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EFFICIENCY OF BEECH WOOD DUST SEPARATION FROM AIR WITH INCREASED RELATIVE HUMIDITY

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Abstract
The paper deals with fractional separation efficiency of beech wood dust from air by pulse-jet filtration using bags made of polyester needlefelt. The separation efficiency depends on the air relative humidity, particle size and duration of filtering process.

Key words: *wood dust, pulse-jet filter, air filtation, beech wood*

INTRODUCTION

Woodworking is closely connected with formation of the large amount of wastes. Considerable rate of these wastes are dusts. Wood dust is the cause of many problems because of the wood matter strongly reduced in size and suspended in the indoor air in a industrial plant is a reason of decrease of a working environment quality. There is the relationships between occupational wood dust exposure and respiratory diseases or symptoms (Dutkiewicz et al. 2001). It causes also a fire and explosion danger and impediments of the operation of woodworking machines. Wood industry is a source of the emission of particulate matter to the atmosphere (Dolny 1999, Mukhopadhyay 2009).

The only effective way to control air pollution in wood industry is immediate removal of the dust particles with the air outside the production rooms. Effective separation of the very small dust particles requires the usage to filtering separators, especially pulse-jet bag filters (Dolny 1995, Mukhopadhyay 2010).

The analysis and the evaluation of the run of dedusting process should be done based on the dust separation efficiency. The dust separation efficiency is represented on the basis of the number or the mass concentration of dust particles removed from the air stream or also staying in it. It can be expressed by following formula:

$$\eta = \frac{C_1 - C_0}{C_1}$$

where:
C_1 – mass concentration in the inlet gas stream,
C_0 – mass concentration in the outlet gas stream.

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The wood dust created on the woodworking positions includes the particles differed in size, shape and mass which should be separated from the air stream. The dependence between the separation efficiency and the particle size is called the fractional separation efficiency (Warych 1998, Callé et al. 2001, Ginestet and Pugnet 1997). The total separation efficiency is therefore a sum of separation efficiencies of the dust particles with different sizes:

$$\eta = \Sigma x_i \eta_i$$

where:
X_i – mass fraction,
η_i – separation efficiency in particular fractions.

Pulse-jet fabric filtration is a very efficient way to remove of fine particulate matter from the air. Fabric filters are the versatile dust separation devices and their capital and operating costs give them a considerable advantage over the other kinds of separators. So they are in common usage in the woodworking industry. Pulse-jet fabric filters give the possiblilty of the efficient removal of wood dust particles from the recirculated air in production rooms. (Dolny 1999, Dzurenda 2007).

Separation efficiency of pulse-jet bag filters depends on some factors. These factors are the size and shape characteristics of dust particles, operating parameters of filter, properties of filtering fabrics, parameters of filtering process and properties of the gas stream. The gas motion stream for wood dust particles is the air from working positions in woodworking factories. It can be characterized by various relative humidity which influences on the efficiency of filtering process (Mukhopadhyay 2009).

The aim of present work was to determine the influence of increase of the air relative humidity on the separation efficiency of dust coming from the beech wood sanding.

MATERIAL AND METHODS

Comparative tests of pulse-jet filtering separation processes of the beech wood dust at the air relative humidity 30 % and 60 % were conducted. The tests were done using the pilot-scale lab stand for tests of filtering bags. Construction and principle of operation of this stand were described in many previous works (Dolny 1998, Dolny 1999). The experimental filtering processes were conducted at the filtration velocity 0,0405 m/s and the dust concentration at inlet 10 g/m^3. They serve as a base of evaluation of the separation efficiency of the polyester needlefelt type PES with standard superficial finishing.

Concentration of the dust particles in the cleaned air in the range < 25 μm was measured by the laser particle counter HR 5250A (fig. 2). The inhalable dust particles were included in this measurement range.

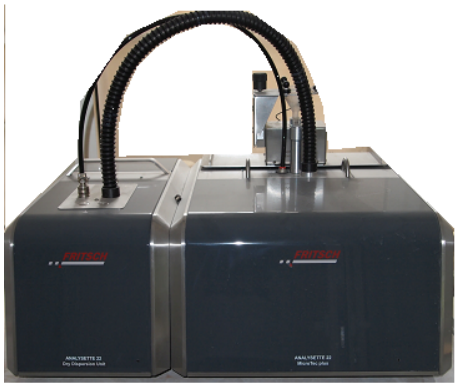

Fig. 1. Particle sizer Analysette 22 MicroTec Plus

Fig. 2. Laser particle counter HR 5250A

Wood dust used in the test came from the sanding positions of furniture elements. These elements were sanded by paper with granulation signed 180. Particle-size distribution of the dust was determined by the laser particle sizer Analysette 22 MicroTec Plus (fig. 1). Percentage content of the particles from the range < 25 µm was separated from the overall particle-size distribution obtained by this sizer. Comparison of rates of the particles from the investigated range in the overall mass of inlet dust and the rates of these particles in the dust remaining in the cleaned air enabled to calculate the fractional separation efficiency. The fractional separation efficiency was determined for the both levels of the air relative humidity in the initial stage of the filtering process (after 50 cleaning cycles) and at the end of the process (after 200 cleaning cycles). Operation of the pules-jet cleaning system was characterized by the air pulse pressure 0,5 MPa and. Duration of filtering cycle amounted 1 minute.

RESULTS

The result of the analysis of particle-size distribution of the dust done by usage of the laser particle sizer Analysette 22 MicroTec Plus was presented on fig. 2. It the the dust used in the tests is very fine. The size range under 80 µm includes 28 % of particles. The size over 300 µm have only 15% of particles. The rates of further investigated fractions between 0,5 and 25 µm were taken from this particle-size distribution.

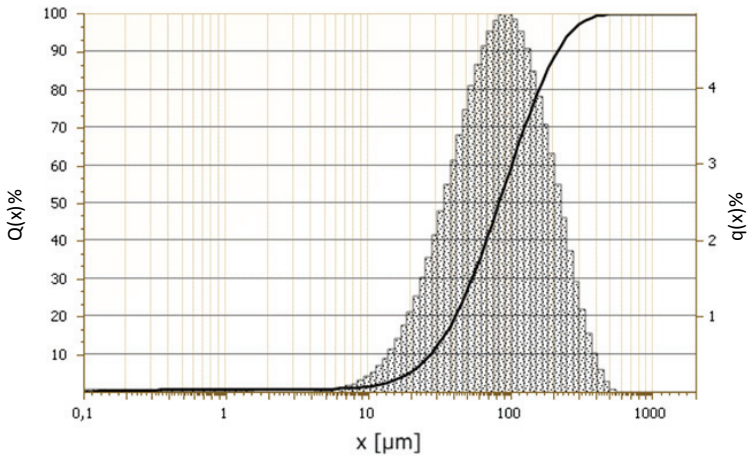

Fig. 3. Particle size distribution of dust

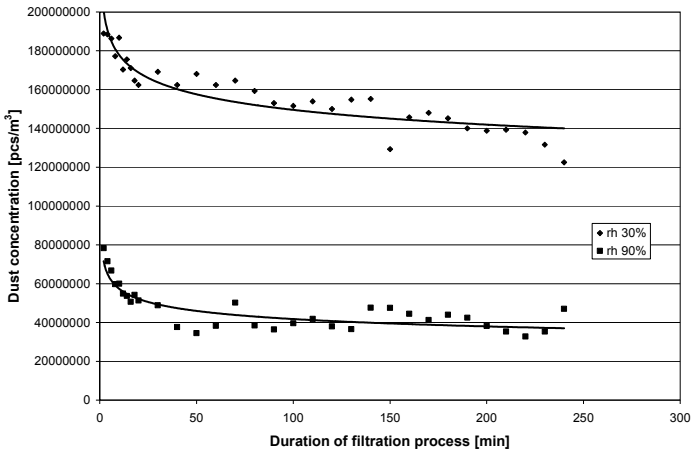

Fig. 4. Total content of dust particles in the outlet air

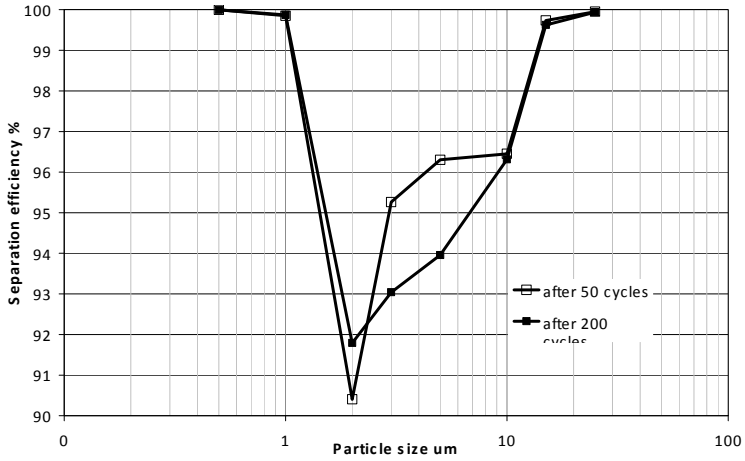

Fig. 5. Fractional separation efficiency (air relative humidity 30%)

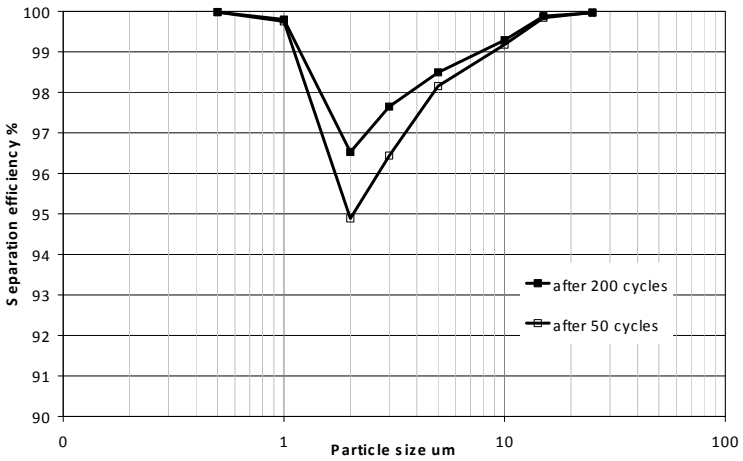

Fig. 6. Fractional separation efficiency (air relative humidity 90%)

Fractional efficiency of the filtering needlefelt was calculated on the base of the measurements (fig. 3 and 4) of the particle size distribution of the dust and particle concentration in the outlet air. It shows the characteristic minimum for particles with size about 2 μm (fig. 5 and 6.). It is typical for dust separation conducted by filtration method. The particles with smaller size are captured from the air stream under the effect of diffusion while the bigger particles are captured by interception mechanism. Total effect of physical mechanisms of particle capture causes the appearance of such minimum most often for the particles with size under 1 μm for various industrial dusts. Different properties of wood dust particles influence on the number of particles penetrating the needlefelt bag filter. It cause that the wood dust most penetrating particles are larger in size than the particles of other dusts.

The increased moisture content is a factor influencing on the separation efficiency of pulse jet filter. There the improvement of separation efficiency was observed. The separation efficiency for particles with size 2 μm increases from the level of 92% to 96% after the 200 one-minute filtering cycles.

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