Contract No. 212206

Cost-Effective

Resource- and Cost-effective integration of
renewables in existing high-rise buildings

SEVENTH FRAMEWORK PROGRAMME
COOPERATION - THEME 4
NMP-2007-4.0-5 Resource efficient and clean buildings
Grant Agreement for: Collaborative Project
(ii) Large-scale integrating project

D3.4.2 Natural ventilation system with heat recovery Prototype Report

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Organisation name of lead contractor for this deliverable: TNO - Piet Jacobs

Revision [2] – 13/05/2011

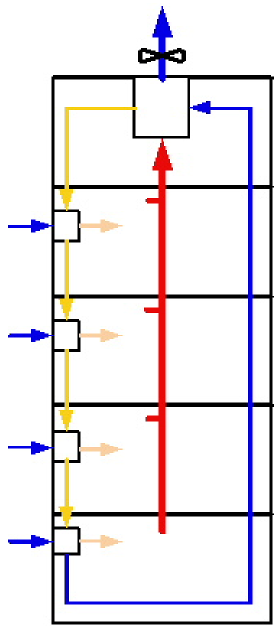
Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	√
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (incl. the Commission Services)	
CO	Confidential, only for members of the consortium (incl. the Commission Services)	

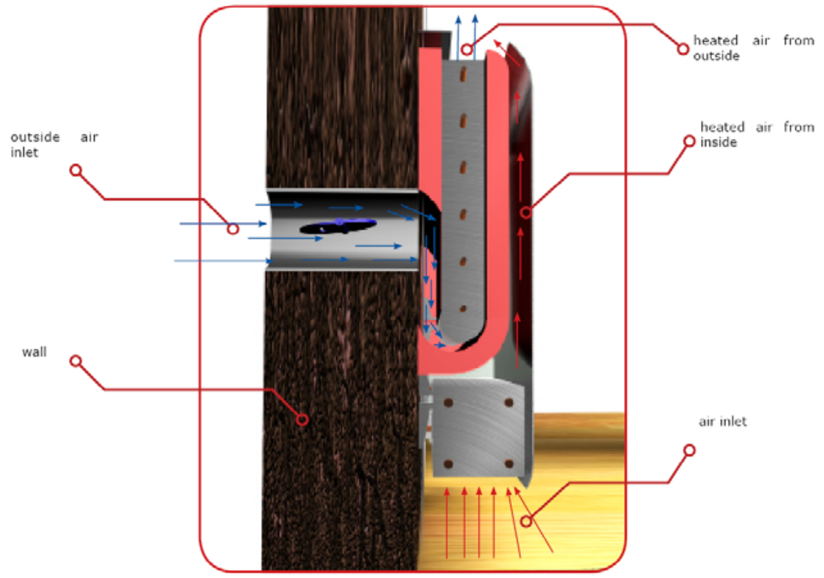
Introduction

To regain heat from the exhaust air in the existing stock a new ventilation concept has been developed. It consists of natural supply through ventilators in the facade and mechanical exhaust of air (see figure 1). In 2007 patent has been applied. The system exists of at least two heat exchangers. One heat exchanger is placed at the end of the existing mechanical exhaust duct just below the roof and gains heat from the exhaust air. The heat is transferred to water and transported to the heat exchangers placed in the façade. With the heat the supplied outside air is preheated.

Specifications for the prototype façade unit:

- Flow rate 10 – 25 dm^3/s @ 1 Pa
- Heat recovery efficiency 75%
- Maximum dimensions: 60 cm height
- Combination with radiator/convector advantageous
- Easy to clean
- Anti-frost security
- Water and wind proof
- Suitable for renovation

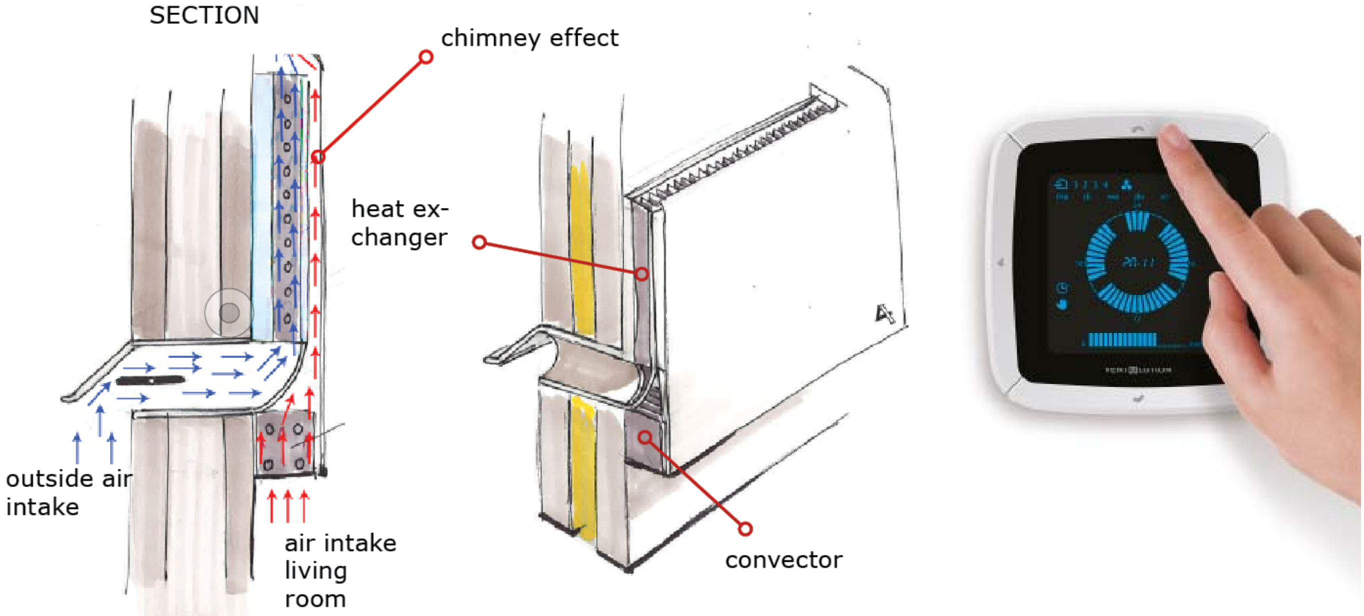




1. Ventilation concept on building level; 2. Schematic drawing of the prototype

The façade heat exchanger is the main challenge. Several heat exchangers have designed, manufactured and tested in the TNO lab. In parallel Alusta has performed a study to optimize the functionality of the façade unit, see figure 2. A convector has been integrated for room air heating. The specific alignment of both heat exchangers has led to a new patent application. Moreover special attention has been given to the thermal insulation of the heat exchanger, resulting in the use of vacuum insulation panels.

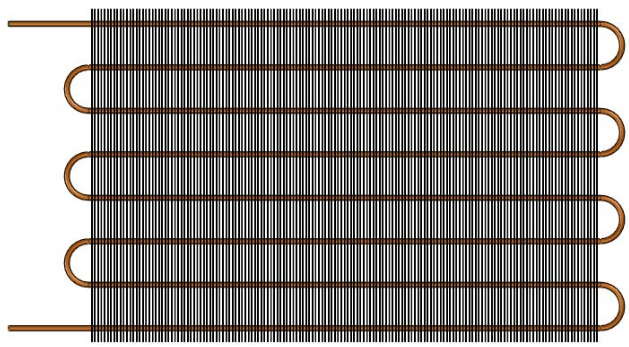
Results



3. Cross sections and control

A structured design study has led to the concept in figure 3. It consists of a single coil finned heat exchanger to preheat the outside air. The amount of preheating can be adjusted to the needs of each individual room. Outside air is transported by two outside air inlets in the façade. The amount of ventilation air is controlled by a valve based on the CO_2 concentration measured in the room air. On the bottom the facade unit contains a convector for room air heating. The patented position (2010) of the convector permits an optimal chimney effect, which is beneficial for the heating capacity and the compactness of the unit. Appendix A contains more renderings which describe the working principle of the unit.

The target of 75% for the heat recovery at 1 Pa pressure drop over the façade unit has been full filled with a finned single coil heat exchanger, see figure 4 and 5.

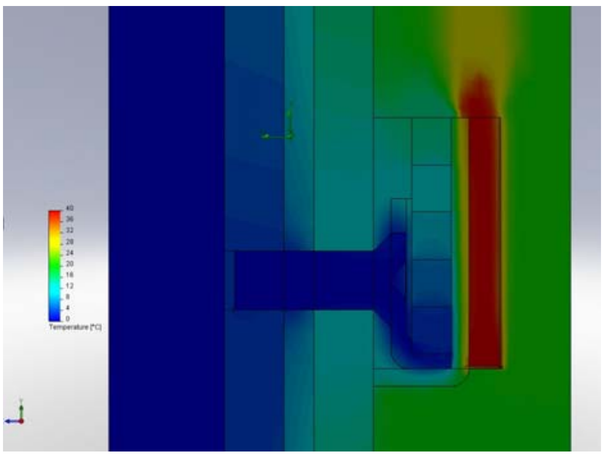


4. Principle of a single coil finned heat exchanger; 5. Tested heat exchanger.

The convector is used to heat the interior air to a comfortable level. The convector has to be small to maintain a slender design but still large enough to be able to transfer enough heat to the ambient air. The convector, see figure 6, has a heating capacity of 1200 W/m at 75/65/25 ºC (NEN-EN442).

6. The convector

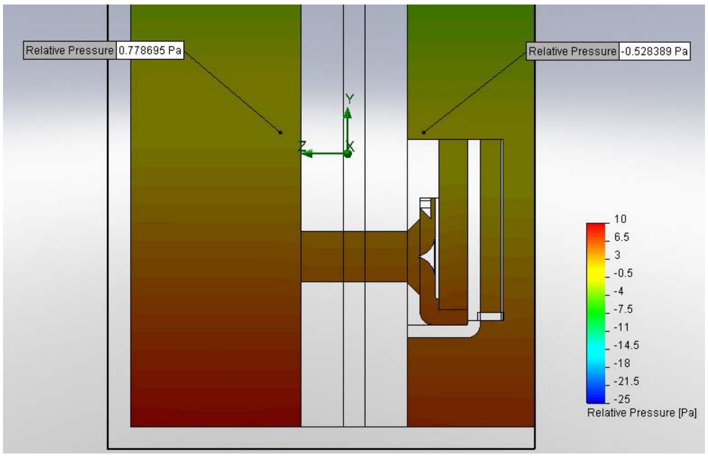
The insulation around the heat exchanger is essential to reach a high heat recovery efficiency. Heat absorption from the room in stead of heat delivered by the exhaust heat exchanger spoils the heat recovery efficiency. Moreover “cold spots” with temperatures below the dew point of the room air can lead to condensation problems. For this reason with the program “Solids works Flow Simulation” CFD simulations have been carried out to calculate in 3D the heat loss and wall temperatures at several insulation levels, see figure 7 for an example. To reach sufficient insulation between the convector and heat exchanger vacuum panels have been used, see figure 8.



7. CFD plot of temperature

8. vacuum insulation sheet between heat exchanger and convector chimney

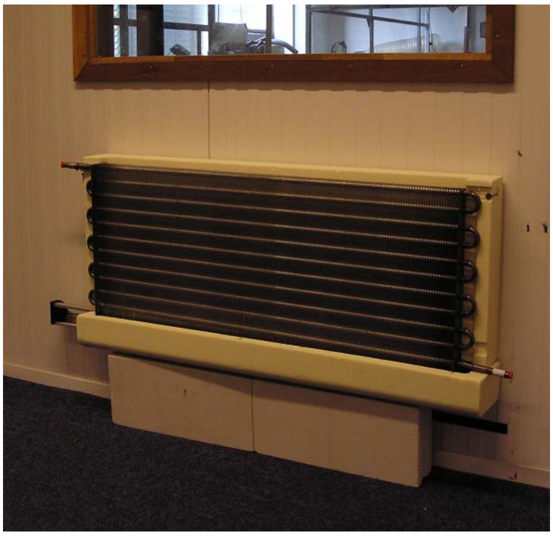
With the same CFD program simulations have been carried out to minimize the air side pressure drop, see figure 9 for an example. This has led to an design with minimal air side pressure drop.



9. CFD plot of air pressure

Based on the CFD simulations an insulation package has been developed, produced and assembled from PIR and vacuum insulation panels.

10. Insulation package and self regulating valve



11. Prototype with heat exchanger

Conclusion

During the design process several choices have been made. From the initial idea the concept evolved with the patented integration of room heating capacity. To meet the pressure drop and temperature efficiency requirements for heat recovery in the laboratory 4 different types of heat exchangers have been tested. The finned type proved to be the only type that could meet the stringent requirements. With the use of CFD tools an insulation package has been developed, produced and assembled from PIR and vacuum insulation panels.

The system is ready for the Long-term laboratory test (T4.7). In these tests the control strategy and the functioning of the system will be tested over a longer period. Based on these results further steps will be taken towards commercialisation.

Disclaimer
Cost-Effective is a Collaborative Project (CP) funded by the European Commission under FP7 COOPERATION - THEME 4 – ‘NMP-2007-4.0-5 Resource efficient and clean buildings';
Contract: 212206 Start date of Contract: October 1st 2008; Duration: 4 years

Appendix A: 3D renderings