Noise as a Physical Risk Factor in Furniture Industry Machines

Sekip Sadiye Yasar,[a] Osman Komut,[b] Mehmet Yasar,[a] and Muhammed Said Fidan [c,]*

This study aimed to determine the risk level of noise, which is an important physical risk, in small and medium-sized furniture industry enterprises. The noise levels of the circular sawing machines, edge banding machines, and mitre cutting machines, which are among the main processing machines of the sector, were measured. The study was carried out in 32 furniture businesses. The possible risks of noise on the operators of the machines in question and other employees were evaluated. Noise level measurements were made with the help of TESTO 815 measuring device. Dunnett's T3 test was used to detect differences in noise levels for machine operators and other employees. It was determined that the edge banding machine does not pose an occupational health and safety risk in terms of noise risk factors. However, the mitre cutting machine and the circular sawing machine pose a risk for the machine operator in active production by creating noise above the established exposure limit value. The mitre cutting machine carries the same risk for the machine operator when it is in operation but in passive production. The results revealed the need for personal protective equipment for machine operators for mitre cutting and circular sawing machine.

DOI: 10.15376/biores.19.2.2017-2028

Keywords: Noise level; Furniture; Forest products industry; Machinery

Contact information: a: Afyon Kocatepe University, Department of Industrial Design, Afyonkarahisar 03200 Türkiye; b: Gümüşhane University, Department of Forestry, Gümüşhane 29100, Türkiye; c: Bursa Technical University, Department of Forest Industry Engineering, Bursa 16310 Türkiye;
** Corresponding author: said.fidan@btu.edu.tr*

INTRODUCTION

The forest products industry sector plays an important role in the sustainable development of countries (Mikkila and Toppinen 2008). In general, this sector has a structural feature dominated by small and medium-sized enterprises (SME) (SGK 2021). The sector is also known as one of the most dangerous working areas in terms of occupational health and safety, together with its sub-sectors (Ma *et al.* 1991; Michael and Wiedenbeck 2004).

According to ISIC Rev4 and NACE Rev2 classification, the forest industry sector is divided into 3 main sub-sectors: (1) wood, wood products and cork manufacturing; (2) paper and paper products manufacturing; and (3) furniture manufacturing (ISIC 2008; NACE 2008). A total of 39,042 businesses operates in the furniture manufacturing sector in Türkiye. Some 38,999 (99%) of these workplaces are in the SME scale, and the total number of employees is 197,733 (TURKSTAT 2019). It is reported that enterprises included in the SME classification have a higher occupational health and safety risk (Mendeloff and Kagey 1990; Fabiano *et al.* 2004; Sinclair and Cunningham 2014).

Therefore, the furniture industry is also among the high-risk areas of activity (Kim and Park 2006; ILO 2015; Karademir and Koç 2020).

Employees in furniture manufacturing and other forest industry enterprises are exposed to different risk factors such as various chemicals, wood dust, vibration, and noise, as well as occupational accidents (Tankut *et al.* 2014; Çota *et al.* 2020; Komut *et al.* 2020). Noise is one of the most common and dangerous exposures in the manufacturing industry (Fidan *et al.* 2020). Noise is reported to affect more than 22 million workers in the US alone (Tak *et al.* 2009; Masterson *et al.* 2018). Although it is stated that noise is a natural situation for woodworking industries (Qutubuddin *et al.* 2013), it is stated that it causes negativities such as threatening employee health, reducing work efficiency, and increasing work accidents (Korkut and Gedik 2010; Çota *et al.* 2020). Some parts of wooden furniture factories are exposed to higher noise levels than the limit values determined compared to other sectors (Çota *et al.* 2019). On the other hand, with reference to Themann *et al.* (2013), Masterson *et al.* (2018) reported that chemicals such as ototoxic heavy metals, suffocating gases and organic solvents directly threaten employee health as well as increase the sensitivity of employees to noise.

Within the scope of the Regulation on the Protection of Employees from Noise-Related Risks in Türkiye, the lowest exposure action value for 8 hours of work has been determined as 80 dB, and the highest exposure action value is 85 dB. In this legal regulation, the noise exposure limit value is limited to 87 dB (ÇSG 2013). Legal regulations require taking measures to reduce the noise level in case this limit value is exceeded, and if this is not possible, the use of personal protective equipment is required (ÇSG 2013). Many studies in the literature on the subject have concluded that personal protective equipment must be required in the furniture industry (Adu *et al.* 2015; Ratnasingam *et al.* 2016; Indrawati *et al.* 2018; Handayuni *et al.* 2019; Sunaryo 2020). It has been reported that noise levels above the limit values specified in the legal regulation were detected in the studies carried out in different machine and environmental conditions in the enterprises operating in the furniture manufacturing sector (Serin *et al.* 2013; Gedik and İlhan 2014; Özdemir and Çali 2018; Yavuz *et al.* 2018).

This study aimed to measure noise levels on the basis of different variables related to machines with general usage characteristics in small and medium-sized furniture manufacturing enterprises. The study focused on identifying situations that require precautions and areas that require personal protective use, by revealing the potential threat to employee health of machines that are widely used in the furniture industry. With these qualities, the research will serve as a resource for furniture industry businesses to ensure occupational health and safety and will guide researchers for more detailed studies in this field.

EXPERIMENTAL

This research was carried out in furniture industry enterprises that are widely distributed throughout the country, outside the main industrial regions. The Turkish furniture industry generally has an important place in the country's economy in terms of the number of businesses and employment, with its small and medium-sized business structure. The number of businesses operating in the furniture industry across the country is 25,942 (SGK 2021). This study was carried out at 32 furniture industry enterprises operating in Gümüşhane province, Türkiye. In the research, access was provided to 78%

of the enterprises within the scope of activity on a provincial basis. It is reported that 98% of the businesses within the scope of Gümüşhane province have a small and medium-sized structure (SGK 2021). It was assumed that Gümüşhane province, with its small and medium-sized business structure in the field of furniture and sub-industry, has the quality to set an example for the sectoral structure outside the industrial zones.

The study focused on basic production machines widely used in the industry. In this context, circular sawing machines, edge banding machines, and mitre cutting machines were taken as basis. Measurements were carried out in two areas: the entrance section of the operating machines and the machine operator position. In measurements made when other machinery-equipment within the enterprise was passive, the locations where sound echoes would be least were selected as measurement points.

The measurements consisted of recordings every 5 seconds, for a total of 36 minutes. The total number of measurements obtained was 432. The measurements were based on PN-EN ISO 9612 (2011) standards (Bilski 2017; Dudarewicz *et al.* 2018; Pleban 2019). TESTO 815 measuring device was used in measurements. The device was calibrated before measurement, taking into account the effect of environmental conditions. The measurement sensitivity of this device is ±0.5 dB. In addition, the device complies with IEC 60942 Class 2 (TESTO 2023). The distance between the measurement point and the machine was applied as 1 m (Çakır 2010; Kürklü *et al.* 2013; Aydoğdu and Çatkafa 2019). For each location, the arithmetic average of at least 3 repeated measurement values is taken as basis. The measurement location and measurement numbers in question were repeated during the machines' workpiece processing (at load) and when they were operating at idle (Fig. 1).

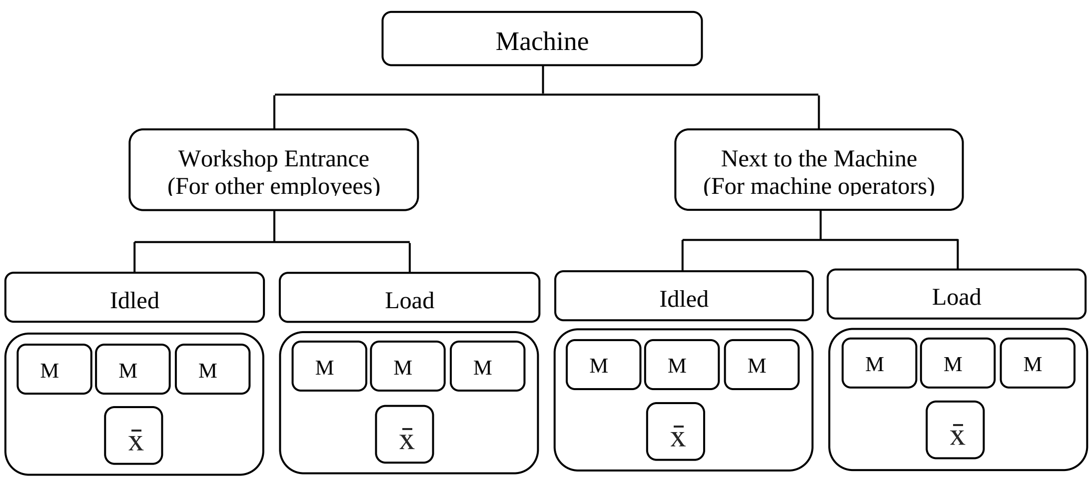

Fig. 1. Algorithm for obtaining measurement values

The International Labor Organization (ILO) has determined the noise exposure limit value as 85 dB. On the other hand, the permissible exposure limit value in the Regulation on the Protection of Employees from Noise-related Risks of the Ministry of Labor and Social Security in Turkey is 85 dB (Official Gazette 2013). Therefore, evaluations in this research were made based on this value.

The data obtained in the study were analyzed with the help of SPSS statistical analysis program. In this context, a homogeneity test and One-Way Analysis of Variance were applied to the obtained data. The significance level was taken into account as 5% in the analyses.

RESULTS AND DISCUSSION

In the study, the homogeneity test results applied to the data obtained from the measurement results of the circular sawing machine, edge banding machine, and mitre cutting machine, which are used in all small and medium-sized furniture businesses, are presented in Table 1. According to the homogeneity test results, it is seen that the groups have different variance values, as p<0.05 (Table 1).

Table 1. Homogeneity Test Results for Machines Used in Furniture Industry

Name of machines	Stt.	df1	df2	Sig.
Circular sawing machines	120.501	3	4604	0.000
Edge banding machines	174.452	3	4606	0.000
Mitre cutting machines	555.258	3	6336	0.000

Variance analysis results for the 3 main machines selected for the furniture industry sector revealed that the measurements of the load/idle and operator position/business entrance variables in these machines differed statistically (at the 1% significance level) (Table 2).

Table 2. Variance Analysis Results of Noise Levels of Machines Used in Furniture Industry

Machine	Variation source	Degrees of freedom	Sum of squares	Mean squares	F- value	Sig.
Circular sawing	Between Groups	65171.732	3	21723.911	3394.169*	0.000
	Within Groups	29467.268	4604	6.400		
	Total	94639.000	4607			
Edge banding	Between Groups	38864.578	3	12954.859	7091.437*	0.000
	Within Groups	8414.385	4606	1.827		
	Total	47278.962	4609			
Mitre cutting	Between Groups	147625.319	3	49208,44	13603.560*	0.000
	Within Groups	22919.344	6336	3.617		
	Total	170544.663	6339			

Since the data of noise level measurements were not distributed homogeneously, Dunnett's T3 test (Post Hoc) was performed to determine which variables had a statistically significant difference (Table 3).

Post hoc analysis using the Dunnett T3 test found that there was no statistically significant difference (p>0.05) in terms of noise level between the variables for the position adjacent to the machine when the edge banding machines were active or passive. It has been determined that the edge banding machines in question create noise below the exposure limit value determined for the different measured positions and active/passive operating states (Fig. 1 and Fig. 2). It was determined that there were statistically significant differences (p<0.05) on the basis of active and passive operating states in the measurements made in different locations for the other machines within the scope of the review (Table 3).

Table 3. Groups Formed According to Dunnett T3 Test for Noise Levels of Machines Used in Furniture Industry

	Measurement location - Machine status	Circular sawing machines			Edge banding machines			Mitre cutting machines		
		Mean difference (I-J)	Standart error	Sig.	Mean difference (I-J)	Standart error	Sig.	Mean difference (I-J)	Standart error	Sig.
Workshop Entrance - Idled	Workshop entrance - Load	-3.87292*	0.095	0.000	-1.63194*	0.050	0.000	-2.39659*	0.094	0.000
	Next to the machine - Idled	-8.20816*	0.080	0.000	-6.55391*	0.041	0.000	-10.91868*	0.079	0.000
	Next to the machine - Load	-9.54670*	0.135	0.000	-6.45995*	0.050	0.000	-10.46909*	0.080	0.000
Workshop Entrance - Load	Workshop entrance - Idled	3.87292*	0.095	0.000	1.63194*	0.050	0.000	2.39659*	0.094	0.000
	Next to the machine - Idled	-4.33524*	0.064	0.000	-4.92196*	0.062	0.000	-8 .52208*	0.053	0.000
	Next to the machine - Load	-5.67378*	0.126	0.000	-4.82801*	0.068	0.000	-8.07249*	0.054	0.000
Next to the Machine - Idled	Workshop entrance - Idled	8.20816*	0.080	0.000	6.55391*	0.041	0.000	10.91868*	0.079	0.000
	Workshop entrance - Load	4.33524*	0.064	0.000	4.92196*	0.062	0.000	8.52208*	0.053	0.000
	Next to the machine - Load	-1.33854*	0.115	0.000	0.09395*	0.062	0.560	0.44959*	0.017	0.000
Next to the Machine - Load	Workshop entrance - Idled	9.54670*	0.135	0.000	6.45995*	0.050	0.000	10.46909*	0.080	0.000
	Workshop entrance - Load	5.67378*	0.126	0.000	4.82801*	0.068	0.000	8.07249*	0.054	0.000
	Next to the machine - Idled	1.33854*	0.115	0.000	-0.09395*	0.062	0.560	-0.44959*	0.017	0.000

Average noise values of the machines measured within the scope of the research on the basis of the determined variables are shown in Fig. 2. On the other hand, the change in noise level based on comparative measurement values for each variable used is shown in Fig. 2.

Measurements made on circular sawing machines determined that the highest noise level for this machine was 85.4 dB in the location adjacent to the machine. For this machine, the lowest noise level was measured as 75.8 dB at the entrance of the workplace and when the machine was not yet actively producing. The detected values showed that if the machine was actively producing, it reached a noise level above the limit value of 85 dB. However, it was observed that the limit value was not exceeded for other measurement points (Fig. 2).

For the edge banding machine, the lowest average measured value on the basis of variables was determined at the entrance of the workplace, with 68.9 dB when the machine was running but in passive production state. For this machine, the highest average measured value on the basis of variables was obtained in the active production state and the position adjacent to the machine, with 75.5 dB. The analysis has shown that the edge banding machine, one of the most widely used machines in the furniture industry, operates at a noise level below the established exposure limit value (Fig. 2).

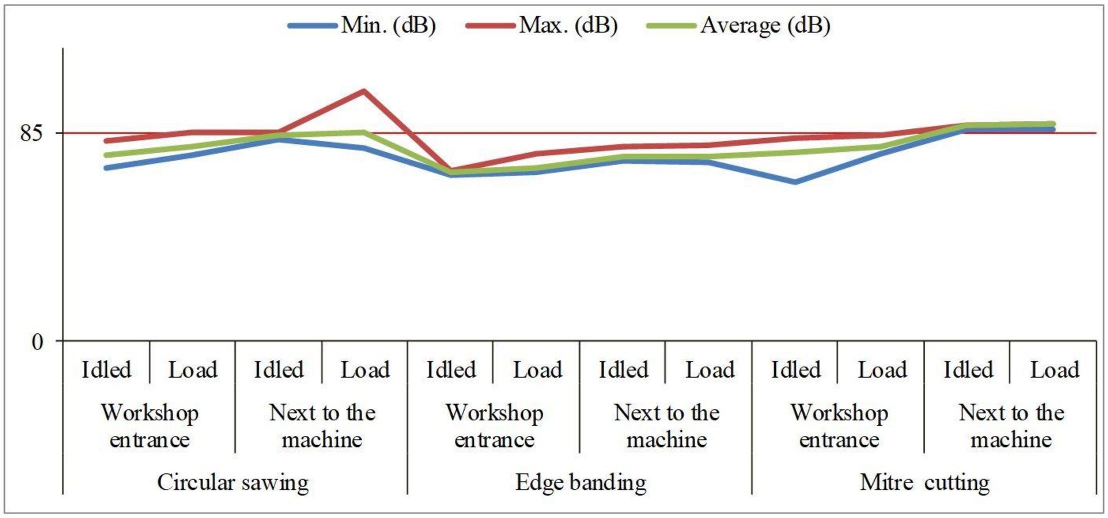

Fig. 2. Noise values of machines used in the furniture industry based on different variables

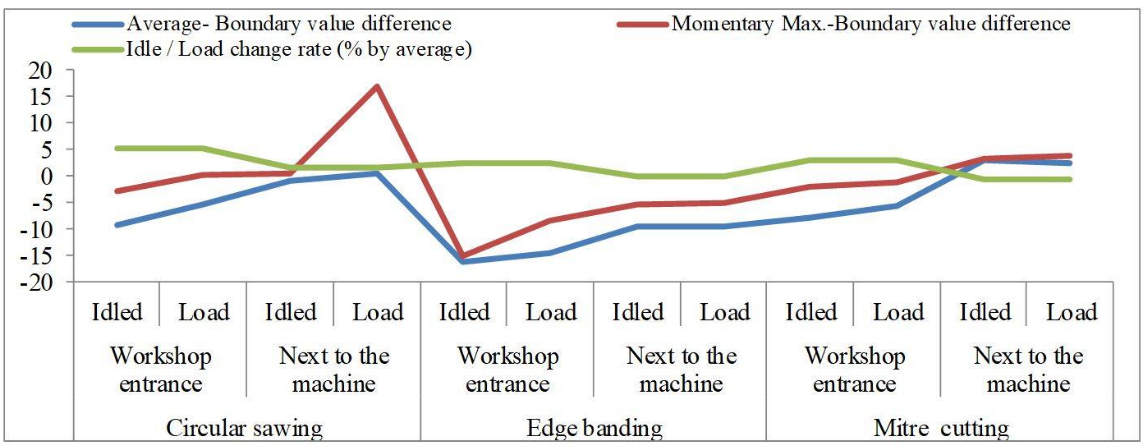

Fig. 3. Noise change rates and limit values of machines used in the furniture industry based on different variables

Based on the average of measurement values for each variable, it was observed that the highest noise level in the mitre cutting machine was 88.6 dB, in the position adjacent to the machine and in active production. According to the determined evaluation criteria, the lowest noise level for this machine was determined as 77.1 dB at the entrance to the workplace and in the passive production state of the machine. These data revealed that in the active production state of the mitre sawing, a noise level exceeding the established exposure limit value occurs. Considering the average noise level measurement value of mitre sawing and circular sawing machines as well as the highest measured value, it was observed that they produced noise above the determined exposure limit value. It has been determined that the noise levels of edge banding machines operating in the furniture industry are quite different from each other according to the idle/loaded situation and the workshop entrance & machine sides (Fig. 2).

The issues detected in the highest measured noise level and average values on the basis of variables also emerged in a similar way in the noise change rates on the basis of variables (Fig. 3). It is reported that many factors such as the number of saw teeth, design, and technological structure are effective on the noise level of circular saw machines (Kvietková *et al.* 2015; Wu *et al.* 2021). On the other hand, suggestions have been made that the problem can be solved by using low-noise circular saw blades (Maue and Hertwig 2004).

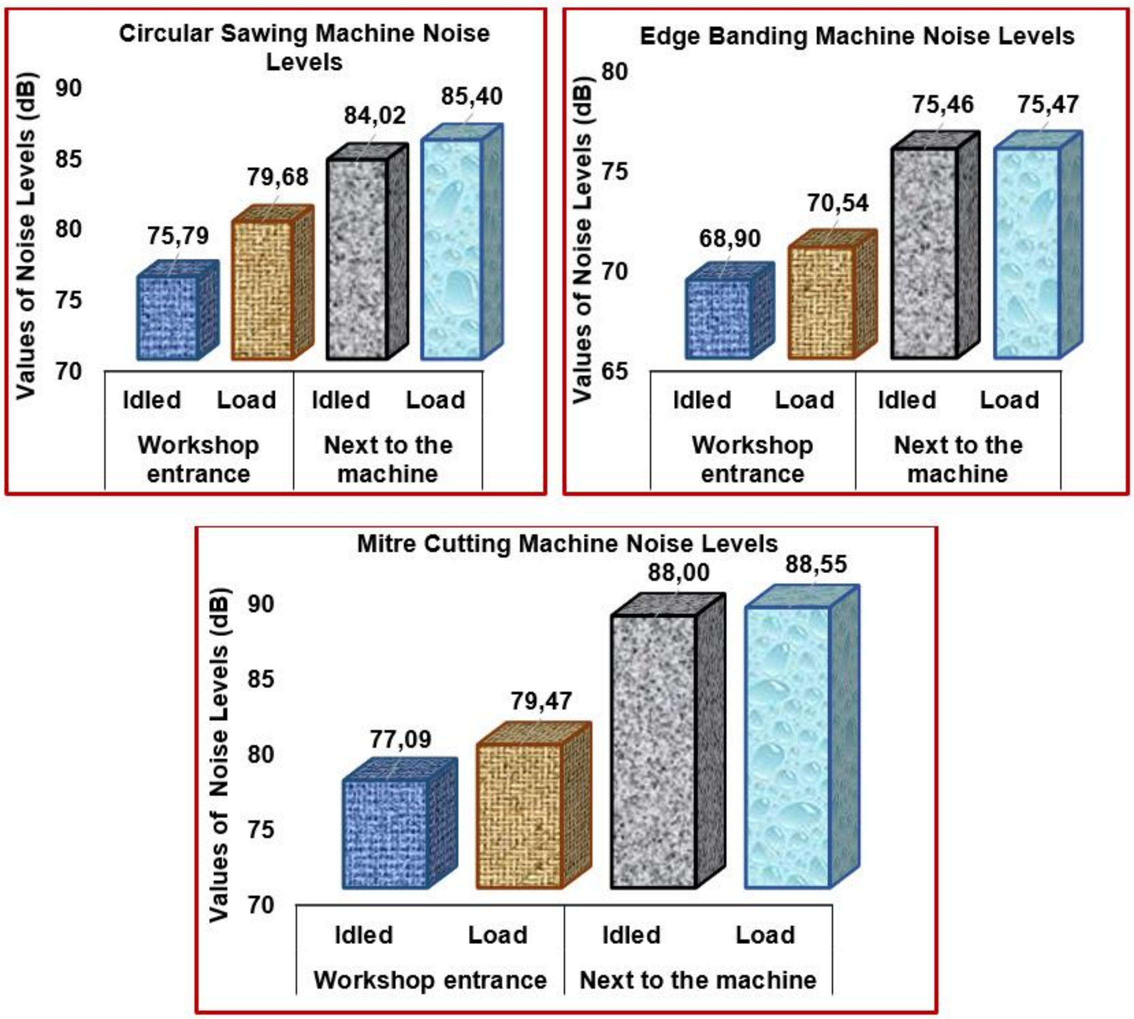

Fig. 4. Average values of noise levels of machines used in furniture industry

As can be seen in Fig. 4, it has been determined that the noise levels of edge banding machines operating in the furniture industry are quite different from each other according to the idle/loaded situation and the workshop entrance and machine sides. It has been determined that the noise levels of circular saws and mitre cutting machines operating in the furniture industry are at significantly different values at the workshop entrance and adjacent to the machines (Fig. 4). The noise level values measured for these machines have shown that they can exceed the established exposure limit values (Fig. 4). In a similar study conducted in Greece (Ntalos and Papadopoulas 2005), it was reported that furniture industry machines generally generate noise above the exposure limit values, which may pose a threat to the health of employees. It has been determined that noise-related disorders are the most common occupational diseases suffered by workers in the furniture industry in Malaysia (Ayak *et al.* 2017). It is reported that the noise levels of the machines used in the furniture manufacturing sector reach up to 117.4 dB, levels that can harm human health (Filipe *et al.* 2014). On the other hand, research has been conducted showing that high levels of noise detected in the sector can cause physical and psychological discomfort as well as loss of motivation for employees (Muzet 2007; Leventhall 2009). Noise is considered among the most important basic health and safety risk factors in the furniture industry sector (Skovgaard Nielsen and Stewart 2007; Ratnasingam *et al.* 2010; Durcan and Burdurlu 2018). It is reported that hearing loss in employees exposed to noise is especially concentrated in the group of employees who do not use personal protective equipment (Daniell *et al.* 2006; Tal *et al.* 2009; Thepaksorn *et al.* 2019).

CONCLUSIONS

In this study, machines that are widely used in small and medium-sized furniture enterprises were analyzed in terms of active production status and noise level in passive production status.

1. In terms of noise, when the edge banding machine is in operation, but in passive production and active production, it does not create an effect that could threaten the health of the machine operator or other personnel.
2. The noise of a circular sawing machine does not pose a health threat to the machine operator and other personnel with the noise level it creates when it is in operation but in passive production. However, when in active production, the noise level exceeds the specified exposure limit value and poses a risk to the machine operator in terms of occupational health and safety.
3. While the mitre cutting machine does not pose a risk to other employees in the business with the noise level it creates in passive production and active production, both of these situations pose an occupational health risk due to exceeding the exposure limit value determined for the machine operator.
4. The results obtained in the study showed that measures should be taken to reduce the noise level of circular sawing and mitre cutting machines in small and medium-sized furniture industry enterprises. Considering the operating principles of the machines in question, it has been determined that it is an important requirement for the operators of these machines to use personal protection against the noise factor.

ACKNOWLEDGEMENTS

This study was supported as scientific research Project (Project Number: 17.B0116.02.01), Gumushane University, Gumushane 2018 (in Turkish).

REFERENCES CITED

Adu, S., Adu, G., Effah, B., Kwasi, F. M., and Antwi-Boasiako, C. (2015). "Safety measures in wood processing: An important component for the entrepreneur – The case of a local furniture industry in Ghana," *Safety* 4(5), 2677-2686.

Ayak, A. S. A., Rohani, J. M., and Zainal, A. M. (2017). "Ergonomics and noise hazard at wood based furniture industry," *Jurnal Mekanikal* 40, 47-52.

Aydoğdu, Ö., and Çatkafa, A. (2019). "PLC based fuzzy logic control of a hydraulic deep draw press machine," *Konya Journal of Engineering Sciences* 7(3), 573-584. DOI: 10.36306/konjes.613867

Bilski, B. (2017). "Exposure to infrasonic noise in agriculture," *Annals of Agricultural and Environmental Medicine* 24(1), 86-89.

Çakır, A. (2010). "Determination of noise level in 7 factories working on furniture manufacturing and investigation of hearing loss due to noise," M.Sc. thesis. Gazi University Faculty of Health Sciences, Ankara, 70 pp.

Çota, H., Lato, E., and Quku, D. (2019). "Analysis of noise level at MDF and particleboard processing with different feeding speed," *Pro Ligno* 15(2), 10-17.

Çota, H., Stafasani, M., Lato, E., Quku, D., and Shumka, L. (2020). "Noise levels of pollution during processing of maple wood (Albania)," *EurAsian Journal of BioSciences* 14, 4901-4905.

ÇSG (2013). "Regulation on the protection of employees from noise-related risks," Ministry of Labor and Social Security, Official Gazette Issue: 28721, Ankara, Türkiye.

Daniell, W. E., Swan, S. S., McDaniel, M. M., Camp, J. E., Cohen, M. A., Stebbins, J. G. (2006). "Noise exposure and hearing loss prevention programmes after 20 years of regulations in the United States," *Occupational and Environmental Medicine* 63(6), 436.

Dudarewicz, A., Zaborowski, K., Wolniakowska, A., Pawlaczyk-Luszczynska, M., and Sliwinska- Kowalska, M. (2018). "Evaluation of on-the-job noise exposure in the case of bartenders," *Medycyna Pracy* 69(6), 633-641.

Durcan, F. M., and Burdurlu, E. (2018). "Effects of some machining parameters on noise level in planing of some wood materials," *BioResources* 13(2), 2702-2714.

Fabiano, B., Curro, F., and Pastorino, R. (2004). "A study of the relationship between occupational injuries and firm size and type in the Italian industry," *Safety Science* 42(7), 587-600.

Fidan, M. S., Yaşar, Ş. Ş., Komut, O., and Yaşar, M. (2020). "A study on noise levels of machinery used in lumber industry enterprises," *Wood Research* 65(5), 785-796. DOI:10.37763/wr.1336-4561/65.5.785796.

Filipe, A. P., Silva, J. R. M., Trugilho, P. F., Fiedler, N. C., Rabelo, G. F., Botrel, D. A., and Almeida Andrade, A. C. (2014). "Assessment of noise in furniture factories," *Cerne* 20(4), 551-556.

Gedik, T., and İlhan, A. (2014). "A study on occupational health and safety in furniture manufacturers in Sakarya province," *Turkish Journal of Forestry* 15, 123-129.

Handayuni, L., Amran, A., Razak, A., and Hermon, D. (2019). "Relationship of dust level with use of self-protective equipment on acute respiratory infection disorders in furniture workers in Solok district," *Int. J. Recent Technol. Eng.* 8(1), 188-190.

ILO (2015). "Investigation of occupational accidents and diseases," International Labour Organization web page, http://www.ilo.org/labadmin/info/pubs/WCMS_346714/lang--en/index.htm, Acccessed: 28.04.2018

Indrawati, S., Prabaswari, A. D., and Fitriyanto, M. A. (2018). "Risk control analysis of a furniture production activities using hazard identification and risk assessment method," In MATEC Web of Conferences (Vol. 154, p. 01102). EDP Sciences.

ISIC (2008). "International standard industrial classification of all economic activities (ISIC Rew.4)," Statistical Paper. Series M. No 4, Rew 4. Printed in United Nations, NewYork.

Karademir, D., and Koç, K. H. (2020). "Evaluating the work environment in Turkish furniture industry from the point of occupational health and safety," *Fresenius Environmental Bulletin* 29(4), 2639-2645.

Kim, H, and Park, D. (2006). "Selecting high-risk micro-scale enterprises using a qualitative risk assessment method," *Industrial Health* 44, 75-82.

Komut, O., Yaşar, Ş. Ş., and Yaşar, M. (2020). "Occupational health and safety awareness in wood, wood products and mushroom production sector in Turkey," *Turkish Journal of Forestry* 21(3), 260-266.

Korkut, D. S., and Gedik, T. (2010). "A Research of occupational safety in forest products industry in Turkey," *African Journal of Business Management* 4(7), 1423-1430.

Kürklü, G., Görhan, G., and Burgan, H. İ. (2013). "Effect of noise in working life and evaluation in terms of construction technologies education," *SDU International Technologic Science* 5(1), 22-35.

Kvietková, M., Gaff, M., Gašparík, M., Kminiak, R., and Kriš, A. (2015). "Effect of number of saw blade teeth on noise level and wear of blade edges during cutting of wood," *BioResources* 10(1), 1657-1666.

Leventhall, G. (2009). "Low frequency noise. What we know, what we do not know, and what we would like to know," *Journal of Frequency Noise, Vibration and Active Control* 28(2), 79-104.

Ma, W. S. A., Wang, M. J. J., and Chou, F. S. (1991). "Evaluating the mechanical injury problem in the wood-bamboo furniture manufacturing industry," *International journal of Industrial Ergonomics* 7(4), 347-55.

Masterson, E. A., Themann, C. L., and Calvert, G. M. (2018). "Prevalence of hearing loss among noise-exposed workers within the agriculture, forestry, fishing, and hunting sector, 2003-2012," *American Journal of Industrial Medicine* 61, 42-50.

Maue, J., and Hertwig, R. (2004). "Noise reduction of circular saws by means of low-noise saw blades," *Mechanika* 23(2), 237-241.

Mendeloff, J. M., and Kagey, B. T. (1990). "Using occupational safety and health administration accident investigations to study patterns in work fatalities," *Journal of Occupational Medicine and Toxicology* 32(11), 1117-1123.

Michael, J. H., and Wiedenbeck, J. K. (2004). "Safety in the wood products industry," *Forest Product Journal* 54(10), 8-18.

Mikkila, M., and Toppinen, A. (2008). "Corporate responsibility reporting by large pulp and paper companies," *Forest Policy and Economics* 10, 500-506. DOI:10.1016/j.forpol.2008.05.002.

Muzet, A. (2007). "Environmental noise, sleep and health," *Sleep Medicine Reviews* 11, 135-142.

NACE (2008). NACE Rev. 2. Statistical Classification of Economic Activities in the European Community. Eurostat Methodologiesand WorkingPapers. Office for Official Publications of the European Communities, Luxembourg.

Ntalos, G. A., and Papadopoulas, A. N. (2005). "Noise emission levels in greek wood and furniture processing industry," *Journal of the Institute of Wood Science* 175(98), 99-103.

Official Gazette. (2013). Ministry of Labor and Social Security regulation on the protection of employees from noise-related risks. https://www.resmigazete.gov.tr/eskiler/ 2013/07/20130728-11.htm. Date of Access: 05.10.2023

Özdemir, F., and Çali, A. (2018). "Determination of noise levels in furniture industry production stages," *International Artvin Symposium Proceedings Book*, 18-20 October 2018, Artvin, Türkiye, 225-234.

Pleban, D. (2019). "Admissible values and methods of measurement of noise ultrasonic noise and infrasonic noise at workplaces Poland," in: *Proceedings of the 23rd International Congress on Acoustics*. 9-13 September 2019 in Achen, Germany, 7057-7063.

PN EN ISO 9612, (2011). "Acoustics – Determination of occupational noise exposure-engineering method," Warszawa.

Qutubuddin, S. M., Hebbal, S. S., and Kumar, A. C. S. (2013). "An ergonomic study of work-related musculoskeletal disorder risks in Indian Saw Mills," *Journal of Mechanical and Civil Engineering* 7(5), 7-13.

Ratnasingam, J., Natthondan, V., Ioras, F., and McNulty, T. (2010). "Dust, noise and chemical solvents exposure of workers in the wooden furniture industry in South East Asia," *Journal of Applied Sciences* 10, 1413-1420.

Ratnasingam, J., Ramasamy, G., Ioras, F., Thanesegaran, G., and Mutthiah, N. (2016). "Assessment of dust emission and working conditions in the bamboo and wooden furniture industries in Malaysia," *BioResources* 11(1), 1189-1201.

Serin, H., Şahin, Y., and Durgun, M. (2013). "Noise analyses in small-scale furniture enterprises," *Düzce University Faculty of Forestry Journal of Forestry* 9(2), 1-8.

Sinclair, R. C., and Cunningham, T. R. (2014). "Safety activities in small businesses," *Safety Science* 64, 32-38.

SGK (2021). "Distribution of workplaces within the scope by activity group and workplace size (4-1/A)," 2020. http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_ istatistik_yilliklari. Date of Access: 20.03.2022.

Skovgaard Nielsen, K., and Stewart, J. S. (2007). "Woodworking machinery noise," in: *Handbook of Noise and Vibration Control*, M. J. Crocker (ed.)," John Wiley & Sons, Inc., Hoboken, NJ, USA. DOI: 10.1002/9780470209707.ch79.

Sunaryo, M. (2020). "The effect of environmental factor and use of personal protective equipment on the symptoms of acute respiratory tract infections in furniture industry workers," *Laboratory Examinations Support in Medical Toxicology* 2(1), 42-49.

Tak, S., Davis, R. R., and Calvert, G. M. (2009). "Exposure to hazardous workplace noise and use of hearing protection devices among US workers-NHANES, 1999–2004," *American Journal of Industrial Medicine* 52, 358-371.

Tankut, A.N., Kurban, H., and Melemez, K. (2014). "Investigation on ergonomics effect of wood dust in forest produces enterprises," in: *II. National Mediterranean Forestry and Environment Symposium*, 22-24 October, Isparta, Turkey, pp.785-794.

TESTO (2023). Testo 815 - Noise level measuring device. https://www.testo.com/tr-TR/testo-815/p/0563-8155. Date of Access: 20.11.2023.

Themann, C. L., Suter, A. H., and Stephenson, M, R. (2013). "National research agenda for the prevention of occupational hearing Loss-Part 1," *Semin Hear* 34, 145-207.

Thepaksorn, P., Koizumi, A., Harada, K., Siriwong, W., and Neitzel R. L. (2019). "Occupational noise exposure and hearing defects among sawmill workers in the south of Thailand," *International Journal of Occupational Safety and Ergonomics*, 25(3), 458-466. DOI: 10.1080/10803548.2017.1394710.

TURKSTAT (2019). "Small and medium sized enterprise statistics," Turkish Statistical Institute, Ankara.

Wu, T., Wang, D., and Zhao, M. (2021). "Optimization of diamond circular saw blade by vibration noise analysis," Conf. Ser.: *Materials Science Engineering* 1138, 012045. DOI: 10.1088/1757-899X/1138/1/012045

Yavuz, L., Ateş, E., and Bulduk, İ. (2018). "Noise evaluation in a manufacturing company," *Turkish Medical Association Occupational Health and Safety Journal*, 30-36.

Article submitted: Peer review completed: November 18, 2023; Revised version received: November 22, 2023; Accepted: January 21, 2024; Published: February 5, 2024.
DOI: 10.15376/biores.19.2.2017-2028