INFLUENCE OF FEED SPEED ON EMISSION OF FINE SAWDUST DURING CIRCULAR SAWING

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Abstract

This paper presents granulometric analysis of sawdust generated in processing oak-wood, fir-wood and particleboard with circular saw at three different feed speeds and two working table position.

Woodworking machines and cutting parameters, as well as processed material properties determine the particle size distribution of chipped wood and as a result also the emission of airborne wood particles at the workplace. The objective of this paper was to clarify the influence of feed speed, cutting angle and wood material characteristics on particle size distribution of sawdust generated during sawing of solid fir-wood (Abies Alba Mill.), oak-wood (Quercus Robur L.) and laminated particleboard with circular saw.

Generally, the results showed that the share of small particles in sawdust decreases with the increase of feed speed. Working table position and cutting angle have very important influence on particle size distribution of sawdust when cutting solid wood.

Key words: *sawdust, fir-wood, oak-wood, particleboard, particle size distribution*

INTRODUCTION

Woodworking machines and cutting parameters, as well as wood material properties determine the particle size distribution of chipped wood. Workers' exposure to airborne wood dust particles in the surrounding air of the workplace may cause different occupational health problems in wood industry workers (Kohler, 1995). Consequently, particle size distribution of sawdust, especially the share of airborne wood particles, originating from different mechanical working of different wood species, is frequently the object of research (Očkajová and Dzurenda, 2002; Očkajová and Beljaková, 2004; Dzurenda, 2004; Beljo Lučić et al, 2005).

Many authors investigate the possibility of reducing the finest (airborne) particles by the control of machining parameters and by varying the cutting speed, feed speed, tool type and tool size, cutting angles, number of blades and processed material (Fujimoto and Takano, 2003; Varga et al, 2003; Hemmilä et al, 2003). Airborne dust is determined as a fraction of dust where aerodynamic particle size is 100 µm or less (Hemmilä et al, 2003).

According to the results of these researches, the average chip thickness is one of the most important parameters for the resulting particle size distribution of wood dust generated during mechanical woodworking. The influence of cutting direction and processed material is also considerable.

Chip thickness increase with the increase of feed speed but decrease with the increase of cutting speed (Kos and Beljo Lučić, 2004). In the report of experiment results Hemmilä et al. (2003) stated that the cutting speed was proportionate to the airborne dust, i.e. lower cutting speed resulted in decreased dust emission. They also stated that lowering feed speed caused decreasing of airborne dust emission or that it had no clear effect on airborne dust emission. Based on performed investigations, Varga et al. (2004) also stated that increasing feed rate and cutting speed resulted in a larger fine dust fraction when cutting oak-wood and particleboard.

The effect of cutting parameters on particle distribution of chipped wood is not quite clear because of complex and varying morphology of the processed material, which ranges from softwood through light and dense hardwoods to particleboard, and differences in fragmentation of chips generated during sawing.

The objective of this paper was to clarify the influence of feed speed, working table position and processed material characteristics on particle size distribution of sawdust generated during circular sawing of solid wood, fir (*Abies Alba* Mill.) and oak (*Quercus Robur* L.), and laminated particleboard (ITLaFo).

RESEARCH METHOD

Sampling of chipped wood was carried out during machining of oak-wood (hardwood), fir-wood (softwood) and laminated particleboard with circular saw. Table 1 shows the data of cutting parameters and Figure 1 shows the arrangement of experimental sawing.

The circular saw blade 1 had alternately slanted teeth and it was usually used for longitudinal and transversal cut of solid wood. The circular saw blade 2 was used for particleboard material cutting.

Table 1: Data of wood material and woodworking machine

Woodworking machine	Circular saw 1	Circular saw 2
Power , P_{mn} (kW)	1.1	1.1
Rotation speed, n_v (min^{-1})	3824	3824
Tool diameter, D (mm)	300	300
Number of cutting edges, z	24	60
Cutting speed, v_c (m/s)	60	60
Moisture content of wood material, (%)	7.7 – 12.2 %	
Working table position, h_{t1} (mm)	55	55
Working table position, h_{t2} (mm)	106	106
Cutting height, h_1 (mm)	21 – 27	9 and 31

Granulometric analysis of chipped wood was carried out on samples weighing 40 g with five repetitions. The samples were sieved by use of a laboratory electromagnetic sieve shaker (medium power, vibration amplitude 1.5 mm; τ = 15 min), type RP 08 ϕ200-ϕ203 mm (manufactured by CISA Cedaceria Industrial, Barcelona, Spain). The samples were screened on five mash screens: 1.25; 0.8; 0.5; 0.25 and 0.1 mm (ISO 2395:1990). The mass of individual fractions of chipped material was weighted by electronic precision scales, type Acculab Vicon VIC 412 (Acculab Europe, Sartorius group, Goetingen, Germany). The results of granulometric analysis are shown in accordance with ISO 9276-1:1998.

Table 2 shows the fraction of particles in view of the screen mash size and the related particle size.

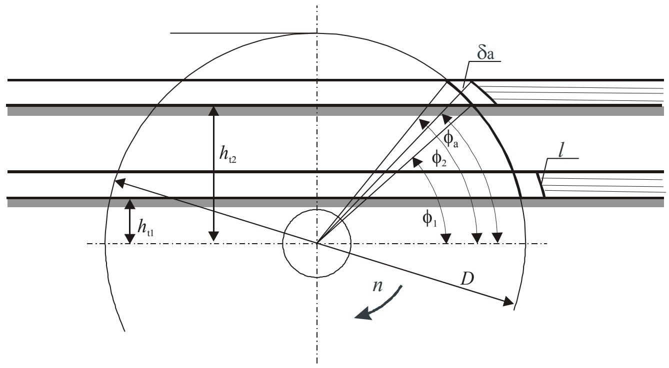

Figure 1 - Presentation of the arrangement of experimental circular sawing and chip crosscut

Table 2: Fraction of particles and related particle size

Fraction of particles, mm	Particle size number
< 0.1	0.1
0.1 – 0.25	0.25
0.25 – 0.5	0.5
0.5 – 0.8	0.8
0.8 – 1.25	1.25
1.25 <	P1.25

Longitudinal sawing of samples was performed with feed speed of 33; 18.35; 9.18; 4.58 and 1.8 m/min for fir-wood and 18.35; 13.77; 9.18; 4.58 and 1.8 m/min for oak-wood and at two working table positions (see Figure 1). Sawing of laminated particleboard was performed at working table position h_{t1}=55 mm and feed speeds 2,07; 8,73; 18,66 m/min, and at working table position h_{t2}=106 mm and 1,95; 8,23 i 17,43 m/min.

RESULTS AND DISCUSSION

Diagrams in Figures 2, 3 and 4 present cumulative particle size distribution of analysed fir-wood, oak-wood and particleboard sawdust, respectively.

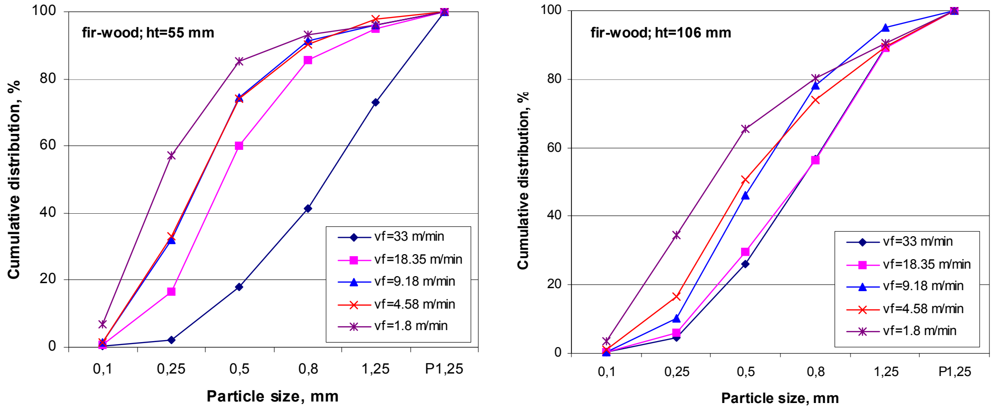

Figure 2 - Particle size distribution of fir-wood sawdust generated during circular sawing with different feed speed and at different working table position

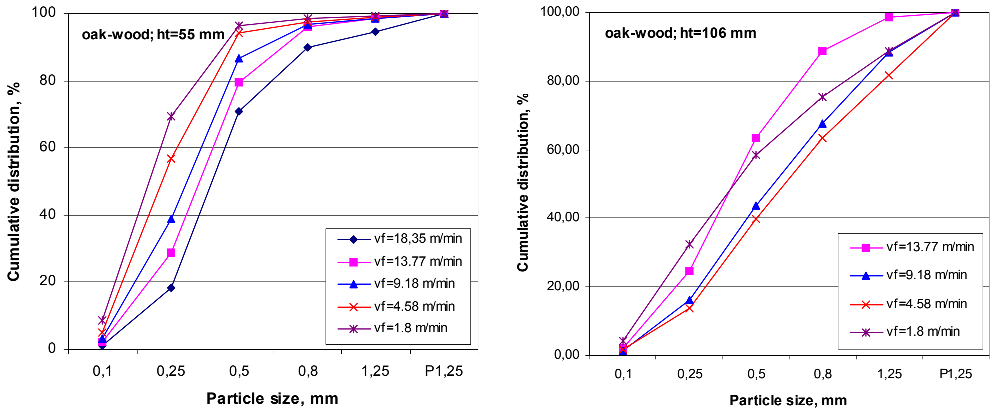

Figure 3 - Particle size distribution of oak-wood sawdust generated during circular sawing with different feed speed and at different working table position

When sawing oak-wood and fir-wood at a lower working table position (h_{t1}=55 mm), the effect of reducing feed speed obviously results in the increase of share of smaller sawdust particles, which is quite the opposite of the conclusions reached by Hemillä et al (2003) and Varga et al (2003). However, when sawing at a higher working table position (h_{t2}=106 mm) the effect of reducing feed speed on particle size distribution is not so obvious and cannot be clearly interpreted. This part of research is in accordance with the results of research reached by Hemillä et al (2003) and Varga et al (2003).

Cutting direction is influenced by the working table position. Lower working table position, or small cutting angle, has resulted in cutting nearly perpendicular to grain and producing shorter and thicker chips. On the other hand, upper working table position has resulted in cutting along the grain and producing longer and thinner chips.

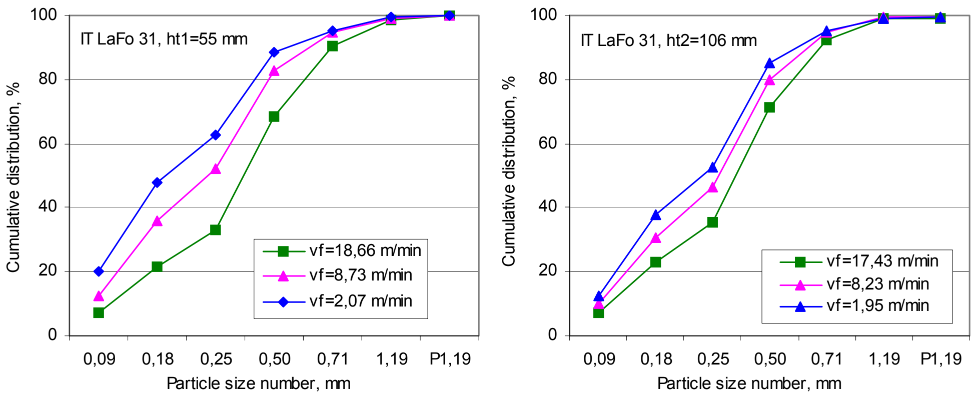

Figure 4 - Particle size distribution of particleboard sawdust generated during circular sawing with different feed speed and at different working table position

It can be concluded from the experiment results that in sawing wood with a circular saw, when chips are generated by cut perpendicular to grain, the reduction of share of small particles in the sawdust can be achieved by the increase of feed speed. When sawing at higher working table positions, i.e. nearly along the grain, the influence of feed speed on particle size distribution is not clear but it seems that with increasing feed speed the share of small particles also increases. It is very interesting that there are more small chips in fir sawdust than in oak sawdust when cutting is performed along the grain.

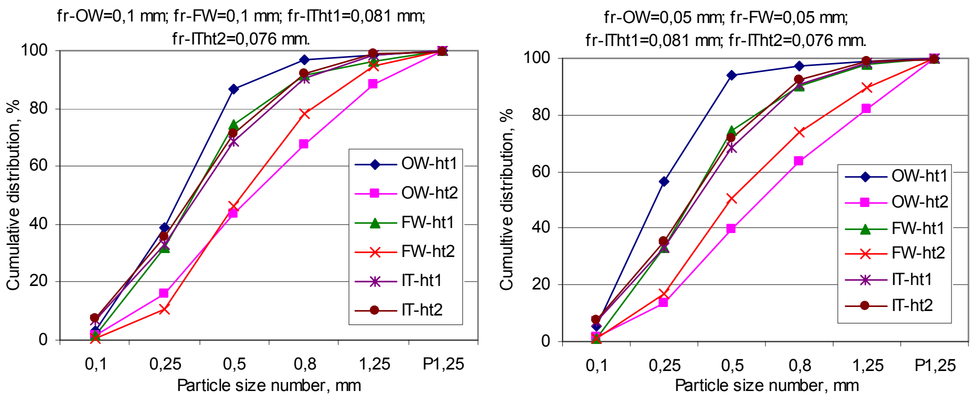

Figure 5 – Particle size distribution of different wood material sawdust generated during circular sawing (*fr* – feed rate (mm), OW – oak-wood, FW - fir-wood, IT - particleboard)

The influence of feed speed change at particleboard sawing on particle size distribution of sawdust is equal to the influence of feed speed at sawing of solid wood in direction perpendicular to the grain, so the increase of feed speed decreases the share of small particles. Results have shown that the position of working table does not change the influence of feed speed on particle size distribution of particleboard sawdust.

The working conditions at sawing the laminated particleboard are not completely comparable to conditions of sawing the solid wood, but still, comparison of the particle size distribution of sawdust created at sawing of oak-wood, fir-wood, and laminated particleboard in conditions of nearly equal feed rate is inidicated on Figure 5. It can be concluded that the amount of fine particles in particleboard sawdust is equal or lesser in the sawing at lower position of table than in oak-wood and fir-wood sawdust while at the higher position of the working table, the share of fine particles in particleboard sawdust is higher.

Palmqvist and Gustafsson (1999) have researched the influence of cutting parameters and mean chip thickness on the mass concentration of airborne wood particles during the machining of different materials, also. Their results show that the dustiness ratio of solid pine, solid beech and MDF was 1:5:6, respectively.

CONCLUSIONS

The optimisation of machining parameters should involve the influence of machining parameters on generating airborne wood dust. One of the most important parameters is certainly average chip thickness (Palmqvist and Gustafsson, 1999; Kos and Beljo Lučić, 2004). However, according to the results of researches considered in this paper, in circular sawing of solid wood the most important parameters influencing particle size distribution of sawdust is cutting direction related to grain direction and form of generated chips.

When cutting solid wood or particleboard, if trying to optimise machining parameters related to the production of airborne dust, low feed speed should be avoided, especially when cutting perpendicular to grain. When cutting with circular saw solid wood at a high working table position, high feed speed should be avoided because chips show a tendency to fragment and generate airborne dust.

It is obvious that the form of an individual particle, which is different with respect to the working table position, also defines the fragility of the produced particle, and hence also the production of even smaller particle fraction. Physical and mechanical features of wood also have a significant impact on the production of airborne wood dust, and to this respect more comprehensive research should be carried out of fragility of specific wood species and wood material.

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