THE EFFECT OF ENTHALPY RECOVERY VENTILATION ON THE RESIDENTIAL INDOOR CLIMATE

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ABSTRACT

The indoor climate in residential buildings is affected by the people that live in the house and their activities. One of the goals of a ventilation system is to prevent excess humidity in the house by removing part of the moisture. The moisture balance can however be distorted in winter with a low humidity in the house as a result.

An enthalpy exchanger can be used in a recovery ventilation system to reduce the risk of very low indoor humidity levels in winter. While heat recovery ventilation (HRV) is recovering energy in terms of temperature, enthalpy recovery ventilation (ERV) is recovering energy in terms of both temperature and moisture.

In a house in Rotterdam, The Netherlands, the temperatures and humidities of the air streams in a recovery ventilation system were monitored. Eight day periods with HRV and ERV are compared with each other during mild outdoor conditions.

In the monitored house, the measured recovered amount of absolute humidity with ERV is about 1-2 g/kg with an average humidity recovery efficiency of 65%. In the monitored house, ERV brings the indoor relative humidity up to 10 percentage point higher than HRV.

The measured average thermal efficiency and humidity efficiency correspond well with the laboratory values from the specifications.

KEYWORDS

Enthalpy recovery, residential ventilation, indoor air quality, moisture balance

1 INTRODUCTION

The indoor climate in residential buildings is affected by the people that live in the house. The presence of people and their activities (like cooking and showering) and the presence of plants make the indoor climate rise in humidity. One of the goals of a ventilation system is to prevent excess humidity in the house by removing part of the moisture. The indoor air is replaced by winter outdoor air, which usually has a lower moisture content than the indoor air.

The moisture balance can however be distorted in winter (e.g. with high ventilation rate and very low outdoor air humidity) with a low humidity in the house as a result. An indoor relative humidity lower than 30% can affect our well-being as it causes dry throat or nose, and it can affect construction of the house or the (wooden) carpets or furniture.

An enthalpy exchanger can be used in a recovery ventilation system to reduce the risk of very low indoor humidity levels in winter. While heat recovery ventilation (HRV) is recovering energy in terms of temperature, enthalpy recovery ventilation (ERV) is recovering energy in terms of both temperature and moisture.

The effect of ERV can only be seen in houses that are air tight, and when there are moisture sources (cooking, showering, plants) in the house. Without any moisture sources there is nothing to recover, and there is no difference between ERV and HRV.

2 THE MONITORING SET-UP

Figure 1: The monitored house in Rotterdam

A house (fig. 1) in Rotterdam, The Netherlands, is ventilated with a balanced ventilation system. The air distribution system is a flexible circular duct system with separate channels leading to the rooms in the house. The ventilation unit is controlled by a main CO_2 control in the living room. The air flow rate is set to a minimum of 210 m^3/h and is increased automatically when the CO_2 level in the living room rises or as a result of a humidity sensor in the bath room.

In the winter of 2012 the ventilation unit was equipped alternately with a heat exchanger and an enthalpy exchanger. Unfortunately, the winter was a very short one with only two week period of cold sub-zero temperatures. In the cold period, the heat exchanger was used, but after placement of the enthalpy exchanger, the very low outside temperatures have not returned!

In order to compare the indoor climate for similar outdoor conditions, two periods of eight days were compared. These days had similar outdoor conditions with temperature between 5 and 10 °C and absolute humidity between 4 and 6 g/kg. During these periods, the air temperatures and humidities were monitored for each of the four air streams: outdoor air, supply air, extract air and exhaust air.

3 ENTHALPY RECOVERY

A heat exchanger is transferring heat between two air streams and therefore in winter the supply air stream is increased in temperature. An enthalpy exchanger is transferring heat between two air streams and also transferring moisture between two air streams. Therefore the supply air stream in winter is not only increased in temperature, but also increased in humidity.

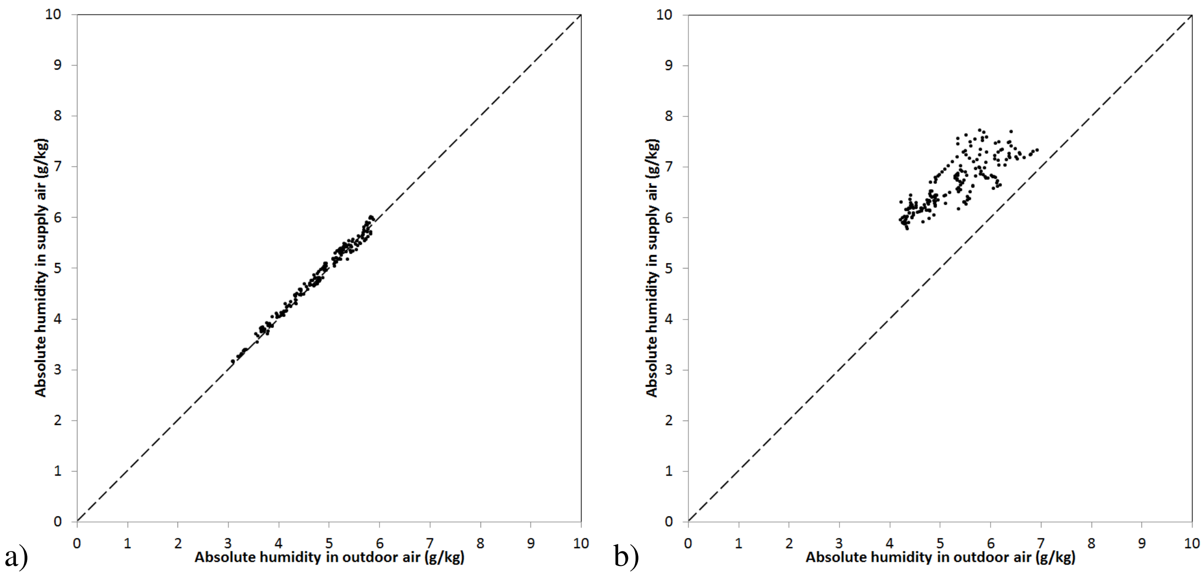

Figure 2: The effect of heat recovery (a) and enthalpy recovery (b) on the humidity of the supply air.

In fig. 2 the effect of heat exchanger (HRV) and enthalpy exchanger (ERV) on the supply air humidity is shown by hourly averaged values in the 8-day period. The absolute humidity of the outdoor air is shown on the horizontal axis and the absolute humidity of the supply air is shown on the vertical axis. HRV (fig. 2a) has no effect on the humidity of the supply air, but for ERV (fig. 2b) it is apparent that the supply air is increased in humidity. This humidity is recovered from the extract air, and thus from the humidity in the house.

The average increase of absolute humidity in the supply air is about 1 – 2 g/kg. For a typical ventilation air flow of 150 m^3/h this means a recovery of 4 – 8 liter of water per day.

4 THE INDOOR CLIMATE

In fig. 3 the hourly values of temperature and humidity levels are shown in Mollier diagrams for the 8-day periods with heat exchanger (fig. 3a) and with enthalpy exchanger (fig. 3b).

Focusing first on the supply air stream, the air coming from outside is expressed with green dots and the supply air just after the exchanger is expressed with red dots. Fig. 3 shows that for HRV the temperature is increased by heat recovery to a level of 20 °C, almost the indoor temperature. For ERV, the same is happening for the temperature, but also the moisture level is increased as indicated by the black arrow that is slanted to the right.

In fig. 3 the extract air from the house is expressed with yellow dots, and it is shown that for the same outdoor conditions, the indoor humidity is higher when the enthalpy exchanger is used. For HRV, the indoor relative humidity varies in this (relatively mild) period between 35% and 45%, while for ERV the indoor relative humidity varies between 45% and 50%.

From this we can conclude that the use of ERV increases the indoor relative humidity in winter up to 10 percentage point, with HRV as reference.

a) b)

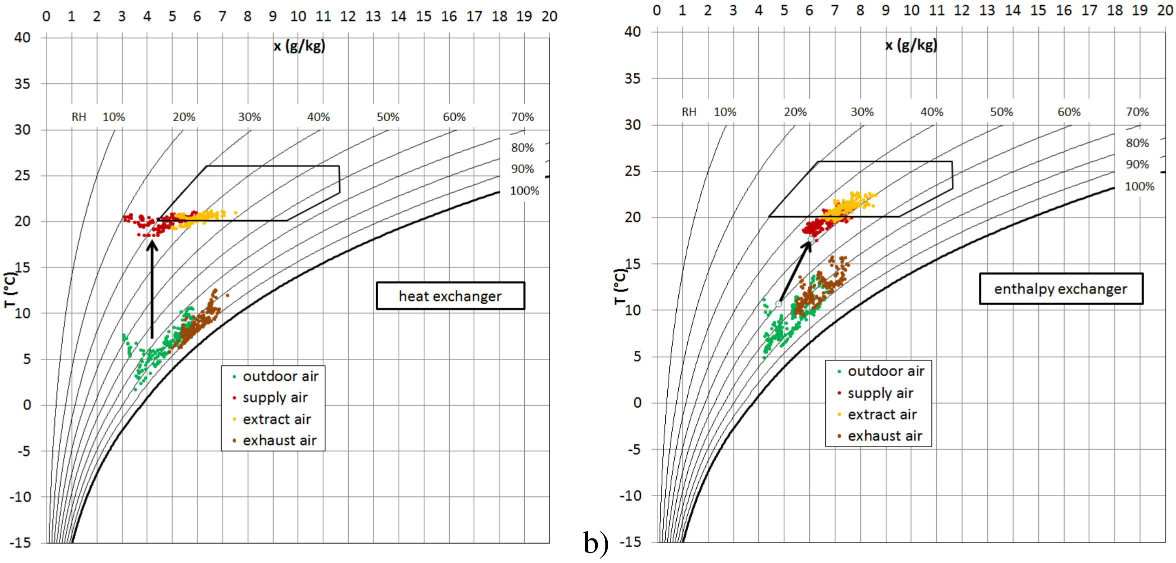

Figure 3: The effect of a heat exchanger (a) and an enthalpy exchanger (b) on the supply air and the indoor air.

5 RECOVERY EFFICIENCY

For the whole monitored winter the efficiencies are summarized in table 1. The thermal efficiency η_{th} can be calculated from the temperatures T and the humidity efficiency (or latent efficiency) η_{hum} can be calculated from the absolute humidities x according to the following formulas.

$$\eta_{th} = \frac{(T_{supply} - T_{outdoor})}{(T_{indoor} - T_{outdoor})} \quad (1)$$

$$\eta_{hum} = \frac{(x_{supply} - x_{outdoor})}{(x_{indoor} - x_{outdoor})} \quad (2)$$

For the heat exchanger, the average thermal efficiency is 89% for mild outdoor temperatures. With cold outdoor air, condensation in the return air of the exchanger may be formed and the flow of return air maybe partly blocked, with the effect that the thermal efficiency drops to 70% in condensing states. As the heat exchanger does not transfer moisture, the humidity efficiency is zero.

For the enthalpy exchanger, the measured thermal efficiency has an average value of 88%, while the humidity efficiency is averaged to 65%. These values correspond well with the values in the specifications.

Table 1: Thermal efficiency and humidity efficiency of the two exchanger types.

Exchanger type	**Thermal efficiency**	**Humidity efficiency**
Heat exchanger	89% (non-condensing) 70% (condensing)	0%
Enthalpy exchanger	88%	65%

6 CONCLUSIONS

Ventilation removes stale air, and therefore also humidity from the indoor climate of a house. In winter, the moisture balance may be distorted causing relatively dry indoor climate, because dry outdoor air is entering the indoor climate. An enthalpy exchanger recovers a part of the humidity from the extract air to the supply air, helping to maintain the moisture balance.

In the monitored house, the recovered amount of absolute humidity is about 1-2 g/kg. Therefore, the use of enthalpy recovery brings the indoor relative humidity up to 10 percentage point higher than the use of heat recovery (for instance from 35% to 45%). In the monitored house, the thermal efficiency and the humidity efficiency correspond well with the values from the specifications.