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Ventilation Requirements in Modern Buildings.

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Ventilation requirements in modern buildings

Synopsis

Besides the hygienic aspect, also the aspect of energy saving of heating residential buildings is very important. This is only possible by mechanical ventilation with heat recovery. This paper describes a part of the large variety of systems, which are nowadays available on the market. The main difference of these systems are:

-single room unit/decentral unit and
-central unit for one dwelling or a single family building

For the heat recovery are used:

-only a plate heat exchanger (return air/supply air)
-only a heat pump (return air/supply air or return air/heating water) or
-a plate heat exchanger combined with a heat pump (return air/supply air)

As heat source for the heat recovery are used:

-only the return air
-the return air mixed with the flue gas by using a gas heating system.

List of symbols

k	overall heat transfer coefficient [W/m^2K]
k_m	average of the overall heat transfer coefficient [W/m^2K]
$\dot{Q}_{tot}$	total heat requirement [kWh/m^2a]
$\dot{Q}_V$	ventilation heat requirement [kWh/m^2a]
$\dot{Q}_T$	transmission heat requirement [kWh/m^2a]
t	temperature [°C]

1. Introduction

Due to the energy savings the buildings are more tightly joined today and the basic ventilation is not longer guaranteed. A simple solution to extract the pollutants and moisture is the ventilation through the windows. The comfort for the inhabitants is very often impaired and the heat loss is not irrelevant.

However, if in the future the new regulations of energy demand for buildings is given by law, the buildings must be changed in their construction (walls, windows, insulation) and their ventilation. The demand to save the greatest possible part of energy is justifies a mechanical ventilation system. This kind of system allows a controlled ventilation and in combination with a heat recovery system is it possible to reduce the expenditure of energy. The following paper describes ventilation systems recently introduced in Germany to reach a maximum of comfort with low energy demand.

2. Ventilation of residential buildings

As everyone knows, the function of the ventilation of residential buildings is to create comfortable indoor air quality. As far as "comfort" is concerned, we always talk about the thermal comfort, the temperature and the air velocity, and forget that there are also other important parameters. The heat tranfer from the occupants is radiation, convection, and also evaporation of moisture. The latter is mainly due to breathing, but occasionally also occurs through the skin. Approximately 20 - 22% of heat loss from a person doing regular activity is evaporation of moisture. We produce water vapour and this inevitably leads to uncomfortable indoor air quality.

3. Improvement in the window areas

Frequently, there are discussions to improve the insulation of the buildings by increasing the layers of insulation material on the walls. In the next few years it is necessary to improve the thermal quality of windows. There are already many different kinds of windows on the market and research will help to improve the particular window constructions currently available.

An easy way to improve the windows is to use multiple glass with thermal insulated roller shutters. Radiopacity or radiopaque foils can be partitioned

between the glass of the window to trap the energy of the sunlight during the day and the long-wave thermal energy of the building during the night. This idea is, at the moment, in development and prototypes are on the market and currently being tested.

As for the indoor surface temperature in which we are interested at the moment, we can reach a k-value of less than 1.0 W/m^2K in the window area. We should not insulate the walls repeatedly but rather do something in the window area in order to get a symmetrical indoor surface temperature to meet the demand of comfort and humidity. It should be clear where the thermal insulation has to be placed because the k-value is only one parameter and the storage the other. An old rule of thermodynamics is that we have to install the thermal insulation always on the cold face, but that means in buildings, in winter on the outside and in summer on the inside.

4. Ventilation heat requirements

Figure 4.1 illustrates the percentage of the ventilation heat requirements to the total heat requirements –according to the kind of insulation against loss of heat of the building– compared to the transmission heat requirements.

It is possible to decrease the transmission heat requirements with certain insulation measures on all parts of the building covering, but the ventilation heat requirements as a rule does not change. There is, regardless of the way of ventilation, a certain amount of energy necessary to heat the supply air from the outdoor temperature up to room temperature. As better the insulation of a building, as higher is the percentage of the ventilation heat requirements to the total heat requirements.

The left beam in **figure 4.1** shows the annual expenditure of energy of a single family dwelling. This building, built before 1978, needed approximatly 290 kWh/m^2a, which means nearly a fuel consumption of 28 l fuel oil $/m^2a$. The right beam illustrate the expenditure of energy by using a mechanical ventilation system with heat recovery.

Since 1982 a regulations of energy demand for buildings is given by law. The second beam shows the conditions of the present situation in Germany. The result shows the reduction of the transmission heat requirements clearly. That means, that the losses, due to the uncontrolled ventilation

have a main share in the total expenditure of energy. The inset of a heat recovery system leads to improvements by nearly 15% related to the total expenditure of energy.

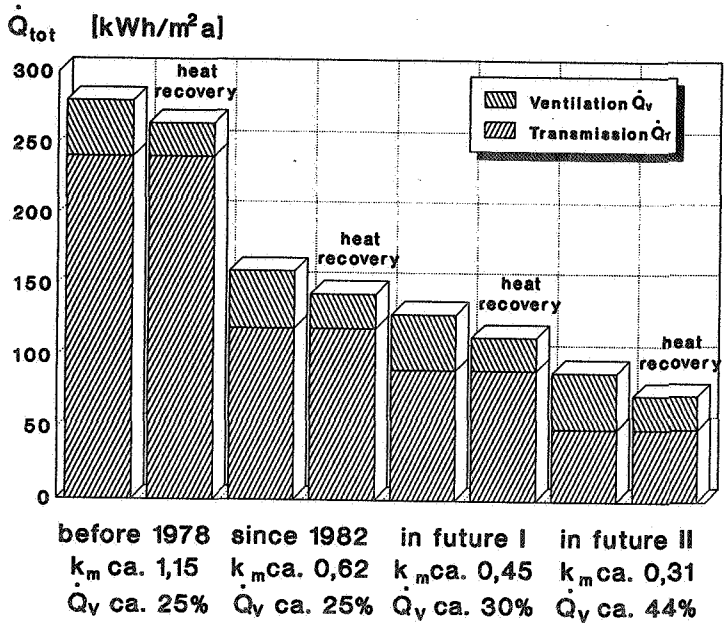

Figure 4.1: Relationship ventilation-/transmission heat requirements

By intensifying the regulations of energy demand in buildings (k-value reduced to 30%), only a slight increase of energy saving is possible. To obtain values of about 60 to 70 kWh/m^{2}a is only possible with a heat recovery system. Without using the heat of the return air -without the inset of a heat recovery system-, the k-values must be minimized. In this case we have to ask for the cost effectiveness.

By using a ventilation system with heat recovery it is possible to save 35% of the total filament energy demand for one single-family dwelling. Furthermore, the CO_2-emission of for example a fuel heating system goes down to 1/3 approximately.

5. Heat recovery in residential buildings

We have different ways to use a heat recovery system in residential buildings. The best way is to extract the air from the kitchen, the bathroom and the toilet, because these are the rooms with the highest pollution. The

supply air is coming into the bedrooms and the living rooms. It is also possible to change it over during the night to have more supply air in the bedroom and during daytime more in the living room. All air is going through a heat exchanger.

The following describes ventilation systems with heat recovery, which are most common in Germany at the moment. **Table 5.1** explains the components and the symbols for the skeleton sketch of the ventilation system in **figures 5.1 - 5.4.**

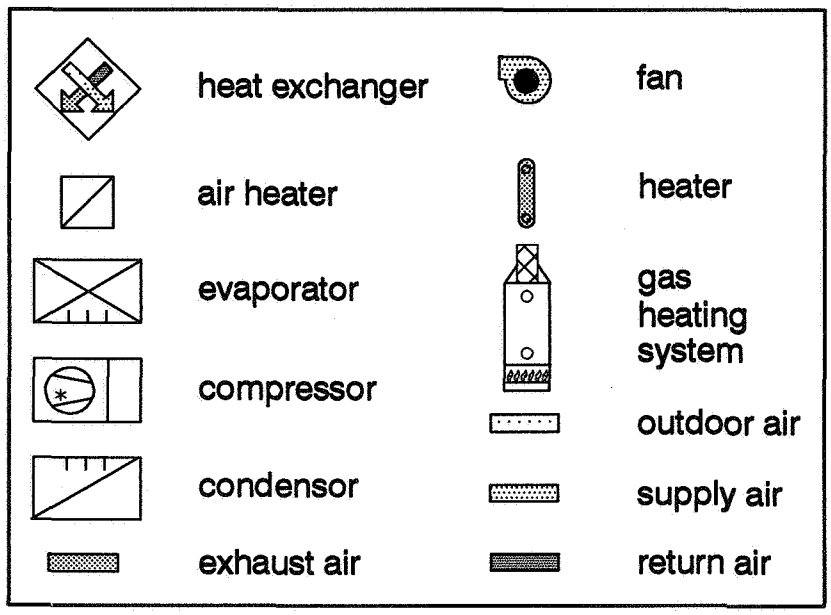

Table 5.1: Components and symbols for a ventilation system

Figure 5.1 shows a mechanical ventilation system for single rooms with a plate heat exchanger. This system is used for single rooms if there are moisture problems (decentral unit). The supply air temperature is lower than the room air temperature, therefore a special installation is necessary to avoid draughts. It is also possible to install an extra heater before the supply air gets into the room. The supply- and the exhaust air fan are both on the same shaft with one driving motor. This system is independent from the heating system and it saves a part of the energy by a plate heat exchanger.

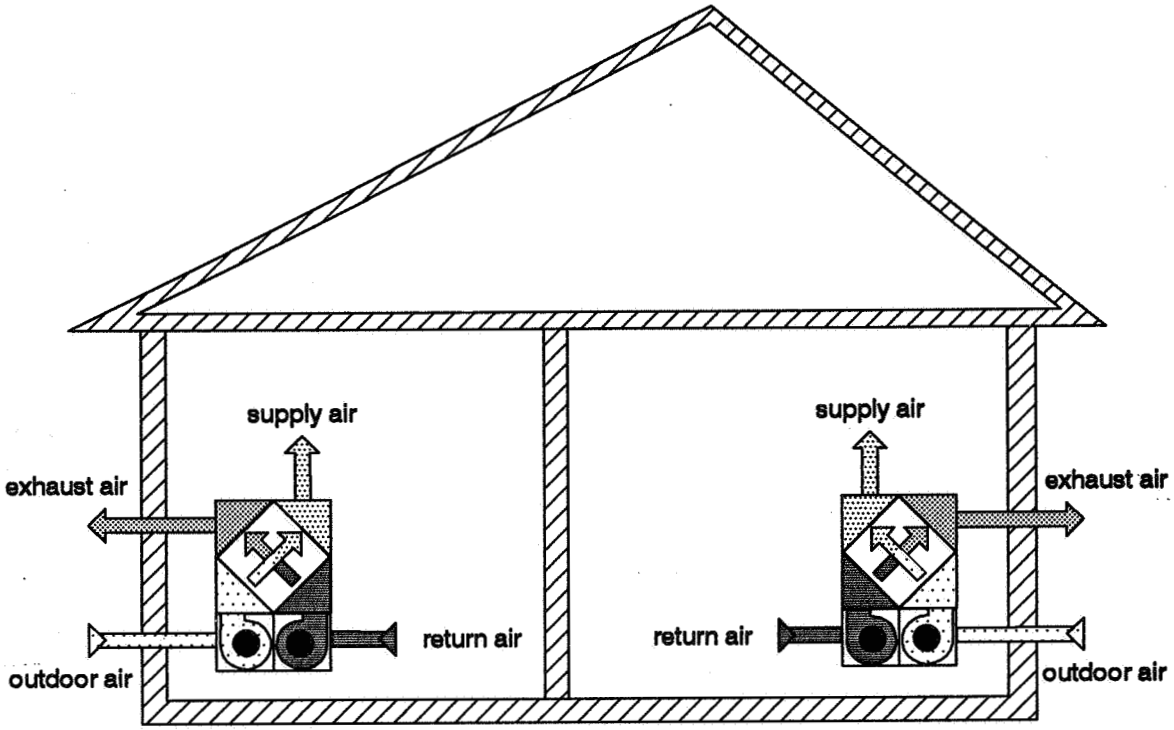

Figure 5.1: Ventilation system for single rooms

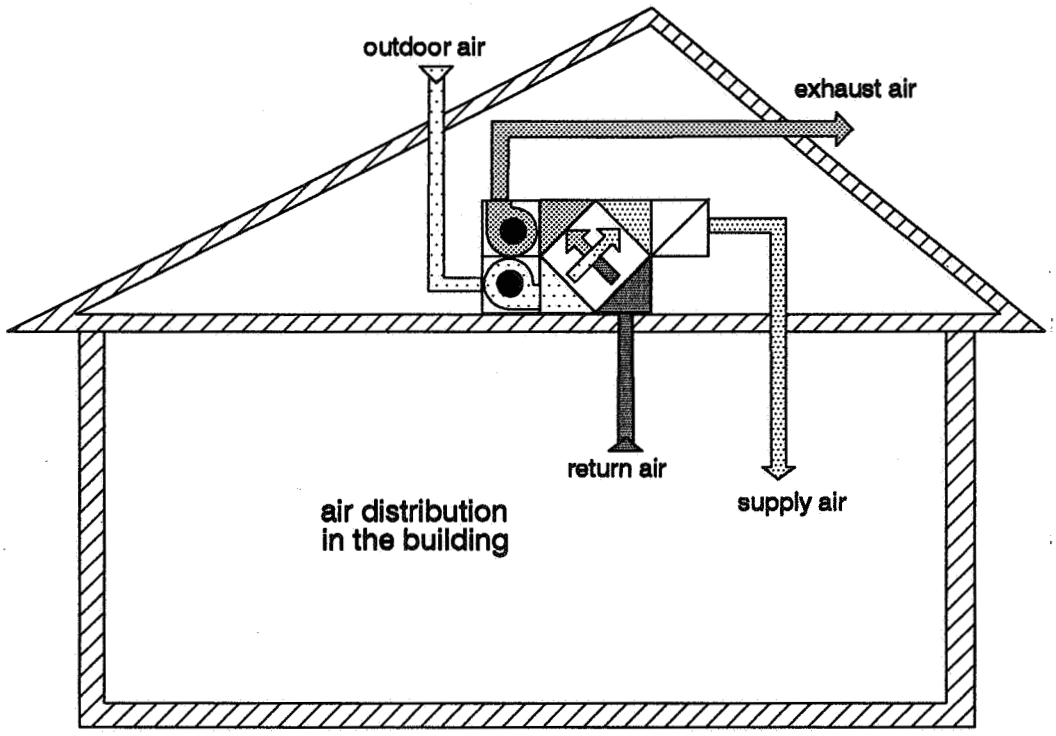

Figure 5.2: Ventilation system for one dwelling or one single family building

A simple system for dwellings or single family buildings is illustrated in **figure 5.2.** It concerns a central unit with a heat exchanger, and a reheater for the supply air. The position and the type of construction of this ventilation unit can be done for the dwelling in different ways. For example, horizontal in the loft, vertical in the dwelling or hanging combined with a hood in the kitchen or from the ceiling in the area of the hall. This system is independent from the heating system and the reheating of the supply air is made by an electrical heater or by an air/water heat exchanger, which is combined with the heating system.

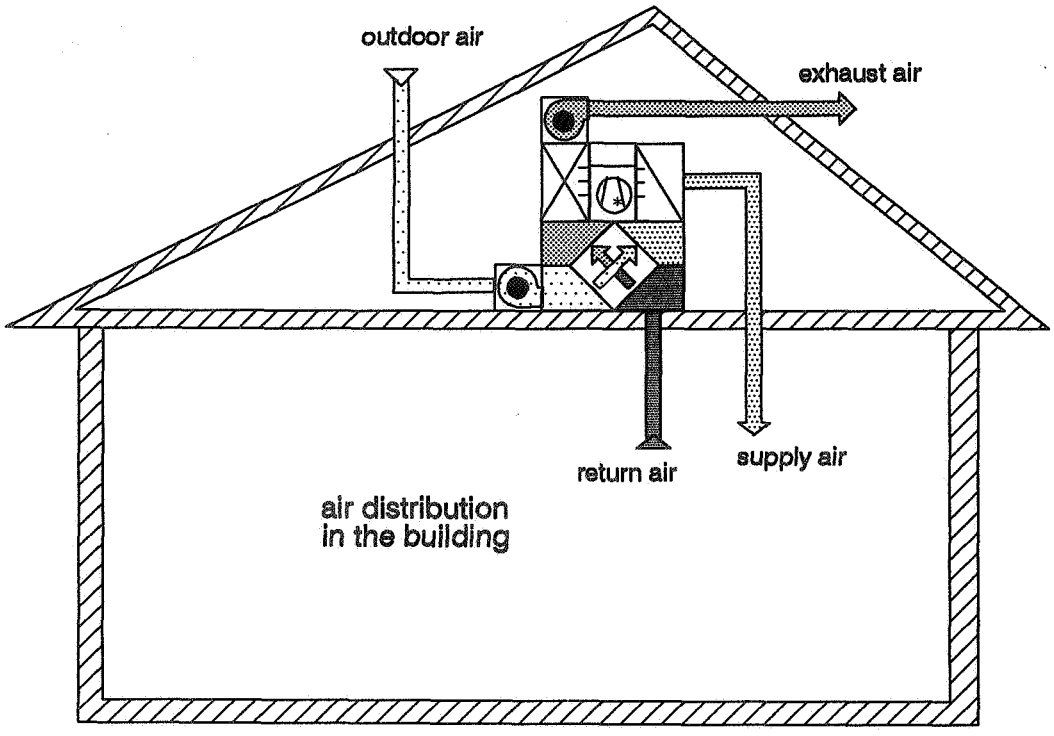

Figure 5.3: Ventilation system with heat exchanger and heat pump

Figure 5.3 shows a ventilation system with heat exchanger and heat pump. The application of this system is also in dwellings or single family buildings and the position and the type of construction is the same as in the system in **figure 5.2.** The heat recovery is made by a plat heat exchanger and a heat pump, which is added. The heating capacity is larger than the ventilation heat requirements, that the transmission heat requirements can be covered partly. Additional heat capacity is in a high insulated building only necessary if the outdoor temperature t is lower than 0 - 5°C.

If there is a gas heating system in the dwelling or single family building it is possible to use a ventilation system, which is illustrated in **figure 5.4.** The central ventilation unit should be installed near the rotate water heater. When the flue gas is mixed with the exhaust air the regulations of chimneys for the exhaust air ducts has to be considered. In this part of the ductnetwork negative pressure must be garanteed. For this reason the exhaust air fan must be installed near the external covering of the building. The reheating of the supply air by a heat exchanger is integrated in the heating system. The control device is installed separately in the supply air with a thermostat valve. In this system, the heating capacity is larger than the ventilation heat requirements, that the transmission heat requirements is covered partly.

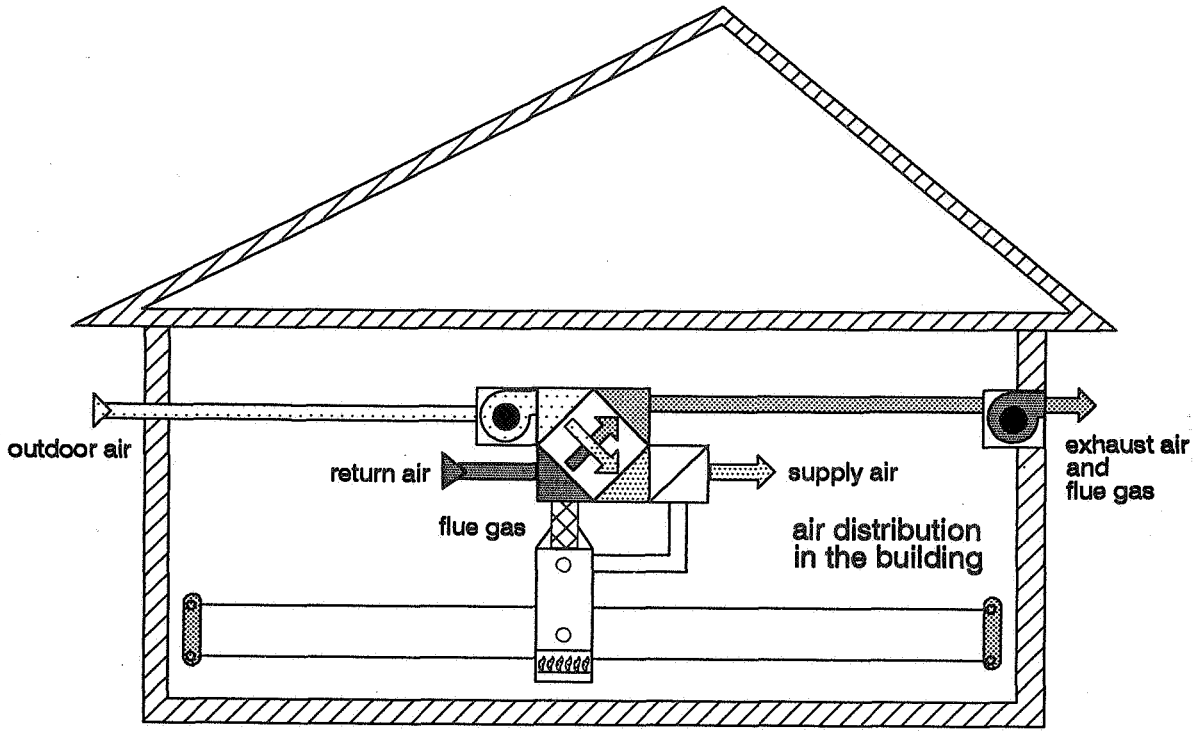

Figure 5.4: Ventilation system combined with the heating system