Temperature and Humidity Individual Controll HVAC System with the New Desiccant Device – DESICA-

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Annex 40 Workshop
The effectiveness of the Temperature and Humidity Individual Control (THIC) HVAC System Using VRF and Heat Pump Desiccant
1. Background
2. Introduction of the New HVAC System
3. VRF Technology Specializing for the Sensible Heat Load
4. High Performance Heat Pump Desiccant System
5. The Demonstration Test
6. Evaluation of the Whole Year Operation
7. Case Study
8. Conclusions
GHG emission in commercial buildings increased by 66% in last two decades in Japan

- GHG emission in commercial section has increased roughly 66%
There are two types of approaches for ZEB.

- **Passive method**
  Consumes really small (sometimes zero) energy.
  Necessary to built the tip top high quality buildings.

- **Active method**
  Consumes some amount of energy.
  Can be installed in various conditions/sites.
  Requires less designing work in installations.
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To achieve ZEB, the energy consumption required for the air conditioning should be reduced by 72%.

* Required Energy Conservation for Air Conditioning to Achieve ZEB *
Area: Nihonbashi, Tokyo
Floor Space: About 3000m²
Story: 8F
Usage: office

Back Ground

Most of the air-conditioning load occurs in less than 50% of the peek load.

Annual distribution of the partial air-conditioning load required
Introduction of the New HVAC System

THIC can achieve higher performance in each of the sensible or latent heat treatment

- Temperature control (Higher evaporating temperature)
- Humidity control (Use Humidity sensor)

Higher sensible heat capacity
Multiple split air-conditioning system “Variable Refrigerant Flow (VRF)”

Highly Effective Compact Desiccant Unit “Heat Pump Desiccant (HPD)”

• For temperature, performance improvement was easily achieved by raising evaporating temperature.
• For humidity, we focused on desiccant technology to achieve high performance.
VRF Technology Specializing for the Sensible Heat Load

In partial load operations, the performance of VRF can be improved drastically by the adoption of low temperature/pressure difference operations.

![Diagram showing the comparison between conventional VRF and Sensible Capacity Enhanced VRF. The diagram illustrates the changes in pressure and enthalpy levels, highlighting the benefits of raising the evaporative temperature and lowering the condensation temperature for improved energy consumption and cooling capacity.]
By raising the evaporative temperature, the efficiency of VRF is improved but dehumidification capacity becomes low.
VRF Technology Specializing for the Sensible Heat Load

The development of new compressor prevent the drop of the compressor efficiency in the low load operations.

![Graph showing efficiency of compressor vs. compressing ratio](image_url)
The development of new compressor prevent the drop of the compressor efficiency in the low load operations.
VRF Technology Specializing for the Sensible Heat Load

Calculated performance behavior in accordance with the ambient temperature and load factor.
VRF Technology Specializing for the Sensible Heat Load

Measured performance is much higher than the conventional VRF in partial load operation as calculated.
High Performance Heat Pump Desiccant system

The desorption heat required in the conventional desiccant system have to be provided on the air before the adsorption rotor and it makes the temperature very high.

*Conventional Desiccant Dehumidifier with Two Rotors*

Outdoor Air at Point 1

- Dehumidified by Adsorption rotor (Point 2)
- Cooled by Sensible heat recovery rotor and
- Supplied to Indoor (Point 3)
High Performance Heat Pump Desiccant system

The new device with the adsorbent coating on the surface of the heat exchanger enabled the direct cooling and heating of adsorbent.

*New Type of Heat Exchanger Combined with Adsorbent*

Hybrid desiccant Element (HDE)

- HDE FIN
- Normal Cross-fin
- Adsorption rotor
- Heated Coil
Dehumidification

Every each interval 4way valve

Humidity of the outdoor air is adsorbed

The humidified air is exhausted to outdoor

High Performance Heat Pump Desiccant system

Humidity of the outdoor air is adsorbed

The humidified air is exhausted to outdoor

Every each interval
4way valve (refrigerant), Damper (air)
High Performance Heat Pump Desiccant system

The HP desiccant is realized with 2.5 times higher performance and 1/3 of compactness.

Structure of HPD
The Demonstration Test

The demonstration test was conducted in the office space in Nagoya university

**THIC system**
- Indoor unit $\times 4$
- Humidifiable HRV $\times 2$
- $151.2m^2$
- Occupant: 12

**Conventional system**
- Indoor unit $\times 3$
- HP Desiccant $\times 2$
- $226.9m^2$
- Occupant: 22
The Demonstration Test

Room air condition in Summer (Set temperature is 28 deg C). Conventional System can’t dehumidify the room enough.
The Demonstration Test

Room air condition in Summer (Set temperature is 26 deg C). Conventional System over-dehumidify the room.

THIC System

Conventional System
The Demonstration Test

The result of questionnaire shows that the THIC system can provide more comfortable inner air conditions.
The Demonstration Test

The energy consumption of summer was reduced by almost half.

- Set temperature was 28 deg C
- Set temperature was 26 deg C
The demonstration test

The energy consumption of winter was reduced by almost 30%.

Set temperature was 20 deg C
Evaluation of the Whole Year Operation

In case that the THIC system is installed in the high quality buildings, total amount of the energy consumption through a year will be reduced by more than 70%.
To achieve ZEB, the energy consumption required for the air conditioning should be reduced by 72%.
Case Study

The new HVAC system also shows that the energy consumption for air conditioning can be reduced down to 5.24 kWh/m² annual ⇒ can fulfill the condition to achieve ZEB.

The High Quality Building’s Case Study

- Ventilation Air is Controlled in Accordance with Room’s CO2 Density
- Air Conditioning only operates in summer and winter.

Result

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Engy Consumpt</td>
<td>4581 kWh</td>
</tr>
<tr>
<td>HP Desiccant Engy Consumpt</td>
<td>4104 kWh</td>
</tr>
<tr>
<td>Air Conditioned Area</td>
<td>1658.8 m²</td>
</tr>
<tr>
<td>Energy Consumption / Area</td>
<td>5.24 kWh/m²</td>
</tr>
</tbody>
</table>
Conclusion

This newly developed THIC system was demonstrated and showed its potential to ...

– maintain (or improve) indoor comfort
– reduce the energy consumption drastically.

I believe that this THIC system will become one of the key technologies to achieve Zero Energy Buildings in the near future.
Thank you very much for your attention.