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Energy savings and manifold supply ventilation systems

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ABSTRACT

The total energy demand for mechanical ventilation systems depends on the pressure drop. Except for fans, any component in a mechanical ventilation system creates a pressure drop. The fan has to provide a sufficient pressure to compensate for the pressure drop caused by the components.

A reduction of the energy required for ventilation is therefore a question of limiting the pressure drop in the individual components. In this study, a mechanical ventilation system incorporating a manifold with multiple fans was designed aiming at reducing the energy consumption for the main fan by decreasing the pressure drop.

The key advantage of using a manifold is that it is suitable for residential buildings with limited space for air handling unit and duct-work. In this study, the use of a manifold in combination with multiple fans instead of dampers is presented.

The results from the experimental studies supported the conclusion that a ventilation system with manifold and multiple fans required 40% less energy compared with a ventilation system with manifold and dampers.

1. Introduction

Energy savings are important parts of the Danish national energy policy. Ventilation in buildings is energy intensive. In Denmark, the energy consumption of buildings is about 40% of the total energy consumption, of which electricity consumption for the operation of ventilation systems accounts for 30–50% of the energy consumed [1,2].

The energy use for a fan is dependent on the pressure drop, the airflow, the time and the efficiency of the fan. To reduce energy costs one of the challenges is to design air distribution system with a minimum of bends and obstacles in the duct system to have as low a pressure drop as possible. Assuming that the fan in the distribution system has a high efficiency, the energy demand will therefore be as low as possible. According to the fan affinity laws correct dimensioning and design of ventilation systems can reduce the energy used by fans and result in lower operational costs [3–5].

Assuming that a ventilation system is designed with the lowest pressure drop possible and with the most energy efficient components on the market; then the question is: *How can the pressure drop be reduced further without compromising the indoor climate?*

Dampers are usually used to control the airflow in a distribution system. When a damper is used there is always an overpressure across it. This is because the fan is dimensioned to deliver the maximum pressure and airflow to the entire system.

In this paper, a novel design of a mechanical ventilation system with manifold and fans is used to lower the pressure drop in comparison with a mechanical ventilation system with manifold and dampers. By using fans in the manifold, the pressure drop in the ventilation system is lowered by eliminating the pressure drop across the dampers.

One of the advantages of using a manifold for ventilation is that manifold systems are perfectly designed for residential buildings. The ventilation unit is directly connected to the manifold with a duct that fits the size of the ventilation unit. The airflow from the unit goes into the manifold and is managed within and distributed through smaller ducts in the manifold. Because the ducts are connected in parallel, there is no need for additional sound absorbers to eliminate cross talk [6].

A previous study described the balancing method of a mechanical ventilation system with multiple decentralised fans. It was found that it is possible to balance a ventilation system with decentralised fans instead of dampers. Further, it was concluded that energy saving can be obtained. The magnitude of the energy saving is dependent on the pressure difference between the branch with the least pressure and the branch with the highest pressure [7].

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The energy performance of a mechanical ventilation system with multiple decentralised fans implemented in an office building was analysed in a previous paper. The authors conclude that savings of up to 30% on the required energy can be achieved when compared with a conventional mechanical system with flat plate dampers [8].

The objective of this study was to examine the energy saving potential of manifold supply ventilations systems. This paper presents the study of an experimental mock-up in a laboratory environment in order to examine the performance of a ventilation system with manifold and fans compared with a ventilation system with manifold and dampers. The study focused on the energy-saving potential of the proposed ventilation system in a residential building in Copenhagen, Denmark.

2. Method

2.1. Ventilation system with manifold and dampers

In a traditional ventilation system, flat plate dampers are used to regulate airflows, see Fig. 1. This ensures an air distribution in accordance with the desired airflows in different rooms. A ventilation unit is directly connected to the manifold with a diameter of the duct to match the spigot size of the ventilation unit.

For example, a ventilation unit with a given diameter spigot would have the same diameter primary duct connecting the unit to the manifold. The airflow from the ventilation unit is supplied to the manifold. The airflow from the manifold can be controlled by dampers to the various rooms. The balancing dampers set the airflows to meet the design requirements.

When dampers are required, the fan needs to be able to produce the necessary airflow and pressure required for the entire system. This gives an overpressure across all of the dampers.

2.2. Novel design of a manifold with fans instead of dampers

For this novel design, the ventilation system with dampers was converted into a new system with fans instead of dampers, see Fig. 2. When the dampers were replaced with fans, the overpressure in the duct system was eliminated.

In Fig. 3, a simple visualisation of the dimensioning method is shown. The diagram to the left shows a ventilation system with dampers and equal airflow in all branches. In the system with dampers, the fan has to be dimensioned according to the total airflow and the maximum pressure – which corresponds to branch D.

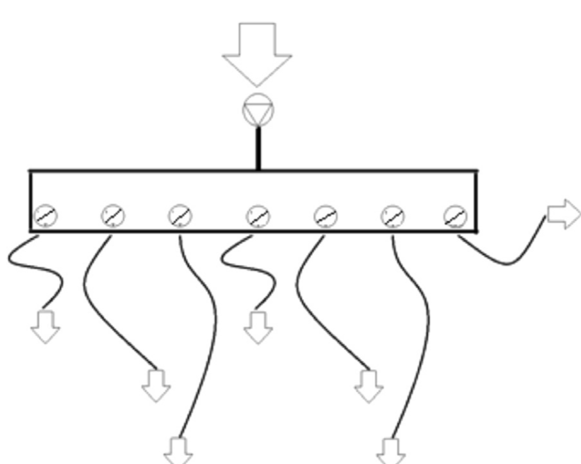

Fig. 1. Sketch of a manifold with 7 dampers and 1 main fan.

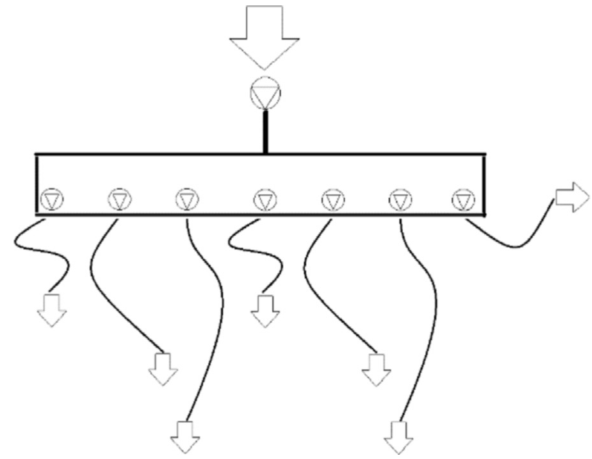

Fig. 2. Sketch of a manifold with 1 main fan and 7 fans instead of 7 dampers.

The diagram on the right shows a ventilation system with fans and equal airflow in all branches. The fans in the branches all have different operating points and thereby they assure that equal airflow is attained. In the system with multiple fans, the main fan only had to be dimensioned for the total flow and the branch with the least pressure – in this case branch A [7].

Fig. 4 shows the system characteristic for the two different ventilation systems. In the figure, it can be seen that there is a potential for energy saving when using fans to balance the air in a ventilation system [8]. The magnitude of the energy saving is dependent on the efficiency of the fans.

2.3. The ventilation system

The calculations and experimental mock-up was based on the layout of the ventilation system in an apartment in a residential building. The ventilation system consisted of 7 inlets, 4 exhausts and 1 kitchen hood. The ventilation system had three different settings for the airflow rate; low, medium or high air change rate. These rates corresponded to inlet volume airflow rates of 55 m^3/h, 185 m^3/h or 370 m^3/h respectively.

Experimental mock-ups of the supply ventilation system with manifold and dampers and the novel supply ventilation system with manifold and fans were carried out in a laboratory environment.

The manifold had an inlet diameter of 315 mm and seven outlets with diameter of 100 mm; see Fig. 5.

Static pressure and air velocity in the distribution system was measured for six different set-ups. The measurements were made for three different total airflows for the system with dampers and three different total airflows for the system with fans. The total airflow was distributed as shown in Table 1.

For both distribution systems, the main fan was a centrifugal fan with backward curved blades with a diameter of 190 mm, manufactured by ebmpapst. For the distribution system with dampers, the flat plate dampers were a manually adjusted type DRU from Lindab with a diameter of 125 mm. The tested fans were axial fans also manufactured by ebmpapst. In order to achieve the required airflows, three different fans were chosen. The fan type fixed to the first two inlets was 8412 (80 × 80 × 25 mm), the fan type fixed to the third and fourth inlets was 3412 (92 × 92 × 25 mm) and the fan type fixed to the last two inlets was 5214 (127 × 127 × 38 mm).

The mock-up was built in a laboratory environment with an average temperature of 20 °C and a relative humidity of 45%.

Measurement device accuracy – Pressure and air velocities were measured by means of a handheld Testo measurement instrument