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AN EVALUATION OF ON-TOOL SYSTEM FOR SANDING DUST COLLECTION: PILOT STUDY

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Abstract:
Hazards identification is essential step in framework of occupational health & safety (OH&S) management system. The task of spruce wood sanding with hand-held power belt sander is considered as a significant resource of exposure to wood dust. Dust from spruce wood is hazard that can cause negative health effects such as asthma and chronic bronchitis. A dust collection box is a commonly used technical measure for reducing exposure to wood dust for this task in practice. The objective of this pilot study was to evaluate the effectiveness of commercially available dust collection box at reducing exposure to wood dust during the task of sanding spruce wood using hand-held power belt sander. Laboratory experiment involved sanding spruce planks (250 mm × 50 mm × 500 mm) in longitudinal direction using belt sander (Bosch, PBS 75 A) with 120 grit sanding belt. Spruce dust mass concentrations were sampled using an aerosol monitor (TSI Inc., DustTrak DRX 8533) in the breathing zone of operator. Inhalable and respirable dust concentrations were both significantly lower ($P < 0.0001$) when dust box was attached to belt sander compared with sander without a dust box. Results from this pilot study indicate that dust collection box is efficient technical measure for decreasing exposure to aerosol mass concentration during sanding spruce wood with hand-held belt sander.

Key words: *belt sander, dust extraction, efficiency*

INTRODUCTION

The largest development with occupational health & safety (OH&S) management systems in the past few years is the establishment of the international standard ISO 45001:2018 [16, 17, 22]. The aim and intended outcomes of OH&S management system are to prevent work-related injury and ill health to workers and to provide safe and healthy workplaces; consequently, it is critically important for the organization to eliminate hazards and minimize OH&S risks by taking effective preventive and protective measures [11]. According to ISO 45001:2018 the organisation should have a process to determine and have access to health and safety legal requirements applicable to its OH&S management system. In case of woodworking companies, one of these legal requirements is also requirement set out in Machinery Directive (2006/42/EC) concerning risks to health due to the emission of hazardous materials and substances produced by portable hand-held machinery. Where airborne emissions of wood dust cannot be sufficiently avoided or reduced, machinery has to be fitted with the equipment necessary to contain wood dust in order to protect persons against exposure.

A large amount of dust is generated when sanding wood with hand-held power belt sander. In Slovakia, occupational exposure limit (based on an 8-hour time-weighted average) is 8 mg/m³ for inhalable wood dust except dust from exotic species (1 mg/m³). Moreover, there is sufficient evidence of carcinogenicity of beech and oak dust. Prolonged exposure to these dusts could lead to nasal and sinonasal cancers. Limit value for occupational exposure to hardwood (beech, oak) dusts is 3 mg/m³. Belt sanders, because of their particularly high rates of wood removal, produced the highest dust concentration, typically between 5 and 10 times greater than concentrations produced by the orbital sanders [24]. According to [23], determinants that influence the quantity of wood dust produced concurrently with sanding are density and hardness of the wood, sandpaper grade and contact pressure.

In selecting the most appropriate methods of reducing risk of exposure to wood dust, the manufacturer of belt

sander should take measures to reduce the risks as close to the emission source as possible. For that reason, most commercially available belt sanders are equipped with some sort of dust extraction unit. Dust extraction unit being either an external one (such as a dust extractor or centralized exhaust system) or an integral one. Integral dust extraction unit typically uses a fan indirect driven by the motor to create suction for the dust collection system. Dust particles generated at the sanding process are drawn into housing by an airflow caused by the rotation of the fan, and they are exhausted from the housing through duct into the dust collector (such as filter bag, dust box or container).

Several researchers have examined performance of dust separation units during grinding metal [2, 5, 13, 21, 27, 29], sandstone [10], concrete [1], stone [10, 14] or sanding drywall [28] and wood [3, 9, 15, 18, 19, 20, 24, 26]. Results from these studies indicate that personal exposures to dust are substantially lower when on-tool systems for sanding dust collection were used. On the contrary, Douwes et al. [6] reported that the application of integral dust extraction unit to orbital sander was useless in decreasing exposure to wood dust. The objective of this pilot study was to assess the performance of commercially available dust collection box at decreasing exposure to wood aerosol during sanding spruce wood with hand-held power belt sander.

MATERIALS AND METHODS

Experimental design

Assessment of the performance of the dust collection box at decreasing wood dust concentration was evaluated by sampling photometric data in the operator breathing zone. The laboratory pilot study employed a paired samples design. Sanding dust exposure levels were determined when belt sander was equipped with dust box in comparison with same sander without a dust box. The layout of the instruments in the experiment is presented in Fig. 1.

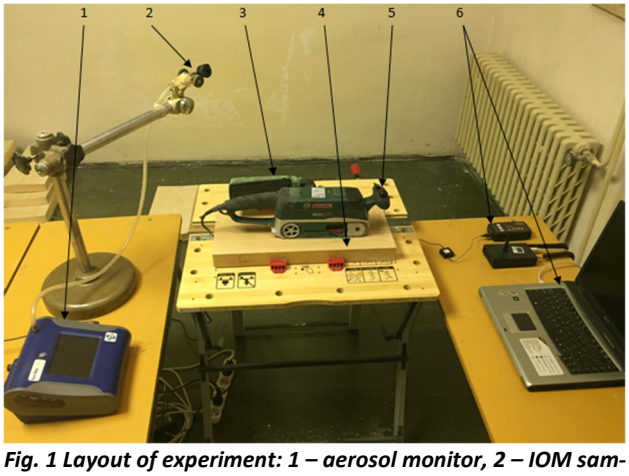

Fig. 1 Layout of experiment: 1 – aerosol monitor, 2 – IOM sampler, 3 – belt sander, 4 – spruce plank, 5 – pressure force sensor, 6 – pressure force monitoring system

Test specimens

The input material for the production of the test specimens were planks of spruce *(Picea abies)*. Test specimens were cut to the required dimension of 500 mm × 250 mm × 50 mm (length × width × thickness) by the longitudinal cutting using band saw (Mebor, HZT 1000) and following by the cross cutting using cross cut saw (TOS Svitavy, KRU). Moisture content of the planks was 12%. The mobile workbench (Bosch Power Tools, PWB 600) was used for clamping the test specimens.

Sanding procedure

Sanding was performed in longitudinal direction using a commercially available hand-held belt sander (Bosch, PBS 75 A). No-load belt speed was 350 $m.min^{-1}$. Sanding belt with grain size P120 (Klingspor Inc., model LS309XH) was replaced after each measurement. To ensure consistent sanding operation, monitoring the pressure force was performed by the load cell capacity sensor (Hoggan Scientific, ErgoPAK FSR). The pressure force 50 N ± 5 N was applied on the sanding surface.

Wood removal measurement

The total quantity of aerosol produced when sanding wood with hand-held power belt sander depends on the total mass of wood removed. Remaining dust was eliminated from each plank manually with the brush before weighting procedure. The weighting procedure was performed using an analytical balance (Sartorius AG, BP 3100 P). Wood removal ratios were determined by multiplying mass of material extracted from the boards and the sanding time.

Photometric sampling

Photometric data were collected utilizing laser photometer (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. In order to obtain representative data, sampling location within operator's breathing zone was chosen. According to [8], the breathing zone corresponds to a hemisphere (generally accepted to be 30 cm in radius) extending in front of the human face, centred on the midpoint of a line joining the ears. The base of the hemisphere is a plane through this line, the top of the head and the larynx. Ten repetitions were performed in each trial. The average speed of air flow rate at sampling point was measured using anemometer (Testo, model Testo 480) and ranged from 1.6 $m.s^{-1}$ to 3.3 $m.s^{-1}$.

Statistical analysis

Measured data were approximately log normally distributed and the geometric mean (GM) and geometric standard deviation (GSD) were determined. Using the log transformed photometric data, a Student's t-test was performed to examine if there was a statistically significant difference in mass concentrations when belt sander was used with dust box and without dust box. All statistical

analyses were carried out using the software Statistica v.10 (StatSoft Inc.).

RESULTS

Removal ratios for the spruce wood ranged from 7.78 g.min^{-1} to 11.25 g.min^{-1} using dust collection box and from 8.11 g.min^{-1} to 10.88 g.min^{-1} for the sanding without sand box. Fig. 2 shows an example of the temporal variations in aerosol monitor response with time for generated spruce dust during sanding with dust box.

Two-sample *t*-test on the logarithms of the collected photometric data indicated a statistically significant difference in geometric mean concentrations for both particle size fractions. All sample *t*-test P-values were < 0.0001 (Table 1). Use of belt sander equipped with dust box reduced exposure by about 70% compared to exposure without using dust box.

Table 1

Geometric mean (GM) and geometric standard deviation (GSD) of photometric dust concentrations (mg.m^{-3}) measured when sanding with and without dust box

Particle size fraction	n	Dust box GM (GSD)	No dust box GM (GSD)	*t*-Test P-value
inhalable	10	3.20 (1.22)	10.60 (1.20)	P < 0.0001
respirable	10	0.58 (1.26)	1.98 (1.14)	P < 0.0001

DISCUSSION AND CONCLUSIONS

For sanding wood with hand-belt sander the traditional engineering control measures include integral dust extraction unit, mobile local exhaust ventilation, and downdraft Table [4]. As observed in this pilot study, it is clear that use of hand-held belt sander without appropriate engineering control enhances risks related to spruce wood dust inhalation exposure. There are several approaches to verify the effectiveness of on-tool extraction system. Real-time inhalable and respirable dust measurements in breathing zone of sander's operator were used to assess the efficiency of examined integral dust extraction unit. The results of this pilot study have demonstrated that airborne wood dust concentration can be considerably decreased by utilizing market accessible dust collection box while sanding spruce wood with hand-held belt sander. Our results are consistent with results reported by Thorpe and Brown [24]. In their study, electric belt sander with cotton cloth filter bag was used to sand beech wood and they reported reduction in airborne dust concentrations ranging from 66 to 72%. On the contrary, Douwes et al. [6] showed that the use of integral dust extraction unit caused increase of airborne aerosols. However, their laboratory experiment involved sanding medium density fibreboard using the different type of sander with finer grain size of abrasive.

Two limitations of our study need to be mentioned. First, the aerosol monitor was not adjusted for the measurement of spruce wood dust. Dust Trak DRX has two calibration regimes. We performed only zero calibration procedure for compensation of zero drift. In case that sampled aerosol has different properties from reference aerosol, a user calibration regime serves for determination of photometric and size correction calibration factors [25]. However, the intention of this pilot study was to examine if there is any difference between two conditions related to dust box using rather than to determine real occupational exposure to wood dust. For this reason, it was sufficient to know the relative mass concentration values. Second, reported values of inhalable wood dust are underestimated due to limitation in the size range (0.1 µm-15 µm) of DustTrak DRX.

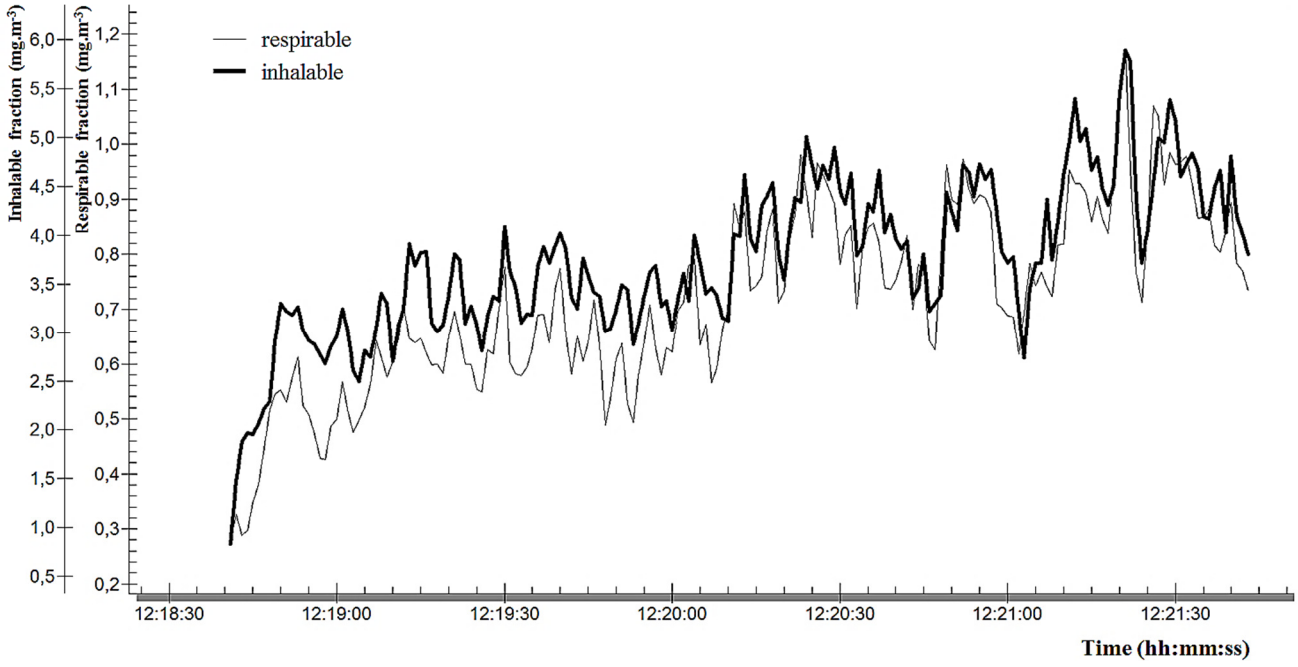

Fig. 2 Temporal variations in aerosol monitor response with time for generated spruce dust during sanding with dust box

In conclusion, this pilot study proved that dust collection box is efficient engineering control for decreasing inhalable and respirable fractions of dust during sanding spruce wood with hand-held belt sander. Nevertheless, we would emphasize that even with considerable reductions; on-tool system for sanding dust collection never completely eliminated exposure and the use of supplementary respiratory protective equipment is required. Our further research efforts will be focused on investigation of effects of the sandpaper grade and wood species on effectiveness of integral dust extraction system.

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