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The influence of filters in the structure of air treatment plants units (ATP) on energy efficiency

Influența filtrelor din componența CTA-urilor asupra eficienței energetice

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Abstract. *The paper aims to analyze the major influence of filters on the consumption of electricity in ventilation systems, especially in air treatment plants in accordance with ISO EN 16890. On-site measurements are made with the help of the air treatment plant within the HVAC laboratory, with a flow rate of 2700 m3/h, on two filters with dimensions of 287 mm x 592 mm x 500 mm. The results indicate an energy class C for the analyzed filter. As future directions of study for the achievement of energy efficiency within an HVAC system, simulation with the help of the TRNSYS software can be used, for different scenarios.*

Key words: air handling unit, filters, energy efficiency, HVAC.

1. Introduction

People spend on average up to 90 % of their life indoors. Not only at home, but in various places such as offices, schools, restaurants, shopping malls or cinemas. It goes without saying that having a clean air indoor is crucial for the health of the population as a whole and in particular vulnerable groups such as babies, children or elderly people [1].

The energy consumption of air filters in general ventilation systems has become the focus of attention as energy prices increase, and as demands to reduce CO_2 emissions get tougher.

All air filters can be graded from A+ to E. Grade A+ stands for the lowest energy consumption and E for the highest. The classification, based on the filter test method **EN ISO16890**, will give you a better understanding of annual energy consumption, average efficiency and minimum efficiency [2].

Classifying the air filters based on the new test standard will be more precise. Deciding the filter efficiency based on the indoor requirements is the first step in choosing the best energy efficient filter.

2. Energy consumption evaluation of air filters for general ventilation purposes

The energy consumption of a fan in an air handling unit can be evaluated as a function of the volume flow rate supplied by the fan, the fan efficiency, the operation time, and the difference of the total pressure (static plus dynamic pressure) after the fan and the static pressure of the ambient air (assuming that the fan sucks in air from a static reservoir).

Typically, the volume flow rate supplied by the fan and the pressure difference the fan has to overcome, are related to each other by the characteristic fan curve. The efficiency of the fan is a function of the fan speed [3]. The actual fan efficiency also strongly depends on the design and the layout of the fan and can be in the best case as high as 0,80 or even higher, and in the worst case as low as 0,25 or even lower. The portion of the total yearly energy consumption which is related to the filters' pressure drop can be calculated using Eq. (1):

$$W=\frac{q_v \cdot \Delta p \cdot t}{\varepsilon \cdot 1000} \quad (1)$$

where: W – total yearly energy consumption [kWh], q_v – air flow volume [m^3/h], Δp – the pressure drop [Pa], t – operating time [h], ε - fan efficiency [%]. If fan efficiency and/or operating time are not known, the default values can be used as a substitute: t = 6.000 h/y, ε = 0,5

In case filters are changed when they have reached the final pressure drop, the average pressure drop is not time dependent (as long as the time interval for calculating the average pressure drop always considers full filter lifetime intervals), and the only variable to determine the average pressure drop is the shape of the pressure drop curve as a function of the time. In this case, the average pressure drop can be estimated by using Eq. (2):

$$\Delta p=\tfrac{2}{3}\Delta p_0 + \tfrac{1}{3}\,\Delta p\mathrm{final} \quad (2)$$

where: Δp_0 is the initial point and Δp_{final} is the predefined final pressure drop at which filters are changed.

3. Case study and results comparison

We started this research from the example according to EN ISO 16890, and the calculation method shown based on test results for a panel filter rated as ISO ePM1 50% at 0,277 m^3/s. We also used as a point of reference the data from Figure 1, presented in the code of good practice of Eurovent 4/24, where the red line marks the average pressure drop, for a filter with dimensions 592 mm x 592 mm x 50 mm and an accordingly fitted volume flow rate of 0,556 m^3/s.

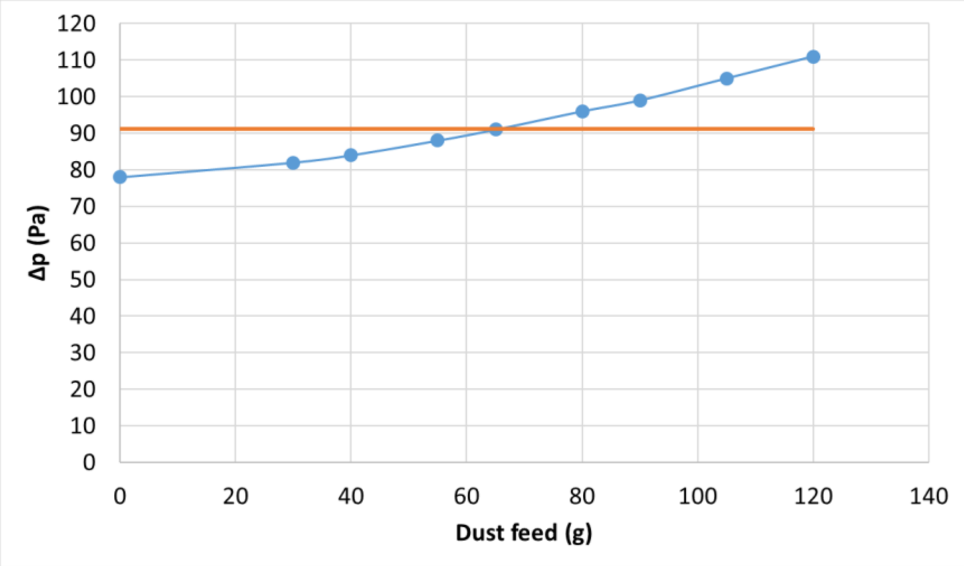

Fig. 1. Pressure drop as a function of dust loading at 0,944 m^3/s according to EN ISO 16890-3.

In our research laboratory we have an experimental stand composed of an air handling unit with an air flow of 2700 m^3/h including a filtration area with 2 filters with size of 287 mm x 592 mm x 500 mm. The values measured, according to the methodology presented in EN ISO 16890-3, are centralized in table 1.

Table 1

Test data for the pressure drop

Step	Dust feed [g]	Pressure drop [Pa]	Dust increment [g]	Av. Pressure drop [Pa]t
0	0	81		
1	35	84	35	70,1
2	45	88	10	72,8
3	55	91	10	72,9
4	70	95	15	75,6
5	80	98	10	76,5
6	95	102	15	79,3
7	110	107	15	80,5
8	125	113	15	83,5

By using Eq. (1) with the data given in Table 1, the average pressure drop calculates to $\overline{\Delta p}$ = 92,4 Pa and the yearly energy consumption to W = 831,6 kWh/a.

According to these results, the filter G4 is classified in energy class C.

6. Conclusions

Following the results obtained, it is possible to observe the major influence of the filter on the consumption of electrical energy within an AHU (air handling unit).

To reduce energy consumption, it is recommended to use filters that are part of energy class A, they will generate a value for *W* less than 600 kWh/a.

As a future research directions, we propose to carry out a comparative study on several types of filters through real-time simulations with TRNSYS software, regarding the energy consumption within an AHU in different scenarios, using the interconnection scheme between modules according to Figure 2.

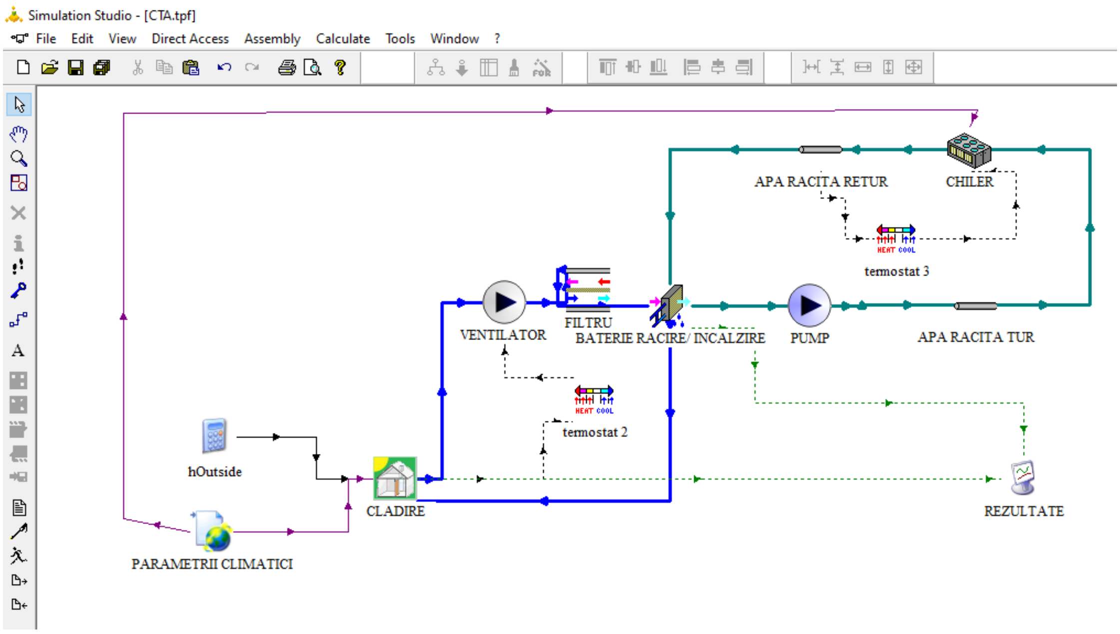

Fig. 2. TRNSYS scheme for simulate the yearly energy consumption in AHU

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