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VARIABILITY OF GRAIN-COMPOSITION OF DUST IN AIR CLEANED ON THE HOMOGENEOUS FILTERING UNWOVEN FABRIC

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SYNOPSIS. The analysis of the concentration of the dust particles in the air cleaned by homogenous filtering unwoven fabric was done. The tests were conducted at the so-called larger scale. The results received in this way may be directly related to the condition of industrial operation of dust collectors in wood industry.

KEY WORDS: dedusting, filtration, wood dust, unwoven fabrics

INTRODUCTION

A set of phenomena shaping the filtration dedusting process results in the separation of single particles from the air stream flowing in the fibrous barrier in diverse ways (Niezold 1984, Filters and filtration 1992, Brown 1993).

The separation process with use of filtration materials with homogeneous insidestructure conducts with appearance of depth filtration. It is characterized by the penetration of its inside by dust particles that thicken the structure of the filtration material and increase its separation ability (Brown 1993, Batel 1993). It could be favourable if it weren't the cause of other unfavourable effects.

The particles that penetrate the central layer have a tendency to gradual movement inside the material during the regeneration impulses and after some time to complete penetration trough the filtration barrier. A very high effectiveness of the air cleaning cannot be in general assured by depth catching of dust particles.

THE AIM

The subject of this research became the estimation of the intensity of the wood dust particles penetration trough unwoven fabric made of polyester that is

a typical raw material for production of filtration elements (bags, sleeves) for dust collectors applied in wood industry. The fundamental aim of this research was to pay attention to shaping of the concentration of dust particles in the cleaned air in various dimensional ranges.

Information about the amount of particles is very important in relation to the largest particles from these that come through the filtering barrier because it has a great influence on the mass concentration of dust in the mouth of dust collector. The concentration of smaller particles, especially in the range of respirabile particles, decides about a health risk degree of workers being in zones with air polluted by this type of dust (Möller 1992).

MATERIALS AND METHODS

Under the assumption that results of tests may have a direct practical usefulness a research method in larger scale testing was chosen (Dolny 1997, 1999). The usage of filtering elements with shape and dimensions typical for industrial dust collectors characterizes this method. Assembling of such elements (filtering bags) on the test stand where the filtering process is continuously running with permanent repeating of regeneration treatment (compressed air reverse impulses) gives the possibility of carrying out the tests with very high resemblance to industrial dust collectors operating.

Velocity of filtration and air to cloth ratio

Two velocities of filtration were used in the tests for obtaining of a full view on the searched dependences. Their values were defined on the following levels:

– velocity I – 0.0484 m/s,

– velocity II – 0.0766 m/s.

The air to cloth ratio values approximately amounted to 174 $m^3/(m^2 \cdot h)$ and 276 $m^3/(m^2 \cdot h)$ according to the mentioned above filtration velocities. Assumed values vary round the upper limit – 180 $m^3/(m^2 \cdot h)$ of this parameter specified in guidelines VDI-3926 for general testing of filtration materials or else this limit is significantly exceeded (VDI-Richtlinien 1992).

Given values of the filtration velocity and air to cloth ratio derive from indication of flow velocity meters in measuring pipe of the test stand. They are to a large degree similar to filtration velocities in dust collectors for wood dust.

Mass concentration of dust

Mass concentration of dust was a constant factor in these tests. It was kept on the level 10-11 g/m^3. The appearance of unimportant oscillations (up to 15%) of its values has no significant influence on the received results (Badania... 1995, Dolny 1998).

The assumed level of dust particles concentration in air conveyed to the filtering medium surface did not differ from the value recommended in the guidelines VDI-3926 (VDI-Richtlinien 1992). It fulfilled also the conditions of the filtering process in the wood industrial dedusting devices (Dolny 1999, Löffler et al. 1991, Wawrzyniak and Witos 1973).

Frequency and intensity of regeneration

Cleaning of the filtration material surface of dust was conducted with a constant intensity as a result of supplying the pneumatic regeneration system with compressed air with pressure 0.5 MPa. Successive blows followed at one-minute intervals.

This manner of the conducted regeneration treatments was assumed as a constant factor in this research work.

Thermodynamic variables of air – dust carrier

In all the test procedures, constant temperature and relative humidity of dust conveying air were assumed in order to protect from the influence of relative humidity changes on the conditions of dust layer formation. It was obtained by supplying the test stand with air from laboratory room where the temperature amounted to 18-20°C and relative humidity was formed at the level of 35-40%. The maintenance of this range of relative humidity almost completely eliminates the danger of the appearance of the influence on the flow resistance on the filtration layer. An assumed by calculation of the flow resistance taking this parameter into consideration humidity correction coefficient k_φ differs only about 0.005 (k_φ for RH 35% amount 0.880 and for RH 40% – 0.885).

Measurement of air cleaning degree

The air cleaning degree during filtration on the tested material was determined on the basis of the dust particles concentration in the samples of the cleaned air. It was done with use of the particle counter MicroAir 5250A consisting of a laser sensor which counts the particles distinguishing their dimensions in eight ranges. The scale of the measured particles dimensions is contained in the limits 0.5-25 µm. The recognized sizes of particles are: 0.5, 1.0, 2.0, 3.0, 5.0, 10.0, 15.0, 25 µm.

The results obtained by this device are continually shown on its display and printed after the measurements on the self-copying tape giving particle number in individual dimension classes and the total number of particles in the analysed sample of air.

Grain-composition and kind of dust

The tests were conducted with use of wood dust with the most reduced size which occurs in industrial conditions and is produced in large quantities. It was

dust from finish sanding of bent furniture. Such dust may be with much conviction recognized as a reflection of most difficult conditions of working of the dust collectors in wood industry. The grain-composition of dust is shown on Figure 1.

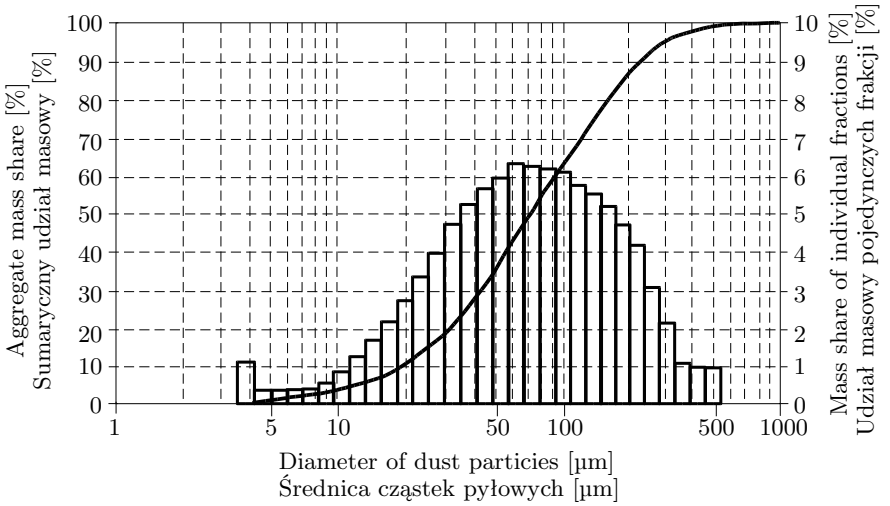

Fig. 1. Grain composition of dust
Rys. 1. Skład ziarnowy pyłu

Characteristic of filtering medium

A typical for wood industry surfaced by thermostabilisation, singeing and smoothing polyester unwoven fabric signed KYS-series PROGRESS was used as the filtering medium in the tests. The basic application characteristic of this unwoven fabric is presented in Table 1.

Table 1. Technical and operational data of the unwoven fabric KYS-series PROGRESS
Tabela 1. Dane techniczno-eksploatacyjne włókniny KYS-serii PROGRESS

Property – Właściwość	Value – Wartość
Titr (thinness of fiber) – Titr (cienkość włókien)	1.5 dtex
Diameter of fiber – Średnica włókien	13 µm
Basic weight G.S.M. – Masa powierzchniowa (gramatura)	500 g/m^2
Thickness – Grubość	2.1 mm
Air transmittance – Przepuszczalność powietrza	240 l/(dm^2·min)
Highest tensile force – Najwyższa siła rozciągająca:	
in longitudinal direction – w kierunku wzdłużnym:	140 daN
in transverse direction – w kierunku poprzecznym:	220 daN
Shrinkability at 140°C – Kurczliwość przy 140°C	< 1%
Thermal resistance – Odporność na temperaturę:	
permanent – stała	140°C
momentary – krótkotrwała	150°C

RESULTS

An initial stage of the filtering medium is always characterized by meaningful speed changes of separation capacity (Dolny 1997). It was confirmed by the results of tests conducted for over 200 filtering cycles at both velocities of filtration (Fig. 2). A total number of wood dust particles in the cleaned air is on the decrease in function of the time of operation of unwoven fabric KYS-series PROGRESS. In the final stage of the tests the concentration of these particles had a clear stabilizing trend. An increase of the velocity of filtration has a negative influence on the efficiency of air cleaning. The number of the dust particles was larger at the higher velocity.

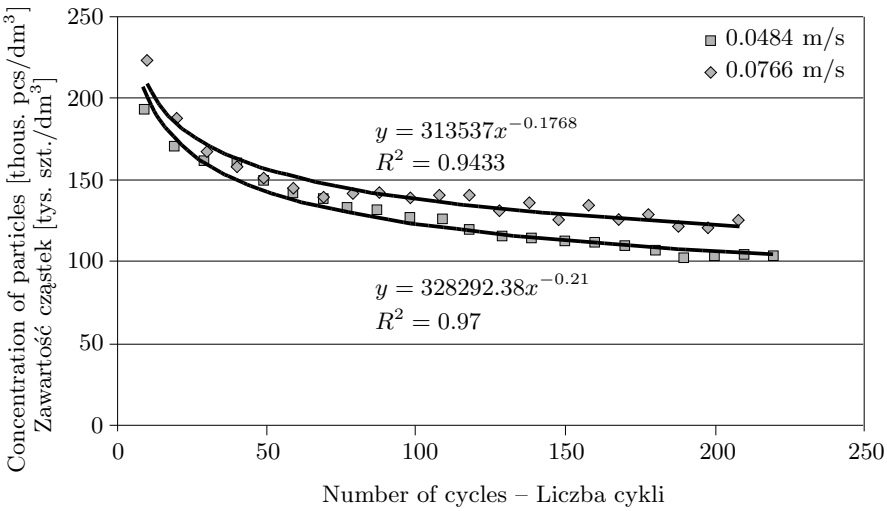

Fig. 2. Total number of the dust particles in cleaned air
Rys. 2. Całkowita liczba cząstek w odpylonym powietrzu

Both velocities of filtration gave a very high efficiency of the dust particles from the air stream. A concentration of dust fractions in the cleaned air amounted to below one milligram per cubic meter. The air cleaning degree at the velocity of filtration 0.0484 m/s is yet about 60% higher than the one at the velocity of filtration 0.0766 m/s. Therefore the applying of lower velocities of filtration in industrial conditions creates more favourable possibilities of the air cleaning from wood dust.

An analysis of the particle counter indications permits to describe precisely a level and trend of the concentration of the dust particles in individual dimensional fractions. It is characteristic of these changeabilities that their trends are heterogeneous for various dimensions of the particles. The number of the finest particles is constantly diminishing. There is no dependence on the velocity of filtration (Fig. 3 and 5). It has an influence on the decreasing of total concentration of the dust particles in the cleaned air. However, the number of particles with diameter over 5 µm at the velocity of filtration 0.0484 m/s and particles with diameter over 3 µm at the velocity of filtration 0.0766 m/s have an opposite trend.

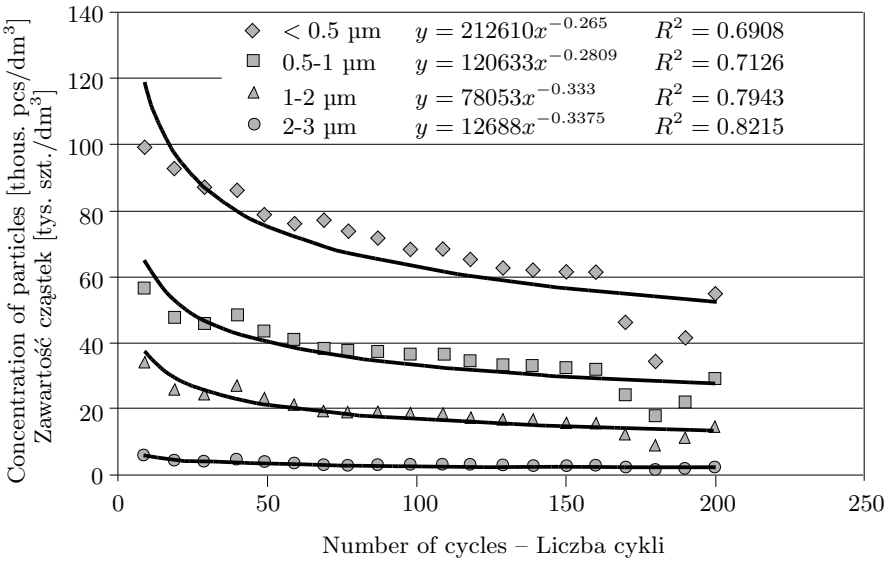

Fig. 3. Number of particles in cleaned air in dimensional classes below 3 µm at the velocity of filtration 0.0484 m/s
Rys. 3. Liczba cząstek w odpylonym powietrzu w przedziałach wymiarowych do wielkości 3 µm, przy prędkości filtracji 0,0484 m/s

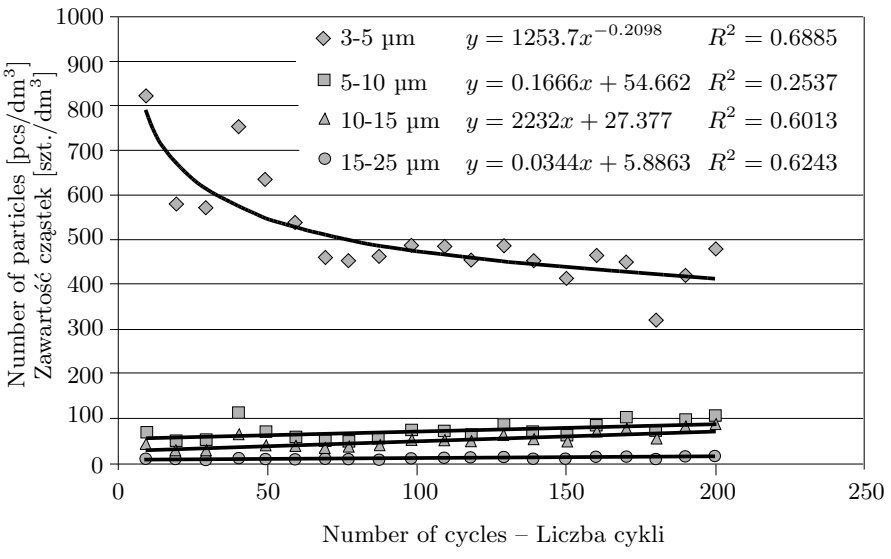

Fig. 4. Number of particles in cleaned air in dimensional classes above 3 µm at the velocity of filtration 0.0484 m/s
Rys. 4. Liczba cząstek w odpylonym powietrzu w przedziałach wymiarowych powyżej 3 µm, przy prędkości filtracji 0,0484 m/s

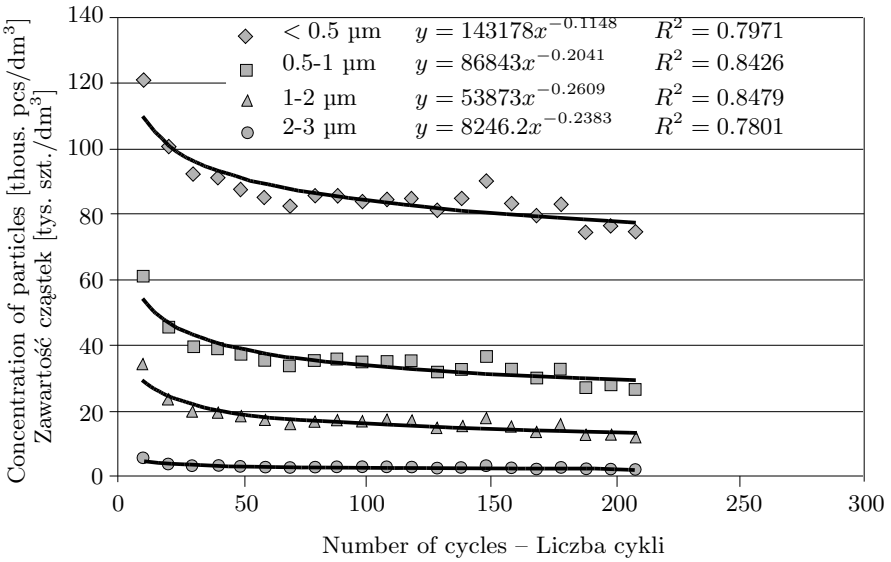

Fig. 5. Number of particles in cleaned air in dimensional classes below 3 µm at the velocity of filtration 0.0766 m/s

Rys. 5. Liczba cząstek w odpylonym powietrzu w przedziałach wymiarowych do wielkości 3 µm, przy prędkości filtracji 0,0766 m/s

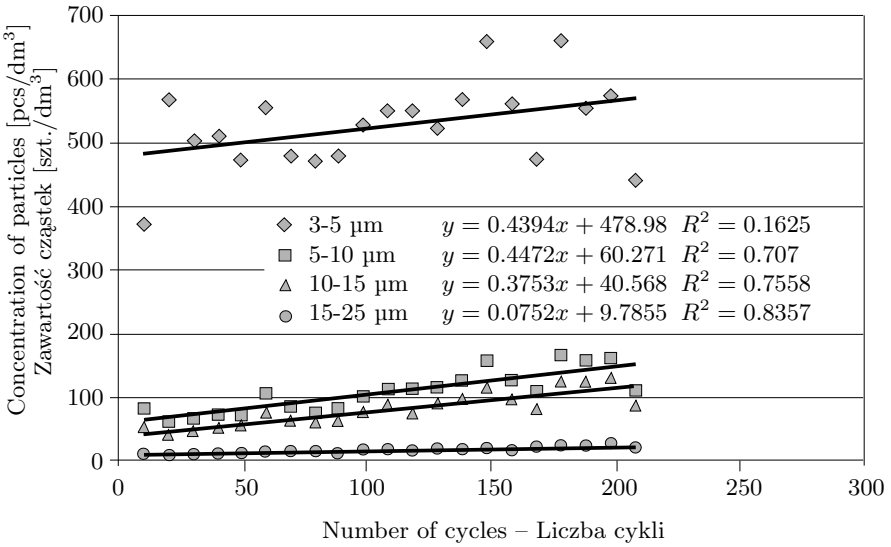

Fig. 6. Number of particles in cleaned air in dimensional classes above 3 µm at the velocity of filtration 0.0766 m/s

Rys. 6. Liczba cząstek w odpylonym powietrzu w przedziałach wymiarowych powyżej 3 µm, przy prędkości filtracji 0,0766 m/s

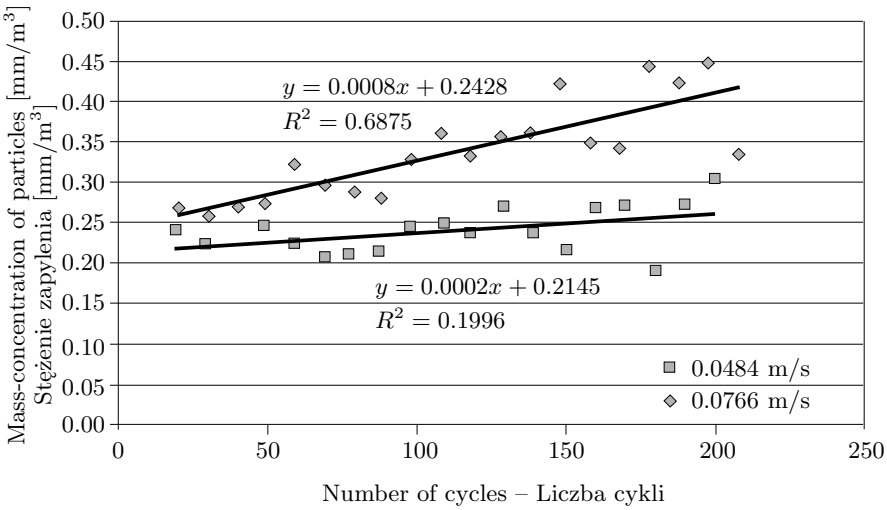

Fig. 7. Mass-concentration of the dust in the cleaned air
Rys. 7. Stężenie zapylenia powietrza

As long as the filtering process is running the concentration of these fractions of the dust particles in the cleaned air is still growing (Fig. 4 and 6).

The mass concentration of the dust in the cleaned air was estimated on the basis of the total number of dust particles in an unit of air volume. The results received in this way point to the obvious increase of this concentration along with the filtration process (Fig. 7). This increase is considerably larger at the velocity of filtration 0.0766 m/s than the one at the velocity of filtration 0.0484 m/s. These diversities are the result of the revealed variable trends of the numbers of dust particles in the cleaned air. It especially relates to the largest particles.

The conducted tests show a negative effect of the increase of the filtration velocity on the mass efficiency of the homogenous filtering unwoven fabric. There is no ground for the assertion that the intensification of the permeability of the largest particles at extending of filtering process has a steady trend. A time range of the conduced tests is too short to formulate these conclusions.

CONCLUSIONS

1. The homogenous filtering unwoven fabrics give the possibility of getting a very high effectiveness of air cleaning of very fine wood dust.
2. The increase of the velocity of filtration contributes to worsening of the air cleaning degree.

3. The total number of dust particles in the cleaned air decreases during the filtering cycles. Their concentration in the cleaned air is higher at the larger velocity of filtration.
4. The concentration of the finest particles (below 3 µm) continuously decreases in function of duration of the filtration process. A number of particles with larger diameters grows at the same time. This second dependence is the cause of the worsening of the filtration process efficiency.

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ZMIENNOŚĆ SKŁADU ZIARNOWEGO PYŁU W POWIETRZU OCZYSZCZONYM NA JEDNORODNEJ STRUKTURZE FILTRACYJNEJ

Streszczenie

Praca zawiera wyniki badań skuteczności separacyjnej włókniny filtracyjnej o budowie jednorodnej zastosowanej do oczyszczania powietrza z pyłów drzewnych. Cząstki pyłu drzewnego oddzielane są od strumienia nośnego z wysoką sprawnością. Istnieje jednak

zróżnicowanie tej sprawności dla cząstek pyłowych o różnych wymiarach. Cząstki najdrobniejsze, poniżej 3 µm, mają stałą tendencję do zmniejszania się ich liczby. Zawartość cząstek o wymiarach powyżej tej wartości w odpylonym powietrzu przyrasta. W rezultacie tego masowe stężenie zapylenia zwiększa się wraz z liczbą przeprowadzonych cykli filtracyjnych.

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