Brief Report

Generation rate and particle size distribution of wood dust by handheld sanding operation

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Abstract: Objectives: The International Agency for Research on Cancer (IARC) and Japan Society for Occupational Health (JSOH) classified wood dust as a human carcinogen. Former studies have suggested that sanding with a portable sander is one of the processes that are liable to cause highest exposure to wood dust. However, the wood dust by sanding operation has not been investigated sufficiently. In this study, the generation rate and the particle size distribution of the wood dust produced by handheld sanding operation were observed by laboratory experiments. **Methods:** Beech and cypress were taken as typical hard and soft wood specimen respectively, and sanded with a portable sander. Three grades of sand paper (coarse, medium, fine) were attached to the sander in turn to be tested. The quantity of the wood dust produced by the sander was measured by weighing the specimen before and after the sanding and then the generation rate of the dust was calculated. **Results:** Soft wood generated more dust than hard wood due to the difference in abrasion durability. A coarse sand paper produced more dust than a fine sand paper. The particles of less than 1 μm diameter were scarcely observed in the wood dust. When the specimens were sanded with a fine sand paper, the mass median aerodynamic diameters of beech dust and cypress dust were 9.0 μm and 9.8 μm , respectively. **Conclusions:** Respirable wood dust is able to be controlled by general ventilation with more than 0.7-4.2 m^3/min ventilation rate. (J Occup Health 2016; 58: 640-643)
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Key words: Exposure, Sanding, Ventilation, Wood dust

Introduction

In 1995 the International Agency for Research on Cancer (IARC) has categorized hard wood dust as carcinogenic to humans (Group 1)¹⁾, and soft wood dust was also classified in Group 1 seven years later. In 1998, Japan Society for Occupational Health (JSOH) issued “Recommendation of Occupational Exposure Limits (1998-1999)”²⁾ and classified wood dust as a human carcinogen without providing a concrete limit value. Although several studies on wood dust hazards^{3,4)} had already been reported by Japanese researchers, wood dust came to be known widely as a type of human carcinogen in Japan after the 1998 JSOH statement. While each organization with authority such as OSHA, NIOSH, and ACGIH is regulating occupational wood dust exposure independently now, the occupational exposure limit (OEL) for wood dust has not yet been prescribed in Japan. Therefore, the concentration of wood dust in a work place is conventionally regulated by the OEL as an ordinary organic dust in Japan (2 mg/m^3 for respirable dust and 8 mg/m^3 for total dust, respectively; both are set based on non-carcinogenic health effects).

In general, significant amount of wood dust will be dispersed during any wood work process. Previous studies have suggested that sanding with a portable sander is one of the processes that are liable to cause highest exposure to wood dust^{5,6)}. However, as far as the author knows, the characteristics of wood dust produced by sanding operation has not been investigated sufficiently. In this study, the generation rate and the particle size distribution of wood dust produced by handheld sanding operation were observed by laboratory experiments because both observations will be essential in taking measures against occupational wood dust exposure.

In addition, ventilation requirements for preventing occupational exposure were estimated based on the measurements of generation rate and particle size distribution of wood dust.

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Fig. 1. Micrographs of wood dusts by sanding.

In the experiments, two kinds of wood—hard wood and soft wood—were used as the specimens to be sanded since each wood type has different abrasion durability and exhibits different health effects on humans.

Materials and Methods

Beech and cypress were taken as typical hard wood and soft wood specimen, respectively. Hard wood is commonly used in a furniture industry, and soft wood is widely used as materials for house construction in Japan. Each specimen was cut to a board of 10×20×1.5 cm in size and sanded with a 130 W portable electric sander (Finishing Sander Model-9035N; Makita Co., Japan) for 5–15 minutes in order to produce wood dust. All sanding in this study was carried out by the same 170 cm male worker, which simulated normal working practice. When sanding, three grades of sand paper (#60, #120, and #240; corresponding to the abrasive grain size of “coarse (>212 μm),” “medium (>90 μm),” and “fine (<110 μm),” respectively) were attached to the sander in turn. The quantity of the wood dust produced by the sander was measured by weighing the specimen before and after the sanding and

then the generation rate of the dust was calculated. An electric balance (EW-300G; A&D Co., Ltd., Japan) was used for weighing the specimen. The morphology of the wood dust particle was observed by a desk-top digital microscope (ViTiny UM06 digimicroscope; Microlinks Technology Corp., Taiwan). The particle size distribution of the wood dust was measured by an 8-stage Andersen cascade impactor (Model AN-200; Tokyo Dylec Corp., Japan). The sampling flow rate of the cascade impactor was 28.3 L/min. The particle ranges of each stage were >11 μm, 7.0–11 μm, 4.7–7.0 μm, 3.3–4.7 μm, 2.1–3.3 μm, 1.1–2.1 μm, 0.65–1.1 μm, 0.43–0.65 μm, respectively. A precision electric balance of 0.01 mg readability (Genius balance ME235S; Sartorius AG, Germany) was used for weighing the filters of the cascade impactor before and after loading the wood dust.

After measuring the generation rate and the particle size distribution, ventilation requirements for preventing respirable wood dust exposure at a steady state were estimated according to following simple equation⁷⁾.

$$Q = G/C \quad (1)$$

where Q: ventilation rate [m³/min]

G: generation rate of contaminant [mg/min]

C: concentration of contaminant [mg/m³]

Results and Discussion

Fig. 1 presents the optical micrographs of beech dust and cypress dust. Both dusts in Fig. 1 were produced by sanding with a #60 sand paper and were sampled in the immediate vicinity of the sander. It was observed that the major portion of the wood dust particles were larger than 10 μm in both dusts, which agreed with previous studies^{8,9)}. Although the morphological difference of each dust could not be recognized, a few coexisting aggregated particles (more than hundreds micro-meters size) in the cypress dust were found outside this microscopic view field.

Table 1 presents the generation rates (the amounts of generated dust per minute) of the wood dusts that were produced from the beech and the cypress specimen. All data are given as the arithmetic mean of six repeated tests. As expected, soft wood generated more dust than hard wood due to the difference in abrasion durability. Compared to the beech specimen, approximately 2.7–6 times more dust was generated when the cypress specimen was sanded. A coarse sand paper produced more dust than a fine sand paper. Approximately 8 times more dust was generated when the beech specimen was sanded with a coarse paper, and 3.6 times more dust was produced when the cypress was sanded.

Fig. 2 presents the particle size distributions of beech dust and cypress dust. Since the amount of #60 cypress dusts deposited on the 5th stage and the 6th stage were both very small (less than 0.1%), their plots could not be included in Fig. 2. The finer wood dust particles tended to

Table 1. Generation rate of wood dust for each specimen and sanding paper

	Generation rate [g/min]*		
	#60 (coarse)	#120 (medium)	#240 (fine)
Beech (hard wood)	0.32 (20.5%)	0.09 (7.03%)	0.04 (21.2%)
Cypress (soft wood)	0.87 (8.21%)	0.34 (12.25%)	0.24 (15.48%)

*Value are the arithmetic mean of 6 measurements.

The RSD for each measurement is shown in parenthesis.

Fig. 2. Particle size distributions of wood dusts.

be produced by a fine sand paper whichever specimen was sanded. Particles of less than 1 μm diameter were scarcely observed in the dust regardless of the sand paper grade. Although the majority of common wood dust consists of large particles of more than 10 μm in size, somewhat smaller particles of several μm size could be produced when the specimens were sanded with a fine sand paper. It was found that when the specimens were sanded with a fine paper (#240), the mass median aerodynamic diameters of beech dust and cypress dust were 9.0 μm and 9.8 μm, respectively. Thorpe⁶⁾ reported the median diameter of 1.75-1.96 μm for beech dust; however, it may due to the difference in the sampling locations in each experiment. Thorpe sampled airborne wood dust a few meters from the sanding machine whereas the author sampled in the immediate vicinity of the sander. It is known that the sanding of wood specimen often generates ultra-large particles (particles larger than 100 μm diameter) that may dominate total mass of wood dust¹⁰⁾. As mentioned above, a small number of such large particles were found in the #60 cypress dust in this study. However, the gravimetric contribution of the ultra-large particles seemed to be little because the particle size distribution of #60 cypress dust was similar to that of #60 beech dust in which ultra-large particles were not found in this study.

Table 2 presents the mass ratios of respirable fraction of the wood dusts, which were approximately estimated from the particle size distribution measurements described above. As it has been mentioned that most wood dusts consist of thoracic and inhalable fractions^{8,9)}, the ratio of the respirable dust was low and was not more than around several percent in this study. Although the adverse health effects of wood dust is caused mainly by the inhalable particles, the hazard of the respirable particles, which may bring about allergy or asthma should not be ignored. The requirements for the ventilation rate in which the respirable wood dust is to be controlled by general ventilation can be obtained by substituting 2 (= current OEL for respirable organic dust in Japan) as C in equation (1). Table 2 also presents the ventilation requirements (theoretical minimum ventilation rate) for beech and cypress dust controls, respectively. Each value in Table 2 shows the ventilation rate required for one sanding operation. It should be noted that the actual ventilation re-

Table 2. Respirable fraction ratio and ventilation requirement for wood dust for each sanding paper

	Mass ratio of respirable fraction			Ventilation requirement [m ³ /min]		
	#60 (coarse)	#120 (medium)	#240 (fine)	#60 (coarse)	#120 (medium)	#240 (fine)
Beech dust	0.6%	1.5%	5.0%	>1.0	>0.7	>1.0
Cypress dust	0.4%	1.5%	3.5%	>1.7	>2.6	>4.2

quirement in a sawmill ought to be larger than the requirement presented in Table 2 because of incomplete indoor-air mixing¹¹⁾. The actual ventilation requirement usually becomes 1-10 times larger than the theoretical requirement.

As opposed to the respirable dust, inhalable wood dust which exhibits more serious health effects such as nasal cancer should be controlled by local exhaust ventilation (LEV) system or its equivalent since common general ventilation mentioned above is not suitable for controlling inhalable dust. Large-size particles like inhalable wood dust, which probably has higher kinetic energy and tend to disperse directionally, will be captured certainly by a properly designed LEV hood. Effective operating condition of LEV for inhalable wood dust control should be considered in a further study.

Information about a generation rate of wood dust will also be useful for estimating required performance of a dust collector or an air cleaner in a woodworking shop. Likewise, information about the particle size of generated wood dust will be helpful in selecting an optimal respirator or a personal protective equipment for a woodworker. Besides, risk assessment of wood dust exposure will be carried out more effectively by utilizing these information as references. The author hopes that the data presented above are useful when planning for wood dust control in a workplace.

Conflicts of interest: The authors declare that there are no conflicts of interest.

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