RESHYVENT
DEMAND CONTROLLED RESIDENTIAL HYBRID VENTILATION

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ABSTRACT

A Demand Controlled Hybrid Ventilation System is a two-mode system using natural forces as long as possible and electric fans only if necessary. Sensor technologies are used to establish the exact required airflow for indoor air quality and thermal comfort to a minimal energy demand.

A large part of the Dutch dwellings are foreseen with a ventilation system consisting of natural supply with mechanical exhaust. Fan power for these systems typically is 30 - 40 W (Specific Fan Power 0.7 – 1.0 kW/(m^3/s)). Small improvements lead to a laboratory reference of 21 W. In the EU TIP-VENT project improvements on ductwork and fan have resulted in a fan power of 7 W (SFP 0.17 kW/(m^3/s))

A further step forward in energy reduction is now realized within the RESHYVENT project. In this project a Dutch industrial consortium together with TNO develops a demand controlled hybrid ventilation systems for residential buildings. The system consists of self-regulating inlets and vents, round 225 mm ductwork, a DC fan and an optimized roof outlet. A CO_2 sensor based control system will adjust the ventilation to required airflows with respect to indoor air quality. Target fan power is lower than 2 W (SFP < 0.04 kW/(m^3/s)).

KEYWORDS

Hybrid ventilation, energy consumption, SFP, demand controlled, CO_2 sensor.

INTRODUCTION

A large part of the Dutch dwellings are foreseen with a ventilation system consisting of natural supply with mechanical exhaust. Fan power for these systems typically is 30 - 40 W (Specific Fan Power 0.7 – 1.0 kW/(m^3/s)). Small improvements lead to a laboratory reference of 21 W for a flow rate of 42 dm^3/s. In the EU TIP-VENT project improvements on ductwork and fan have resulted in a fan power of 7 W (SFP 0.17 kW/(m^3/s)). The pressure drop over the fan unit decreased from about 50 to 30 Pa.
A further step forwards in energy reduction is now realized within the RESHYVENT project. The aim of this project is to develop and construct prototypes of demand controlled hybrid ventilation systems for residential buildings. A Demand Controlled Hybrid Ventilation System is a two-mode system using natural forces as long as possible and electric fans only if necessary. Sensor technologies are used to establish the required airflow for indoor air quality and thermal comfort to a minimal energy demand.
The RESHYVENT project contains four Industrial Consortia (IC) who are supported by a scientific group. In this paper results will be presented from IC-2 the Dutch consortium. Target fan power for IC-2 is lower than 2 W for 56 dm^3/s (SFP $<$ 0.04 kW/(m^3/s)). The target pressure drop over the fan is 10 Pa.

The following ventilation system parts are optimized:

- Self regulating inlets;
- Self regulating vents;
- Duct work;
- Fan;
- Roof outlet.

This paper describes the developed hybrid ventilation system and the energy use of the optimized system under laboratory conditions.

In the autumn of 2003 the system will be installed in a dwelling (Brno, Czech Republic), which will render data under real conditions. A CO_2 sensor based control system will control the ventilation with respect to indoor air quality.

SYSTEM DESCRIPTION

Figure 1 gives an overview of the system. A single-family house is shown, with the living room and the kitchen at the ground floor and the bathroom and the bedrooms at the first floor. To reduce the flow resistance the exhaust is lined up under the roof outlet.
The ventilation flow is demand controlled. For the living room and the bedrooms CO_2 sensors are foreseen. Also other sensors to detect the presence of persons like infrared (IR) can be used. A central control unit receives information from these sensors and gives set points to the self-regulating inlets and vents and, if necessary, starts and controls the fan. The nominal total flow rate is 56 dm^3/s. However the maximum flow rate is foreseen at 100 dm^3/s, which can be used during cooking, showering and for passive cooling.

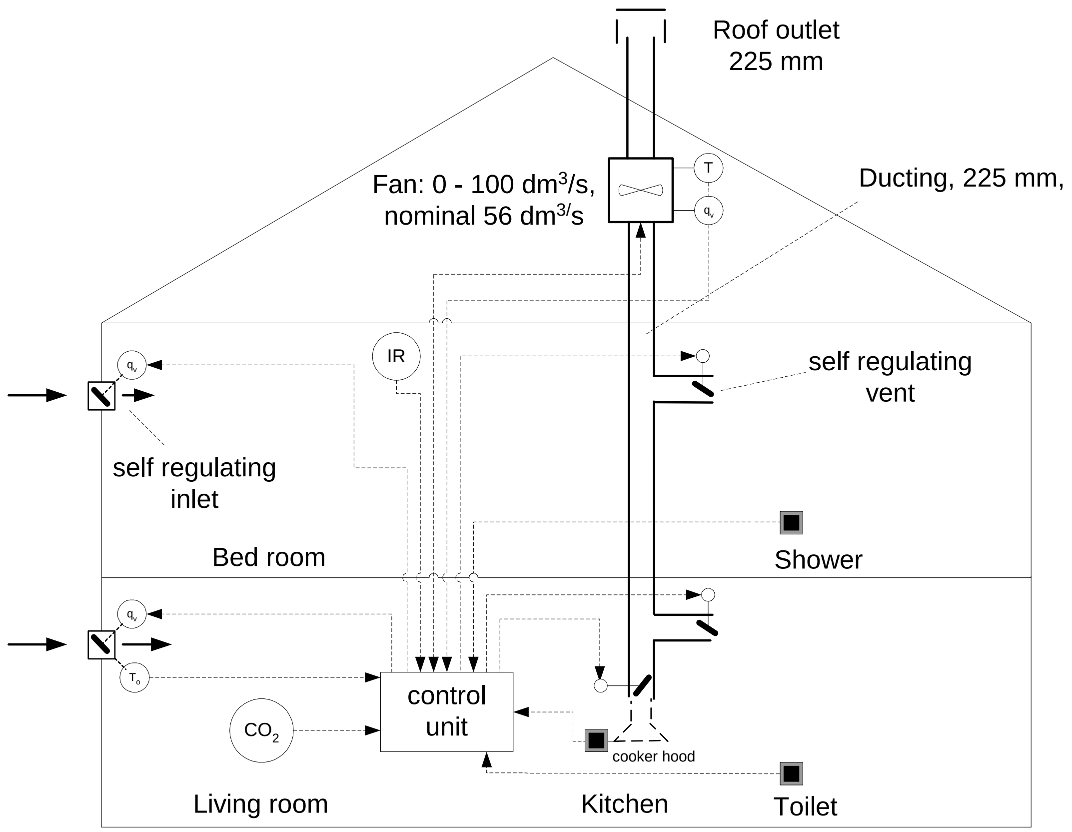

Figure 1: demand controlled hybrid ventilation system in family house.

Supply

The supply inlets comply with the following requirements:

- Self-regulating inlets;
- Placement in window frame;
- Draught correction (comfort);
- Allow for (separate) cooker hood, compensation of supply during use of hood by control unit;
- Possibility for passive cooling (through ventilation) through extra fixed inlet with larger geometric aperture;
- Building leakage compensation on inlets.

Distribution

The distribution components will comply with the following requirements:

- Pressure drop over ducting @ 56 dm^3/s maximum 2 Pa;
- Ducting round maximum 225 mm;
- Improved coupling fittings;
- Limited noise propagation (cross transmission of noise) especially with regard to fan;
- Special fittings for apartments with individual units on central exhaust;
- Development self-regulating vents at approximate 5 Pa pressure difference with controllable flow rate.

Fan
The fan complies with the following requirements:

- Energy consumption fan: 1 – 2 W @ 56 dm^3/s and 10 Pa (nominal flow);
20 W @ 100 dm^3/s and 40 Pa (excess for cooker hood, shower or limited passive cooling);
- DC power supply and controls, max. 1 - 2 W energy consumption;
- Low speed fan, max. 800 rpm;
- Low noise generation;
- Limited noise propagation especially with regard to large size ducting;
- Flow controlled.

Roof outlet
The roof outlet will comply with the following requirements:

- Optimized for wind conditions;
- Max. static pressure 1Pa;
- Condense water drain or provisions to prevent the formation of condense water;
- Rainproof.

Control
The controls comply with the following requirements:

- Demand control;
- Limited investment costs;
- Minimum energy consumption, 1 - 2 W continue.
- Temperature control (passive cooling), outside temperature through self regulating inlets and inside temperature through sensor at fan system;
- Possibility for overruling system by inhabitant;
- User-friendly interface for control by inhabitant.
- Minimum wiring, e.g. sensor position near inlet;
- Indoor Air Quality controllable at several levels of CO_2 concentration*.

* Note: with regard to energy saving this is only interesting during the heating season. During summer the control strategy should strive to minimize the CO_2 concentration at maximum thermal comfort.

LABORATORY PROTOTYPE

To test the several components a prototype ventilation system has been mounted, see figure 2. In this test facility the same duct lay-out has been used as intended in the single family house shown in figure 1. As the influence of wind could not be tested simple inlet valves have been used instead of self regulating inlets and self regulating vents.

Two fan prototypes will be tested. The first prototype had a relatively high speed. Due to the high speed the noise production was relative high. A second prototype, with a lower speed, is developed. The test results of this low speed fan integrated in the prototype ventilation system are not available yet.

Figure 2: measurements on laboratory prototype.

EVALUATION ENERGY CONSUMPTION

The (fan) energy consumption of a ventilation system is determined by the following factors:

- Flow rate;
- Pressure drop over the flow elements;
- Fan efficiency;

To evaluate the energy consumption of ventilation systems often the concept of Specific Fan Power (SFP) is used, unit kW/(m^3/s). The SFP can be determined with the following equation:

$$SFP = \frac{Q}{q_v} = \frac{\Delta P}{\eta}$$

Q = fan energy consumption [kW]
q_v = flow rate [m^3/s]
ΔP = pressure drop [kPa]
η = fan efficiency [-]

In table 1 the SFP for a conventional ventilation system and the TIPVENT system are compared with the RESHYVENT prototype. As the duct size has been enlarged from round 125 up to round 225 mm and the duct lay-out has been optimized it is expected that a further reduction in pressure drop becomes more and more difficult. Clearly most space for improvement can be found in the fan efficiency.
In case of a hybrid ventilation system the energy consumption can be reduced further by making use of the wind pressure and the stack effect. For these effects the low pressure drop is advantageous.

Another observation is that the power consumption of the fan power supply (approximately 10 W) and the control system (e.g. CO_2 sensors) becomes more and more important.

TABLE 1
Fan energy consumption for several ventilation systems and Reshyvent prototype I.

	Flow rate [m^3/s]	Fan power Q [kW]	Fan efficiency η [-]	Pressure drop ΔP [kPa]	SFP [$kW/(m^3/s)$]
Conventional	0.042	0.03 – 0.04	0.05 – 0.07	0.050	0.7 – 1.0
Tipvent	0.042	0.007	0.18	0.030	0.17
Reshyvent I	0.056	0.0036	0.23	0.015	0.064

CONCLUSIONS

A demand controlled hybrid ventilation system has been developed. A prototype of the system is characterized by a Specific Fan Power (SFP) which is half of which has been achieved in the TIP-VENT project. Compared to the systems currently used in Dutch dwellings the SFP is nearly a factor 16 lower.

To meet the project targets a further reduction of fan power is required.

The energy consumption of the fan power supply is larger than the energy consumption of the fan. New energy efficient power supplies and CO_2 sensors are required.

REFERENCES

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