Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology No 90, 2015: 157-161
(Ann. WULS - SGGW, For. and Wood Technol., 90, 2015)

An approach to the determination of wood dust separation efficiency in pulse-jet filters

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Abstract: *An approach to the determination of wood dust separation efficiency in pulse-jet filters*. This paper describes the efforts to determine the fractional filtration efficiency of nonwoven filter fabrics. The standard fabric and the fabric with layered structure used were for the comparison. The study has shown that the modification of the surface of nonwoven fabric by layer of microfibers leads to increase of its efficiency.

Keywords: wood dust, pulse-jet filter, nonwoven fabric

INTRODUCTION

Woodworking operations, especially carried out in furniture industry, are associated with the risk of workers' health. This risk results from the workers' exposure to wood dust which is created during machining and then dispersed in the air ***(Baran and Teul 2007, Čavlović et al. 2013, Jacobsen et al. 2010, Kauppinen et al. 2006***). The air polluted with wood dust should be expelled from the woodworking shops by an effective exhaustion system. And then, if it is to be returned to the work area, dust must be removed from the air in the required extent. This condition can be only met by filter dust collectors, or combined systems containing device operating on the principle of fabric filtration. Fabric filters used in wood industry operate as pulse-jet filters. It is an effective technique to cleaning and regenerate filter bags which leads to improvement of the process of dust separation. It results in reduction in the pressure drop trough efficient online dust cake detachment and very high efficiency of fine particulates collection (Dolny ***1989, Dobak and Dolny 2004, Dolny 2007, Dolny and Rogoziński, 2014***) However there are reported some problems with sudden increases of particle concentration in the cleaned air immediately after the cleaning pulse (Simon et al. 2014). So there is a continuing need to study processes of separation of wood dust in pulse-jet filters because many types of filter materials can be selected and different operation parameters can be used in wood industry. Finally, it should be noted that the term "wood dust" is no clear definition. There are many types of dusts created during woodworking, which differ in technological and material origin, causing for example different particle-size distribution and other characteristics ***(Očkajová et al. 2014, Rogoziński et al. 2015***).

The aim of this work was to describe the studies on the separation efficiency of beech wood sanding dust in a pilot-scale pulse-jet filter

MATERIALS AND METHODS

The dust separation efficiency can be represented basing on the number (1) or the mass concentration (2) of dust particles removed from the air stream or also coming out of the filter. It is expressed as following:

$$\eta = \frac{N_1 - N_0}{N_1} \qquad (1)$$

where:

N_1 – number concentration of particles at the inlet of the filter,
N_0 – mass concentration particles in the outlet air,

or:

$$\eta = \frac{C_1 - C_0}{C_1} \qquad (2)$$

where:

C_1 – mass concentration of particles at the inlet of the filter,
C_0 – mass concentration of particles in the outlet air.

It refers to particles with given size d_i. If examined dust is polydisperse and the efficiencies in all fractions η_i are known, the general efficiency and be calculated as:

$$\eta = \Sigma x_i \eta_i \qquad (3)$$

where:

x_i –fraction of particles with certain size,
η_i – separation efficiency in particular fractions.

This function describes the dependency between the separation efficiency and particle size of dust and can be called the fractional separation efficiency.

The studies leading to the determination of separation fractional efficiency were done using a pilot-scale test rig for testing the filtration processes. Set-up for this test filter and its operation principle were earlier described by ***Dolny and Rogoziński* (*2006*), *Dolny and Rogoziński* (*2014*)**. Number concentration of the wood dust particles in the outlet air in the range < 25 in 8 dimensional classes (<0.5, 0.5 - 1, 1 - 2, 2 – 3, 3 – 5, 5 – 10, 10 – 15, 15 - 25 μm) was measured by the laser particle counter HR 5250A (Pacific Scientific, USA). It was converted into mass concentration taking into account the density of the wood matter. Dust concentration at the inlet of the test filter was 10 g/m^3. Particle-size distribution of the this dust was measured using the laser particle sizer Analysette 22 MicroTec Plus (Fritsch, Germany). Percentage content of the particles from the range < 25 μm in the same 8 classes was separated from the overall particle-size distribution generated by this sizer for calculation of the fractional separation efficiency.

Two non-woven polyester filter media were tested for the comparative estimation of their separation efficiency. One of them was a material with standard surface finish and the other was covered by layer of microfiber on the working surface. Filtration processes were carried out during 250 clogging and cleaning cycles. Each cycle lasted for 1 min and was finished by a cleaning pulse of compressed air (0,5 MPa). Number particle concentration of dust in the outlet air was measured every 5 min during the experimental process. For the calculation of filtration efficiency average value of the last 5 measurements was taken.

RESULTS

Figure 1 shows the particle size distribution of dust flowing to the filter. It was generated by the software MaScontrol, which governs the operation of the laser particle sizer and collects and processes the results. On the base of this result the mass concentration of dust of the assumed dimensional classes at the inlet of the filter was calculated. It was compared to

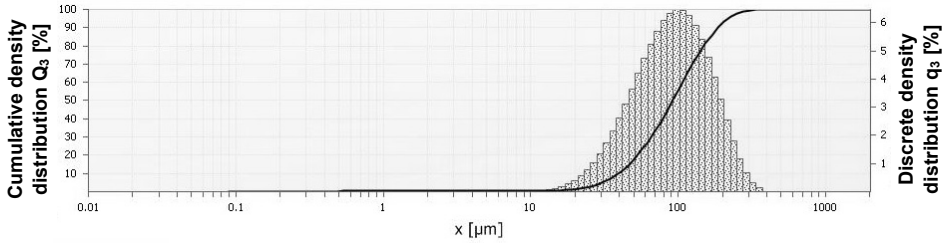

Fig. 1 Particle size distribution of dust ant the inlet of the filter

the mass concentration of dust particles in the outlet air. The general number concentration measured by the particle counter is shown on the fig 2. On the base of presented results the fractional separation efficiency was calculated. It was shown on fig 3. It can be noted that a minimum filtration efficiency of the tested materials is in the range of particle size 2-3 µm. The separation efficiency of smaller and bigger particles reached a very high level of more than 90%. The comparison of the tested materials showed significantly greater filtration efficiency of the modified nonwoven fabric. This applies particularly to the dust particles with size of 3 µm.

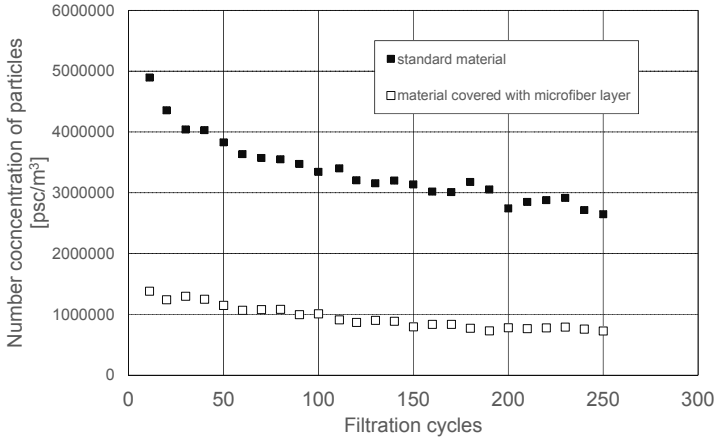

Fig. 2 Cumulative number concentration of dust in the outlet air

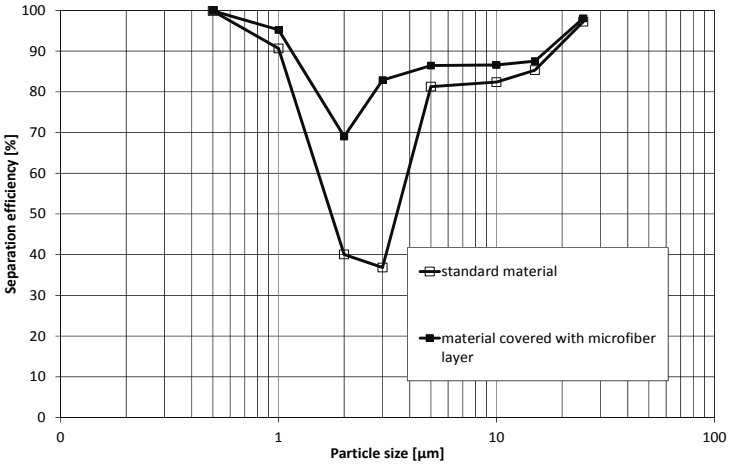

Fig. 3 Filtration efficiency

CONCLUSION

1. Modification of filter medium surface by incorporating of microfiber layer improves the filtration collection efficiency of wood dust
2. Wood dust particles with sizes of 2-3 µm are the most penetrating particles through the media used in test.

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Streszczenie: *Określenie sprawności separacyjnej pyłu drzewnego w filtrze z regeneracją pneumatyczną*. W pracy opisano działania zmierzające do określenia frakcyjnej skuteczności włóknin filtracyjnych. Do porównania wykorzystano włókninę standardową oraz włókninę o strukturze warstwowej. Wykazano, że modyfikacja powierzchni włókniny warstwą mikrowłókien prowadzi do zwiększenia jej skuteczności.

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