.004

(6). Freeman, K. (2008). Ambius White Paper Plants in " Green Buildings " Green Building rating schemes (pp. 1–13). Buffalo Grove. Retrieved from http://www.ambius.com/biophilia/downloads/plants_in_green_buildings.pdf

(7). Harimi, D. J., Narayanan, S. P., & Ming, C. C. (2007). EFFECT OF VENTILATION ON INDOOR TEMPERATURE IN MALAYSIA (pp. 5–7). Kota Kinabalu: Conference on Sustainable Building South East Asia. Retrieved from http://www.irbnet.de/daten/iconda/CIB11374.pdf

(8). Irga, P. J., Torpy, F. R., & Burchett, M. D. (2013). -Can hydroculture be used to enhance the performance of indoor plants for the removal of air

pollutants? Atmospheric Environment, 77, 267–271. doi:10.1016/j.atmosenv.2013.04.078

(9). Irigaray, P., Newby, J. a, Clapp, R., Hardell, L., Howard, V., Montagnier, L., … Belpomme, D. (2007). Lifestyle-related factors and environmental agents causing cancer: an overview. Biomedicine & Pharmacotherapy = Biomédecine & Pharmacothérapie, 61(10), 640–58. doi:10.1016/j.biopha.2007.10.006

(10). Li, J., Wall, J., & Platt, G. (2010). Indoor Air Quality Control of HVAC System. In J. Li (Ed.), Proceedings of the 2010 International Conference on Modelling, Identification and Control (pp. 756–761). Okayama: IEEE. Retrieved from http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5553469

(11). Llewellyn, D., & Dixon, M. (2011). Can Plants Really Improve Indoor Air Quality ? In Comprehensive Biotechnology (Second Edi., Vol. 1, pp. 331–338). Guelph: Elsevier B.V. doi:10.1016/B978-0-08-088504-9.00325-1

(12). Nicol, J. F., & Humphreys, M. A. (2002). Adaptive thermal comfort and sustainable thermal standards for buildings. Elsevier, 34, 563–572.

(13). OSHA. (2011). Indoor Air Quality in Commercial and. Washington. Retrieved from https://www.osha.gov/Publications/3430indoor-air-quality-sm.pdf

(14). Philomena BLUYSSE, Christian COCHET, Manfred FISCHER, Helmut KN~PP, Leonard LEVY, Bjsrn LUNDGREN, Marco MARON, Lars MBLHAVE, Heinz ROTHWEILER, Kristina SAARELA, B. S. (1997). Evaluation of VOC Emissions from Building Products (pp. 1–55). Luxembourg. Retrieved from http://www.inive.org/medias/ECA/ECA_Report18.pdf

(15). Raza, S. H., Shylaja, G., & Gopal, B. V. (1995). Different abilities of certain succulent plants in removing CO2 from the indoor environment of a hospital. Environment International, 21(4), 465–469.

(16). Soreanu, G., Dixon, M., & Darlington, A. (2013). Botanical biofiltration of indoor gaseous pollutants - A mini-review. Chemical Engineering Journal, 229, 585–594. doi:10.1016/j.cej.2013.06.074

(17). Torpy, F. R., Irga, P. J., & Burchett, M. D. (2014). Profiling indoor plants for the amelioration of high CO2 concentrations. Urban Forestry and Urban Greening, 13(2), 227–233. doi:10.1016/j.ufug.2013.12.004

(18). Wang, Z., Pei, J., & Zhang, J. S. (2014). Experimental Investigation of the Formaldehyde Removal Mechanisms in a Dynamic Botanical Filtration System for Indoor Air Purification. Journal of Hazardous Materials, 1–22. doi:10.1016/j.jhazmat.2014.07.059

(19). Yu, C. (1998). A Review of the Emission of VOCs from Polymeric Materials used in Buildings, 33(6), 357–374.

June 2015, vol 12, No. 1 : 221-226

Respiratory Symptoms In Tea Mill Workers

Naemah Binti Tajol Arus[1] , YM Tengku Hanidza Binti Tengku Ismail[2], , Suhaily Binti Amran[1], Norhafsam Bin Maghpor[1], Ahmad Sayuti Bin Zainal Abidin[1], Nurzuhairah Binti Jamil1, Rochi Bakel[1]

National Institute of Occupational Safety and Health, Lot 1, Seksyen 15/1,43650,Bandar Baru Bangi,Selangor, Malaysia. Faculty of Environmental Studies, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

Email: naemfateh@gmail.com

Abstract

In the recent years, an extensive number of scientific researches on occupational diseases have been done to identify occupations at high risk of inducing diseases. There are many categories of occupational diseases, and unitary of them are occupational respiratory diseases. This study was conducted in a tea factory located in Cameron Highlands, Malaysia, with an output of 600,000.00 kg per annum. Its objective was to evaluate respiratory diseases among the workers, conducted via questionnaires, interviews and lung functional tests. A total of 38 workers participated in this study, 19 in the exposed group and 19 in the control group. The most common chronic symptoms for the exposed group are wheezing, dyspnea (short of breath) and phlegm. The result shows that, among the tea processing workers, the exposed group suffer from respiratory diseases.

Keywords:Tea dust, respiratory disease, Cameron Highland

Introduction

Occupational respiratory diseases can be defined as the accumulation of conditions of the respiratory system which can have occupational factors as risk factors for the particular diseases. As for occupational respiratory diseases, they can be further divided into three more classifications which are acute, sub-acute and chronic respiratory diseases (Australian Safety and Compensation Council, 2006).

A normal human being breathes about 20,000 times each day. At rest, a normal adult takes in more than 7000 l of air daily. Breathing which is crucial for human survival could not happen without respiratory systems. Respiratory system or ventilator system is a biological system consisting of specific organs and structure responsible to ensure that oxygen is brought into the body and made available to each cell that needs it while also ensuring that carbon dioxide leaves the cells and is removed from the body (Donald E.Gardner, 1999).

A previous study has proven that organic dust called fluffy tea dust produced in the processing industry could affect respiratory functions (Shieh *et al.*, 2012). Tea is a beverage consumed all over the world and brewed from the tea plant called *Camelia sinensis.*

Thus, a continuous exposure of tea dust to the workers may affect their respiratory functions if there exists a correlation between dust exposure and impaired respiratory system. Therefore, this study was conducted to determine respiratory diseases among tea mill workers.

Materials And Methods

Study population

This study was conducted in a tea factory located in Cameron Highlands, Malaysia. A total of nineteen workers within the age range of 24-51 years old participated in this study. The duration for each shift is at least 8-10 hours a day. The workers were provided with recycled disposable respiratory masks and hair covers while the factory was equipped with a general ventilation system. Another group of nineteen administrative personnel within the age range of 24-51 years old also were involved as a control group.

Study Design

The study design used in this study is a cross-sectional comparative type.

Framework of the Study

The study population comprised workers involved in the tea processing industries. These workers were categorized as the exposed group. Workers from the administrative section were selected as the non-exposed group. The test was divided into two parts; questionnaires and lung function test.

Sampling Method

The sampling method used to carry out this study was purposive sampling since this study selected only the respondents who fulfilled the inclusive criteria in this study. The inclusion criteria were as follows:

- Healthy individuals without lung and respiratory diseases and history of chronic disease
- Age between 20 – 55 years old
- Have been working for more than one year

The exclusion criteria were as follows:

- Chest injury
- Any operation affecting the chest
- Previously had pulmonary tuberculosis
- Workers who had reported bronchial asthma before employment in the tea processing industry.

Respondents in the exposed group who fulfilled the above inclusive criteria were selected for lung function tests. It was to determine the abnormality based on the FEV_1 and FVC. The main reason those with the exclusion criteria were not selected was to avoid unnecessary impacts on the results of the study.

Sample Size

In order to carry out this study, the sample size was determined for the data collection process. For that purpose, an adequate sample size was very essential to represent the study population. All workers in the production lines of the factories were eligible participants.

Questionnaire Examination

The questionnaire was used to obtain some information directly from the respondents. Since most of the workers were foreigners and unable to understand our national and international language, answering the questionnaire was done by having the physician to interview the respondents and to fill the questionnaire with help by a translator. The questionnaire was adapted from the European Community Respiratory Health Survey (ECRHS II). It consisted of the respiratory symptoms that were currently experienced by the respondents such as phlegm, cough, wheezing and chest and tightness. Other information requested from the workers was their background information and smoking status.

Lung Function Examination

Spirometer was used to measure the lung function test. The spirometer measured the volume of air in the lungs and the volume breathed out in one second. The functions of this instrument were to measure air flow by electronic or mechanical displacement principles using a microprocessor and recorder to calculate and plot the air flow, to record the amount and the rate of air that respondents breathe in and out over a period of time-spirogram and to show the volume of air moved and the rate at which it travels in and out of the lungs.

The type of spirometer used in this study was Micro loop spirometer Sn 105-03164 Model. Data such as the respondent's age, gender, height (cm), weight (kg) and date of birth was keyed into the spirometer before the spirometry test was performed. The test was repeated three times and performance recommendations were made based on American Thoracic Society (1995) following the lung function tests. The respondents were explained about the testing procedures in order to get their fullest cooperation and to ensure that they did not have flu, cough, allergic and had not had recent intake of heavy meal.

The test procedures were demonstrated to the workers with regards to the correct posture; head elevated and standing in a straight position. The respondents were

Table 1: Demographic and baseline pulmonary function between exposed group and control group

Characteristics	Exposed group (N=19)	Control group	*p*
Age (year) (mean± SD)	36.4 ± 8.6	27.3 ± 2.64	<0.01
Height(cm) (mean± SD)	160.0 ± 8.6	168.2 ± 6.3	0.01
Weight (kg)(mean± SD)	60.4 ± 9.4	70.7 ± 11.4	<0.01
Smoking Habits			
Yes	9	5	
No	10	14	
Baseline pulmonary function			
FVC(L) (mean± SD)	3.1 ± 1.0	3.5 ± 0.7	0.26
FVC(%pred) (mean± SD)	96.7 ±21.9	91.9 ± 13.0	0.57
FEV1(L) (mean± SD)	2.5 ±0.2	3.1 ± 0.6	0.08
FEV1(%pred) (mean± SD)	87.5 ±21.2	84.7 ± 22.3	0.59
FEV1/FVC (mean± SD)	82.3 ± 9.4	88.3 ± 6.7	0.06
PEF(L/min) (mean± SD)	334.2 ±134.1	469.2 ± 140.9	0.03

asked to inhale completely and position mouthpiece and exhale maximally as soon as lips were sealed around the mouthpiece.

Ethic

The management and workers were explained before sampling about the aims and goal of this study and they were asked to fill in the written consent form if they agreed to participate in the study.

Statistical Analysis

Data was analyzed using windows Statistical Package for Social Science version 16. , 20.0 and ANOVA. The findings were presented as numbers and percentage and significance level was set at $p < 0.05$. Chi square test was used for qualitative variables to compare between expose group and non-exposed group.

Results

Overall, a total of 19 tea workers and 19 office workers participated in this study. Demographic data such as age, height, weight, smoking habits and baseline pulmonary function, indicated successful matching (Table 1). The section groups were similar in terms of height, weight, and smoking habits, but the respondents in the control group were younger than those in the exposed group.

For the lung function, four parameters were measured; FEV_1, FVC, PEF and Forced Expiratory Ratio (FEV_1/FVC). FVC is the maximal volume of air exhaled with maximally forced effort from a position of maximal inspiration expressed in litters. While, FEV_1 is the volume expired in the first second of maximal expiration after a maximal inspiration and is a useful measurement of how quickly full lungs can be emptied.

Forced Expiratory Ratio for the exposed group was 82.3 ± 9.4, lower compared to that of the control group (88.3 ± 6.7). This may be due to the fact that there were more smokers in the exposed group with more exposure to tea dust. Distribution of age, height and weight were more similar for both groups.

As shown in Table 2, the exposed groups were divided into sections; Withering, Rolling, Sorting, Drying, Hammer mill and others according their task. The numbers of workers were different in each section.

FEV_1/FVC for rolling were the lowest among all the room sections followed by those for withering, others and sorting .Other groups included Lab, Mandor and Burner sections.

Based on the observation made, most of the workers were provided with personal hair covers and disposable respirators. They did daily housekeeping work before end of shift. The temperature and humidity readings were taken twice during sampling. All the nine room sections were sampling randomly.

Figure 1 shows comparisons between exposed group and control group. Most of chronic respiratory symptoms

Table 2 : Demographic and baseline pulmonary function among sections

Characteristics	**Withering (N=2)**	**Rolling (N= 4)**	**Sorting (N=7)**	**Others (N=4)**	***p***
Age (year) (mean± SD)	40.0 ± 8.6	38.5 ± 11.7	36.0 ± 8.0	26.7 ± 0.6	<0.01
Height(cm) (mean± SD)	163 ± 8.42	163.0 ± 6.3	155.3 ± 9.3	159.3 ± 10.7	0.06
Weight (kg)(mean± SD)	63.5 ± 2.12	64.3 ± 10.4	55.9 ± 6.2	62.7 ± 19.3	0.08
Smoking Habits					
Yes	2	4	2	1	0.08
No	0	0	7	4	
Baseline pulmonary Function					
FVC(L) (mean± SD)	3.8 ± 1.8	3.3 ± 0.9	2.9 ± 1.1	2.6 ± 1.2	0.67
FVC(%pred) (mean± SD)	101.0 ± 39.6	98.5 ± 22.7	96.7 ± 18.4	81.0 ± 32.2	0.80
FEV1(L) (mean± SD)	3.1 ± 1.5	2.4 ± 0.7	2.5 ± 0.9	2.1 ± 1.0	0.56
FEV1(%pred) (mean± SD)	87.5 ± 21.2	79.0 ± 15.1	93.4 ± 18.4	70.3 ± 25.1	0.77
FEV1/FVC (mean± SD)	78.5 ± 10.6	72.8 ± 5.9	87.6 ± 9.0	82.7 ± 11.0	0.05
PEF(L/min) (mean± SD)	382 ± 210.7	346.8 ± 107.5	351.0 ± 134.8	230.3 ± 172.7	0.39

Figure 1: Respiratory symptoms among exposed group and control group

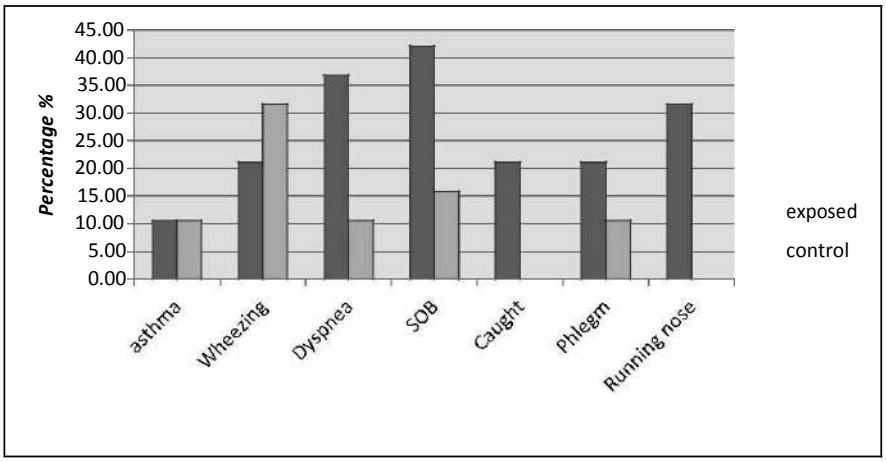


Table 3: Chronic respiratory symptoms among exposed group by room sections

SECTION	Asthma	Wheezing	Dyspnea	SOB	Cough	Phlegm	Running Nose
Withering				✓		✓	✓
Rolling			✓	✓	✓	✓	✓
Sorting	✓	✓	✓	✓	✓	✓	✓
Drying							
Hammer mill		✓	✓	✓			
Others		✓		✓			✓

were shown by tea workers especially SOB, cough and dyspnea. For asthma and running nose, the total number of cases was almost the same with the control group. Table 3 below shows that most of the respondents in the exposed group faced the same problem of short of breath either after doing exercise or work. Running nose was also a major problem especially during working hours.

Discussion

There are four stages of respiration which are breathing, external respiration, internal respiration and cellular respiration. The first stage, breathing, involves two basic processes identified as inspiration that moves air from the outside of the body into the lung and expiration that moves air form the lungs back to the outside of the body Brea. The second stage, external inspiration, is the gas exchange processes of oxygen and carbon monoxide between air and blood. The third stage, internal inspiration, is the gas exchange processes between blood and tissue fluid. Lastly, cellular respiration is a series of energy releasing chemical reaction that occurs within the cells. Size and volume of dusts inhaled are two important factors of the respiratory effects of tea dusts.

A limitation in this study is that there are not many references for comparison purposes since this is the first such study in Malaysia. The daily tea processes depend on the crop. The study patterns were cross sectional so the data was limited, taken during sampling only. Disposable respiratory masks for daily use are not suitable for this factory and it is suggested that the factory conduct medical surveillance for workers and dust monitoring for workers and surrounding area especially for critical rooms.

Conclusion

This is the first study in Malaysia which highlights respiratory problems in tea mill. Exposure to tea dust has caused several respiratory problems to the workers.

Abbreviations

ATS: American Thoracic Society; FEV_1: Forced Expired Volume in one second; FVC: Forced Vital Capacity; PEF: Peak Expiratory Flow; FEV_1/FVC: Forced Expiratory Ratio; SOB: Short of breath

Acknowledgements

We are thankful to the participants without whom this study could not have been carried out, and to those involved in this study, either directly or indirectly. We would also like to thank the National Institute of Occupational Safety and Health for financial support for

us to conduct this research. Our gratitude is also extended to all, who in any way has helped in making this study possible: the factory managements and colleagues at NIOSH and UPM.

References

(1). Ragnar Rylander,Robert R.Jacobs (1994) Organic Dusts. Exposure, Effects, and Prevention.1994 Lewis Publishers1-15

(2). Donald E.Gardner (1999) Toxicology of the lung 4th edition Target organ toxicology series, Taylor & Francis.1-18

(3). Laakkonen, A. (2008). Occupational exposure to organic dusts and cancer among Finnish workers: special emphasis on the food industry and agriculture. Helsinki: People and Work.

(4). Corn M: Handbook of Hazardous Materials San Diego: Academic; 1993.

(5). Shieh, T.-S., Chung, J.-J., Wang, C.-J., Tsai, P.-J., Kuo, Y.-C., & Guo, H.-R. (2012). Pulmonary functions, respiratory symptoms, and dust exposure among workers engaged in early manufacturing process of tea: a cohort study. BMC Public Health, 12, 121.

(6). European Community Respiratory Health Survey (ECRHS II), Prof Peter Burney Dr

(7). Deborah Jarvis, Dept Public Health Sciences, King's College London

(8). NIOSH Manual of analytical Method 4th Ed 0500

(9). Cailaud, et al. BMC Public Health 2012, Association between occupational exposure and the clinical characteristics of COPD 12:302

(10). Sakrawi et al. BMC Pulmonary Medicine 2011, Dust exposure and chronic respiratory symptoms among coffee curing workers in Kilimanjaro: a cross sectional study 11:54

(11). NIOSH Manual of analytical Method 4th Ed 0600

(12). American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents and biliological exposure indices. Cincinnati (OH):ACGIH: 2009.

(13). Melville AM, Pless-Mulloli T, Afolabi OA, Stenton SC: (2010) COPD prevalence and its association with occupational exposures in a general population. Eur Respir J, 36:488–493.

(14). Hamdy A. Mohammadien ,Mona T.Hussein Raafat T.El Sokkary (2013) Effects of exposure to flour dust on respiratory symptoms and pulmonary function of mill workers, Egyptian Journal of chest disease and tuberculosis 62,745-753

(15). Imran Naeem Abbasi,Adeel Ahsan,Asaad Ahmed Nafes. BMC Pulmonary Medicine (2012) Correlation of respiratory symptoms and spirometric lung patterns in a rural community setting, Sindh, Pakistan: a cross sectional survey12:81

(16). Debra K. Nims (1999) Basics of industrial hygiene John Wiley & Sons, Inc., 51-109

June 2015, vol 12, No. 1 : 227-232

Community Perception On Human Health Effect Of The Biodiesel As An Alternative Fuel

A.M. Leman[1], Amir Khalid[2] R.Mamat[3], A.A Abdullah[3], Dafit Feriyanto[2] and N. H. Abdullah[2]

[1]*Faculty of Engineering Technology, UniversitiTun Hussein Onn Malaysia (UTHM) 86400, Parit Raja, BatuPahat, Johor, Malaysia*

[2]*Faculty of Mechanical & Manufacturing Engineering, UniversitiTun Hussein Onn Malaysia (UTHM) 86400, Parit Raja, BatuPahat, Johor, Malaysia*

[2]*Faculty of Mechanical Engineering, Universiti Malaysia Pahang (UMP) 26600 Pekan, Pahang, Malaysia*

Email: mutalib@uthm.edu.my

Abstract

In this research, the biodiesel from WCO is used in order to reduce the exhaust emission and to investigate the community perception regarding to the human health. Biodiesel production is conducted using trans-esterification process with holding time of 2 hours, temperature of 60 ^{o}C and conventional frequency of 20 kHz and then followed by washing process with holding time of 1 hours, temperature of 50 ^{o}C and the frequency of 5 kHz. Biodiesel can reduce exhaust emission of NOx up to 55%, NO gas up to 57%, increase CO gas up to 25% and increase CO_2 gas up to 43.18% as compared to diesel fuel. In addition, biodiesel is achieve good responds from 35 respondents about the biodiesel importance.

Keywords:Biodiesel, Waste Cooking Oil (WCO), exhaust emission and human health

Introduction

The combustion of fossil fuel has an adverse affect on human health through increased air pollution in cities, acid rains, build up of carbon dioxide, changing heat balance of the earth. In fact, projections for the 30-year period from 1990 to 2020 show that vehicle travel, and consequently fossil-fuel demand, will almost triple and the resulting emissions will pose a serious problem [1 - 3].

The main reason of increased pollution levels, in spite of the stringent emission norms that have been enforced, is the increased demand for energy in all sectors and, most significantly the increased use of automobiles. These are the main reason for exploring alternatives, which are abundantly available and less polluted in nature from multiple feedstock of biodiesel fuel. In this context, agro industrial wastes such as animal fats, wood, manure and waste cooking oil (WCO) play an important role as energetic material [4]. In Malaysia, the ministry of energy, green technology and water involved in reducing the CO_2 emissions up to 40% between 2005 and 2020. One of the most alternative fuel is biodiesel from WCO which abundant in Malaysia. The conversion from WCO to biodiesel is shown in Figure 1.

The effect of biodiesel on hydrocarbon (HC) and carbon mono dioxide (CO) was more preeminent over the cold start cycle, where absolute emission level are high. Over such cycle, biodiesel fuel results in 25% higher HC and CO emissions than conventional diesel fuel [5]. However, the effect of NO_x emission from biodiesel

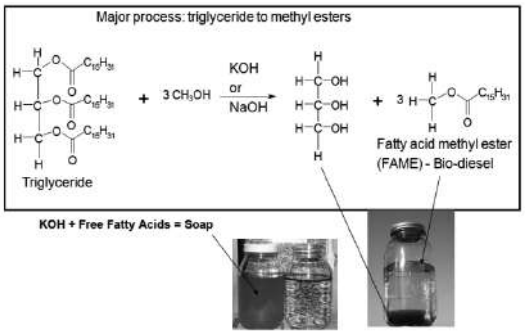


Figure 1 : Conversion of vegetable oil to biodiesel [4]

blended is variable, which ranging from (-) 7% to (+) 11% average, depending on the origin of the feedstock. In terms of PM emission, it resulted a consistent positive effect in reducing the mass of PM from 13% to 25%. This results also approved by Shimazaki *et al*., (2003) [6] where the emission of CO and NO are decreased which biodiesel blends while that of NOx increased.

The main problem of diesel engine is widely contribute the Nickel Oxide (NO_x), Hydro Carbon (HC), Carbon Monoxide (CO) and Particular matter (PM) pollutant into the atmosphere [5]. This biodiesel program will generate new technique of biodiesel processing, product innovations and new combustion strategies in the renewable bio fuel industry, which will elevated Malaysia to be at the forefront. Recently, the Department of Labor's Mining Safety Health Administration (MSHA) tested and approved using biodiesel in underground mining equipment where workers are exposed to high levels of diesel exhaust ([7]. Therefore, it will improve

the human health quality via cleaner air environment condition.

Methodology

Properties of WCO as biodiesel

Biodiesel is defined by ASTM International as a fuel composed of monoalkyl esters of long-chain fatty acids derived from renewable vegetable oils or animal fats. The required standard of diesel is ASTM D975 and for biodiesel standard use ASTM G6751. The research flowchart includes of biodiesel development and the some treatments in order to achieved the objective is shown in Figure 2.

The level of agreement on the 5 point scale provided which are strongly disagree, disagree, neutral, agree, strongly agree. General perception regarding petroleum and petroleum production used as questions to the respondent. The correspondent is addressed to the Univeriti Tun Hussein Onn Malaysia's students which have the car and has proposed the biodiesel as alternative fuel. Analysis of the data results is conducted using t-Test analysis in order to know the significance respond from respondents about the biodiesel and petroleum fuel.

Results and Discussion

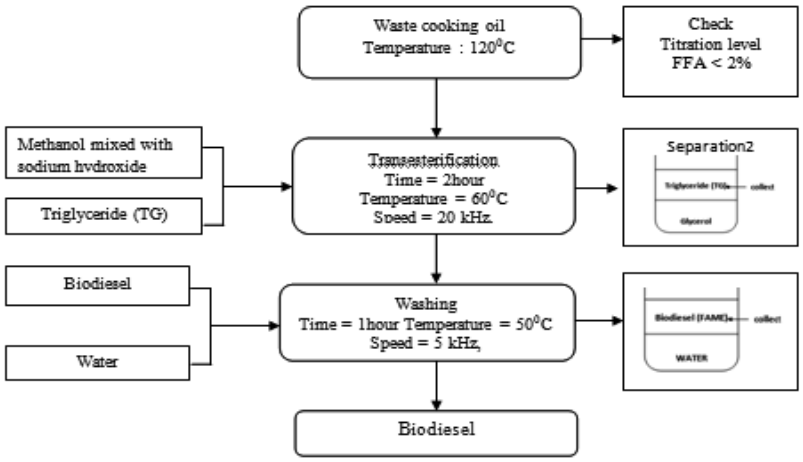


Figure 2 : Research flowchart

Engine testing

The experimental work was conducted on a four-cylinder, 4-cycle, Indirect Injection (IDI),water-cooled Mitsubishi 4D68 diesel engine that coupled to a 150 kW eddy-current type water-cooled Dynalec dynamometer model ECB-200F for the engine loading. It used for examine the diesel, biodiesel and biodiesel blended which detail designation of the samples is listed in Table1.

NO and NO_x emission analysis

NO_x is produced by the oxidation of the atmospheric nitrogen at high temperature. the basic equations for thermal NOx formation are described by the following chemical reaction:

Table 1 : Sample designation

Sample designation	Condition			
	Diesel	Biodiesel	Ethanol	Methanol
Diesel	100%	-	-	-
B20	80%	20%	-	-
B100	-	100%	-	-
B20 E5	75%	20%	5%	-
B20 M5	75%	20%	-	5%

The equation for combustion efficiency is determined as follows [8].

$$Percent\ Efficiency = \frac{100(H_{fuel} - H_{exhaustgas})}{HV_{fuel}} \quad (1)$$

Where ; H = Enthalpy, defined as Energy + (pressure x volume)
HV = The maximum heat available from burning the fuel.

$$H_{exhaustgas} = \frac{H_{CO_x} + H_{CO} + H_{NO_x} + H_{NO}}{w} \quad (2)$$

where; w = The molecular weight of the fuel.

In this research the questionnaire is consist of thirty statements about the biodiesel production and effect of it.

$$N_2 + O \rightarrow NO + N \quad (3)$$

$$N + O_2 \rightarrow NO + O \quad (4)$$

$$N + OH \rightarrow NO + H \quad (5)$$

The comparison of brake specific of NO and NO_x emission for selected samples at various load is shown in Figure 3.The lowest and the highest brake specific of NO_x emission is shown by diesel fuel and biodiesel 100%, respectively. It means that the diesel engine produce highest NO_x emission and biodiesel 100% produce lowest NO_x emission. Highest percentage of biodiesel produce smallest of NO_x emissions because the oxygen content of the fuel mixture that enhance the combustion process with higher combustion temperature. Smallest brake specific or highest NO emission is located at diesel fuel because in diesel fuel have lower cetane number and lower solvent properties. Therefore, the engine part is not cleaned completely from various impurities

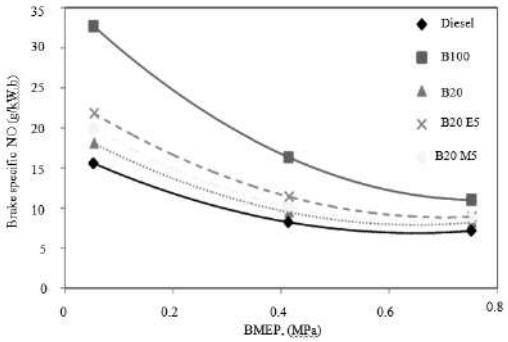


Figure 3 : BSNO and B SNO_x emissions with engine loads for different test fuels at 2500 rpm

which led to higher emission when combustion process. Higher biodiesel concentration which configured such as biodiesel-diesel-ethanol, biodiesel-diesel-methanol and biodiesel-diesel have higher combustion efficiency approximately of 75% as compared to pure diesel fuel. Biodiesel mixture with ethanol is more effective to reduce NO and NO_x emission as compared to biodiesel blends with methanol due to the production of the methanol via hydrogen (H) and carbon monoxide (CO) or carbon dioxide (CO_2) which lead to increasing the pollutant when the combustion temperature increased. Comparison of the methanol with ethanol concentration in the biodiesel blends also show in cooling process. The ethanol becomes more dominant which produces lower combustion temperature and a significant reduction in NO and NO_x emissions as compared to methanol.

NO and NO_x is usually produced during the high temperature combustion process. on other hand B20 E5 and B20 M5 showed that their NO and NO_x content was almost similar to that of diesel even though the combustion temperature was lower than diesel. This phenomenon might have happened because of the interesting characteristic of biodiesel such as its structural oxygen content that improved that oxidation of nitrogen and raised the combustion bulk temperature during the combustion period.

CO and CO_x emission analysis

The emission of CO and CO_2 is one of the main concern in this study because it is the main component of greenhouse gases contributes to the global warming. Figure 4 shows the comparison curve of the CO and CO_2 emission in various engine loads. Highest brake specific of CO emission is located at the diesel engine with the value of 82 g/kW.h at lower engine load followed by B20 M5, B20 E5, B20 and B100 respectively. Higher engine load in high speed of 2500 rpm is effect to the high contribution of the CO emission to the air. The percentage of the CO_2 emission between diesel to biodiesel-diesel-ethanol and biodiesel-diesel-methanol approximately of 25% and 37.5% respectively. Highest CO_2 emission is located at the B100 as compared to the samples due to biodiesel has high oxygen content. Therefore the biodiesel as renewable energy should be much more attention to investigate in order to replace the fossil fuel.

Higher CO and CO_2 emission from the combustion process is caused by higher acid value of the fuel as this denotes an excessively high content of free fatty acids. Higher acid number cause lowers the ester yield and increase potassium hydroxide required consumption for neutralization. Another reason is the higher viscosity and poor spray characteristic of biodiesel and biodiesel

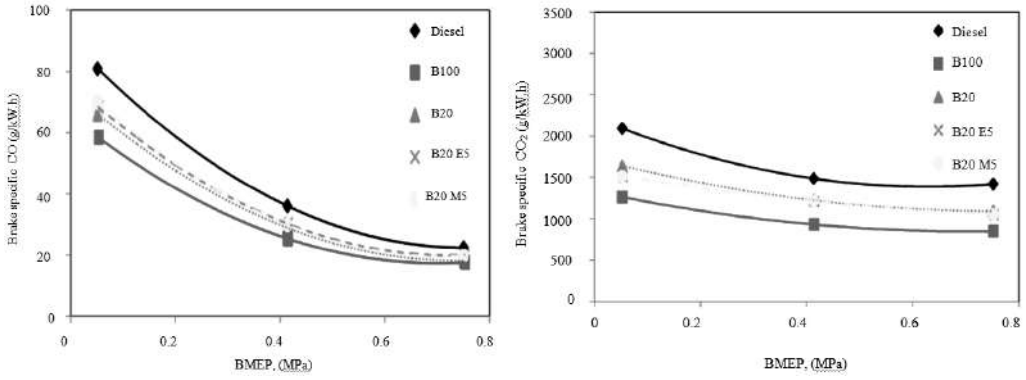


Figure 4 : BSCO and BSCO2 emissions with engine loads for different test fuels at 2500 rpm

Table 2 : Questionnaire result of the biodiesel fuel

Questions No.	**Biodiesel fuel** Quantity of respondent (person)					**Petroleum fuel** Quantity of respondent (person)				
Level of agreement	1	2	3	4	5	1	2	3	4	5
Equal Respondent	**0**	**0**	**204**	**404**	**267**	**78**	**208**	**295**	**230**	**73**

blends which effect to the air fuel mixing and leading to incomplete combustion process and oxygen shortage under low temperature. CO and CO_2 emission increased proportionally to increased in ethanol and methanol concentration. It caused by lower cetane number of alcohol fuels that can increase the ignition delay and producing incomplete combustion process.

Questionnaire of the biodiesel and petroleum

In the questionnaire presents 25 questions both of fuels. the question is conducted in order to know the social perception and knowledge about the biodiesel and biodiesel production. Each respondent answer the question regarding to the level of agreements. The questionnaire result is shown in Table 2

From the Table 2 is clearly shown that there are the significant differences of responds agreement about biodiesel fuel or petroleum fuel. It is shown in equal of each fuels. Biodiesel fuel obtained strongly responds where 404 persons is agree and 267 persons is strongly agree. It means that the use of biodiesel fuel and important of biodiesel production is very useful in social and environment. In other hand, use of petroleum as diesel fuel is obtaining 78 people is strongly disagree, 208 person is disagree and 295 persons is neutral. Its means that the petroleum fuel is promote negative impact to the social and environment which lead to dissatisfaction of respondents. Four of the tables are not significant result but twenty one tables are shown the significant data of the questionnaire result. Therefore, it can be concluded that there is significant effect or differences of the respondent agreement about the biodiesel and petroleum fuels. The significance of the data is achieved when the P(T<=t) two-tail is less than 0.05,where in this research is obtain 0.0004<0.05. From the result strongly indicated that the biodiesel fuel and biodiesel production is important to applied in transportation sector and social knowledge. In addition, the biodiesel can promote to the our government to develop he biodiesel fuel in large scale in order to improve the economy and transportation sector.

Conclusions

New Generation Fuel from WCO is successfully produced using transesterification process and then washing process. Its process is promoting the best way to produce the biodiesel with the optimum PH colour indicator.

Biodiesel fuel (B100) is decrease the exhaust emission of the NO_x gas is decrease up to 37.5%, 50%, 52.5% and 55% as compared to B20 E5, B20 M5, B20 and diesel engine respectively. Decreasing NO emission up to 34.3%, 42.8%, 48.5% and 57% as compared toB20 E5, B20 M5, B20 and diesel engine respectively. Increasing CO emission gas up to 6.25%, 7.69%, 11.76% and 25% as compared to B20, B20 E5, B20 M5 and diesel fuel, respectively. Increasing CO_2 emission gas up to 16.67%, 17%, 21.875% and 43.18% as compared to B20 M5, B20 E5, B20 and diesel engine. It can be concluded that the biodiesel engine is effective to decrease the exhaust emission and improve the safety of environment from the transportation emission sector.

Good respond of the respondent about the biodiesel fuel and biodiesel production is achieved from 35 respondents which taken from various level of students that use diesel engine or high knowledge about the biodiesel. Satisfaction of the respondents is shown by 404 persons who choose 4 as agree level and 267 persons which choose 5 as strongly agree level. Therefore, the biodiesel is very challenging to produce in large scale.

Anknowledgments

The authors would like to thank the Ministry of Higher Education Malaysia and UniversitiTun Hussein Onn Malaysia (UTHM) through the funding supported MTUN grant under vote C058, Office for Research, Innovation, Commercialization and Consultancy Management (ORICC) and then Centre for Graduate Studies – UTHM.

References

(1). Stern D. I. Reversal of the trend in global anthropogenic sulphur emissions. Global Environ Change, 16 (2) (2006), pp. 207–20.

(2). National Air Pollutant Emissions Trends 1900–1998. USEPA report no. 454/R-00-002, 2000.

(3). National Air Quality and Emissions Trends Report, special studies edition. USEPA report no. 454/R-03-005, (2003).

(4). Sasaki, S., Ito, T., Iguchi, S. Smokeless Low-Temperature Diesel Combustion Concept (First Report) - Soot-Less Combustion at A Near Stoichiometry and Rich Air Fuel Ratios by A Large Amount of Cooled EGR. Trans. of JSAE, 34-1, (2003), pp. 65-70.

(5). Khalid, A., Hayashi, K., Kidoguchi, Y., and Yatsufusa, T. Effect of Air Entrainment and Oxygen Concentration on Endothermic and Heat Recovery Process of Diesel Ignition. SAE paper, (2011), pp. 1-10.

(6). Shimazaki, N., Nishimura, T. Improvement of Exhaust Emissions of Premixed-Type Diesel Combustion with Fuel-Injection Near Top Dead Centre. Trans. of JSAE, 34-1, (2003), pp. 53-58.

(7). Brajesh, K. M., Rajesh K., Rajat K. Eco-friendly Biodiesel as an Alternative Fuel for Diesel-engine. IOSR Journal of Applied Chemistry (IOSR-JAC),ISSN: 2278-5736. Volume 2, Issue 4, (2012), pp. 41-45.

(8). Dorado, M. P., Arnal, J. M., Gomez, J., Gil, A., Lopez, F. J. The effect of a waste vegetable oil blend with diesel fuel on engine performance. Trans ASAE, 45(3), (2002), pp. 519–23.

June 2015, vol 12, No. 1 : 233-238

Electrical Safety: How To Avoid The Overload Current Using Energy Efficiency Approach

Khairunnisa A. R [1], M.Z.M Yusof [1], A.M Leman[2] and M. N. M Salleh[3]

[1].*Faculty of Mechanical & Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Parit Raja, Batu Pahat, Johor*

[2].*Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Parit Raja, Batu Pahat, Johor*

[3].*Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Parit Raja, Batu Pahat, Johor*

Email: khairunnisa7480@gmail.com

Abstract

The energy price increased significantly since the early 1970's and it shows the pattern of all over the world. According to the estimation of International Energy Agency (IEA), 53% global energy consumption will be increased by 2030, with 70% of the growth in demand coming from developing countries. Malaysia is one of the most developing countries among ASEAN countries next to Singapore, with GDP of US$15,400 per capita (PPP basis), and steady GDP growth of 4.6% in 2009. Malaysia as a developing country focuses on the energy efficiency approach. At this moment a lot of number of fire and electrical incident more towards overload current and the issues has been faced trough out the year. This paper highlight the issue on how to avoid the overload current by introducing the method establish by Energy Commission. The star (*) rating will help us to estimate the current use and the energy efficiency approach by calculate the current load. The data collected from home appliances are the very basic information rather than predict in a large scale as industrial and commercial building since the tariff also different in the category. The equipment such as amp meter, volt meter and the current load data logger will help the current consumption in every home appliances and it will show the direct reading as well. The issue on electrical safety should be response by consumer to prevent safety and health risk.

Keywords:Electrical Safety, Safety and Health, Home Appliances, Energy Efficiency

Introduction

Electricity is used to light our homes, drive our manufacturing facilities and also can provide people with entertainment. The safe and efficient use of electricity in the home is important for our family's welfare but consumers must know how to manage electricity properly. Electricity is important to help people live comfortable in the modern living. Electrical safety, according to Gordon & Cartelli (2006) defines as recognizing hazards associated with the use of electrical energy and taking precautions so that electrical hazards may not cause injury or death. Over the past century, since the beginning of the implementation of electricity into modern technology, the effects of electricity on the human body have been under study.

Electrical Safety

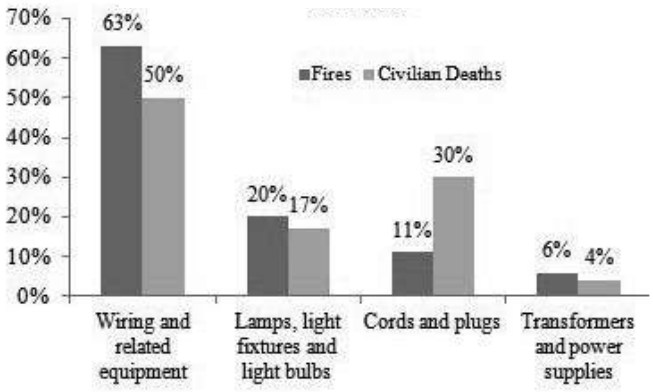
According to Health Safety Executive (HSE) (2014), electricity can kill or severely injure people and cause damage to property but taking simple precautions when working with or near electricity and electrical equipment can help to reduce the risk of injury. The National Fire Protection Association (NPFA) (2014), highlighted that electrical fire is a fire involving some type of electrical failure or malfunction and any equipment powered by electricity can have such a failure. The main hazard that can caused by electricity are electric shock and burns from contact with live parts, injury from exposure to arcing, fire from faulty electrical equipment or installations or explosion caused by unsuitable electrical apparatus or static electricity igniting flammable vapours or dusts, for example in a spray paint booth.

Electrical Safety Overview in US and United Kingdom

Based on the report by NPFA, United States, in year 2011, an estimated 47,700 home structure fires reported to U.S fire departments involved some type of electrical failure or malfunction as a factor contributing to ignition. These fires resulted in 418 civilian deaths, 1,570 civilian injuries, and $1.4 billion in direct property damage. In 2007-2011, home electrical fires represented 13% of total home structure fires, 18% of associated civilian deaths, 11% of associated civilian injuries, and 20% of associated direct property damage.

In 2011, an estimated 16,400 non-home structure fires reported to U.S. fire departments involved some type of electrical failure or malfunction as a factor contributing to ignition. These fires resulted in 13 civilian deaths, 243 civilian injuries, and $501 million in direct

June 2015, vol 12, No. 1



Source: NPFA, 2014

Figure 1: Home Fires Involving Electrical Distribution or Lighting Equipment by Major Group 2007 – 2011

property damage. In 2007-2011, non-home electrical fires represented 13% of total non-home structure fires, 5% of associated civilian deaths, 13% of associated civilian injuries, and 21% of associated direct property damage. In addition, an estimated 21,300 reported U.S non-confined home structure fires involving electrical distribution or lighting equipment resulted in 295 civilian deaths, 840 civilian injuries, and $822 million in direct property damage in 2011. Fires reported as confined fires would add only 2.1% to the estimated non-confined fires and less than 2% to associated losses. Product misuse is the top cause of accidental fires in British homes and the number has increased by over a third since 2009. Millions of people commit basic electric safety 'blunders' in the home without realising that they are exposing themselves to the risk of fire or electric shock. Modern living means using more and more electrical appliances in the home. Just twenty years ago, the average UK home would have had a hi-fi system and one TV or video.

Today, it is more likely that there are at least two TVs, a DVD player, a satellite receiver, games console, microwave, computer and more (Electrical Safety Council, 2014). In conclusion that can be made is the risk of electrical accidents in the home is much higher than before. One of the risk that can caused from this modern living is the use of overloading socket. Most people have extension leads in their homes, using 4-way bar adaptors to increase the number of appliances that they can plug into a wall socket. However, although there is space to plug in four appliances, this does not mean it is always safe to do so. Overloading socket can cause electrical fires especially for house appliances. Normally, most socket are rated are rated at 13 A, but some are rated at only 10 A or less and if too much extension were plugged in it may cause overloaded current.

Electrical Safety in Malaysia

Realising the importance of this electrical safety issue, many awareness campaign have been implemented for helping people understand the importance of electrical safety, especially for residential houses. Water and Energy Consumer Association of Malaysia (WECAM) or formerly known as Environment Desk of FOMCA has developed a 10 year framework, National Energy Efficiency Plan. This campaign is also supported by the Ministry of Energy, Green Technology and Water (KeTTHA), Energy Commission, Tenaga Nasional Berhad (TNB) and National Energy Centre. National Energy Efficiency Awareness Campaign (SWITCH!) is an effort by Non-Government Organisation (NGO) with the support from government and industries for the benefit of the people and country. One of the objective of this campaign is to raise the awareness of the Malaysians on the concept of energy conservation and to promote the practice of energy efficiency among domestic, commercial and industrial consumers. This campaign can enhanced the people knowledge and awareness about electrical safety.

Many fire cases was reported years by years. Based on the fire statistic by type of fire for by Fire and Rescue Department of Malaysia (JBPM), it shows that the fire that was causes by electrical appliances stated high statistic which it state 1,272 cases. From the statistic we can conclude that the electricity were the most cause of the fire. JBPM also exposed the fire statistic by type of building and it showed that the residential building is the highest statistic of fire for 2012 and 2013 where the statistic shows 2,919 cases (2012) and it increase to 3,235 cases for 2013. Mostly, the cause of fire cases in the residential building is due to the overloaded current. Table 1 and Table 2 below showed the fire statistic from JBPM.

Energy and Energy Efficiency

The decade of the 1970s was a period of limited economic growth due in part to the energy crises. The energy crisis was a period in which the economies of the major industrial countries of the world, particularly the United States, Canada, Western Europe, Japan, Australia, and New Zealand were heavily affected and faced substantial petroleum shortages, real and perceived, as well as elevated prices. The two worst crises of this

Table 1: Fire Statistic by Type of Fire for 2013

BIL	*JENIS KEBAKARAN/ NEGERI*	PLS	KED	PP	PRK	SEL	KL	NS	MEL	JOH	PHG	TRG	KEL	SBH	SWK	LAB	PUT	JUM
1.	Bangunan	43	547	387	294	1216	797	222	232	514	254	176	174	459	456	31	3	5817
2.	Kenderaan	17	182	212	322	876	265	215	111	465	170	71	86	129	169	7	13	3313
3.	Mesin	5	1	33	56	41	4	9	21	17	16	7	0	19	11	0	3	203
4.	A.Perkakas	26	12	113	141	279	15	43	23	263	51	54	70	36	100	0	24	1272
5	Petrol	2	3	0	1	8	1	1	1	1	0	0	0	1	2	0	0	21
6	Bhn Kimia	0	0	0	0	2	1	0	0	0	0	0	0	0	2	0	0	5
7	Gas	7	13	115	76	131	8	10	36	95	32	27	39	49	19	0	0	666
8	K. Terbang	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
9	Kapal Laut	0	3	1	2	1	0	0	0	1	4	2	2	4	4	0	0	26
10	Kebun	3	23	16	44	248	0	18	25	276	36	6	19	36	39	0	0	791
11	Hutan	22	18	57	78	337	21	189	152	123	133	31	29	145	134	1	3	1473
12	Belukar	151	771	344	1578	2816	167	396	724	1692	510	710	156	437	653	146	8	11291
13	Gerai	2	12	7	11	49	23	13	3	13	14	1	5	8	5	0	0	167
14	Lain-lain	133	612	761	1209	1632	605	449	801	1096	411	342	302	243	358	15	23	8594
	JUMLAH	**412**	**2197**	**2046**	**3772**	**7639**	**1907**	**1568**	**1729**	**4578**	**1663**	**1427**	**914**	**1576**	**1954**	**200**	**86**	**33640**

Table2: Fire Statistic by Type of Building in Malaysia for 2013

BIL	*JENIS KEBAKARAN/ NEGERI*	PLS	KED	PP	PRK	SEL	KL	NS	MEL	JOH	PHG	TRG	KEL	SBH	SWK	LAB	PUT	JUM
1.	Kedai	6	68	61	31	134	95	35	35	68	25	12	28	2	58	4	0	742
2.	Kilang	0	33	36	17	96	12	49	25	42	8	3	3	18	20	0	0	332
3.	Setor	4	15	10	29	55	12	12	6	27	15	8	8	18	14	2	1	236
4.	Worksyop	1	4	6	2	21	12	2	5	9	9	5	8	4	7	1	0	96
5	Hotel	0	10	2	0	5	11	1	5	2	4	0	0	7	2	0	0	49
6	P. belibelah	0	2	1	1	6	22	1	3	0	1	0	0	3	0	0	0	40
7	Pejabat	1	13	6	3	34	54	7	4	11	4	4	0	8	15	2	0	165
8	Tmpt hiburan	0	3	1	2	7	9	0	4	2	2	0	0	3	3	2	0	38
9	Restoran	1	15	3	6	15	25	0	3	3	1	1	2	5	6	2	0	88
10	R. kediaman	23	303	158	167	656	412	106	117	252	145	106	106	294	272	16	2	3235
11	Setinggan	1	9	8	5	32	26	2	0	4	5	0	0	10	4	0	0	106
12	Bilik dapur	2	8	28	12	35	1	14	5	13	9	6	3	12	4	1	0	153
13	Makmal	0	0	2	0	1	1	0	0	6	0	2	0	1	2	0	0	15
14	Sekolah	1	16	6	1	20	11	10	3	5	3	5	3	8	5	0	0	97
15	Asrama	0	2	2	4	10	4	1	0	9	1	4	0	5	14	0	0	54
16	Hospital/Klinik	0	1	3	1	1	7	3	0	2	3	3	1	6	6	0	0	37
17	Gudang	0	5	3	0	17	0	0	0	1	1	0	0	1	1	1	0	32
18	Lain-lain	5	20	22	13	71	13	9	17	38	18	17	12	23	24	0	0	300
	JUMLAH	43	547	387	234	1216	797	222	232	514	254	176	174	469	458	31	3	5817

Source: Jabatan Bomba dan Penyelamat Malaysia (JBPM)2.

period were oil crisis on 1973, and the energy crisis on 1979 and it caused by interruptions in exports from the Middle East.

In the case of Malaysia, oil price is set by the government and it is under government subsidy since 1970s. Despite the fact that Malaysia is exporting oil, the country also imports oil from other countries. Therefore, the oil crises also give a major impact to Malaysia. The surplus of exporting value over the importing value makes Malaysia a net oil exporting country. The repercussions from price increase in the world market could not be avoided from affected to the local market (Jalil, Ghani, & Duasa, 2008). At the height of these crises, Renewable Energy (RE) and Energy Efficiency (EE) were touted as Malaysia's fifth fuel. However, the discovery of substantial deposits of oil and natural gas in the 1980s relegated EE issues to the back burner in no time.

Energy efficiency is where we use lesser energy to carry out similar or more work without jeopardising the comfort or actual desired output. According to International Energy Agency (IEA) (2014), Energy efficiency was defined as a way of managing and restraining the growth in energy consumption and it is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input. In addition, the United State Department of Energy (2014) also noted that energy efficiency is one among the most cost effective and the easiest way to fight climate change, cleaning up the air we breathe, enhance the competitiveness of our business and reduce energy costs to consumers. According to Tan, C.S, M.S, Suhaida & Peng, L.Y (2011), energy efficiency covers the efficiency of power generation, transmission and distribution of electricity as well as various end uses of energy such as in the industrial, commercial and residential. In other words it can be divided into supply and demand side perspective.

Energy Efficiency Initiative in Malaysia

The promotional of EE was intensively in the 1990s by the Ministry of Energy (now the Ministry of Energy, Green Technology and Water, or KeTTHA) and the Electricity and Gas Supply Department (EGSD) and it also promotion through Seventh Malaysia Plan (1996-2000). Looking back, there was actually an EE unit that was established under EGSD (now the Energy

Commission), but its regulatory scope covered only lamp chokes and fans (The Economic Planning Unit, 1996). Efforts at consumer education on EE was spotty and haphazard, though under the 8th Malaysia Plan (2001-2005), there was again some official proclamation of making EE (and renewable energy) the "fifth fuel", after oil, natural gas, coal and hydroelectric (The Economic Planning Unit, 2001)

In 9th Malaysia Plan (2006-2010), the 6th Prime Minister Tun Abdullah Ahmad Badawi said that adequate and quality energy supply is key to the nation's development. An energy conservation culture must be inculcated. Buildings should be designed to optimise energy usage and resources need to be prudently and carefully utilised. In his speech, he stated that the Government will adopt measures to reduce wastage by enhancing energy efficiency and increasing energy sufficiency. The Government is also committed to reduce dependence on petroleum products through the increased usage of alternative fuels such as biofuel and biodiesel as well as renewable energy (The Economic Planning Unit, 2006).

The Malaysian Standard MS1525 (2001) was introduced by 2001. It contains the code of practice on energy efficiency and use of renewable energy for non-residential buildings which provides guidance on the effective use of energy, including the application of renewable energy in new and existing non-residential buildings (Chan, S. A, 2009). With the urbanization and environment problem serious, green building was widely spread throughout the world. Due to Green Malaysia Index (GBI), green building giving priority to improve the efficiency of energy use, water, and materials. During the building's lifecycle, attention should be given to reducing the impact of buildings on human health and the environment - through better placement, design, construction, operation, maintenance, and removal. The development of alternative source of energy by 2015 is one of the major initiative in 10th Malaysian Plan (The Economic Planning Unit, 2010).

Based on the Energy Commission 2009 report, a total of 92753 GWj (GigaWatthour) electricity were sold in Malaysia. Nearly 20 percent of the overall usage and issue 11.7 million tonnes of CO_2 (Carbon Dioxide) is in the domestic sector. Therefore, a total of 20 percent improvement in energy efficiency in the domestic sector will be able to reduce more than 2.34 million tonnes of CO_2 a year from 2025 onwards if non-energy efficient products be out of the market by 2020. Increase in the demand for energy resources has resulted in these energy sources became more expensive and it has contributed to the increase in electricity tariff and energy prices.

Realized on the target to focus on issues related to water, energy and environment, Association of Water and Energy Research Malaysia (AWER) has done their reports and case studies reviewed regarding on this issues. Few major economies in Asia Pacific (Australia, China, Hong Kong, India, Japan, South Korea, and New Zealand) and all ASEAN members has selected for the purpose of data collection and tabulation to outline a baseline status on EE implementations across these countries. Based on this study, a conclusion can be made where a combination of mandatory and voluntary labelling coupled with Minimum Energy Performance

Table 3: Energy Use, Carbon Emission, Standard and Labelling Summary for Selected Asia Pacific and ASEAN Countries Compiled by AWER

No.	Country	Current income status [1]	CO2 emissions (metric tons per capita) [1] for 2007	CO2 emissions (metric tons per capita) [1] for 2008	Electric power consumption (kWh per capita) [1]	Standard and labelling for energy consuming equipments: Mandatory Label	Voluntary Label	MEPS
1	Australia	HI	18.1	18.6	11,113	/	-	/
2	Brunei	HI	25.3	27.5	8,662	-	/	X
3	Cambodia	LI	0.3	0.3	131	-	-	X
4	China	UMI	5.2	5.3	2,631	/	/	/
5	Hong Kong	HI	5.8	5.5	5,925	/	/	X
6	India	LMI	1.4	1.5	597	/	/	/
7	Indonesia	LMI	1.6	1.7	590	-	-	X
8	Japan	HI	9.8	9.5	7,819	-	/	/
9	South Korea	HI	10.3	10.5	8,980	/	/	/
10	Laos	LMI	0.3	0.3	n.a.	-	-	X
11	Malaysia	UMI	7.2	7.6	3,614	-	/	X
12	Myanmar	LI	0.3	0.3	104	-	-	X
13	New Zealand	HI	7.8	7.8	9,346	/	-	/
14	Philippines	LMI	0.9	0.9	593	/	-	X
15	Singapore	HI	7.8	6.7	7,949	/	-	/
16	Thailand	UMI	4.2	4.2	2,045	-	/	/
17	Vietnam	LMI	1.3	1.5	918	-	/	X

Source: Association of Water and Energy Research Malaysia (AWER)

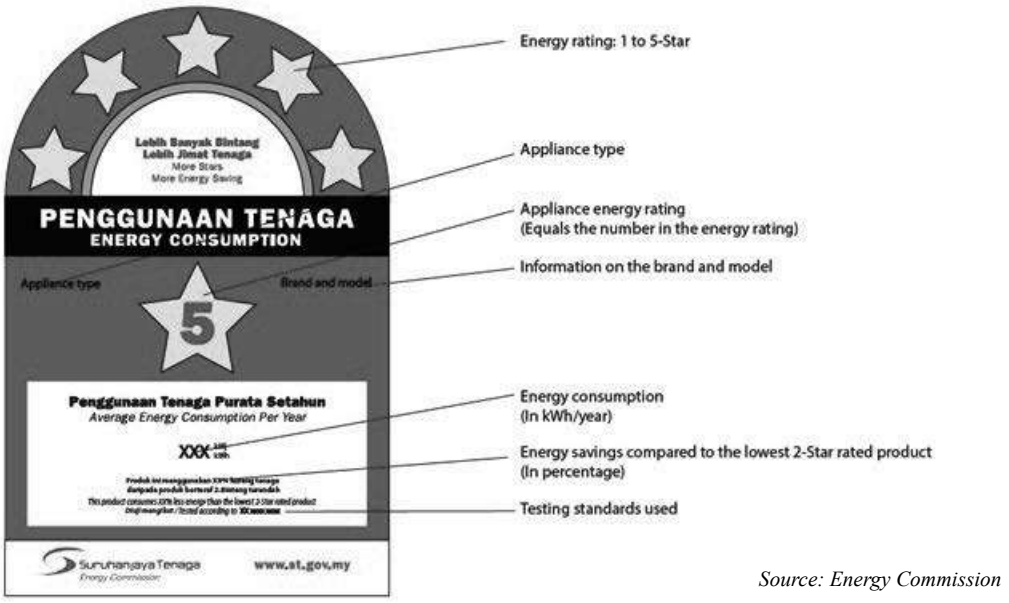
Standard (MEPS) is vital to remove inefficient products from the market successfully. Table 3 below shows the carbon emission indicators for selected Asia Pacific and ASEAN countries. Energy use is directly proportionate to carbon dioxide (CO_2) emission. From the table, we can observe that a country's energy use and carbon emission is tied closely with its income level and development status.

Minimum Energy Performance Standards (MEPS)

Minimum Energy Performance Standard (MEPS) is a minimum performance level set for many types of energy consuming products. This eliminates consuming inefficient consuming products from entering a market by mandatory requirements is a specification containing a number of performance requirements for an energy-using device, and that effectively limits the maximum amount of energy that may be consumed by a product in performing a specified task. MEPS is usually made mandatory by a government energy efficiency body. A MEPS generally requires use of a particular test procedure that specifies how performance is measured. Only 8 out of 17 countries have implemented MEPS. South Korea and China are leading economies in MEPS implementation. This is the primary function of MEPS implementation. In addition to that, there should also be a review in five star energy efficiency labelling policy. Products that have voluntary energy efficiency star rating labelling implemented now must be upgraded to a mandatory labelling with revised energy efficiency rating requirements and MEPS. Introduction of an energy efficiency star rating labelling scheme for a new product must begin with voluntary labelling for a 12 months period. After that, it can be upgraded to mandatory labelling. This is how many energy efficiency rating requirements are implemented internationally. Mandatory labelling is usually imposed for equipment with high energy consumption or likely to be consumed in large quantities or with long hours of usage duration. Korea is a leading country in mandatory labelling implementation to assist end users to choose the right products. Indirectly, this allows product technology and human capital development.

Energy Efficiency Label

Mahlia, Masjuki, & Choudhury (2002) highlighted that the purpose to introducing labels is to convince consumers to buy and manufacturers to produce energy efficient appliances. A label is a mandatory sticker that is affixed to products or their packaging containing information on the energy efficiency or energy consumption of the product. The three types of labels that being used in various countries were endorsement, comparison and a combination of both. (Energy Commission Malaysia, 2014). With the regulations in place, the five domestic appliances will be issued with a Certificate of Approval (COA) by the Energy Commission Malaysia. In order to be issued with a COA, the five domestic appliances must satisfy both the safety and performance requirements. The five domestic appliances are domestic fan, domestic lamp, air-conditioner, refrigerator and television. The two stars means the appliances have the minimal efficiency and the maximum efficiency showed with five stars label. Based on Electricity Regulation 1994 (Amendments 2013) Regulation 101A (3) *"Any equipment that meets all the requirements of efficient use of electricity under sub regulation (1) shall be affixed with an efficiency rating label in such form and manner as may be determined by the Commission."* All manufacturers and importers of the following products: television, refrigerator, domestic fan and air conditioner, must affix the Energy Efficiency Label onto the products before it can be sold to the customer. Figure 4 shows the energy efficiency label that's been used in Malaysia.



Source: Energy Commission

Figure 4: The Energy Efficiency Label

Conclusion

Star rating is one of the approach that can help consumer to achieve the targets in order to reduce the electrical fire incident especially for electrical appliances for residential buildings. Many cases that occur resulting in death or severely injury and may also cause damage to property. Consumer need to ensure that the electrical appliances that purchased has the energy efficiency label or star rating that usually affixed on the product. The risk and incidence that caused by overloaded current can be reduced by ensuring the electrical appliances used meet the minimum energy standards and have a high energy efficiency. In other hand, awareness campaign and public media information can prevent overloaded current that always can cause electrical fires. It is important for consumers to have the knowledge on how to make the right choice before purchasing household electrical appliances. In addition to reducing the risk of any fire can also help the country save energy for sustainable development.

References

(1). Chan, S.A. (2009). Green Building Index MS1525: Code of Practice on Energy Efficiency and Use of Renewwable Energy for Non-Residential Buildings (pp. 1–22).

(2). Association of Water and Energy Research Malaysia (AWER) (2012). Retrieved on 2nd October 2014 from http://www.malaysiakini.com/letters/215372

(3). Electrical Safety First (2014). Retrieved on 4th October 2014 from http://www.electricalsafetyfirst.org.uk/about- us/annual-report/

(4). Energy Commission (2014). Retrieved on 4th October 2014 from http://www.st.gov.my/

(5). Gordon, L. B & Cartelli, L (2006). A Complete Electrical Hazard Classification System and Its Application. Material IEEE ESW-23, 1-12

(6). Health Safety Executive (HSE) (2014). Retrieved on 4th October 2014 from http://www.hse.gov.uk/

(7). International Energy Agency (IEA) (2014). Retrieved on 4th October 2014 from www.iea.org/topics/energyefficiency

(8). Jalil, N. A., Ghani, G. M., & Duasa, J. (2008). Oil Prices And The Malaysia Economy Field of Research : Macroeconomics, 1–31.

(9). Mahlia, T. M. I., Masjuki, H. H., & Choudhury, I. A. (2002). Theory of energy efficiency standards and labels. Energy Conversion & Management, 43, 743–761.

(10). National Energy Efficiency Awareness Campaign (SWITCH!), SWITCH! 2014. Retrieved from http://www.switch.org.my/v1/index.php/about-the-campaign

(11). National Fire Protection Association (NFPA), (2014). Retrieved from http://www.nfpa.org/safety-information/for-consumers/causes/electrical/electrical-safety-in-the-home

(12). Perangkaan Kebakaran, Menyelamat dan Khidmat Khas dari Januari Hingga Disember 2011 (2012, Mei 7). Jabatan Bomba dan Penyelamat Malaysia (JBPM) (2012). Retrieved from http://m.bomba.gov.my

(13). Tan C.S; M. Sood, Suhaida; Peng, L. Y. (2011). Sustainability Development through Energy Efficiency Initiatives in Malaysia. Green & Energy Management, 4–5.

(14). The Economic Planning Unit. (1996). Seventh Malaysia Plan 1996-2000 (pp. 1–40).

(15). The Economic Planning Unit. (2001). Eighth Malaysia Plan 2001-2005 (pp. 1–21).

(16). The Economic Planning Unit. (2006). Ninth Malaysia Plan 2006-2010 (pp. 1–53).

(17). The Economic Planning Unit. (2010). Tenth Malaysia Plan 2011-2015 (pp. 1–451).

(18). US Department of Energy (2014). Retrieved on 2nd October 2014 from http://energy.gov/

GUIDELINES FOR CONTRIBUTORS

The Journal of Occupational Safety and Health is concerned with areas of current information in occupational safety and health issues in Malaysia and throughout the world.

General Guidelines

- Manuscripts should be sent to the Secretariat, Journal of Occupational Safety and Health, Communication, Business and Information Dissemination Division (CBID), NIOSH, Lot 1 Jalan 15/1, Section 15, 43650 Bandar Baru Bangi, Selangor, Malaysia (fax: 6 03-8926 5655, tel: 6 03 -89113879/3867/3871, email: journal@niosh.com.my). Please send hardcopy and softcopy of original submissions.

- Prepare manuscripts in accordance with the guidelines given below.

- Submit a cover sheet including: article title, author(s) name(s), affiliation(s), and complete mailing address, phone, fax, and e-mail address of the corresponding author. If at any time during the review or publication process this contact information changes, please contact the secretariat with the updated information.

- Manuscripts must be printed double spaced on A4-sized paper using 12-point type (font Times New Roman). Include page numbers.

- Organisation of material for original research should follow standard reporting format - "Introduction", "Methodology", "Results", "Discussion" and "Conclusion".

- For editorials, review articles, short communication and case studies, appropriate headings should be inserted to provide a general outline of the material.

- Clarity of language and presentation are essential, and care should be taken to avoid unnecessary technical terminology. The publication uses English spelling (UK).

- An abstract, up to 250 words, should accompany the manuscript. This should summarize the study and include the subheadings "Introduction", "Methodology", "Results" and "Conclusion". It may not be necessary for all subheadings to be included, based on the nature of the manuscript.

- Authors must include five keywords or phrases for indexing.

- Each author should complete a declaration form.

- Define all abbreviations.

- Permission to reproduce published material must be obtained in writing from the copyright holder and acknowledged in the manuscript.

- Keep a copy of the manuscript for reference.

- The editorial office retains the customary right to style.

- All material submitted for publication is assumed to be submitted exclusively to the journal unless otherwise stated.

- Copyright of all material published lies in NIOSH Malaysia.

- Once your manuscript is accepted for publication, it may be reproduced with the consent, stored in the retrieval system or transmitted in any form or by any means, electronic, mechanical and photocopying with the consent and permission by the publisher. Application for permission should be addressed to : CBID, NIOSH, Lot 1, Jalan 15/1 Section 15, 43650 Bandar Baru Bangi, Selangor Darul Ehsan, Malaysia. e-mail: journal@niosh.com.my

References:
All references must be formatted in accordance with the Publication Manual of the American Psychological Association (APA), Fifth Edition.

For example:
Journal Articles:
Smith, A.B., Adams, K.D., & Jones, L.J. (1992). The hazards of living in a volcano. Journal of Safety Research, 23(1),81-94.

Book:
Perez, A.K., Little, T.H., & Brown, Y.J. (1999). Safety in numbers. Itasca, IL: National Safety Council.

On-line Publication:
National Institute of Occupational Safety and Health. Sick Building Syndrome. www.niosh.com.my/safetytips.asp?safetyid=1 (accessed October 2004)

Government Publication:
Ministry of Health Malaysia & Academy of Medicine Malaysia (2003). Clinical Practise Guidelines on Management of Obesity 2003.

Tables and Figures:
Tables and figures should be on separate sheets from the text, in accordance with APA style, numbered consecutively and given a short but explicit title. Title for table should be above table. Title for figures should be below figure, Figures must be supplied as glossy photographs or professionally or electronically drawn artwork using heavy white paper and black ink. A notation should be made in the text showing approximately where each table or figure should appear (e.g., Insert Table 3 here). When referring to a particular table or figure in the text always use its number. All tables will be re-set in the production process. All figures will be scanned from the original.

Computer Disks:
If you send a computer disk with your submission, please label it with the author(s) name(s) and manuscript title. Disks will not be returned. Only Microsoft Word format is accepted.

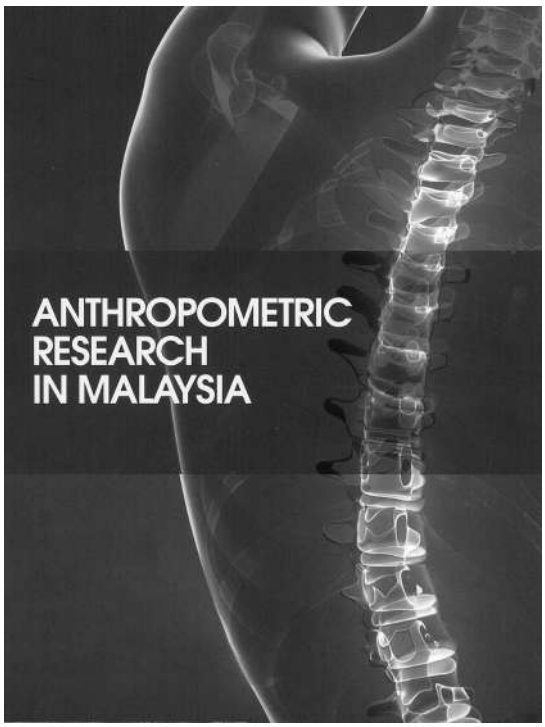
Contributor's copy:
Each author will receive 1 copy of the journal.

Subscription Information
Journal of Occupational Safety and Health (ISSN 1675-5456) is published bi-annually by Communication, Business and Information Dissemination Division (CBID), NIOSH, Malaysia. Subscription prices are available upon request from the publisher or from www.niosh.com.my Issues are sent by standard mail. For orders, claims, product enquiries and advertising information, contact Ms Roslina / Ms Nor Akmar / Ms Siti Badariah 603-8911 3879 / 3867 / 3871 or journal@niosh.com.my

Advertising Rates
Enquiries to be directed to the secretariat.

Secretariat Address
National Institute of Occupational Safety and Health
Lot 1, Jalan 15/1, Section 15, 43650 Bandar Baru Bangi
Selangor Darul Ehsan, Malaysia
Tel.: 603-8911 3879 / 3867 / 3871 Fax.: 603-8926 5655
Email: journal@niosh.com.my Website: www.niosh.com.my

New book…
Now Available!



ANTHROPOMETRIC RESEARCH IN MALAYSIA

First published in 2013
ISBN: 978-967-12137-2-8
Price: RM58.00
Published by:
National Institute of Occupational Safety and Health (NIOSH), Malaysia

Anthropometry has long been a subject that needs attention as Malaysia is moving into a developed nation status. Malaysia's Vision 2020 has definitely put us on the right track in achieving its status and also not forgetting as we move along in the industry, new technologies and advances are ensuing rapidly. Infrastructure wise, we have reached world-class level and up-to-date OSH information come hand-in-hand to supply and contribute in ensuring optimization and appropriate practice of human factors utilization.

The Anthropometric Research in Malaysia book is a compilation of researches made in Malaysia consisting of different focus and subject matters that cover particularly on the well-being of school children, the work force and retired individuals which are showing the effects either happening during the duration of tenure and/or having the effects later on in the future. This book serves as an eye-opener on the effects and risks faced by individuals ranging from school children to adults on the importance of having the proper facilities and equipment in enhancing peak performance and also the prevention of facing future health risks.

This book can be purchased at NIOSH Library Bandar Baru Bangi, Selangor, Malaysia.

Order Today!

NIOSH
National Institute Of Occupational Safety And Health

To order, visit us online at www.niosh.com.my, email: mohammad.affendi@niosh.com.my, or contact NIOSH Library by phone (603)-89113884/3890, Fax: 03-89265655
(Mr Mohammad Affendi Mohammad Zahari).

Institut Keselamatan dan Kesihatan Pekerjaan Negara
National Institute of Occupational Safety and Health
Kementerian Sumber Manusia
Ministry of Human Resources
Lot 1, Jalan 15/1, Section 15, 43650 Bandar Baru Bangi, Selangor Darul Ehsan.
Tel : 03-8769 2100 Fax : 03-8926 2900
www.niosh.com.my