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Long-term operation of pulse-jet filters for wood dust

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Abstract: *Long-term operation of pulse-jet filters for wood dust*. The study specifies the value of flow resistance and separation efficiency of filter material during long-term use in pulse-jet filters for wood dust. The experiments were carried out for one type of material working in two different filtration installations in one furniture factory. The bags were obtained from the installations after working for 67, 133 and 272 days, respectively. All tests were performed on the pilot-scale test stand under identical filtration conditions. Studies have shown that long-term filter material use increases airflow resistance and improves filtration efficiency. The range of these changes depends on the operating conditions of the pulse-jet filters. The obtained results made it possible to determine the properties of the long-term use of filter materials in various filtration conditions.

Keywords: filtration efficiency, pressure drop, filter bag, nonwoven fabric

INTRODUCTION

Due to their small size, dust spreads very easily in the atmosphere, causing negative changes in working conditions, can cause many respiratory diseases [1], pose a fire hazard and affect the efficiency of machine tools and devices, and can also affect the continuity of operation of some production units [2]. The occurrence of these problems was noticed by scientists [3] and eventually resulted in the establishment of legal regulations [4] relating to particulate pollution in the work environment. In order to meet all these requirements, it is necessary to carefully select both the filtration parameters and the filter material itself in a dust collector operating in a recirculation system [5]. In order to guarantee a very high level of separation efficiency and thus proper air quality, it is necessary to analyze the factors affecting the final effect of the operation of a filter dust collector in a furniture production plant. These factors are filtration velocity, dust particle size and dust quantity in a unit of air volume, filter medium properties, and air stream properties.

Scientific publications on the discussed issue are based on research on many kinds of new and unused filtration nonwovens [6]. They mainly focus on studying the properties of unused materials that were new to the industry. These studies focused on assessing the solutions used in the construction of the bag or determining the separation properties of nonwoven fabrics. These studies provided answers to a number of questions concerning, among others, filtration efficiency and the accompanying airflow resistance [7], but only at the beginning of the separation process. In these studies, filter media worked for a short time and were tested in laboratory conditions [8]. Despite their conditioning, the tested media did not show signs of wear corresponding to industrial conditions during the long-term operation of the bags [8], and the results concerned only new, unused non-woven fabrics. In addition to the limitations associated with the use of a reduced scale of laboratory equipment, the problem is also the lower interest of researchers in wood dust [9]. The most common

publications concern dusts of other origin (ceramic, limestone, fly ash, coal dust, plant dusts) [10]. This state of knowledge does not allow for a good understanding of the phenomena accompanying filtration processes in real industrial conditions, which can often change over many years of using filter materials in dust collectors for wood dust. Due to the long service life of the filter bags, these processes cannot be easily reproduced in the laboratory. The use of materials exploited in real industrial conditions for testing gives an unprecedented opportunity to look at the issue of wood dust separation from the point of view of the filter user. In terms of long-term use, the samples used for this type of research have had a sufficiently long, in some cases over a year, working time in industrial filters, so their filtering properties are gradually changing. It was therefore decided to use bags previously installed in industrial filters for wood dust. The bags worked continuously for a period of two months to about a year. The research material obtained in this way allowed the observation of the variability of the operational characteristics of nonwoven fabrics during long-term use in industrial filters.

The aim of the work was to determine the impact of the long-term operation of filter bags in industrial conditions on changes in their operational properties. The research focused on determining the impact of long-term industrial use on the resistance to airflow through the non-woven fabric during wood dust filtration in the furniture factory and on determining changes in the separation efficiency of filter bags occurring during this time.

MATERIALS AND METHOD

The aim of the research was to install new bags in a filter dust collector in an extraction system operating in a large wood-based furniture factory. The installation was equiped in the filter baghouses of the SBF-140-5.0S-1A type by JKF (Berzyna, Poland). Two filtration nonwovens were used: fiber with the designation FP-PB400PS2, polyester with copper fibers (Filterapol, Łódź, Poland) and polyester with PP film, the manufacturer (Gutshe, Fulda, Germany). Then, the bags were taken directly from the filter at time intervals for over a year. The list of the obtained bags working in industrial conditions is presented in Table 1.

Table 1. Test bags obtained from the furniture factory

Dust exhaust installation	Bag working Time [Days]	Bag producer
Narrow surfaces treatment line	0, 67, 133, 272	Gutsche
Drilling centers line	0, 67, 133, 272	Gutsche
Narrow surfaces treatment line	0,85,143,275,382	Filtrapol

The bags collected at the factory were subjected to appropriate measurement procedures using a laboratory stand for testing the filtration process on a larger scale. The construction and operation of the station have been described in detail in previous works [7,8].

All bags ware tested under the controlled filtration conditions presented in table 2.

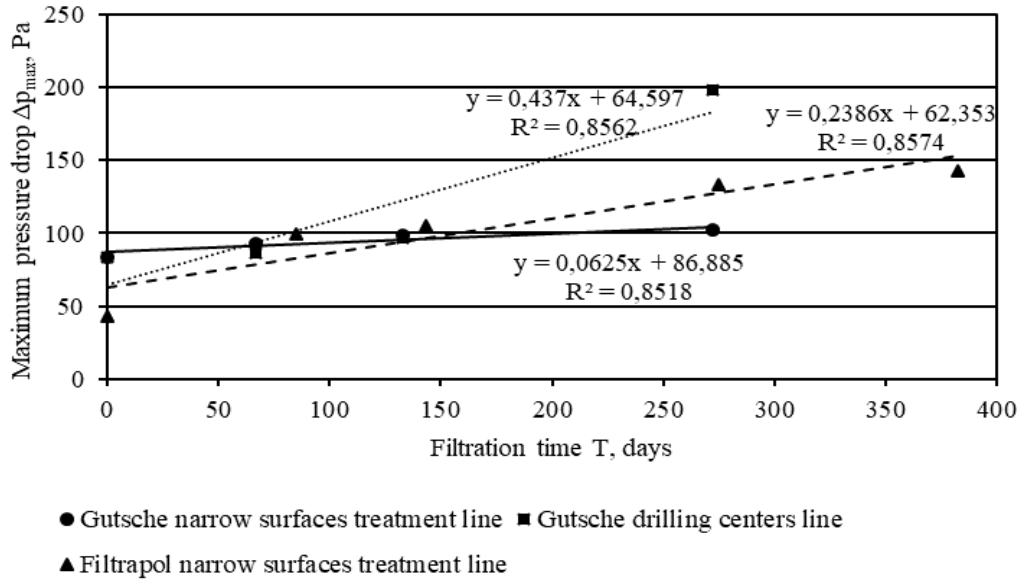
Table 2. Filtration parameters during testing of filtration bags

Parameter	Unit	Parameter Value
Filtration velocity w_f	$m \cdot s^{-1}$	0,0405
Dust concentration	$g \cdot m^{-3}$	10

The test dust with a mass arithmetic mean particle size of 91 μm used for the test came from grinding bent beech wood elements in industrial conditions.

RESULTS

The maximum pressure drop during the entire study for all tested bags was presented on the Figure 1.



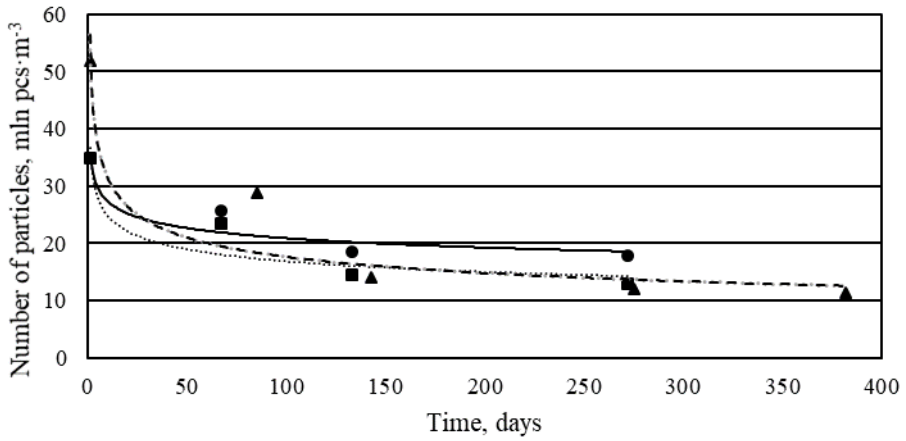
● Gutsche narrow surfaces treatment line ■ Gutsche drilling centers line

▲ Filtrapol narrow surfaces treatment line

Figure 1. Maximum flow resistance Δp_{max} through the filter fabric

The obtained results show that with the extension of the filtration time, the maximum flow resistance increases for all tested materials. This increase depends both on the working conditions of the filter bags (comparison of Gutsche bags working in different lines) and on the type of material used for the production of the bags (use of different materials in the narrow surfaces treatment line).

The content of dust particles in the air after filtration for tested bags was presented on figure 2.



● Gutsche narrow surfaces treatment line ■ Gutsche drilling centers line

▲ Filtrapol narrow surfaces treatment line

Figure 2. The number of particles in purified air)

As time passes, number of particles in the cleaned air was decreasing for all analyzed filtration bags. A decrease in the number of particles in the purified air will result in an increase in the filtration efficiency of the tested bags. Based on the obtained results, it can be

stated that filtration properties of bags depend, as in the case of flow resistance, on the working conditions and the type of filter bags.

CONCLUSIONS

The value of air flow resistance and filtration efficiency depends on the working time of the bags, the properties of the non-woven fabric, the conditions in which it works (dust load, frequency of bag regeneration) and the properties of the filtered dust.

Observed constantly increasing filtration resistance and increasing separation efficiency of filter bags operating in industrial conditions in the examined period allow us to conclude that they have a much longer useful life than one year.

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Streszczenie: *Długotrwała eksploatacja pulsacyjnych filtrów dla pyłu drzewnego.* W pracy określono wartość oporów przepływu i skuteczność separacji materiału filtracyjnego podczas długotrwałego użytkowania w pulsacyjnych filtrach dla pyłu drzewnego. Eksperymenty przeprowadzono dla jednego rodzaju materiału pracującego w dwóch różnych instalacjach filtracyjnych w jednej fabryce mebli. Worki pozyskano z instalacji po odpowiednio 67, 133 i 272 dniach pracy. Wszystkie testy przeprowadzono na stanowisku pilotażowym

w identycznych warunkach filtracji. Badania wykazały, że długotrwałe stosowanie materiału filtracyjnego zwiększa opory przepływu powietrza i poprawia skuteczność filtracji. Zakres tych zmian zależy od warunków pracy filtrów impulsowo-strumieniowych. Uzyskane wyniki pozwoliły na określenie właściwości przy długotrwałym użytkowaniu materiałów filtracyjnych w różnych warunkach filtracji.

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