PERFORMANCE OF VENTILATION SYSTEMS IN A DAY-CARE CENTRE

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Abstract

The performance of four ventilation systems placed in the same building and equipped with plate heat exchangers were examined during winter and spring of 2012. In addition to temperature measurements supply and exhaust air flows measurements were performed. The result shows, that the measured supply and exhaust air flows differ from the design values. Furthermore, the efficiencies of the ventilation units differ from the estimated. Although, the units are placed in the same location (e.g. one building) and therefore subject to approximately similar conditions, their performance is not comparable when the amount of measurements, when the damper is open or closed and when the reheater is turned on or off amongst the different ventilation units, is taken into account.

Keywords: Plate heat exchanger, efficiency, air flow, damper, reheater, performance.

1 Introduction

If energy savings are to be taken both in new buildings and in existing buildings the performance of the ventilation system is one of the significant factors. In both new and existing buildings the most significant factor regarding energy need for ventilation is the installing of a heat recovery. Other influencing factors on the energy use (and indoor climate) are the air flow and the operating mode. The performance in the operating stage is important to study, among other things to compare to the design values. Long term temperature measurements to determine heat exchangers efficiencies have been conducted by Bagge et al [1], Steen Larsen et al [2] and instantaneous temperature measurements have been conducted by Sikander et al [3]. In a day-care centre with four departments four identical ventilation units for mechanical supply and exhaust ventilation have been installed. The objective of this study is to study the performance of the ventilation system including the efficiency of the heat exchangers, the air flows and operating modes.

2 Method

2.1 Building and ventilation system

In a day-care centre with four departments four mechanical supply and exhaust air systems have been installed. Each department has one unit, which includes; plate heat exchanger, filtration, fans and reheater. The plate heat exchangers have dampers that, when open, prevent frosting during winter and allow bypass during summer. All four ventilation systems are CAV-systems. The day-care centre is a low-energy building, heated with supply air and a floor heating system.

2.2 Measurements of temperatures, air flows and operating modes

Measurements of exhaust, supply, exit (after the heat exchanger) and outdoor air temperatures have been conducted. Measurements of exhaust, exit and outdoor air temperatures have been performed in the ducts leading to and from the ventilation units. The supply air temperature is measured after the plate heat exchanger but before the reheater. Additionally, the outdoor air temperature has been measured on the north façade.

The temperature measurements outdoor and in the ventilation units and/or in the connecting ducts have been conducted between the 4th of February and the 6th of June 2012 with 5 minute intervalls using temperature loggers (Hobo U12-013).

Pressure measurements [4] over each supply and exhaust air device was conducted with mikromanometer. Calculation of corresponding air flows was performed.

The measurement errors magnitude, for the efficiency, has been determined using error propagation for systematic errors [5]. The temperature loggers have a measurement accuracy of ±0.35 ^{o}C in the specific area of measurement.

When temperature measurements are conducted it is also registered whether or not the damper is open or closed and if the reheater is on or off.

3 Results

3.1 Temperature and air flow measurements

Only the temperature measurements conducted on weekdays, during daytime hours (09.00–17.55), when the ventilation unit's reheaters were turned off and the dampers were closed were used to calculate the ventilation units' efficiencies.

Fig. 1 shows exhaust, supply and exit air temperatures corresponding to and sorted after outdoor temperature for the four different ventilation units during operating hours when the damper is closed and the reheater is off.

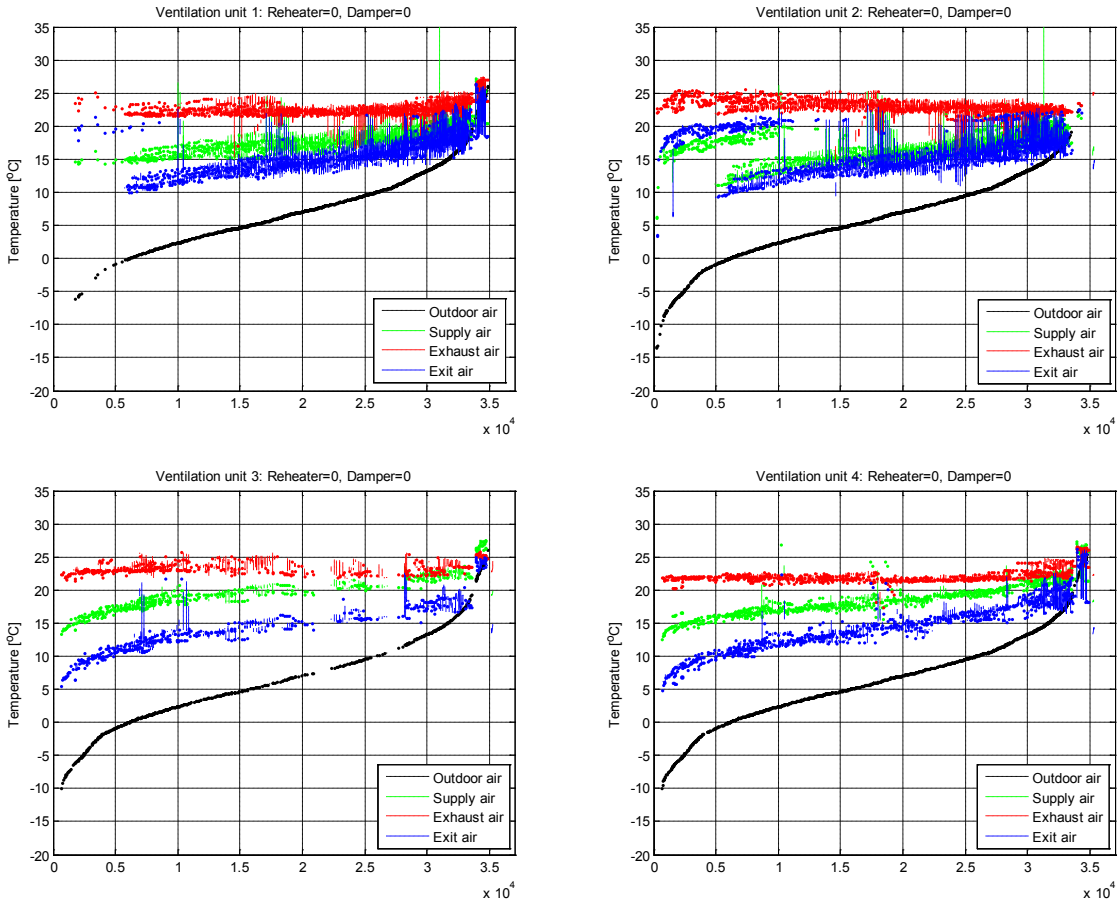

Fig. 1 *Measured temperatures during operating hours for the four different ventilation units.*

When determining the supply and exhaust air flows for the different units it was found that the units 1, 3 and 4 had supply and exhaust air flows in relative balance. Unit 2 had a greater imbalance. Tab. 1 shows the design values and measured air flows for the different departments.

Tab. 1 *Supply and exhaust air flows.*

	Design value of supply air flow [l/s]	**Measured supply air flow [l/s]**	**Design value of exhaust air flow [l/s]**	**Measured exhaust air flow [l/s]**
Department 1	245	184	235	193
Department 2	245	119	235	234
Department 3	215	202	210	209
Department 4	235	203	235	207

3.2 Calculations

Due to temperature gradient over the plate heater cross section [6][7][8], the supply air temperature is not used when calculating the ventilation units efficiencies. Instead the exhaust air efficiency has been calculated and then adjusted to each departments measured exhaust and supply air flows [9], giving an air flow adjusted supply air efficiency.

Due to the operation mode the dampers and the reheater being separate for each of the different ventilation units, the points of measurements used for the calculations has varied.

Tab. 2 *Heat exchanger efficiencies when reheaters are off and dampers are closed and number of measurements.*

	Efficiency [1] (mean)	Efficiency[1] (median)	Efficiency[2] (mean)	Efficiency[2] (median)	Measure-ments
Ventilation unit 1	0.55±0.07	0.56±0.06	0.50±0.07	0.51±0.06	6 386
Ventilation unit 2	1.1±0.07	1.2±0.05	0.55±0.07	0.58±0.05	6 183
Ventilation unit 3	0.54±0.06	0.55±0.04	0.51±0.06	0.52±0.04	1 364
Ventilation unit 4	0.51±0.07	0.53±0.06	0.50±0.07	0.52±0.06	2 520

1) Calculations based on measured air flows
2) Calculations based on design value air flows

3.3 Efficiency according to the manufacturer

The expected air flow adjusted efficencies given by the program supplied by the manufacturer shows that the efficency should assume values between 0.77–0.87.

3.3.1 Operating modes

The consistency of that the ventilation units damper can be open (flow is bypassed the heat exchanger) or closed and the reheater can be on and off, is that four different outcomes are possible. The distribution between these outcomes during the measurement period is shown in the Fig. 2.

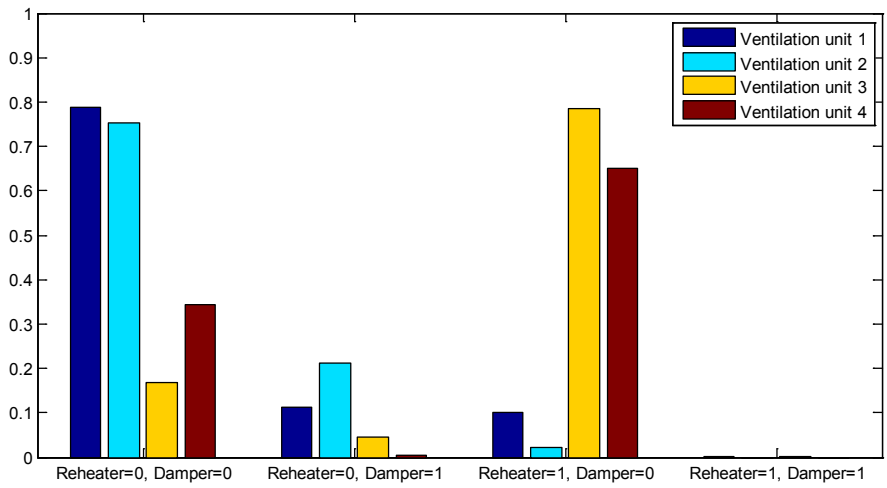

Fig. 2 *Ratio between measurement points in different possible cases due to operating modes*

4 Conclusions

The results show that the measured supply and exhaust air flows differ from the design values. Furthermore, the duration time of the different possible operating modes differ between the different ventilation units. And finally the ventilation units' efficiencies differ from the estimated.

5 Discussion

The results show that the measured air flows differ from the design values, especially for department 2, which has a substantial air flow imbalance and a supply air flow less then half of the design value. This affect the indoor environment and also the efficiency calculations that have been conducted. For ventilation unit 2, the efficiency has a value greater than 1, because of the air flow imbalance. When efficiency calculations have been conducted with measured temperatures but design value flows instead of measured flows ventilation unit 2 has an efficiency in the same magnitude as the other ventilation units. Effect of the air flow imbalance in ventilation unit 2 is also visible when operating modes are studied, this ventilation unit rarely has the reheater on, which in a missleading way can be recogniced as something positive if only energy use is studied.

It is interesting that the operating modes differ between the different ventilation units, as the four ventilation units are subject to approximately similar conditions. The departments that have windows facing northeast, has had reheaters turned on more often than those with windows facing southeast, maybe the differences could be explaned to some extent by greater solar gains in the southeast facing departments. All of the departments had under pressure despite the fact that the design values showed otherwise. The measured efficency differs significantly from that assumed by the program supplied by the manufacturer.

Acknowledgement

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