Acta Sci. Pol.
Silv. Colendar. Rat. Ind. Lignar. 5(2) 2006, 159-166

RESISTANCES OF FLOW DURING FILTRATION OF WOOD DUST-POLLUTED AIR WITH HIGH RELATIVE HUMIDITY

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Abstract. The pressure losses occuring during filtering air purification from the dust waste arisen during machining of wood materials are subjected to the influence of the moisture contained in the air. The carried out laboratory tests with use of standard version of the polyester unwoven fabric KYS series PROGRESS and the other version of the same fabric with hydrophobic protection of working surface let us claim that the usage of silicone appret is plainly advantageous in conditions of air relative humidity 85%. This advantage manifests itself by general reduction of the resistances of air flow by about 2-5% and increasing of the regeneration ability of the hydrophobic unwoven fabric along with the filtration velocity.

Key words: air flow resistance, wood dust, filtration, air relative humidity

INTRODUCTION

Relative humidity of air purified from wood dust particles with use of filtering dust collectors is a strongly influencing factor on working of these devices. This influence manifests itself in changes of adhesion of wood dust particles to surface of fibrous filtering medium and also in changes of cohesion in wood dust cake which may occur as a result of formation of liquid bridges between the dust particles. These phenomena occurring during the process of filtering dedusting of humid air are the main determinants of the filtration efficiency, air flow resistance of the filtration layer and conditions of the regeneration of filtration material surface [Kabsch 1992].

An increase of air flow resistance connected with the increase of the air relative humidity probably results from the capillary condensation of the steam in the pores of dust cake which is formed on the filtration material surface [Rogoziński 2006, Wojciszyn 2006]. It is visible during the process of filtering air purifying from wood dusts, because the large increase of the air flow resistance with the increase of the air relative humidity

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over 65% was observed in research on this problem [Dolny 1987]. The capillary condensation in wood proceeds in this range of the air relative humidity.

Structure of the filtering material surface and its properties determine to a large degree the properties of the dust cake formed during the filtration process. One of the methods of reduction of unfavourable influence of humid air on the filtering process is the usage of filtering materials adapted to the operation in difficult moisture conditions. Impregnated or appreted filtering unwoven fabrics put into practice. Introducing the use of these materials must be preceded by an accurate recognition of all advantages resulting from this. To obtain it is possible it only in the experimental way using laboratory method enabling the simulation of the industrial conditions. Research was therefore carried out on the flow resistance of air with high relative humidity trough the wood dust cake formed during filtration on the working surface of standard, homogenous unwoven filtering fabric made of polyester and on the surface of the hydrophobic variety of the same fabric. This research was conducted in the Laboratory of Pneumatic Transport and Dedusting of the Department of Working Environment Engineering.

MATERIALS AND METHOD

Determination of the shaping of air flow resistance during filtering separation of wood dust particles from the air stream was executed on the stand for examination of the filtering processes in the increased scale. That is to say the conditions of the experiments meet the course of air cleaning processes running in filtering dust separators in wood industry to a large extent [Dolny 1993]. This conformity is possible thanks to application of filtering elements in the form of bags 1500 mm long and 150 mm in diameter that corresponds to the dimensions which are found in the industrial practice. The flow of polluted air proceeded from the outside surface of the bag and the whole filtering system was located in the underpressure part of the experimental installation.

For producing the air – dust mixture, wood dust with a very significant size reduction was used. This dust was obtained during finishing of beech wood of the furniture elements (Fig. 1).

Two separate series of experiments with use of different variety of the filtering unwoven fabric were carried out. Filtration velocity was the variable factor. It was fourtimes changed during all the experiments. These changes were done each after 80 filtration cycles. The other conditions of the course of the filtering process were invariable during its duration (Table 1).

The letter signs ABCDE which mean higher and higher value of the filtration velocity were introduced with the purpose of unequivocal identification of the results obtained at individual filtration velocities.

The carried out research had a comparative character. This character lets to directly link the results obtained for both kinds of unwoven filtering fabrics owing to the application of identical parameters of filtering process.

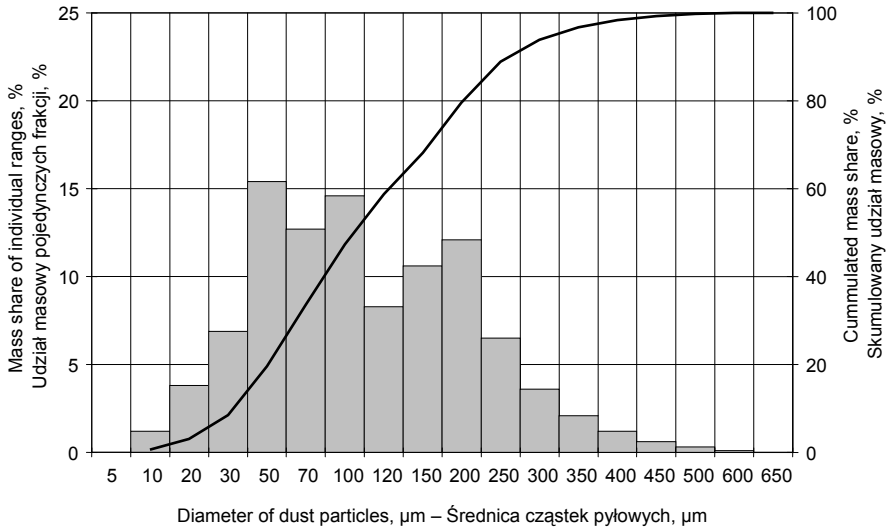

Fig. 1. Grain composition of dust
Rys. 1. Charakterystyka wymiarowa pyłu

Table 1. Methodical assumptions of filtration process by variable filtration velocity
Tabela 1. Założenia metodyczne dla procesu filtracji przy zmiennej prędkości filtracji

Conditions of filtration process Warunki prowadzenia procesu filtracji	Value Wartość
Filtration velocity Prędkość filtracji	A – 0.0375 m·s; B – 0.0484 m·s; C – 0.0553 m·s; D – 0.0632 m·s; E – 0.0766 m·s
Duration of filtration cycle Długość cyklu filtracyjnego	1 min
Air pressure in pulse-jet cleaning device Ciśnienie powietrza w urządzeniu regeneracyjnym	0.5 MPa
Air relative humidity Wilgotność względna powietrza	85%

RESULTS

Forming of the resistance of air flow in the experimental processes with growing filtration velocity was presented on Figures 2 and 3, adequately for the standard and the hydrophobic unwoven fabric. The graphs placed on them show minimum values as well as maximum values of the static pressures on both sides of the filter medium which were measured at the beginning and at the end of the filtration cycles. The immediate stabilization of the air flow resistance through the dust cake after every increase of the filtration velocity was observed in the filtering processes carried out with use of both unwoven fabrics.

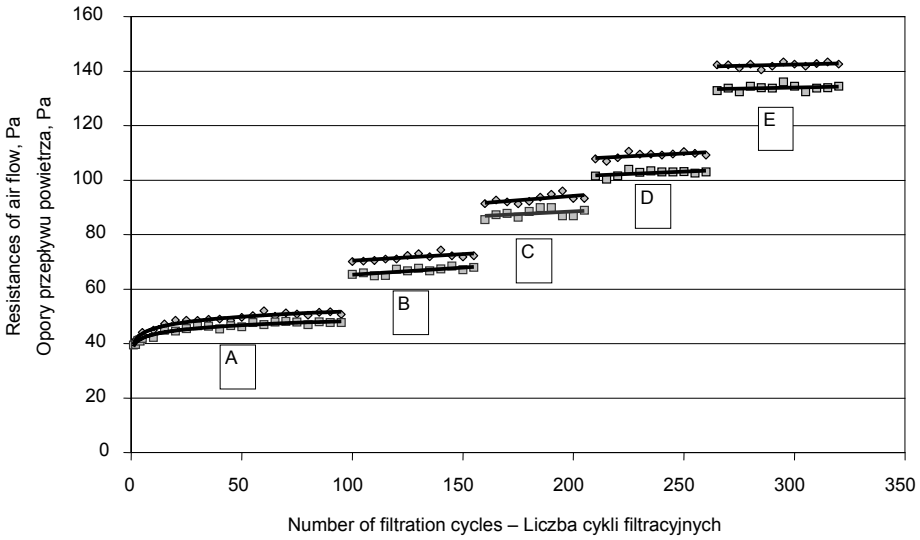

Fig. 2. Flow resistance of with humidity 85% through filtering layer on the standard unwoven fabric at gradual growth of filtration velocity
Rys. 2. Opory przepływu powietrza o wilgotności 85% przez warstwę filtracyjną na włókninie standardowej przy skokowym wzroście prędkości filtracji

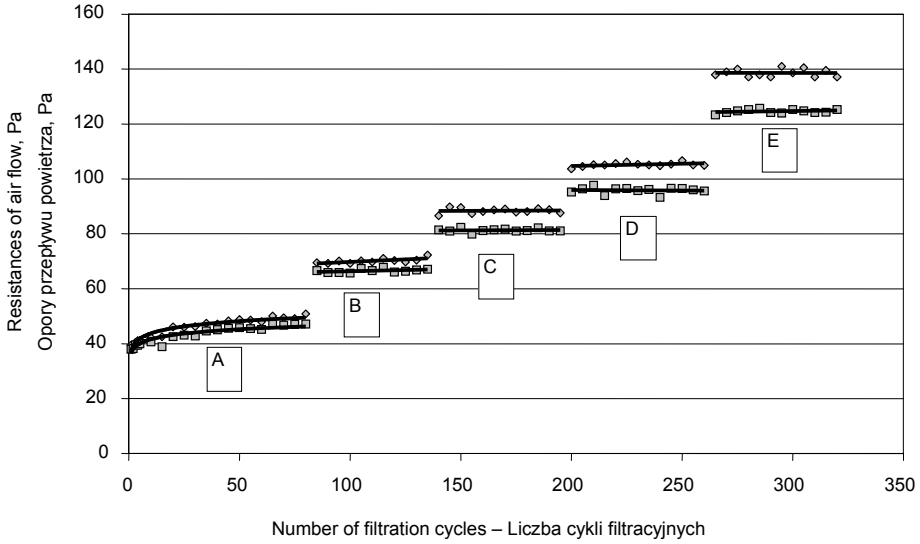

Fig. 3. Flow resistance of air with humidity 85% through filtering layer on the hydrophobic unwoven fabric at gradual growth of filtration velocity
Rys. 3. Opory przepływu powietrza o wilgotności 85% przez warstwę filtracyjną na włókninie hydrofobowej przy skokowym wzroście prędkości filtracji

Direct comparison of the differences between the air flow resistances through the filter layer in both experimental series was obtained as a result of averaging of the values of these resistances at individual filtration velocities. Only the initial phase of the fast growing of the loss of pressure including 50 first filtering cycles was omitted in this calculation. The received in this way results shows Figure 4.

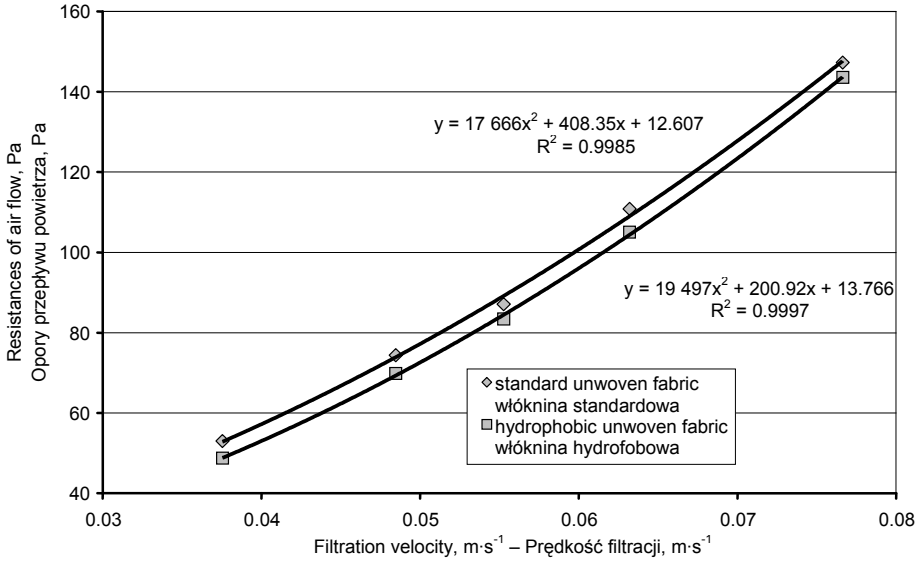

Fig. 4. Average values of resistances of air flow at different filtration velocities
Rys. 4. Uśrednione opory przepływu powietrza przy różnych prędkościach filtracji

The influence of the filtration velocity on the forming of the resistance of air flow through the wood dust cake shows a relationship that can be described with a quadratic function. The appearance of this character of the changeability of the air flow resistance is consistent with the results presented in prior research works. It is a confirmation of the occurrence of changes in internal structure of the wood dust cake evoked by growing of the dynamics of the air stream inflow [Dolny 1998, Dobak 2004].

The hydrophobic unwoven fabric keeps in whole range of the filtration velocity more favourable properties than the standard unwoven fabric. This phenomenon manifests itself by the occurrence of the resistance of air flow lower by about a few percent at the application of the hydrophobic unwoven fabric. It is undoubtedly a result of the influence of hydrophobic silicone appret on the surface of the unwoven fabric. A possibility of durable joint of wood dust particles with outside structure of the unwoven fabric is to a large degree limited in conditions of strongly humid air filtration with the use of this kind of unwoven fabric. It is a reason of faint saturation of this structure by the wood dust, because of that there are no essential changes of internal porosity which could have a significant influence on the air permeability. As a result of it the resistance of air flow for the hydrophobic unwoven fabric is lower than this one for the standard unwoven fabric.

The covering of the unwoven fabric's surface with the hydrophobic appret causes the improvement of the regeneration ability. The differences between the resistances of the air flow within the limits of each filtration cycle are higher for this unwoven fabric than for the standard one in the conditions of experiments carried out at the increased air relative humidity. The comparison of these differences obtained at various filtration velocities shows Figure 5.

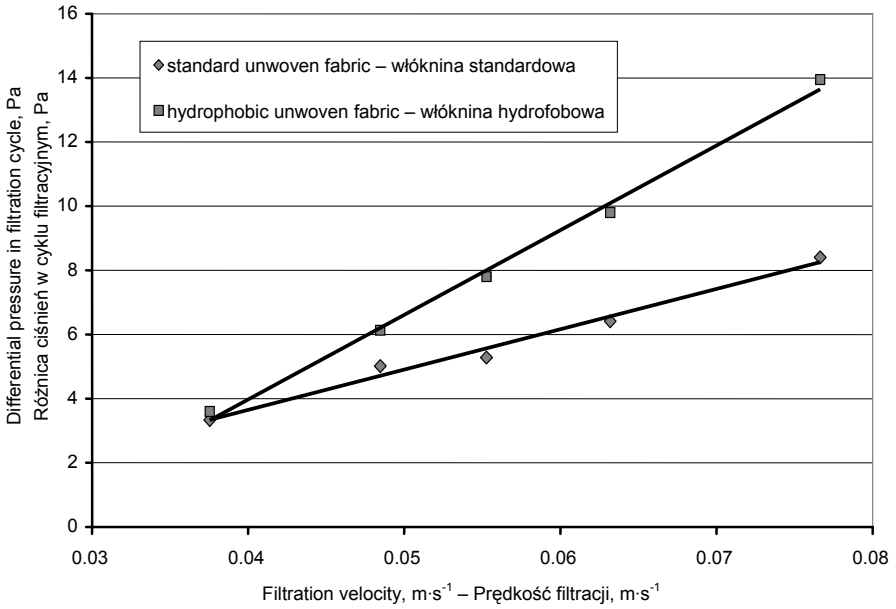

Fig. 5. Changeability of differential pressure in the filtration cycle in dependence on filtration velocity
Rys. 5. Zmienność różnicy ciśnień w cyklu filtracyjnym w zależności od prędkości filtracji

The differences which are outlined in this respect between both of the used unwoven fabrics become clearer and clearer along with the increase of the filtration velocity. The differential pressure in the filtration cycle for the standard unwoven fabrics grows only by about 4 Pa in considered range of the filtration velocity. In the event of the hydrophobic unwoven fabric this growth amounts to almost 10 Pa. On this basis one may also say that the hydrophobic protective coating of the working surface of filtering fabrics is destined for operation in condition of high moisture of cleaned air in wood dust filters. It ensures that the regeneration ability keeps at high level especially during work at high air-to-cloth ratio.

CONCLUSIONS

The comparative studies on the application of the polyester unwoven fabrics in conditions of high relative humidity of the air being cleaned from wood dust let us state as follows:

• The average resistances of air flow through the wood dust layer assumed at the different filtration velocities are always about 2-5% higher in the event of standard unwoven fabric than in the event of hydrophobic unwoven fabric.

• The influence of filtration velocity on the resistance of air flow through the wood dust layer has a character of quadratic function. It is a confirmation of hypotheses resulting from earlier studies, which show the occurrence of changes in internal structure of the wood dust cake evoked by growing of the dynamics of the air stream inflow.

• The hydrophobic protected unwoven fabric has the higher regeneration ability than the standard unwoven fabric. This phenomenon is clearly noticeable at high values of the filtration velocity.

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OPORY PRZEPŁYWU PODCZAS FILTRACYJNEGO OCZYSZCZANIA Z PYŁÓW DRZEWNYCH POWIETRZA O WYSOKIEJ WILGOTNOŚCI WZGLĘDNEJ

Streszczenie. Straty ciśnienia towarzyszące filtracyjnemu oczyszczaniu powietrza z pyłów będących odpadami z obróbki materiałów drzewnych podlegają wpływom wilgoci zawartej w powietrzu. Przeprowadzone prace doświadczalne z wykorzystaniem poliestrowej włókniny filtracyjnej KYS serii PROGRESS, w wykonaniu standardowym i z hydrofobowym zabezpieczeniem powierzchni roboczej, pozwoliły na stwierdzenie wyraźnych korzyści wynikających z zastosowania apretury silikonowej w warunkach wilgotności względnej powietrza wynoszącej 85%. Korzyści te przejawiają się ogólnym zmniejszeniem oporów przepływu powietrza, o około 2-5%, oraz zwiększaniem się podatności regeneracyjnej włókniny hydrofobowej wraz ze wzrostem prędkości filtracji.

Słowa kluczowe: opory przepływu powietrza, pył drzewny, filtracja, wilgotność względna powietrza

Accepted for print – Zaakceptowano do druku: 24.07.2006

For citation – Do cytowania: Dolny S., Rogoziński T., Hyrczyk G., 2006. Resistances of flow during filtration of wood dust-polluted air with high relative humidity. Acta Sci. Pol., Silv. Colendar. Rat. Ind. Lignar. 5(2), 159-166.