A CZECH DEMONSTRATION HOUSE WITH HYBRID VENTILATION

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ABSTRACT

An idea to build a demonstration house fitted with a hybrid ventilation system arose when Brno University of Technology joined the RESHYVENT project. There has not been much attention paid to the residential ventilation in the Czech Republic. Window airing and passive stack ventilation are still the most common ways of ventilation in residential buildings. In this context a decision was made to build a house equipped with a demand controlled hybrid ventilation system. The hybrid ventilation system for the moderate climate, developed by the Dutch industrial consortium, has been installed in the house.

KEYWORDS

residential ventilation, hybrid ventilation, CO_2 controlled ventilation

INTRODUCTION

There has not been much attention paid to the residential ventilation in the Czech Republic. Window airing and passive stack ventilation has been the most common way of ventilation in residential buildings. It is true that apartments in multi-storey residential buildings are mostly equipped with manually controlled exhaust fans, but these fans usually run only during cooking or showering. Moreover, there are no air supply openings through which outdoor air could enter the apartments. This is not a problem as long as the windows are not very airtight. A step people usually make when trying to decrease a heat loss of their apartments is sealing the windows or replacing them with more airtight ones. The air change rate in the apartments is then significantly reduced, and the problems associated with poor ventilation arise.

The situation in single family houses (detached dwellings) is similar to the apartment buildings. Window airing and passive stack ventilation are the most common ways of ventilation. Cooker hoods have become quite common in the houses built or refurbished during last decade, but many of them are re-circulation types. Similar to the apartments there are no air-supply openings in the single family houses.

In this context a decision was made to build a house equipped with a demand controlled hybrid ventilation system. The city of Brno has a moderate climate, and so the hybrid ventilation system for the moderate climate, developed by the Dutch industrial consortium, was chosen for the demonstration house. The house will serve for the demonstration, experimental, and educational purposes.

DEMONSTRATION HOUSE

There was not much time available for the construction of the demonstration house. Because of that the house was designed as a well insulated wood-frame construction (this type of construction is not typical for dwellings in the Czech Republic). The demonstration house was built in the Brno University campus within a period of four month. An important requirement was that the total cost of the house should be comparable with the costs of similar size houses built in the Czech Republic. Otherwise the demonstration value of the house would be significantly decreased.

As can be seen in Fig. 1 the demonstration house is a double story building with a flat roof. The usable are of the demonstration house is 100 m^2. The house has quite a low demand for heating (with regard to the housing stock in the Czech Republic). The calculated transmission heat loss is 1.9 kW at -12°C. The ventilation heat loss, in case of demand control ventilation, is significantly dependant on the occupancy and other factors. For the air change ACH = 0.5 $1.hour^{-1}$ the ventilation loss would be 1.7 kW at -12°C.

Fig. 1 Demonstration house with hybrid ventilation

The low-temperature hydronic heating is used in the house. The schematic of the heating system is in Fig. 2. The vacuum pipe solar collectors are expected to cover a significant portion of the energy consumption for space heating and domestic hot water. An air-to-water heat pump is employed for ventilation air heat recovery. The payback time of heat recovery in case of demand control systems is generally much longer than in case of “conventional” systems. It is because the demand controlled systems enable to achieve lower air change rate without negative impact to the indoor air quality.

The living room has radiator heating as well as floor heating. Both means of heating are design to cover the total expected heat loss of the room. The aim of this arrangement is to investigate the thermal comfort in the living room for the combination of hybrid ventilation with radiator heating, floor heating, and combination of both. The hybrid ventilation system supplies fresh air into the rooms without preheating. The ventilation heat loss, therefore, changes quite quickly, and it can be in some moments higher than the transmission heat loss. The floor heating alone may not be able to respond to the changes in the heat loss of the room quickly enough, and it can have negative impact to the thermal comfort of the occupants.

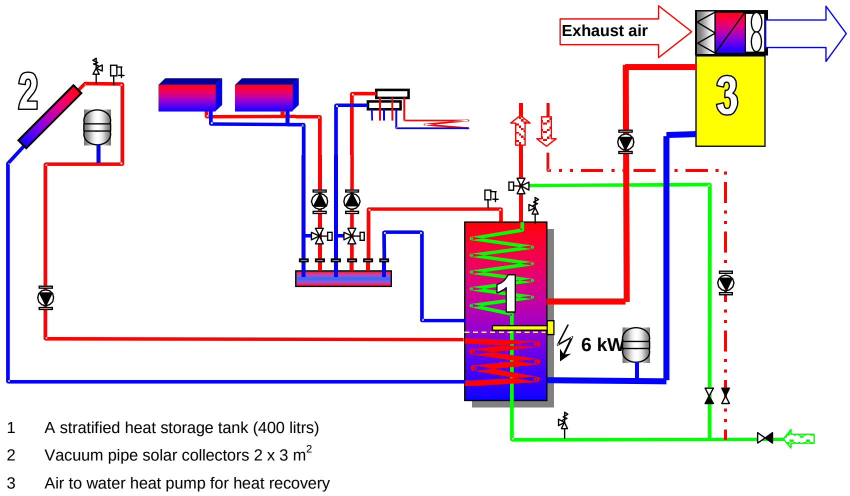

Fig. 2 The heating system in the demo house

HYBRID VENTILATION SYSTEM

The demonstration house is fitted with the hybrid ventilation system developed by the Dutch industrial consortium within the framework of the RESHYVENT project. This ventilation system is primarily intended for the moderate climates. The control of the ventilation system is based on the monitoring of the CO_2 concentration in rooms. The layout of the hybrid ventilation system in the demonstration house is in Fig. 3.

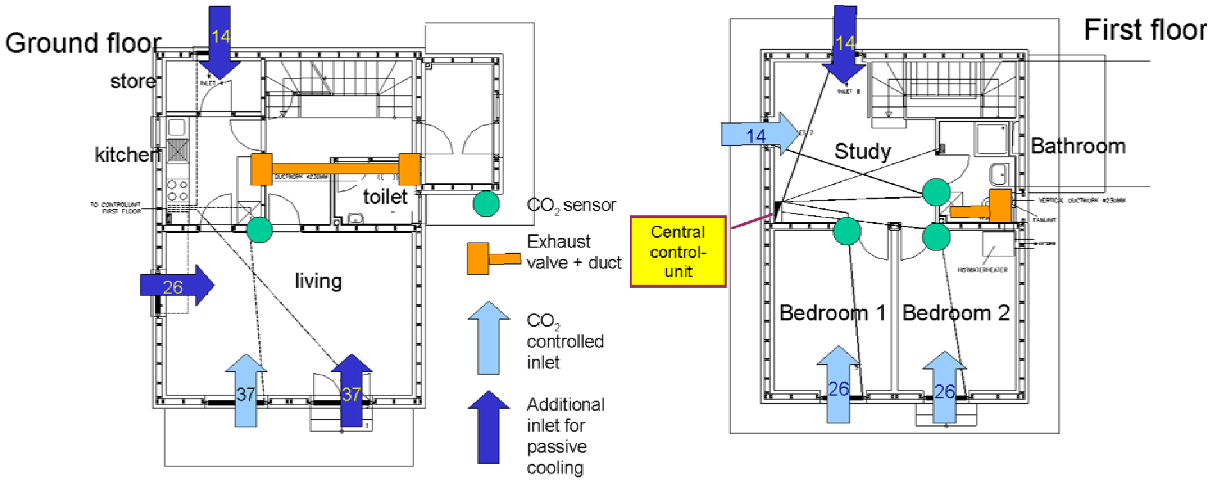

Fig. 3 The layout of hybrid ventilation system

The hybrid ventilation system consists of self-regulating air inlets, CO_2 sensors, central control units (called VENTOSTAT), ductwork, very efficient exhaust fan, motorized damper, and a roof outlet. As can be seen in Fig. 3, there is a self-regulating air inlet in the living room, study and two bedrooms. The self-regulating inlets keep a constant air flow rate when the pressure difference over the inlet is higher than 1 Pa. The control of these inlets (opening and closing) is based on the monitoring of the CO_2 concentration in rooms by means of the CO_2 sensors. When the CO_2 concentration in a room increases to 800 ppm, then the inlet opens to the first position (the first position corresponds to the air velocity of 0.7 m/s in the inlet). If the pressure difference across the inlet is not sufficient to achieve the demanded flow rate, then the fan switches on or increases the speed. If the CO_2 concentration in a room does not decline then the inlet opens to the second position (air velocity 1 m/s in the inlet). This process repeats until the CO_2 concentration in the room begins to decline. Then the inlet will remain in the same position until the CO_2 concentration decreases to 600 ppm. When the concentration decreases to 600 ppm the inlet closes, and the fan (if it is on) either decreases its speed, or switches off. The occupants of the house always have an option to open or close the inlets by means of a remote controller (Fig. 4). There is a switch in the kitchen and the bathroom, which allows the occupants to increase the ventilation rate during cooking and showering.

Fig 4. Air inlets and the remote controller

Fig. 5 shows the exhaust side of the hybrid ventilation system. The flow rate trough the exhaust duct is monitored by means of a flow meter. The motorized damper enables to control the air flow rate when natural driving forces are too high for the demanded flow rate.

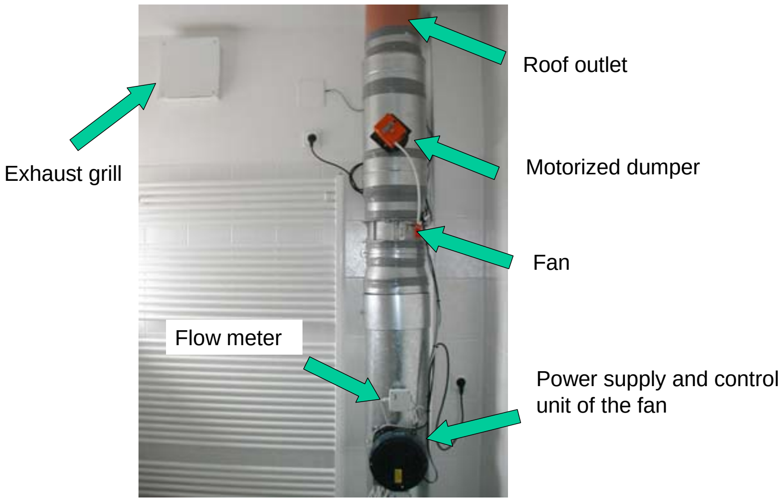

Fig 5 The exhaust side of the hybrid ventilation system

An air-to-water heat pump is used as a heat recovery device. It is actually the only possible arrangement of heat recovery with this ventilation system. The heat pump is connected to the heating system, and so the recovered heat can be used for both space heating and domestic hot water. The ventilation system also has a passive/night cooling mode. In this mode all the inlets open and the fan runs at the maximum speed. There is a solar chimney on the roof, which will assist the ventilation system in passive/night cooling mode. The solar chimney represents the experimental part of the demonstration project, and its performance in cooperation with the hybrid ventilation system is to be investigated.

MONITORING OF THE PERFORMANCE

The central control unit (VENTOSTAT) gathers and stores information about the operation of the hybrid ventilation system. The data file from the VENTOSTAT can be downloaded to a computer and can provide useful information about the ventilation system performance. Beside that another data acquisition system has been installed in the house in order to monitor conditions inside and outside the house. This system involves temperature and humidity sensors in all rooms, heat meters in the heating and solar system and a weather station providing weather data.

Fig. 6 The CO_2 simulation set-up

The demonstration house has not yet been occupied. It has therefore been necessary to simulate the presence of people in order to make the ventilation system respond. The system responds to the increase of the CO_2 concentration, and so the presence of people can be simulated by release of CO_2. Fig. 6 shows a CO2 bottle located in the living room. The bottle is fitted with a manually controlled valve adjustable in the range of 0.1 – 1 l/min of O_2. The variable area flow meters are used to measure the flow rate more accurately, since the CO_2 has different properties than O_2.

The data acquired from the measurements will be used for the evaluation of the performance of the hybrid ventilation system under the climatic conditions in the Czech Republic. The high attention will be paid to the thermal comfort of the occupants. This could be the weakest point of the hybrid ventilation system, which supplies outdoor air to the rooms without preheating. The outdoor air temperature is 20% of year below 0°C in Brno.

Acknowledgements

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