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CORRELATION BETWEEN THE WOOD CUTTING PARAMETERS AND THE DISTRIBUTION OF THE WOOD PARTICLES

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Abstract
Since ancient times the wood has been shaped by mechanical woodworking operations as we do today. In this time we have modern woodworking machines and hand tools; however, the quality and quantity of the raw material is continuously declining. We are forced to use this precious material with care and more economically, reducing waste as much as possible. To fulfil this requirement, efforts are being made worldwide to develop new machines, tools and technologies, for instance thin-kerf saws, wear resistant tools, quality assessment, and using of smaller size raw materials, etc.
The wood cutting's parameters are the most important influencing factors of the wood chips and dust particles. The aim of this study to find the correlation between the wood cutting parameters and the distribution of the wood particles.

Keywords: *wood processing; cutting parameters; size distribution*

INTRODUCTION

Poor air quality has adverse effects on human health, particularly respiratory and cardiovascular systems. These effects are often first noticed as wheezing, coughing, shortness of breath and a worsening of existing respiratory and cardiac conditions, particularly to sensitive portions of the population, including the very young, old or those with existing medical conditions, such as asthma. Industry can be required to minimize emissions through licensing and regulation as well as by the use of pollution control devices, which remove pollutants by filtration. The most effective way of reducing dust exposure is to reduce the emission of dust at the source. The optimization of the chip thickness should be very important for decreasing of workers exposure [3].
Proper dust collection and air filtration is important in any work space, particularly by milling MDF. The milling MDF generated 30 times and 8 times more airborne dust compared to solid pine and particle board, respectively [2]. Repeated exposure to wood dust can cause chronic bronchitis, emphysema, "flu-like" symptoms, and cancer. Wood dust also frequently contains chemicals and fungi, which can become airborne and lodge deeply in the lungs, causing illness and damage.
Wood dust could become explosive material under special conditions. We must recognize and prevent the dangerous situations.

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The energy consumption of the wood dust extraction systems is relatively high therefore the decreasing the energy consumption is a very important task in the wood industry.

Occupational exposure to wood dust in EU countries [4]

- About 3 million exposed workers (2% of the employed)
- About 1.5 million exposed to low levels (<0.5 mg/m^3)
- About 0.2 million exposed to high levels (>5 mg/m^3), esp. in furniture industry

The 2004/37/EC (1999/38/EC) EU Directive gives a limit value of 5 mg/m^3 (inhalable fraction) for occupational exposure to hardwood dust. However, it seems evident that to protect woodworkers from effects on respiratory health, a lower limit value is needed. It appears very well documented in the scientific literature that exposure to wood dust at levels below 5 mg/m^3, including 1 mg/m^3 and lower, is causing sino-nasal as well as pulmonary symptoms.

Dust explosion

Wood dust is considered to be explosive if ignition of part of a cloud of wood dust results in the propagation of flame through the rest of the cloud.
The following three conditions must be satisfied for a dust explosion:
A cloud of combustible substances with a particle size of <0.5 mm. The concentration of this dust cloud must be between the lower explosion limit (LEL) and the upper explosion limit (UEL).

- The LEL for many wood dusts, for example is between 30 and 60 g/m^3, the UEL is 2 to 6 kg/m^3.
- A sufficient amount of air oxygen.
- A suitable ignition source, e.g. an electrical spark which may occur when pulling a plug out of a socket or a hot surface (e.g. 300°C to 400°C).

Energy consumption in the wood industry

The energy requarment of the extraction system is high. The share of the electric energy consumption of the dust extraction and the share of the electric energy consumption of the woodprocessing are almost the same!

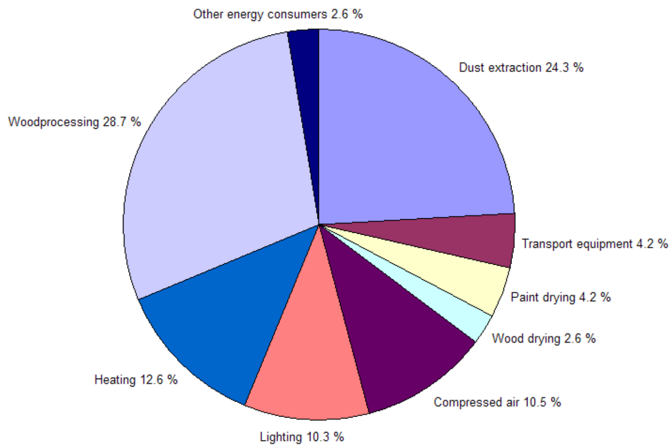

Figure 1. Electric energy consumption of the German Wood Industry in 1999 [5, 6]

MATERIALS AND METHODS

To define the wood dust distribution we used sieve analyse. We collected dust samples of different wood processing's machines. Before the test cuttings we had measured the micro geometry of the tools and we had registered the wood cutting's parameters.
In the first stage of our research work we worked with scotch pine samples.
A representative weighed sample is poured into the top sieve which has the largest screen openings. Each lower sieve in the column has smaller openings than the one above. At the base is a round pan, called the receiver. The column is typically placed in a mechanical shaker. The shaker shakes the column, usually for some fixed amount of time. After the shaking is complete the material on each sieve is weighed.

Figure 2. Mechanical shaker and the sieves

RESULTS

Particle size distribution of the wood dust follows logarithmic distribution, which has the following characteristic values:

- mode $\overline{X}$
- median Mi
- geometric mean G
- standard deviation σ

Distribution function of the logarithmic normal distribution can describe with this equation:

$$y = \frac{1}{\sqrt{2\pi}\ \overline{X}\,\sigma\, e^{\sigma^2/2}} e^{\frac{-\left(ln\frac{x}{\overline{X}}\right)^2}{2\sigma^2}}$$

If we know the data $\overline{X}$ (mode) and σ (standard deviation) we can calculate the y (distribution function). The distribution function is the most important data to choose proper filtering system. The dust content of the filtered air must be under the occupational safety limit.
We illustrated the dust distribution on probability net (Figure 3). We have got straight lines and that means that distribution corresponds to the logarithmic normal distribution.

Calculation of unknown parameters ($\overline{X}$, σ) from experimental results may be done in the following way [1]:

$$QV = e^{0.675\sigma} \rightarrow \sigma = \frac{1}{0.675} ln(QV)$$
$$\mathrm{Mi}/\overline{X} = e^{\sigma^2} \rightarrow \overline{X} = Mi/e^{\sigma^2}$$

where:
quartile ratio QV
X_1 – particle size to 75 %
X_3 – particle size to 25 %

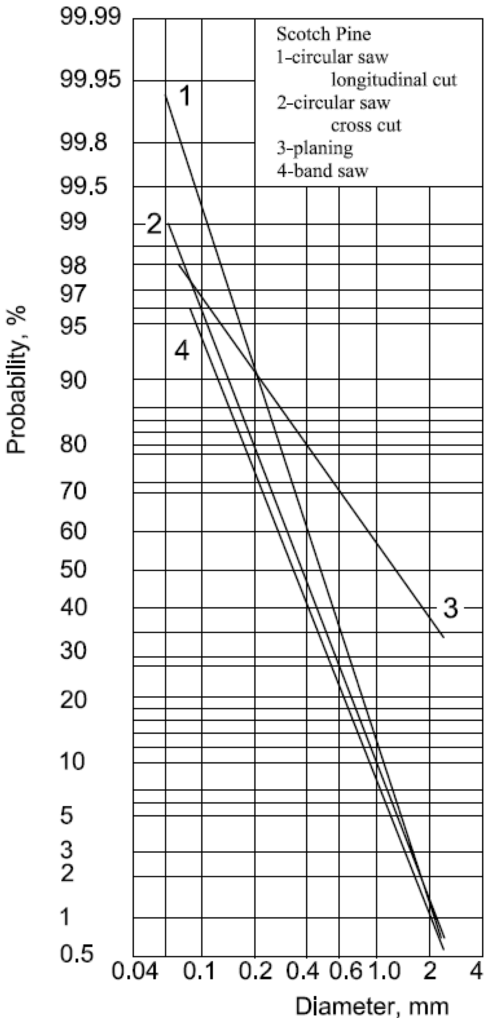

Figure 3. The distribution of wood particles

With this method we can modell the wood dust distribution of different woodworking's operations. Filtering off the fine wood particles is more difficult than removing the bigger particles. Therefore the most important filter characteristic feature is the fractional efficiency [1]:

$$\eta_{fr} = 100\left(1 - e^{-(x/X_k)^n}\right)[\%]$$

The main parameters: X_k – characteristic particle size,
n – exponent (0.9-1.3)

For cyclones: X_k= 15-25 μm;
mat filters: X_k= 5-10 μm.

The quantity of dust in the air after filtering

$$\Delta Q = \sum \left(1 - \eta_{fr}\right) y$$

Where y is given by the distribution functions, therefore

$$\Delta Q = \frac{100}{\sqrt{2\pi}\ \overline{X}\ \sigma\ e^{\sigma^2/2}} \int_0^{\infty} exp\left\{-\left[\left(lnx/\overline{X}\right)^2/2\sigma^2 + (x/X_k)^n\right]\right\} dx\ [\%]$$

The mathematical description of the particle size distribution and the fractional efficiency makes it possible to determine the mass of dust remaining in the air after filtering. Furthermore, if total dust separation efficiency is prescribed, then the appropriate filter characteristics (X_k) can easily be determined.

CONCLUSION

- Woodworking operations have characteristic wood dust distributions;
- Particle size distribution is an important factor to choose proper filtering system;
- Recirculated air contains wood dust which amount must be under the occupational safety limit.

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