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SEPARATION EFFICIENCY OF HYDROPHOBICALLY APPRETED FILTERING UNWOVEN FABRICS WITH REFERENCE TO WOOD DUST

Stanisław Dolny, Tomasz Rogoziński
Agricultural University of Poznań

Abstract. Filtering dust separation proceeds in various conditions. It is necessary to determine the work factors of dust filter for each case of this method of air cleaning – first of all to select a suitable fibrous material on which the separation process of solid particles from air stream occurs. Increased relative humidity of air conveying the dust particles is always a significant difficulty for the separation process in wood dust separators. Application of unwoven fabrics with special finished active surface – hydrophobically appreted – significantly rises air cleaning of wood dust in these cases. At standard unwoven fabrics – with homogenous structure – appears an opposite interaction. The separation efficiency decreases with growth of relative humidity of the air stream.

Key words: wood dust, filtration, unwoven fabric

INTRODUCTION

There is a necessity of a continuous disposal of dust created in the area of woodworking aiming at preventing it from scattering within the working space. Dust pollution in the workplace contributes to aggravating hygienic conditions in working stations as well as within the area of all production buildings. The situation leads both to exposing all the present workers to the dust itself and dangerous for health influence of substances, the existence of which is connected with air dustiness [Chung et al. 2000, Dolny 1998, Kos et al. 2004, Palmqvist and Gustafsson 1999, Skórska et al. 2002, Vinzents et al. 2001].

Particles of wood dust because of their small mass and minute size always have a tendency to scattering in the area to which are additionally conducive air movements and spins caused by the work of machining tools. An efficient way to catch dust waste, and at the same time to limit the dustiness in the working stations, is using retracting installations equipped with suckers the shape and size of which must be adjusted to the

Corresponding author – Adres do korespondencji: Prof. dr hab. Stanisław Dolny, Department of Working Environment Engineering of Agricutural University of Poznań, Wojska Polskiego 38/42, 60-627 Poznań, Poland, e-mail: trogoz@au.poznan.pl

size of machining area and conditions of dust production. There should also be effective separators in those installations. In this case the separators for dust particles will filter dust separators. However, they only bring fully satisfying air cleaning results when filtering insets made of a properly chosen fibrous material are used.

The exploitation conditions of separators working according to the rule of filtering are created to a considerable degree by the relative air humidity which is the means of transport for dust particles. It influences the process of their movement in the transportation canals as well as the creation of dust layers on the surface of the filtering material. Clearing high humidity air of hygroscopic dust, which is a collection of particles created as a result of mechanical wood grinding, is connected with the occurrence of many negative phenomena, such as the risk of increased wear of filtering elements and work at increased resistance of flow through the filtering layer. To mitigate the results of these interactions it is advised to use filtering materials which are protected from humidity – covered on the working surface with a thin layer of hydrophobic substance, obtained as a result of using silicon appret.

Research has been done with the use of unwoven fabric with that kind of surface finishing in order to set the types and the scope of humidity influence on the shaping of efficiency in the process of filtering air clearing of wood dust. The research aimed at defining the proper way of determining work parameters of newly activated dust collectors, or filtering separators already used in woodworking industry.

MATERIAL AND METHOD

The reflection of technical conditions in industrials dust collectors have been achieved by conducting experiments in a station intended for research on filtering processes at an increased scale. A detailed description of the structure and operation of this station in its basic experimental function has been presented in many previous works. [Dolny 1998, 1999]. For the needs of the planned research it has been additionally equipped with a humidifying and accurate relative air humidity measuring system, which enables adjusting this humidity to a desired level. A laser counter of particles of the MicroAir 5250 type has also been inserted in its measuring equipment, thanks to which enabled counting of the whole number of them in cleared air with an accurate qualification to different measuring sections. The concentration of dust in cleared air was also determined with the use of special software.

The examined material was polyester unwoven fabric KYS series PROGRESS whose working surface was covered by hydrophobic appret. In order to obtain comparative results a one-layer unwoven fabric with the working surface which had not been machined (a standard version) was used. Those particular unwoven fabrics were chosen for the examination because they are designed for use in filtering devices for the air polluted by technological dust which occurs in woodworking industry.

Wood dust which was used in the experiments came from grinding furniture elements made of beech wood (Fig. 1). It is a representation of waste of the highest degree of fineness, which in furniture production is considered as the most arduous and troublesome in the sphere of efficient removal from air.

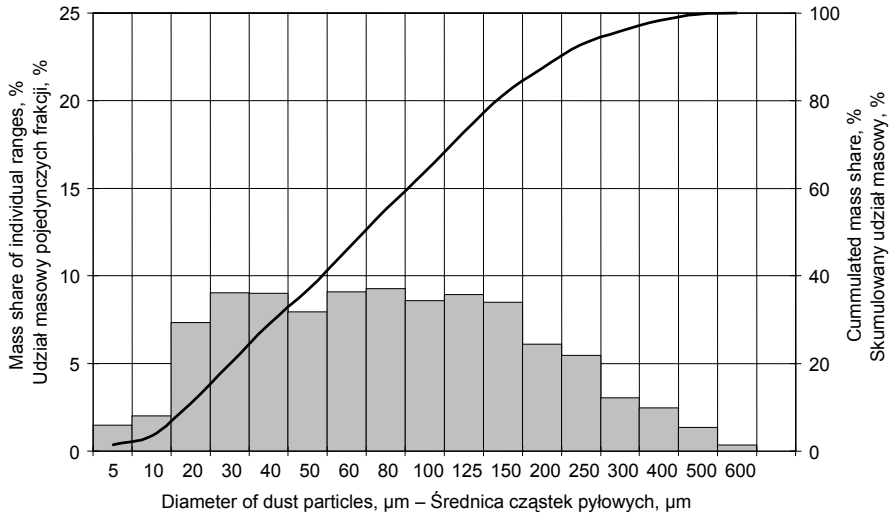

Fig. 1. Grain composition of dust
Rys. 1. Skład ziarnowy pyłu

Two series of experiments were carried out. In the first one, the influence of air humidity changes on the separation efficiency of unwoven fabric with hydrophobic appret on the working surface in the conditions of continuous gas and dust load was being observed (Table 1). Keeping the invariability of these two parameters aimed at eliminating all the influence of factors other than relative air humidity on the process of filtering.

In the other series of experiments the efficiency of filtering dusting with the use of bags made of both of the unwoven fabrics was compared. It was carried out in the conditions of maximum air humidity which had been used in previous experiments. The changing factor was the filtering velocity which was increased each time after obtaining the stage of stabilization of the process of separating dust particles from dusted air. Detailed conditions of carrying out these experiments are characterized by the data in Table 2.

Table 1. Methodical assumptions of filtration process by variable relative air humidity
Tabela 1. Założenia metodyczne prowadzenia procesu filtracji w zmiennej wilgotności powietrza

Conditions of filtration process Warunki prowadzenia procesu filtracji	Value Wartość
Filtration velocity Prędkość filtracji	0.04 $m \cdot s^{-1}$
Duration of filtration cycle Długość cyklu filtracyjnego	1 min
Air pressure in pulse-jet cleaning device Ciśnienie powietrza w urządzeniu regeneracyjnym	0.5 MPa
Mass concentration of dust in the air being cleared Stężenie zapylenia powietrza oczyszczanego	12 $g \cdot m^{-3}$
Levels of relative humidity Wilgotność względna powietrza	45%, 55%, 65%, 75%, 85%

Table 2. Methodical assumptions of filtration process by variable filtration velocity
Tabela 2. Założenia metodyczne procesu filtracji o zmiennej prędkości filtracji

Conditions of filtration process Warunki prowadzenia procesu filtracji	Value Wartość
Filtration velocity Prędkość filtracji	0.0375 $m \cdot s^{-1}$; 0.0484 $m \cdot s^{-1}$; 0.0553 $m \cdot s^{-1}$; 0.0632 $m \cdot s^{-1}$; 0.0766 $m \cdot s^{-1}$;
Duration of filtration cycle Długość cyklu filtracyjnego	1 min
Air pressure in pulse-jet cleaning device Ciśnienie powietrza w urządzeniu regeneracyjnym	0.5 MPa
Levels of relative humidity Wilgotność względna powietrza	85%

THE RESULTS OF RESEARCH

Thanks to the method of carrying out experiments the results of the research on the separation efficiency of filtering materials can be presented both as the effect of the measurement of the number of dust particles contained in a volume unit of the stream of cleared air leaving the separator and in general. In the latter case the data from direct measurements were used for counting with the consideration of the layout of particles' diameters and the density of the material from which they came. It gives a possibility to carry out a discerning analysis of the filtering process as a result of obtaining changeability of filtering efficiency of a material in relation to particles of different size and the picture of the shaping of the efficiency of this process expressed by changes in the mass concentration in the cleared air.

The effects of the experiments conducted at a permanent filtering velocity have been presented in both research aspects – in the numerical aspect (Fig. 2) and mass aspect (Fig. 4).

Experimental filtering processes, performed with different relative humidity have shown that the contents of dust particles in cleared air decreases with the time of dedusting. The inflow of dusted air causes the creation of a dust layer on the surface of filtering material with an increasing thickness which takes over a more and more important function of separating solid particles from the carrier stream.

However, at a remaining downward tendency considerable differences occur in the amount of particles in the air behind the filtering partition in particular cases of filtration carried out at a changing humidity. The increase in relative humidity is initially accompanied by the increase in the number of dust particles in the stream of cleared air. This tendency holds to the humidity level at about 65%. Further rise of humidity causes a decided improvement of the separation efficiency of filtering layer – the number of dust particles decreases significantly on the exhaust end of the separator (Fig. 3). At the relative air humidity on the level of 85% the number falls below 30 million pieces per cubic meter, while the maximum values stated at the humidity of 65% exceeded even 50 million pieces per cubic meter.

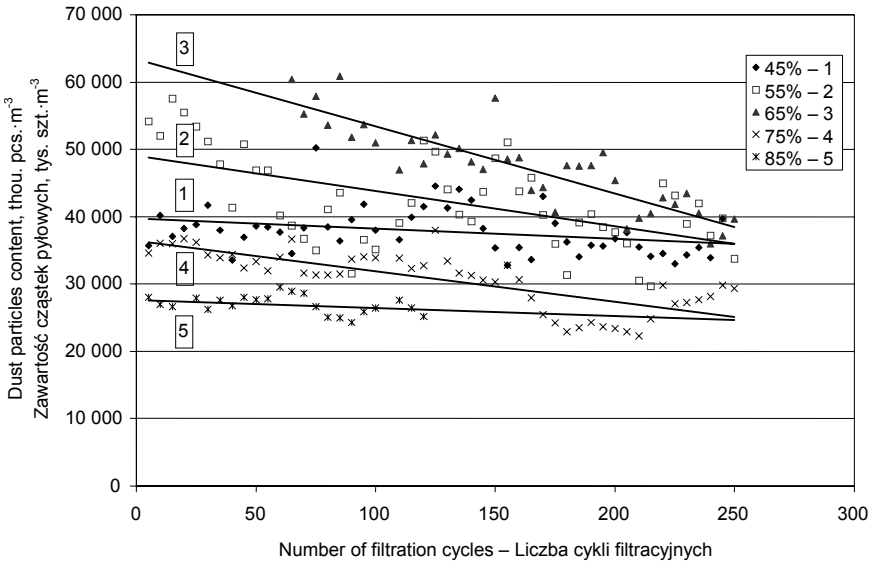

Fig. 2. Number of dust particles in air cleaned on hydrophobically appred unwoven fabric
Rys. 2. Liczba cząstek pyłowych w oczyszczonym powietrzu po stosowaniu włókniny apreturowanej hydrofobowo

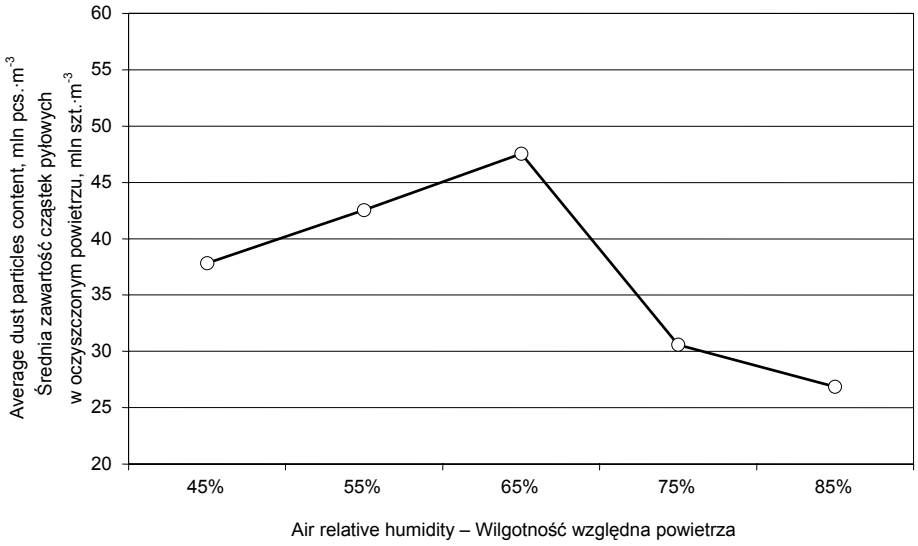

Fig. 3. Average concentration of dust particles in cleaned air
Rys. 3. Uśredniona zawartość cząstek pyłowych w oczyszczonym powietrzu

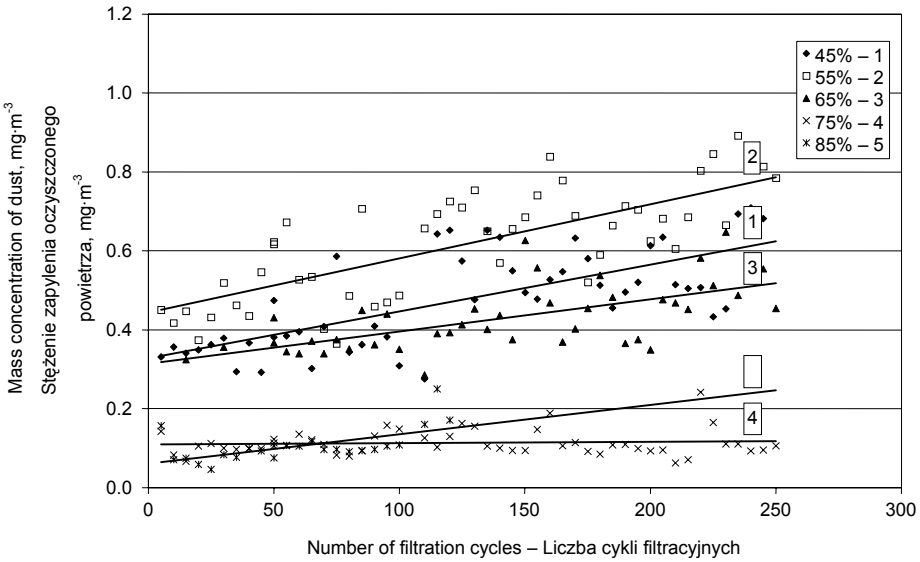

Fig. 4. Mass concentration of dust in air cleaned on hydrophobically appred unwoven fabric
Rys. 4. Stężenie zapylenia powietrza oczyszczonego na włókninie apreturowanej hydrofobowo

The analysis of mass concentration dust showed that there is a significant influence of air humidity on the shaping of separation efficiency of the examined filtering layers. At low humidity levels an increase in dust concentration has been observed, and beginning with the humidity of around 60% it decreased (Fig. 5). With the most humid air the dust concentration stabilized. It reached very low levels – around 0.1 mg·m^{-3}.

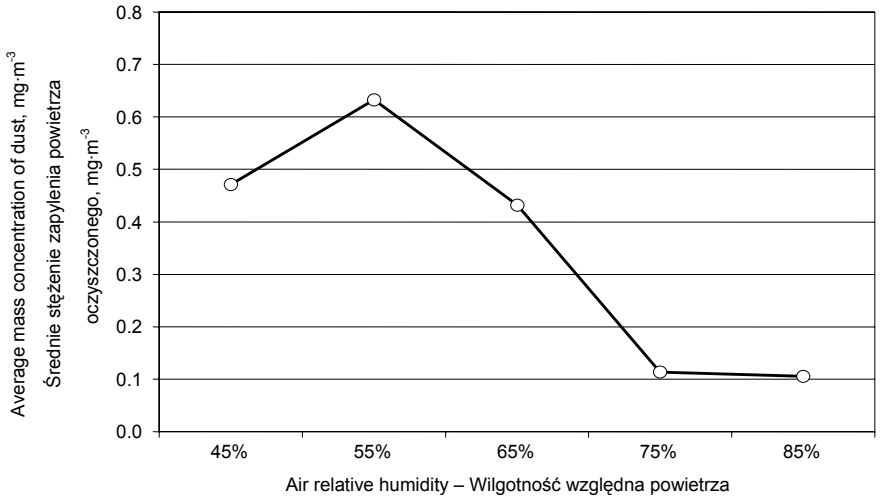

Fig. 5. Average dust concentration in cleaned air
Rys. 5. Uśrednione stężenie zapylenia powietrza oczyszczonego

The reasons for this phenomenon ought to be tracked in a diverse behaviour of particles with different size – having also different weight. The decrease in the number of particles with simultaneous increase in the mass dust concentration can be explained by the fact that during dedusting the separation efficiency of filtering layer changes, especially towards the smallest particles, the number of which decreases at the fastest pace. It is observed up to the level of humidity of around 65%. From that moment on, a general, significant decline of the dust contents in cleared air occurs, which is manifested by the reduction of dust concentration. It proves the fact that relative air humidity is an advantageous factor for the improvement of filtering efficiency.

The average values of this concentration during all the time of experiments has been presented in Figure 5.

The results of the second stage of research (Fig. 6) carried out in the conditions of maximum air humidity show a distinct changeability of the separation efficiency of the dust layer created on the surface of both unwoven fabrics caused by the increasing velocity of filtration. However, the filtering materials used in the research act significantly differently in this respect. Aggravation of separation efficiency has been stated in the case of unwoven fabric without silicon appret. In contrast to this, hydrophobic unwoven fabric improves its properties of keeping in dust particles together with the increase of filtering velocity. This probably takes place because specific surface values of this unwoven fabric cause "weaker" bonding of the wood dust layer which accumulates on it. At the same time under the influence of the air stream pressure the layer becomes more cohesive internally, which makes it more difficult for dust particles to penetrate through it.

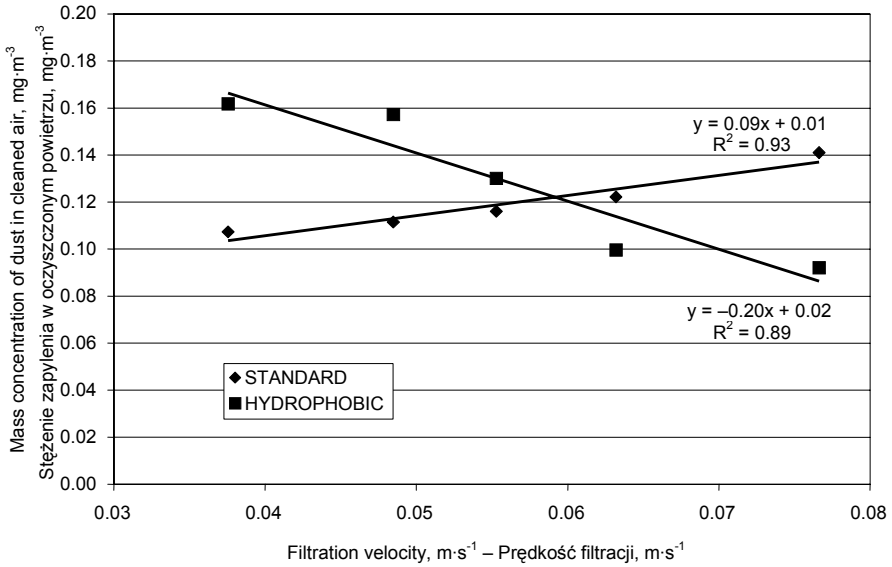

Fig. 6. Influence of filtering velocity on separation efficiency on unwoven fabrics at air relative humidity level 85%

Rys. 6. Wpływ prędkości filtracji na skuteczność separacyjną włóknin filtracyjnych w wilgotności względnej powietrza wynoszącej 85%

Experiments confirm the benefits of modifying work surface of filtering materials intended for work at increased air humidity. However, obtaining the expected result in the form of the increase of efficiency of the filtering process demands a proper choice of the basic parameter of its course, which is the speed of filtration. It is because the speed has a significant influence on the shaping of separating value of the filtering layer – the unwoven fabric with a constantly remaining dust layer.

CONCLUSION

The research on the separation efficiency of hydrophobic unwoven fabric working in the conditions of changeable relative humidity of clearing air lets us state that:

1. The contents of dust particles in number expression increases around 30% in cleared air with humidity changes from 45% to 65%. Above this humidity level a reverse tendency occurs, which leads to decrease in the number of particles to the state of around 75% of the values observed at humidity of 45%.
2. A very significant fall in the dust concentration has been observed (in mass expression) at the increase in cleared air humidity. It decreases around four times for the air of the humidity of 75% and 85% with respect to the values of this concentration occurring in the conditions of air humidity on the level of 45%.

Comparison examination carried out on the humidity level of 85% with an increasing gas load of the surface has shown an improvement in the separation efficiency of hydrophobic unwoven fabric (decrease in dust concentration of about 50%) and an aggravation of this efficiency with the use of standard unwoven fabric (increase in dust concentration of about 40%). This statement applies to the whole scope of filtering speed taken into consideration in the research. At the filtering velocity above 0.06 $m \cdot s^{-1}$ hydrophobically appreted unwoven fabric gains a growing advantage over a standard material.

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SKUTECZNOŚĆ SEPARACYJNA APRETUROWANYCH HYDROFOBOWO WŁÓKNIN FILTRACYJNYCH WOBEC PYŁÓW DRZEWNYCH

Streszczenie. Odpylanie filtracyjne przebiega w bardzo zróżnicowanych warunkach. Podczas oczyszczania powietrza tą metodą należy każdorazowo indywidualnie określić parametry pracy filtra – przede wszystkim właściwie dobrać materiał włóknisty, na którym zachodzi separacja cząstek stałych ze strumienia nośnego. W odpylaczach dla pyłów drzewnych istotnym utrudnieniem dla przebiegu procesu separacyjnego pozostaje zawsze podwyższona wilgotność względna powietrza transportującego cząstki pyłowe. Zastosowanie w takich wypadkach włóknin o specjalnym wykończeniu powierzchni roboczej – apreturowanych hydrofobowo, wyraźnie podnosi skuteczność oczyszczania powietrza
z pyłu drzewnego. Użycie włóknin standardowych, o budowie jednorodnej, powoduje odwrotną reakcję: skuteczność separacyjna maleje wraz ze wzrostem wilgotności strumienia nośnego.

Słowa kluczowe: pył drzewny, filtracja, włókniny

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