MORPHOLOGICAL CHARACTERISTICS OF HARDWOOD PARTICLES IN THE RESPIRABLE RANGE

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Abstract

During mechanical wood processing, particles of various shapes and sizes get detached from the material, as a matter of course. Generated particles are sometimes in the form of dust that may settle in the nose and lungs of the cutting tool's operator. Thus, wood dust is a potential health hazard to woodworkers, as well as an environment contamination agent. Wood dust, especially that of dense hardwoods, may cause tumours through its carcinogenic nature. The present study examines morphology of dust from dense hardwoods such as beech, oak, and black locust, within the respirable range. The size, distribution and morphological characteristics of dust particles are especially important in various diseases. The morphological assessment of wood dusts provides important information about their potential carcinogenic mechanisms and about creating modern, efficient dust extraction technologies.

Key words: *Wood dust, Morphological characteristics, Beech, Oak, Black locust, spirable range, Tumour diseases*

INTRODUCTION

More than 3.5 billion m^3 of roundwood is harvested in the world each year. Millions of people are involved in processing this material, before the end product hits the market. In Hungary alone, about 6 to 7 million m^3 of wood is harvested in the forests, and nearly a 100 thousand people are employed in its processing. Most of these people work daily under circumstances where the atmosphere of the workshop is laden with dust. Over the past decades, many studies dealt with the health-damaging effects of wood dusts, such as e.g. Andersen, Solgaard, Andersen (1976), or Whitehead, Ashikaga, Vacek (1981), Varga et al. (2002). Whitehead et al. differentiated between diseases caused by dense and lightweight hardwoods. According to research results, cancerous diseases in the upper respiratory tracts are most typical (Ahman et al. 1996), but lung tumours are not uncommon, either (Hessel et al. 1996, Ward et al. 1997). By now it is clear that wood dust-related occupational health issues are associated with its carcinogenic nature (Imbus 1994). After our EU accession, environmental regulations for the wood industries have to be complied with, because in 1990, in its proposal nr. 90/326/EGK, cancerous diseases caused by wood dusts were classified by the European Union as occupational diseases.

In order to alleviate the potential tumour type diseases caused by wood dust in the wood industries, workplace dust concentration needs to be kept at a low level. To accomplish this, i.e. to reduce the wood dust exposure concentration, dust extraction systems need to be modernised. The importance of the morphological characteristics of wood is accentuated by the assessment of carcinogenic materials such as asbestos, whereby it was demonstrated that the risk of cancer increases with larger asbestos particles and longer filaments (Gundy 2006). The evaluation of wood dust morphological characteristics is indispensable both for clarifying the mechanisms of cancerous diseases caused by wood dust, and for the modernisation of the extraction equipment.

MATERIALS AND METHODS

From an occupational health point of view, the examination of wood dust generated when cutting dense hardwoods is especially important, because research done up to date established that wood dusts from beech, oak, and other dense hardwoods are especially dangerous carcinogens. These species have an especially large share in Hungary's annual harvest. In terms of wood processing, the proportion of dense hardwoods is 85% – a Hungarian curiosity that further explains our choice of materials. Accordingly, our investigations involved the dust of the most important dense hardwood species, such as beech, oak, and black locust. Chipboard utilisation is also very significant in the Hungarian wood products, which implies considerable chipboard production. Accordingly, dust fractions typical to chipboard utilisation were also included in our investigations.

The so-called respirable range, which includes particles whose geometric parameters fall under the Johannesburg curve (Figure 1), is especially important. Hungarian and international research demonstrated that dust particles that fall into the 0-7 µm size range are continuously present in the atmosphere of woodworking plants (Varga et al. 2003).

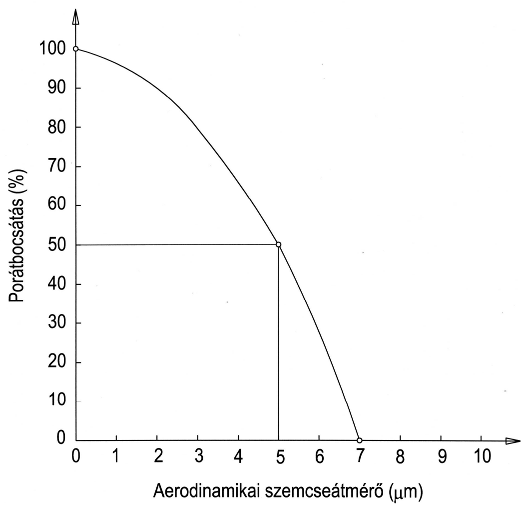

Figure 1 – The Johannesburg curve

Obviously, the dust exposition concentration of the atmosphere, including this dangerous range, is a function of the applied woodworking equipment (Varga, Takács, Fehér 2003). Based on the above, the following parameters of dense hardwood dust, previously proven dangerous, were examined:

- average particle diameter
- dust size frequency function
- relationships between the frequency functions of various species
- characteristic dust particle morphology of each of the species.

The collection of dust samples required for the investigations, generated at typical woodworking machines, in plants processing various species, happened using a persometer. The samples were separated into total and respirable ranges. The characteristics of the particles found in the filter trapping the particles of respirable range were examined using a light microscope and image analyser.

RESULTS AND DISCUSSION

The diameter distribution of the dust particles generated when cutting beech wood suggests that smaller diameter (0-4 µm) particles prevail within the dangerous range (Figure 2). Oak dust fraction is characterised with a similar size distribution, but particles are spread more evenly within the 0-4 µm range (Figure 3). Black locust particle distribution seems most even, and most of the dust particles are found within a narrower (0-3 µm) range (Figure 4).

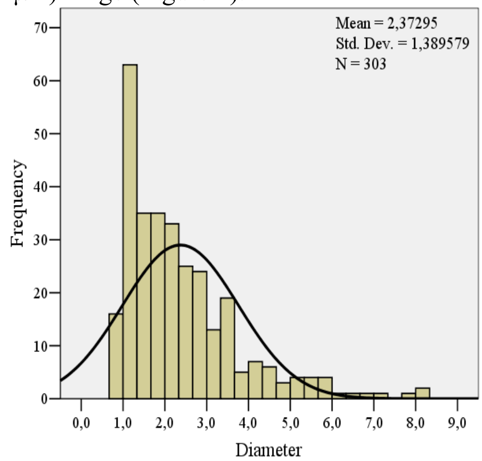

Figure 2 – Beech dust diametric distribution

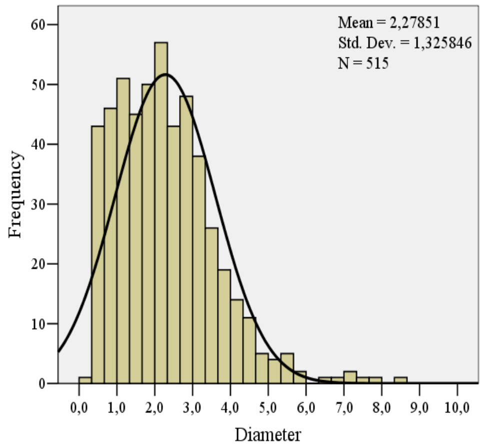

Figure 3 – Oak dust diametric distribution

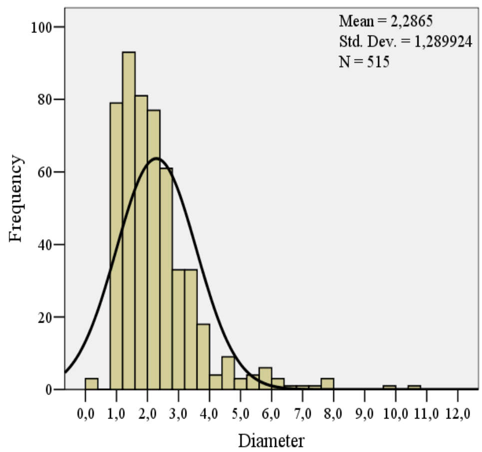

Figure 4 – Black locust dust diametric distribution

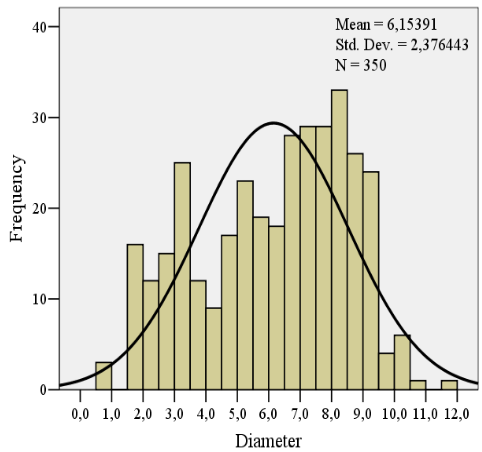

Figure 2 – Diametric distribution of the dust generated when cutting chipboard

The frequency function of the dust created when cutting chipboard is significantly different from those of the three dense hardwood species (Figure 5). The frequency function exhibits a contrasting trend, when compared to hardwood. Larger particles are typically dominant, and most of the examined particles fall outside the so-called dangerous range, i.e. the sizes determined by the Johannesburg curve (0-7 µm). The wide range typical to chipboard, and the predominance of larger-diameter particles is mostly due to the chipboard manufacture technology, and the morphology of the materials (chips) used for its production. Significant differences were not found between the average particle diameter of the three species, 2.378 µm, 2.281 µm, and 2.288 µm for beech, oak and black locust, respectively. On the other hand, significantly larger (an average of 6.154 µm diameter) particles were generated when cutting particleboard (Table 1).

Table 1 – Summary statistics of the examined samples

Stat. parameters	Beech	**Oak**	**Black locust**	**Chipboard**
Minimum (*µm*)	0.897	0.226	0.214	0.869
Maximum (*µm*)	8.189	8.532	10.719	11.634
Average (*µm*)	2.378	2.281	2.288	6.154
Std. dev. (*µm*)	1.389	1.326	1.291	2.376
Std. dev. %	58.43	58.15	56.42	38.62

The range of measurement results for each species is nearly the same, except for black locust where the maximum value is significantly higher than the rest, a little over 10 µm. Standard deviation values are similar, except for chipboard, whose measurement results are more homogeneous, the percentage standard deviation being about 38%, as opposed to nearly 60% for the hardwoods.

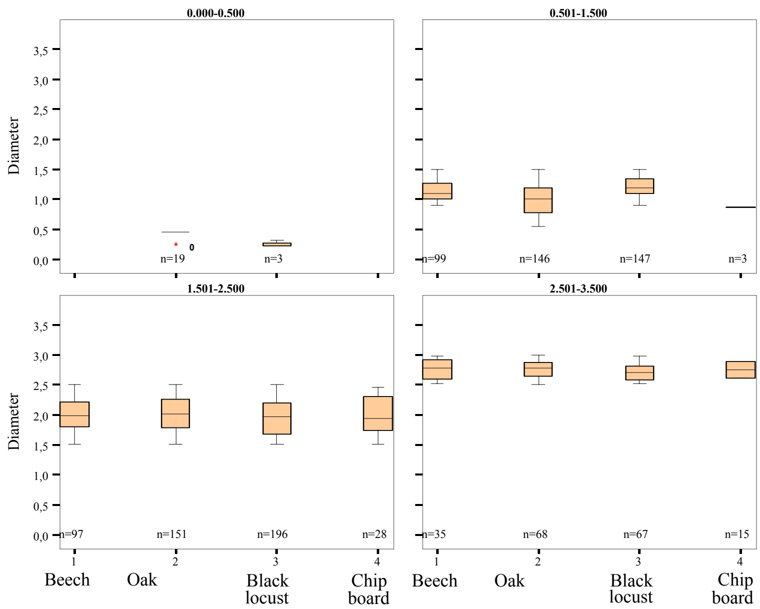

Figure 6 – The analysis of diameter groups by sample

The frequency functions created based on the particle diameter of the various samples showed no significant differences. On the other hand, the analysis of each smaller class provided a more realistic picture of the distribution. The dust particles of only two species, oak and black locust, are found within the smallest class (0-0,500 µm). This implies that very small diameter fractions are generated typically when cutting species with a lot of tyloses. This is confirmed by the assessment of the other three classes as well (Figure 6), i.e. oak and black locust produces particles of somewhat smaller diameter for the most part. Differences get evened out within the middle region, 3,501-7,500 µm (Figure 7).

The proportion of dust particles generated when cutting chipboard is the only one that is unchanged in these middle classes. Even some increase is evident here in the case of chipboard. The analysis of the largest classes (7,501-11,500 µm), which are actually outside the dangerous range (the values under the Johannesburg curve), includes virtually chipboard particles only.

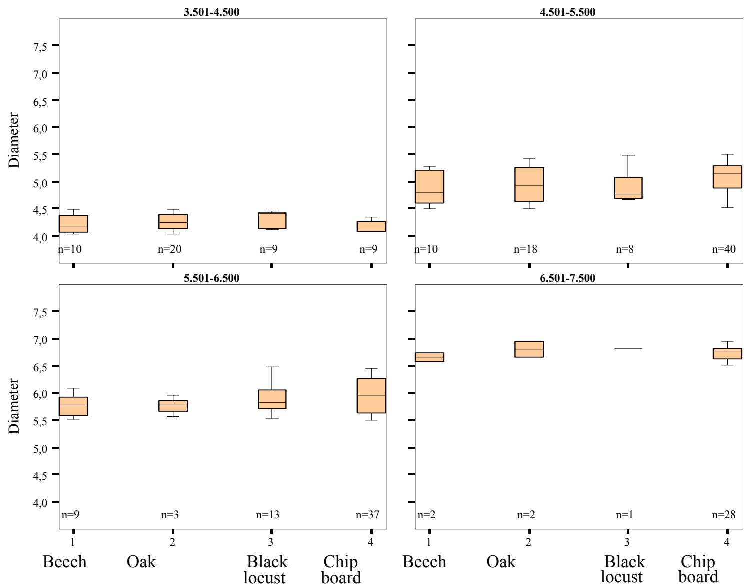

Figure 7 – The analysis of diameter groups by sample

CONCLUSIONS

The morphological investigation of the respirable range of wood dusts provided many results in terms of dense hardwood dusts. Through information about the characteristics of wood particles, more accurate knowledge may be gained about their carcinogenic mechanisms, as well as about creating modern, more efficient dust extraction technologies.

- No significant difference was found between the average diameter of the examined dense hardwood (beech, oak, black locust) dusts. Their average diameter is between 2.2 and 2.4 µm. Wood dust generated when cutting chipboard is an exception; its average diameter (approx. 6 µm) is about three times of that of natural woods.

- The frequency curves of the respirable range show that the distribution of hardwood dust is confined to a smaller range of 1-4 μm. The distribution curve of black locust and oak arches higher, which implies a more even distribution. Chipboard dust distribution covers a wider range, within which larger sizes are predominant.
- Black locust and oak dust includes very small particles of 0.5 μm and smaller, and the smaller diameter classes include more particles than the larger ones. Both of these species are prone to tylosis formation, which implies that these small particle sizes are related to tyloses.

The particle diameter distribution analysis demonstrated that the structural (anatomical) constitution and quality of the raw material, or the structure of the non-natural raw material (e.g. chipboard, etc.) may influence the diametric distribution of the generated dust fraction. Our investigations concerning the shape of the particles revealed some small differences. Beech is characterised by nearly spherical particles with somewhat rounded corners. On the other hand, black locust, oak, and chipboard particles are predominantly elongated rather than rounded.

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