“Breathing Window”
a new healthy ventilation

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ABSTRACT: The breathing window is a smart decentralized low energy ventilation in the skin (envelope) of buildings. A fine-wire heat exchanger is a unique innovation for different low temperature applications in all climates dwellings and glasshouses. It is far from easy to describe the conditions for ventilation for all types of buildings all over the world. The change from natural to forced, mechanical ventilation is fundamental. We did add to the mechanical ventilation a lot of new requirements, like heating and cooling (air-conditioning) vaporisation and dehumidifying, balanced ventilation, heat recovery, filters for the incoming (fresh) and outgoing (exhaust) air, fire compartmentalization and the installations became larger and larger all the time.

The smart breathing window concept does work slightly different. The breathing window is a kind of miniature decentralized small-scale ‘whole-building air-conditioning’. This individualised balanced ventilation in each room at the façades of the building is a kind of thinking lungs care for your health when you forget it. It measures and corrects e.g.: CO2; it can measure radon and combines temperature at day- and night-time, etcetera. I will present and show the first working prototype of this breathing window, which might be the beginning of the end of traditional mechanical ventilation in many types of buildings.

Conference Topic: 2 Design strategies and tools
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STARTING WITH PRESENT INSTALLATIONS

Studies on ventilation in housing, commercial and industrial building in the Netherlands show an incredible difference between the intentions and what is achieved in practice.

Key-features are: concept, design, saving, execution, control, adjustment, use and maintenance.

In every phase mistakes can be made and actually are being made, which in general are camouflaged by over dimensioning. [1].

In the conceptual (draft) phase the architect should design the overall indoor climate in a crosscut fashion, phrase this and explain it to the principal and the installation consultant. In practice it usually does not work this way. The help of consultants and experts is invoked, without much mutual contact.

Without affecting the layout heating, ventilation and air conditioning systems are drafted by advisors and usually concealed in lowered suspended ceilings. The internal thermal mass of the building is for a major part put out of action. Besides these lowered suspended ceilings claim 15% more building volume. In order to conceal air ducts. The building itself should be the main part of the installations. [2]

Figure 1: Standard installation – cross section.
At the estimation before or after the contract, the ventilation is sometimes curtailed. The suddenly required fire compartmentalization is a well-known phenomenon in the last phase before the building permit is granted.

Gradually we arrive at the actual building process on the building site.

2. NEW AND TRADITIONAL PROBLEMS

2.1 Realisation

In order to achieve a good spatial execution of two-dimensional drawings within the nowadays-usual technical communication, a translation is needed more and more between spoken and written specifications. The understanding between the various nationalities on building sites is a new phenomenon in the European Community. The control-system, the different installation manuals, communication with end-users and the reporting of technical failures are no standard procedures so far. The adjustment conform performance measurements is not always feasible. Airstreams turn out to be ‘naughty’, like children; they do not always follow the designed direction and velocities are difficult to measure. Temperatures are measurable, but there is the distinction between air temperatures and more perceptible radiation temperatures, and the average of the two is the temperature we feel.

It is very important for the wellbeing of the inhabitants / users of the building in later stages, that forced ventilation is used in new buildings that still have to dry out, smell like wet concrete, radon gases, paint and synthetic carpeting.

2.2 Use and Maintenance

When everything has gone well, a long period of use and maintenance follows. According to research (De Haas / T.N.O. 2003) it appears that heat exchangers in houses with balanced ventilation are hardly maintained and get clogged up with dust eventually.

It also appears that almost two-thirds of mechanical ventilation as prescribed in the regulations is not achieved in almost new draught-free built houses without opening windows.

In general the average user has no idea of technical installations. In large buildings, which are mechanically ventilated, the ‘sick building syndrome’ is a well-known phenomenon. People feel locked up in non-compliant technology. These complaints are sufficiently remedied by the opening of windows, but the question arises: don’t we have to look for fundamentally different ventilation systems?

3. THE IDEA AND THE METHODOLOGY OF THE DEVELOPMENT OF NEW DECENTRALISED VENTILATION

3.1 We start again from the very beginning.

Every person inside a building needs fresh air. How can we fulfil this individual need all around the world, in all climates, all seasons, in all different types of buildings, with different orientation and sometimes extreme circumstances: varying from traffic noise, sand-, and snowstorms, flies and/or mosquito’s and with extreme high and/or low temperatures?

By using the skin of the building to breath, like insects do. Most office buildings for instance, have large outer wall surfaces that can be used. What we want is a high-tech breathing window!

The shape, dimension and capacity of a breathing window still are unknown:

Figure 3: First generation prototype design.

The limits for healthy air quality start at 20 to 25 m$^3$/fresh air pph. Two persons per room 50 m3/h is put as limit for a breathing window unit.
Vertical position is better for the temperature stratification and to solve the condensation and icing problem in cold climates. The expected personal attitude asks for almost daily contact with users to achieve good indoor air quality and cleaning capacity. ‘Build in’ breathing windows are in upright position easy to mount. With the second generation of the experimental breathing windows, the dimensions are changing slightly.

How this can be achieved and what form this will have is at the moment (April 2004) not entirely known yet. Optimization of the heat recovering to about 95% seems to be feasible.

What should be the driving force, which energy consumption is reasonable, and which noise level belongs to a certain air velocity?

It looks as if the fan(s) need to have a capacity of 6 to 7 Watt, resulting in a noise level below 35 dB.

There are three different possibilities of integration in the façade of several types of buildings: as part of transparent glass, as vertical window frame, or the most probable solution, as part of a closed panel or wall in new or even existing buildings.

The larger the vent hole, the lower the air velocity.

The noise production decreases, however the wind effects increase in high-rise buildings. When turning on the hood, or putting on the light in the toilet or bathroom, the balanced ventilation gets slightly disturbed and causes the necessary overpressure and resulting extra air supply.

And so we arrived at the realisation aspects.

3.3 Realisation of the first prototype

The basic idea behind the breathing window is a smart individual ventilation, which has almost all qualities of the larger centralised ventilation systems and little disadvantages. It is no hopeless mission to re-design and minimalise all parts of this ventilation system.

It is my personal opinion that a solution at micro scale can always be realised.

Five aspects are crucial:

- very high heat-recovery efficiency from the used ventilation air;
- extreme indoor and outdoor static air pressure differences;
- smart control in all parts of the world;
- customer friendly / hygienic aspects;
- low purchase and maintenance costs.

The worldwide search for the best heat exchanger in literature took years and to my great surprise ended on a website fine-wire heat exchanger designed by someone who lives 40 kilometres away from where I live.

The inventor, dr ir Noor van Andel needed a few months to convert the original water/air heat exchanger into an air/air heat exchanger. (He received an honorary doctorate of the University of Amsterdam for his oeuvre in 2001).

Being preoccupied by the name breathing window, I chose the measures of a window frame with a depth which is standard for the (Dutch) cavity wall + insulation of a traditional outside brick wall.

The breathing window consists of three main components:

1. balanced mechanical ventilation,
2. smart control system, and
3. fine-wire counter current heat-exchanger

Figure 4: Photograph of a prototype during testing.

3.2 Descriptions of the design

What measures, outward appearances and ventilation capacities the breathing window will have is still being investigated. The dimensions of the first generation prototypes are (DxWxH) 180/200/700 mm. [3]. The fine-wire heat exchanger fits easily into a standard dishwasher and therefore can be cleaned easily.

The breathing window functions very well together with natural ventilation, hybrid or completely balanced mechanical ventilation. The CO₂ sensor starts automatically, 500 ppm when addition to natural ventilation is needed, but also gives signal when at 1200 ppm (MAC value) doors and windows have to be opened for a healthy indoor climate.
The prototype became a compact transparent synthetic counter current heat exchanger 150/220/500 mm, composed of 15 km (length) 0.1 mm (diameter) copper wires, altogether weighing less than 1 kilogram. The weaving of the prototype on a washing drum however took three days.

4. VALIDATION OF MEASUREMENTS

According to the calculations the prototype, being tested in Iceland appeared to have an average heat-recovering efficiency of over 95% (the most upper curve). [4] This number of more than 95% efficiency calculated (the straight upper line) is some what flattering so one realises that some leakage in the heat exchanger exists.

The temperature meters on the reversible are accurate and simple to achieve high-energy efficiency. Temperature: T1 inside air/T3 fresh air incoming and T2 exhaust air/T4 outside air.

Two small reversible computerised fans could not cope with the extreme differences in air pressure (100-150 Pascal). During the test period we have easterly and westerly storm. The fans combine their capacity to keep the airflow in balance. Fan 1 (outer fan) runs fast reverse at storm leeward and also fan 2 cannot withstand the storm windward. The ventilation systems in large buildings also tend to lose their balance, as told me the director of a great ventilator factory.

By closing the horizontal air supply and -exhaust ducts with heavy winds, in these circumstances there will be enough natural ventilation anyway.

Figure 5: Results of half a day testing period in Iceland December 9 2003 in Iceland.

Figure 6: Schematic section over a building in the Dutch situation; winter day.

Figure 7: Schematic airflow in the night cooling after a hot summer day.

5. CONCLUSION

Although the breathing window is still in ‘statu nascendi’ it seems to be the right answer to the question of desired customised ventilation. Time will prove.

A coincidental – not foreseen advantage compared to the usual plate heat exchangers is that the fine-wire heat exchanger does hardly get frosted up. The explanation is not simple. Is it sublimation? Is the frost evaporation so short that the forming of ice does not take place? [5].

Applied in hospitals the fine-wire heat exchanger can easily be renewed to prevent infection.

The range of application is wide. For instance it fits into a specific small mounting in boats and caravans / mobile homes, and one can use it in offices for night cooling instead of air-conditioning. [6].

The CO2 meter is a very accurate smoke detector too, which signals fire alarm even before any smoke
develops. The weak point at the moment is the noise from the fans and positive displayment fans still are not available on the market. They have to be made.

The breathing window will be developed and produced in the coming years. According to the inspired people who work on it, we believe the breathing window will be the beginning of the end of the traditional mechanical ventilation systems in spaces situated at the outer walls of buildings.

REFERENCES


FOOTNOTE

At the time PLEA 2004 will be held, a student "with two right hands" Yannic Dekking will achieve his master degree as industrial design engineer at the Delft University of Technology. His final work is the second generation of the breathing window. This work ‘how to produce a breathing window’ can also be shown at Eindhoven.