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The Safety and Health of Workers in the Malaysian Wooden Furniture Industry: An Assessment of Noise and Chemical Solvents Exposure

[1]J. Ratnasingam and [2]F. Ioras
[1]Faculty of Forestry, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
[2]Centre for Sustainability, Buckinghamshire New University, Queen Alexandra Road,
High Wycombe, Buckinghamshire HP 11 2JZ, United Kingdom

Abstract: This study was carried out to evaluate the noise and chemical solvents exposure among workers in the wooden furniture industry in Malaysia. Portable noise-level measurements showed that the rough-milling operations recorded the highest noise-level in the furniture factories. Personal dosimeter measurement results showed that 43% of the workers were exposed to noise-levels higher than the permissible limit, while audiometric tests revealed that 34.7% of the workers suffered from hearing handicap, hence strongly recommending the use of noise protection gadgets among workers. As for the chemical solvents, the study found that the current exposure levels for both chemical solvents and formaldehyde in the Malaysian wooden furniture industry were higher than the Permissible Exposure Levels (PEL). Hence, workers in the surface coating departments must be provided with masks with filters, to ensure their exposure to chemical solvents are minimized. This study also revealed that despite the existent of occupational health and safety regulations in Malaysia, its implementation and enforcement within the wooden furniture industry must be improved to ensure the workers safety and health.

Key words: Noise, chemical solvents, wooden furniture, rough-milling, surface coating, hearing loss, protective gadget

INTRODUCTION

Noise and chemical solvents are serious health and safety concern among workers in wooden furniture manufacturing (Fairfax, 1995, 1996). The high noise-level emancipating from the use of many different types of machines in the production process and the use of lacquers and paints, often the acid-curing type, with high amounts of organic solvents (>50%), which is released to the environment during the curing process, have strong effects on the workers health and safety in the furniture factories (Eleftheriou, 2002; Thorud *et al*., 2005).

Noise sources in the furniture manufacturing factories includes: (1) Structural vibration of machine frames, (2) aerodynamic turbulence of the rotating tools and (3) dust and wood chips extraction system (Ratnasingam and Scholz, 2008). Although, the factories and machinery (noise exposure) regulation of 1989 of Malaysia, stipulates that the maximum permitted noise exposure limit for workers in the woodworking industry should not exceed 90 dBA for 8 h period, its effectiveness to provide adequate hearing protection to the workers remain debatable (Ratnasingam and Scholz, 2007; Anonymous, 2008). In woodworking environments, where noise reduction measures implemented are often insufficient due to the variable processing parameters, the use of hearing protection among workers are highly recommended. Further, the woodworking industry is also, known to be relatively low in investments into low-noise processing technologies and tools, as hearing protection is often deemed as sufficient to safeguard the workers hearing (Fairfax, 1995). Nevertheless, the reliability of the noise exposure limit as stipulated in national regulations and the use of hearing protection, as adequate protection for workers hearing remain debatable, as reports on noise exposure of workers in the woodworking industry, particularly wooden furniture manufacturing is relatively sparse (Ratnasingam and Scholz, 2008).

On the other hand, chemical solvents exposure of workers is often from the coating processes, using different types of lacquers such as nitrocellulose, acid-curing, polyurethane and ultra-violet coatings to finish the wooden furniture. In Malaysia, however, acid-curing lacquers have a predominant lead over other types of coating materials, accounting for almost 75% of the market share (Anonymous, 2008). The acid-curing

Corresponding Author: Jegatheswaran Ratnasingam, Faculty of Forestry, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia Tel: +603-89467175 Fax: +603-89432514

lacquers are based on alkyd and amino resins with a high amount of organic solvents. The amino resins are urea-formaldehyde or melamine-formaldehyde resins and the curing is initiated by an acid, usually p-toluene sulphonic acid, which eventually releases some amount of the organic solvents and free formaldehyde to the environment. Hence, during surface coating with acid-curing lacquers, the workers in the furniture factories can potentially be exposed contemporarily to both organic solvents and formaldehyde. Although, the occupational health and safety Use and Standard of Exposure of Chemicals Hazardous to Health (USECHH) regulations 2000 in Malaysia, stipulates the use and standard exposure of chemicals hazardous to health, its effectiveness within the wooden furniture industry in Malaysia remains unknown (Anonymous, 2008). Further, with continuous improvements in coating materials which is likely to affect both exposure pattern and exposure levels, it is important to establish the current industrial exposure levels for chemical solvents from the acid-curing lacquers used.

Therefore, a study was conducted to determine the noise and chemicals exposure level among workers in the Malaysian wooden furniture manufacturing industry and evaluate the extent of hearing damage among the workers in the industry. The findings would possibly help identify measures that could mitigate noise and chemicals exposures faced by workers in the Malaysian wooden furniture industry.

MATERIALS AND METHODS

The study was carried out in 30 large-sized wooden furniture-manufacturing factories (i.e., larges factories are defined as those employing more than 100 workers, with an annual sales turnover in excess of US$ 10 million). The factories located throughout Peninsular Malaysia, were selected on the basis of their reportedly good health and safety records and also their voluntary consent to participate in the study. These factories were chosen from the membership listing of the Malaysian Furniture Industry Council. The study was carried out over a 5 months period, between May to September, 2009 and it was implemented in 4 distinct parts.

The first part of the study involved the evaluation of noise-level and noise-profile in the sample factories. Noise-level measurements were made using a calibrated portable sound level meter (UEI model DSM-101) as reported by Fairfax (1996). The measurements were made by walking through the factories, while continuously measuring the noise level using the portable sound level meter, which was then analysed using the UEI acoustics software to depict the peak noise levels and noise profile throughout the factory, as described by Kokkola and Sorainen (2000).

The second part of the study involved the measurement of noise-level exposure of 1500 workers from the different machining sections, from the 30 furniture factories, using calibrated personal dosimeters, complying with BS6504 which, used the 90 dBA/8 h dose as the reference with a 3 dBA exchange rate. The workers, all of them from the rough milling and machining sections, were selected randomly after consultation with the respective factory management. The measurements provided an overall noise-level exposure experienced by these workers during their 8 h working shift.

The third part of the study quantified the possible noise-induced hearing problems among the workers, using audiometric tests on the same group of 1500 workers, which was carried out by two licensed audiologists, with the aid of audio-chambers and medical equipments capable of testing in the range of 500-8000 Hz in 500 Hz intervals. The measurements made provided an overall assessment of hearing problems due to noise among the workers in the wooden furniture manufacturing factories.

The fourth part of the study involved air sampling at the surface coating departments of the 30 wooden furniture factories. All the factories were applying the coating materials by spray equipment, which was also the most widely used method in the Malaysian industry (Anonymous, 2008). The air sampling was carried out over three subsequent days in the surface coating departments of the factories on a total of 85 workers selected randomly from the surface coating departments (including sprayers, handlers and general workers), with a total of 500 parallel samples of solvents and formaldehyde collected over an average sampling time of 30 min, throughout the 8 h shift of the workers. The solvents were sampled using charcoal sampling tubers (SKC 226-01) supplied by Dorset, UK, while, formaldehyde was sampled using silica sampling cartridges supplied by Millipore Corp., USA. The sampling tubes were placed at the collar of the workers close to the breathing zone, to ensure representative sampling of exposure levels. After sampling, the tubes were stored at -20°C until desorption and analysis. Industrial exposure to organic solvents most often consists of exposure to a complex mixture of solvent vapours. When, two or more solvents with similar toxicological effects are present, the combined exposure rather than the individual exposures is determined, which is often referred to as additive effect (Thorud *et al*., 2005). The concentration of the additive effect of the various

solvents and formaldehyde in the sampling cartridges were determined by external standard calibration using the 3 M organic vapour monitors and the GMD 570 formaldehyde diffusive sampler, respectively, as described in the study by Thorud *et al.* (2005) and Anonymous (2008). The data were then handled by using the statistical package SPSS version 11.0 on a personal computer, to extract and present the results accordingly.

RESULTS

The results of this study are presented in four parts.

Part I: Average noise levels in the Malaysian furniture industry: The average noise-levels recorded in the Malaysian wooden furniture manufacturing industry is shown in Table 1. It is apparent that the highest noise-level of 130 dBA was recorded in the rough milling sections of the furniture factories, while in the machining section, only the high-speed router recorded noise-levels higher than the permissible 90 dBA. The rough milling section, involving heavy-duty wood machining operations such as the moulding, ripping and planning are regarded as machines emitting high levels of noise (Ratnasingam and Scholz, 2007). The relatively large stock removal using large capacity drive motors explain the high levels of noise experienced in the rough milling section of the wooden furniture factories. On the other hand, the noise levels in the machining section were lower due to lower stock removals during the machining operations and also the use of drive motors of smaller capacities (Ratnasingam and Scholz, 2008).

Part II: Noise level exposure of workers: The personal dosimeter results, expressed as percentage of 90 dBA/8 h dose, are shown in Table 2. The results showed that 43% of the workers involved in the study were exposed to higher dose than the permissible one, while the balance 57% were exposed to a less dose, which is quite similar to the reports by Fairfax (1996) and Kokkola and Sorainen (2000). The workers in the rough milling sections of the wooden furniture factories exposed to the higher noise levels than the permissible one, compared to their counterparts in the machining sections, clearly reflects the need for the provision of hearing protection to these workers.

Part III: Noise induced hearing problems among workers: The results of the audiometric tests from this study are expressed as Noise-Induced Permanent Threshold Shift (NIPTS). It is apparent that 25.8% of the workers in this study have a slight handicap with permanent threshold shift between 30 and 40 dB, while 8.9% of the workers have significant handicap with permanent threshold shift greater than 40 dB. The percentage of workers having no hearing handicap is 65.3% (Table 2). These results imply that the noise levels in the wooden furniture factories can significantly impair workers' hearing and hence, the use of hearing protection and job-rotation among the workers must be strictly implemented, in order to ensure a hearing conservation program within the industry.

Part IV: Chemical solvents and formaldehyde exposures: A summation of the chemical solvents and formaldehyde measurements is presented in Table 3. Since, the solvent exposure occurred as complex mixtures of several solvents, the solvents exposures were calculated as additive effects, as described by Thorud *et al.* (2005). The average of all chemical solvents measurements was 1.43 ppm, while formaldehyde measurements averaged 1.93 ppm. The predominant chemical solvents detected in the vapours were ethanol and ethyl acetate (Table 3) although, the proportions of the various chemical solvents will vary according to the formulation of the coating material (Thorud *et al.*, 2005). The average measurements for all solvents and formaldehyde found in this study exceeded the occupational exposure limit, as stipulated in the existing Malaysian regulations for chemical exposure. Although, during the surface coating operations the workers used personal face mask, it proved to be insufficient to prevent exposure to the high levels

Table 1: Noise-levels in wooden furniture manufacturing

Section	Percentage of workers	Percentage of workers using hearing protection	Average noise-level (dBA)	Machine	Average noise-level (dBA)
Rough mill	43 (645 workers)	WP-27	130	Moulder surface-planer thicknesser	150
		HPDW-73			125
					115
Machine shop	57 (855 workers)	WP-5	67	Shaper narrow band-saw router	85
		HPDW-3		mortiser tenoner multi-borer	55
		DHP-92			110
					50
					60
					40

Values represent average values of the 30 factories surveyed. WP: Wear protection, HPDW: Have protection, but do not wear, DHP: Don't have protection

Table 2: Noise Induced Permanent Threshold Shift (NIPTS) among workers

Percentage of workers	Noise Induced Permanent Threshold Shift (NIPTS) in 4-6 kHz band (dB)	Years at work	Hearing impairment
8.9	>40	>10	Significant
25.8	30-40	3-10	Slight
65.3	<30	<3	Not significant

Values based on the workers sample population of 1500

Table 3: Chemical exposure in the wooden furniture industry

	Average exposure	Range	Permissible exposure limit (PEL) as stipulated in standard	Primary solvents
	----------(ppm)----------			
Chemical solvents	1.43	1.03-1.89	0.55	Ethanol, ethyl acetate, aliphatics C_4-C_8, acetone, 1-propanol, methyl ethyl ketone
Formaldehyde	1.93	1.66-2.18	0.30	-

Values based on a sampling size of 500

of solvents and formaldehyde, as the breakthrough of the chemical solvents increased to 56% after 3 h of use, suggesting the need for the use of high quality air-purifying masks with charcoal filters (Anonymous, 2008). The limited numbers of spot measurements at both inside and outside the masks suggest that the suitability of such masks in minimizing chemical solvents exposure is highly in doubt, as it has a reasonably high breakthrough rate after several hours in use.

DISCUSSION

Although, this study is based on a limited number of wooden furniture factories, it is tailored to be representative to assess noise and chemical solvents exposures in the wooden furniture industry, which is predominated by the large manufacturers (Ratnasingam and Scholz, 2008). Thus, this study provides a useful evaluation of noise and chemical solvents exposures in the Malaysian wooden furniture industry, which has not been previously reported (Anonymous, 2008). The results of the study provides evidence to support the fact that noise-levels in the wooden furniture manufacturing industry, especially in the rough-milling operations, is generally higher than the permissible limit. The machines with high cutting rates, such as the moulder, surface planer and rip-saw, explained the high noise-levels recorded (Ratnasingam and Scholz, 2008). The high stock removal rates (often in excess of 1.0 mm) using drive motors of large capacities to produce high cutter-block revolutions results in high noise levels. Further, the labour intensive operations in the rough milling section, explained the high percentage of the workers in the wooden furniture factories exposed to high noise-levels. Inevitably, these workers would experience a hearing handicap, as shown by the shift in the Noise-Induced Permanent Threshold Shift (NIPTS). The study also demonstrates that very little attention is currently given to protecting the hearing of the workers surveyed, as only 33% of the workers who need hearing protection habitually, wear hearing protection gadgets.

In terms of chemical solvents and formaldehyde exposure the results of the study revealed that the current exposure levels exceeds the occupational exposure limits stipulated in the national standard, suggesting that there is a need to enforce stricter the standards to ensure lower exposure levels (Anonymous, 2008). Further, the personal face masks provided to the workers is insufficient to protect them from chemical solvents and formaldehyde exposure, which may seriously affect their health and safety. In this context, masks with charcoal filter or masks with supplies of pressurised air is highly recommended for workers in the surface coating departments to minimize the exposure to chemical solvents and formaldehyde (Thorud *et al*., 2005).

Compared to their counterparts in Europe and Scandinavian countries, the study revealed that workers in the Malaysian wooden furniture industry are exposed to higher noise and chemical solvents levels than the permissible standards (Vinzents and Laursens, 1993; Lazarus, 2003; Fernandez *et al*., 2009) and without stricter enforcement of the existing occupational safety and health regulations in Malaysia, this trend that compromises the workers safety and health is expected to continue. The higher standard of safety and health among workers in the European and Scandinavian countries could be attributed to the stricter enforcement of the related laws (Ratnasingam and Scholz, 2008). Further, the higher chemical solvents exposure in the Malaysian wooden furniture industry as reflected in this study can also be attributed to the use of different grade of coating materials, which is emits higher Volatile Organic Compounds (VOC), while being of lower cost. The low cost phenomenon prevalent in the Malaysian wooden furniture industry also explains the slow adoption of environmental friendly manufacturing practices, which encourages the use of coating materials with lower VOC's, as reported by Ratnasingam and Wagner (2009).

Industrial implications: This study shows that the present occupational safety and health standards, with regards to noise and chemical solvents, are breached in the wooden furniture manufacturing industry. Further, the implementation and enforcement of these regulations

within the industry has been relatively weak and hence, the overall status of the worker's health and safety is compromised within the industry (Rampal and Nizam, 2006). The low-cost economy so, prevalent within the Malaysian wooden furniture industry also implies that workers welfare is often overlooked, while the focus is primarily on cost competitiveness (Ratnasingam and Scholz, 2008). Although, worker's health and safety has a strong bearing on overall labour productivity, the results from this study shows that efficient and environmental friendly manufacturing practices is not widely practiced within the Malaysian wooden furniture industry, as reported previously by Ratnasingam and Wagner (2009). In essence, effective and efficient law enforcement is vital in ensuring the compliance to the existing Occupational Safety and Health (OSH) law in Malaysia. Nevertheless, all stakeholders also need to share this responsibility, as the workers safety and health will significantly affect the labour productivity, which in turn governs the overall business profitability (Arezes and Miguel, 2008). Nevertheless, to re-examine the reliability of the existing standards on noise and chemical solvents exposures in the Malaysian wooden furniture industry to minimize workers safety and health concerns, a more comprehensive and in-depth study of the industry may be necessary to draw safe conclusions.

CONCLUSIONS

This study on the noise and chemical solvents exposured in the Malaysian wooden furniture industry reveals that the workers are exposed to levels higher than the Permissible Exposure Level (PEL). The high noise and chemical solvents exposure suggested that protective gadgets must be provided to all workers and its' wearing must be made compulsory to minimize exposure. Nevertheless, the current protective gadgets do not provide the necessary protection to the workers hence, better quality safety protection gadgets is apparently needed for the workers within the wooden furniture industry. It is also apparent that the existing occupational safety and health regulations must be implemented and enforced strictly to ensure compliance within the wooden furniture manufacturing industry, which it turn will boost labour productivity, thereby enhancing competitiveness.

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