Management Systems
in
Production Engineering

2018, Volume 26, Issue 3, pp. 133-136

Date of submission of the article to the Editor: 04/2018
Date of acceptance of the article by the Editor: 07/2018

DOI 10.1515/mspe-2018-0021

LABORATORY INVESTIGATIONS APPLIED TO WOOD DUST EMMITED BY ELECTRICAL HAND-HELD BELT SANDER

Miroslav DADO, Lucia MIKUŠOVÁ, Richard HNILICA
Technical University in Zvolen

Abstract:
Aim of this paper was to investigate the effects of grit size and wood species on mass concentration and size distribution of wood dust produced by hand-held belt sander. Experimental study was designed as 2x2 full factorial experiments. Experimental parameters and their levels were abrasive grain size (P80, P120) and wood species (European beech (Fagus sylvatica L.), Norway spruce (Picea abies)).The mass concentration of emitted wood dust was measured using aerosol monitor (TSI Inc., DustTrak DRX 8533). Sampler head was sited in place representing breathing zone of operator of sander. The results was analysed employing the analysis of variance (ANOVA) with 5% of significance level. Real-time measurements demonstrated that spruce wood generated higher dust concentrations than beech wood due to difference in abrasion durability. Compared to sanding belt with P80 grit size, approximately 16%-32% higher dust concentration was generated when the sanding belt with P120 grit size was used.

Key words: *belt sander, wood dust, mass concentration*

INTRODUCTION

Sanding with hand-held powered tools has been recognized as one of the most significant factor in personal exposure to wood dust in the woodworking industry. Exposures to wood dust may cause non-malignant respiratory effects such as occupational asthma, increased bronchial responsiveness, upper and lower respiratory tract symptoms and inflammation, and impaired lung function [14]. The most serious health effect is the risk of nasal and sinonasal cancers which have been observed predominantly among workers exposed to hardwood dusts, such as those from beech and oak [1]. According to Machinery Directive 2006/42/EC, belt sander has to meet the basic safety requirements related to the health hazards caused by the emission of sanding dust. Although majority of hand-held belt sanders are equipped with integrated dust extraction system, its efficiency is usually insufficient [2]. Assessing the emission rate of this machine is then necessary in order to propose recommendations regarding their choice [3]. Standard [11] specifies a procedure how to measure the dust concentration produced by an electric power tool under standardized conditions representing typical applications. The mass concentration and particle size distribution of the wood dust generated in the sanding process is influenced by several factors. These factors, according to [12], can be divided into three groups that characterize the properties of sanded wood, the properties of the abrasive and the parameters of the sanding process. Factors as wood density and hardness [9], moisture content of the wood [13], grain size of coated abrasive [6], type of sander [6], sanding pressure [12], cutting speed [12], and sanding direction [7] have been investigated.
Aim of this paper was to investigate the effects of grit size and wood species on mass concentration and size distribution of wood dust produced by hand-held belt sander.

MATERIALS AND METHODS

The mass concentration of wood dust was investigated in sanding operation as function of abrasive grain size and wood species. Experimental study was designed as 2x2 full factorial experiments. Experimental parameters and their levels were as follows: abrasive grain size (P80, P120) and wood species (European beech (Fagus sylvatica L.), Norway spruce (Picea abies)). A photograph of experimental setup is shown in Fig. 1. The input material for the production of the test specimens were cuts of beech and spruce, which were cut to the required dimension of 500 mm x 150 mm x 150 mm by the longitudinal cutting using band saw and following by the cross cutting using chain saw. The humidity of the test samples was determined gravimetrically and ranged from 11% to 12%. Sanding was performed using a commercially available hand-held belt sander (Bosch, PBS 75 A) without dust box. No-load belt speed was 350 m·min-1. Sanding belt (Klingspor Inc., model LS309XH) was replaced after each measurement.

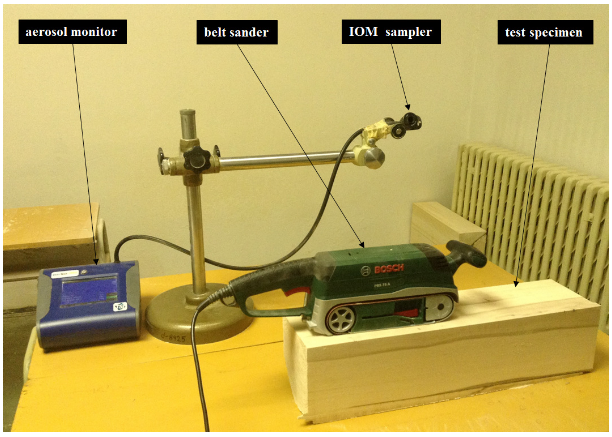

Fig. 1 Experimental set-up

The mass concentration of emitted wood dust was measured using aerosol monitor (TSI Inc., DustTrak DRX 8533). Before each measurement, zero calibration of the instrument was performed. Sampling period (3 minutes) was estimated from the time required to sand the test specimen. Five repetitions were performed in each trial. For the purpose of this study, the flow rate was adjusted to 2 l/min so that, an IOM sampler could be connected to the inlet nozzle on monitor using short length of Tygon tubing. Sampler head was sited in place representing breathing zone of operator of sander. To verify adequate cleaning and ventilation after each measurement, the background concentration in test room was monitored using a photometer (Casella CEL Inc., CEL-712 MicroDust Pro).

The experimental study was conducted in a test room that fulfils requirements according to standard EN 50632-1. Although the temperature and relative humidity inside the test room were not regulated, they remained fairly constant between 20-21°C and 39-40%, respectively, throughout the tests. Average air velocity at sampling point was measured using anemometer (Testo SE & Co., Testo 415), it ranging from 0.21 m·s-1 to 0.28 m·s-1.

Data analysis was performed with statistical software (StatSoft Inc., Statistica v.10). Two-factor analysis of variance was used to determine the influence of type of wood and abrasive grain size on the magnitude of generated wood dust mass concentration. The significance level was set at $p = 0.05$.

RESULTS

The influence of the type of wood and grain size of the abrasive on the magnitude of the mass concentration of the inhalable fraction of wood dust is shown in Fig. 2. Values of inhalable fraction are arithmetic means of five measurements. The statistical results suggest significant effect of wood species ($F(1.16) = 9.979$, $p = 0.006$) and grain size of the abrasive ($F(1.16) = 15.140$, $p = 0.001$) on mass concentration of wood dust. Interaction of examined variables has no statistical significant effect on mass concentration ($F(1.16) = 1.263$, $p = 0.277$).

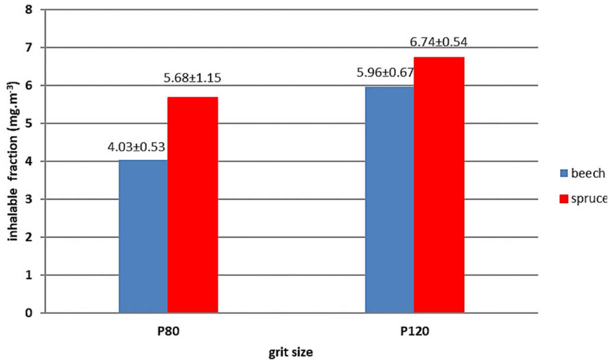

Fig. 2 Effect of wood species and abrasive grain size on inhalable fraction of wood dust mass concentration

Fig. 3 presents the effect of the type of wood and grain size of the abrasive on the magnitude of the mass concentration of the respirable fraction of wood dust. Values of inhalable fraction are arithmetic means of five measurements. The results of analysis of variance have confirmed important influence only for grain size of the abrasive ($F(1.16) = 14.958$, $p = 0.013$) on mass concentration of wood dust.

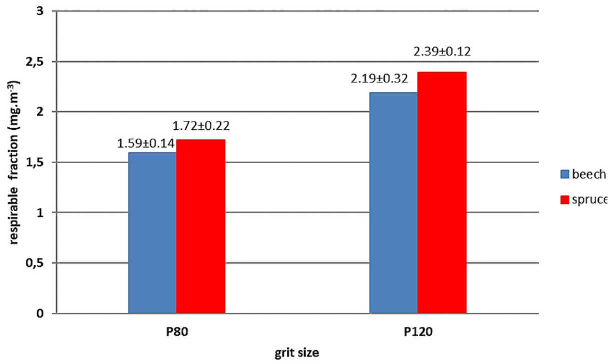

Fig. 3 Effect of wood species and abrasive grain size on respirable fraction of wood dust mass concentration

DISCUSSION AND CONCLUSIONS

This study investigated the generation of wood dust during sanding two different wood species with two different grit sizes of the sanding paper by hand-held belt sander. For this study two well-know and often used wood species – one coniferous and one hardwood species have been chosen. Real-time measurements demonstrated that spruce wood generated higher dust concentrations than beech wood due to difference in abrasion durability. Compared to the beech specimen, approximately 7%-29% higher dust concentration was generated when the spruce specimen was sanded. Results of our study confirm effect of wood species only on inhalable mass concentration of wood dust. We suppose that this could be due limitation in the size range (0,1 µm-15 µm) of aerosol monitor among other. Influence of grit size did seem to have a significant impact on the generation of wood dust. As expected, sanding belt with P120 grit size produced higher dust concentrations than sanding belt with P80 grit size due to enhanced production of small particles. Compared to sanding belt with P80 grit size, approximately 16%-32% higher dust concentration was generated when the sanding belt with P120 grit size was used. Comparing results of wood dust concentration evaluation from different experimental setups and field measurements reported in the literature is very difficult. However, results of this study are in agreement with previous studies [4, 5, 7, 8, 9, 10, 12, 16] who found that harder woods and coarsest abrasive grit produced a lower rate of dust production.

Various limitations to this study need to be considered. First, the pressure exerted during sanding also influences mass concentration and size distribution of generated wood dust. Design of the study did not allow to physically controlling this pressure. However, we choose a method where all the sanding experiments were performed by the same person using the least possible sanding pressure to make experiments in a repeatable way. Second, correct calibration of the aerosol monitor is a basic prerequisite for obtaining meaningful data. Due to the fact that for the purpose of the study, it was sufficient to know the relative mass concentration values and at the same time we assuming that the optical properties of beech and spruce wood aerosols are not diametrically different, the corresponding calibration factors were not determined.

Multi-objective optimization of sanding process parameters involves except traditional objective, like production cost or surface quality, also health and safety requirements. The concentration of airborne contaminant inhaled by operator of sander is determined by the wood dust generation rate and airflow field that transport it into the breathing zone. As observed in this study, it is clear that use of hand-held belt sander without appropriate engineering control increases exposure potential to inhaled particles that could have a negative health effect on operators depending on the type of particle, occupational setting, intensity, duration, and frequency of exposure. In terms of effectiveness, it is beneficial to consider the control of inhalation exposure of sanding machine operator as three distinct components: control at the point of release or source, prevent or control transmission of the wood dust to the operator and protection of the operator to minimize exposure [15]. Hand-held belt sander specific exposure control measures include integrated local exhaust ventilation, mobile local exhaust ventilation, downdraft table and respiratory protection equipment. The most effective way of reducing dust exposure is to reduce the emission of dust at the source. In order to minimize wood dust emission during sanding with hand-held belt sander our further research efforts will be focused on investigation of other factors such a type of sander and development of the system for sanding pressure monitoring.

ACKNOWLEDGEMENTS

The paper is based on work performed under research contract KEGA 008TU-Z/2016 "New forms and methods of education in area of machinery safety" of the Cultural and Education Grant Agency of Ministry of Education of the Slovak Republic whose support is a gratefully acknowledged.

REFERENCES

[1] M. Alonso-Sardón, A.J. Chamorro, I. Hernández-Garcia, H. Iglesias-de-Sena, H. Martín-Rodero, C. Herrera, M. Marcos and J.A. Mirón-Canelo. "Association between Occupational Exposure to Wood Dust and Cancer: A Systematic Review and Meta-Analysis". *Plos One*, vol. 10, no. 7, 2015.

[2] J. Douwe, K. Cheung, B. Prezant, M. Sharp, M. Corbin, D. McLean, A. Mannetje, V. Schlunssen, T. Sigsgaard, H. Kromhout, A. LaMontagne, N. Pearce and J. McGlothlin. "Wood Dust in Joineries and Furniture Manufacturing: An Exposure Determinant and Intervention Study". *Annals of Works Exposures and Health*, vol. 61, no. 4, pp. 416-428, 2017.

[3] F.X. Keller and F. Chata. "Characterization of wood dust emission from hand-held woodworking machines". *Journal of Occupational and Environmental Hygiene*, vol. 15, no. 1, pp. 13-23, 2018.

[4] P. Koleda and P. Koleda. "Optical measurements of sawdust dimensions". *Wood Research*, vol. 61, no. 3, pp. 505-512, 2016.

[5] J. Krilek, J. Kováč, Š. Barcík, J. Svoreň, M. Štefánek and T. Kuvik. "The influence of chosen factors of a circular saw blade on the noise level in the process of crosses cutting wood". *Wood Research*, vol. 61, no. 3, pp. 475-486, 2016.

[6] Marková, E. Mračková, A. Očkajová and J. Ladomerský. "Granulometry of selected wood dust of dust from orbital sanders". *Wood Research*, vol. 61, no. 6, pp. 983-992, 2016.

[7] Očkajová, A. Beljaková and J. Ľuptáková. "Selected properties of spruce dust generated from sanding operations". *Drvna Industrija*, vol. 59, no. 1, pp. 3-10, 2008.

[8] J. Ojima. "Generation rate and particle size distribution of wood dust by handheld sanding operation". *Journal of Occupational Health*, vol. 58, no. 6, pp. 640-643, 2016.

[9] J. Ratnasingam, F. Scholz, V. Natthondan and M. Graham. "Dust-generation characteristics of hardwoods during sanding processes". *European Journal of Wood and Wood Products*, vol. 69, no. 1, pp. 127-131, 2011.

[10] J. Rončka and A. Očkajová. "The influence of sanding machine type and grit size on granularity of sanding wood dust", in *Proc. of the 2nd ISC-Woodwoking techniques*, 2007, pp. 289-294.

[11] STN EN 50632-2-4:2013. Electric motor-operated tools. Dust measurement procedure. Part 2-4: Particular requirements for sanders other than disk type.

[12] Thorp and R. Brown. "Factors influencing the production of dust during the sanding of wood". *American Industrial Hygiene Association Journal*, vol. 56, no. 3, pp. 236-242, 1995.

[13] Welling, M. Lehtimäki, S. Rautio, T. Lähde, S. Enbom, P. Hynynen and K. Hämeri. "Wood Dust Particle and Mass Concentrations and Filtration Efficiency in Sanding of Wood Materials". *Journal of Occupational and Environmental Hygiene*, vol. 6, no. 2, pp. 90-98, 2009.
[14] R.E. Wiggans, G. Evans, D. Fishwick and C.M. Barber. "Asthma in furniture and wood processing workers: a systematic review". *Occupational Medicine*, vol. 66, pp. 193-201, 2016.
[15] D.E. Young-Corbett and M.A. Nussbaum. "Dust Control Effectiveness of Drywall Sanding Tools". *Journal of Occupational and Environmental Hygiene*, vol. 6, no. 7, pp. 385-389, 2009.
[16] A.T. Zimmer and A.D. Maynard. "Investigation of the aerosols produced by a high-speed, hand-held grinder using various substrates". *The Annals of Occupational Hygiene*, vol. 46, no. 8, pp. 663-672, 2002.

Doc. Ing. Miroslav Dado
Ing. Lucia Mikušová, PhD.
Doc. Ing. Richard Hnilica, PhD.
Technical University in Zvolen
Faculty of Environmental Manufacturing of Technologies
Department and Quality and Manufacturing Technology
Studentska 26, 96053 Zvolen, Slovak Republic
e-mail: dado@tuzvo.sk,
lulumikus@gmail.com,
hnilica@tuzvo.sk