A novel algorithm for demand-control of a single-room ventilation unit with a rotary heat exchanger

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Ventilation for renovated apartments

Centralized
- No space for ductwork
- Difficult to plan and install

Single-room ventilation
- Drilled installation
- Low fan power
- Local control of heat recovery

- Development with DTU: Rotary H.Ex. (Breathe 55) & Plate H.Ex. (Spiralflow)
Single-room unit w/ Rotary Heat Exchanger

Variable-speed fans

Sensors
  • Temperature, CO2, RH in exhaust
  • Temperature at all inlets/outlets

Plastic rotary heat exchanger
  • > 80% eff. @ 8 L/s
  • Variable-speed drive
  • Recovers heat and condensation

• Intended for dry rooms

Not drawn to scale.
Three control modes (priority from L to R)

Frost protection → Humidity control → Temperature control

- **Frost protection**:
  - **Toutdoor < 0 °C**: Yes → **Frost Control**
  - No → **RHindoor > 60 %**: Yes → **Humidity Control**

- **Humidity control**:
  - Yes → **Humidity Control**
  - No → **Temperature Control**

- **Temperature control**:
  - Yes
1st priority: Frost control

Below 0°C outside?

Calculate dew-point

Calculate indoor dew-point temperature, $T_{dp,\text{indoor}}$. Decrease heat recovery towards $T_{\text{exhaust}} = T_{dp,\text{indoor}}$. Find stable $T_{dp,\text{indoor}}$.

If yes, cycle unit off

Is supply air too cold?

$T_{\text{supply}} < T_{\text{supply,frost}}$

Yes

Turn off unit for 3 hours

No

$T_{\text{outdoor}} < T_{\text{outdoor,t-3h}}$

END / RESTART

START

$T_{\text{outdoor}} < 0 \, ^\circ\text{C}$

Yes

Frost Control

No

START
2nd priority: Moisture control

Humid indoors?

- **RH_{\text{indoor}} > 60\%**
  - Yes
  - **Humidity Control**
  - Reduce coupled heat + H_{2}O recovery
  - While \( T_{\text{supply}} > T_{\text{supply,min}} \)
  - Decrease heat recovery

Still too humid?

- Yes
  - **RH_{\text{indoor}} > 70\%**

STILL too humid?

- Yes
  - Use more ventilation
  - Ramp up ventilation rate
  - **RH_{\text{indoor}} > 85\%**
  - Yes
    - Ramp up exhaust airflow only
  - No
    - END / RESTART

- No
  - Ramp up exhaust airflow only
3rd priority: Temperature control

Unknown set-point on room thermostat

Too warm? Decrease heat recovery.

Poor IAQ, too-high CO₂? More airflow!

Is there cooling potential?

Take the highest demand for airflow

Hourly average Toutdoor > 18°C

Cooling Mode for 24 hours

Tindoor > 22°C

Ramp down heat recovery

Yes

No

Heating Mode

Tindoor > 25°C

Ramp down heat recovery

Yes

No

Tindoor > 25°C & CO₂ > 850 ppm

Ramp up ventilation rate

Yes

No

Tindoor > 25°C & Toutdoor < 22°C

Compare and take maximum airflow rate

Yes

No

CO₂ > 850 ppm

Yes

No

END / RESTART
Current activities & next steps

• Algorithm written in C code, installed in commercial units
• Simulating controls in IDA-ICE
• Experimental tests
  • Between chambers
  • Test offices at DTU
Thanks for your attention. Questions?

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Uncoated rotary heat exchanger (a.k.a. Heat Wheel)

Drying capacity = 1.76 g H₂O per kg AIR

Source: Smith and Svendsen (2016) *The effect of a rotary heat exchanger in room-based ventilation on indoor humidity in existing apartments in temperate climates*
Concept for a demand-controlled system

Use existing direct exhaust from ‘wet rooms’
- Central rooftop fan + local VAV dampers
- Bathroom
  - Adjusts according to RH
  - From fully-closed up to > 15 L/s
- Kitchen
  - Boosted by high humidity & temperature
  - From fully-closed up to > 20 L/s

Kitchen single-room rotary unit
- Background ventilation of 0.3 L/s/m²
- Increased airflow according to CO₂ + RH
- Temperature control on heat recovery

Source: http://www.sustainsolutions.dk/breathe-55-decentral-komfort/