DEDICATED OUTDOOR AIR SYSTEMS (DOAS)

= Indoor Air Quality + Energy Recovery + Humidity Control

Presented by:
Varun Paha
President
Desiccant Rotors International Pvt. Ltd.
My Presentation Today

- Indoor Air Quality & RH Management
- Traditional Approach – Cooling & Reheat
- Paradigm Shift – Divide & Conquer
- DOAS Technology Options
- DOAS – Some Components
- Installation options
Design of an efficient building

• Reducing energy use:
  – Rationalizing the orientation of building;
  – Improving facade and window design;
  – Improving the performance of HVAC-systems;
  – Adding renewable energy production.

• Improving Indoor Environment Quality:
  – Thermal comfort;
  – Indoor air quality (IAQ);
  – Lighting environment;
  – Acoustic environment;
  – Visual environment.
Indoor Air Quality (IAQ)

Indoor Air Quality (IAQ) refers to the nature of the conditioned (Heat/Cool) air that circulates throughout space/area where we work and live i.e. the air we breathe during most of our lives.

With research clearly indicating that we spend 90% of our time indoors and the growing scientific evidence that the air indoor is almost 10 to 100 times more polluted than outside, the risk to health indoors is much greater than outdoors.
SBS & Effect on Productivity

**Sick Building Syndrome**

- Increase in sickness absenteeism
- Decrease in productivity
- Major occupational hazard

**Cause**
- Airborne Particulates
- Biological Contaminants: Mold, Dust Mites, Animal Dander, Cockroaches, Rodents, Pests, Insects, Bacteria, Formaldehyde, Aldehydes, VOCs, PAH, NO - NO₂

**Effects**
- Poor Indoor Air Quality and Your Health
  - Headaches
  - Memory Impairment, Fatigue
  - Eye, Nose, Throat Irritations, Coughing, Wheezing
  - Respiratory Infections, Skin Rash, Liver, Kidney, Central Nervous System Damage, Cancer, Other Health Risks and Hazards
Effect on Productivity of Good IAQ

William Fisk from Lawrence Berkeley National Laboratory in California was one of the early researchers to examine IAQ effects on health and productivity. In his article, he established a baseline for quantifying benefits from improved IAQ and demonstrated the economic impacts of increased productivity. Findings are showing that improvement in IAQ can:

- Reduce SBS symptoms by 20 to 50%
- Improve office worker productivity by 0.5 to 5%
- Reduce asthma by 8 to 25%
- Reduce other respiratory illnesses by 23 to 76%
Outdoor Air Requirements for Ventilation of Air Conditioned Spaces

The LEED standard states “Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2007 as determined by EQ Prerequisite 1”.

This increased amount of ventilation has definitely solved IAQ related problems, but the inability to maintain the right humidity by our HVAC systems has lead us to other problems.

Mold & Mildew are serious dilemma in itself, which are caused by lack of humidity control. The question is “Have we Traded one problem with the other”.

[LEED logo]
Load Characteristics (Typical)

The largest moisture load in most commercial buildings comes from the ventilation air.

Medium sized retail store in : Atlanta
During : 0.4% dewpoint conditions

Source : Lew Harriman
An example of passive Humidity/Moisture control
In a 3 ton unit

This is what happens in conventional air-conditioning units handling high moisture loads with little sensible loads.

Moisture removal by a conventional cooling unit is small or negligible unless the run time is in excess of 40 to 50%.

Research by Hensender

After the compressor shuts off, moisture condensed on the cooling coil re-evaporates
Traditionally one would immediately talk about a system with low ADP, i.e., having low chilled water temperature, high row deeps (8 row or deeper) and reheat with active energy. Such systems do help but are highly inefficient and drain lot of energy. The fact that one has to first sub-cool and then add active reheat wasting energy twice.
DOAS Approach

- Divide the load into the two components i.e. Sensible & Latent.
- Approach commonly referred to as the “Divide and Conquer”.
- All the latent load brought by outside air is removed at the source & also air is supplied at a low dew point to take care of internal latent load.
- The parallel internal cooling devices are then limited to take care of sensible cooling load.
## Design Parameters

<table>
<thead>
<tr>
<th>Outside Conditions</th>
<th>Doha (46.7 °C DB/33.9 °C WB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>576000</td>
</tr>
<tr>
<td>ERSH (BTUH)</td>
<td></td>
</tr>
<tr>
<td>ESHF</td>
<td>0.91</td>
</tr>
<tr>
<td>OACMH</td>
<td>10000</td>
</tr>
</tbody>
</table>
Conventional Air-Conditioning System

OUTDOOR AIR

TFA
Takes care of OA Sensible and Latent Load

OFF TFA
11°C DP

Recirculation AHU
SHF 0.82
Takes care of Room Sensible and Room Latent Loads

11°C DP
SUPPLY AIR TO ROOM

12.8°C DP
ROOM RETURN
DOAS Approach

OUTDOOR AIR

DOAS
Takes care of OA Total Load
Indoor Latent Load

OFF TFA
9.5°C DP

11 °C DP
SUPPLY AIR TO ROOM

AHU
SHF 1
Takes care of only Room Sensible Loads

12.8 °C DP
ROOM RETURN
Advantages

- Independent control of Temperature & RH - Better RH Management
- Increased Energy Efficiency
  - Flexibility of Chiller Selection because of higher Chilled water temperature
  - No need for Reheat /Over Cooling
- Green Building Rating Points for Innovation/IAQ
- No Condensation on Indoor Units -
  - Better Maintainability
  - Better IAQ
- Can be Coupled with Innovative Technology Like
  - Radiant Cooling
  - Chilled Beam
  - UFAD
DOAS Technologies Evaluation

- **OPTION I**: Baseline system with dehumidification coil only (CC)
- **OPTION II**: Rotary passive desiccant air-to-air heat exchanger coupled with dehumidification coil. (EW+CC)
- **OPTION III**: Rotary passive desiccant air-to-air heat exchanger coupled with dehumidification coil and sensible air to air heat exchanger. (EW+CC+SW)
- **OPTION IV**: Active desiccant dehumidification wheel (with condenser heat reactivation) coupled with DX Cooling coil. (CC+ADES+W)
- **OPTION V**: Rotary passive desiccant air-to-air heat exchanger coupled with dehumidification coil and passive desiccant dehumidification wheel. (EW+CC+PDHC)
# Schedule of DOAS System with Cooling Coil

<table>
<thead>
<tr>
<th>Outdoor Air Conditions</th>
<th>Off Coil Conditions</th>
<th>Cooling Coil Load (TR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBT °C</td>
<td>g/kg</td>
<td>kj/kg</td>
</tr>
<tr>
<td>46.7</td>
<td>28.7</td>
<td>121.17</td>
</tr>
<tr>
<td>43.3</td>
<td>8.24</td>
<td>64.76</td>
</tr>
<tr>
<td>34.1</td>
<td>27.3</td>
<td>104.25</td>
</tr>
</tbody>
</table>

Air Flow (m³/h): 5000
## Schedule of DOAS with Enthalpy Wheel and Cooling Coil

### Air Flow (m³/h): 5000

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outdoor Air Conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBT °C</td>
<td>G/Kg</td>
<td>Kj/Kg</td>
<td>DBT °C</td>
<td>G/Kg</td>
<td>Kj/Kg</td>
</tr>
<tr>
<td>47</td>
<td>29</td>
<td>121</td>
<td>30</td>
<td>16</td>
<td>70</td>
</tr>
<tr>
<td>43</td>
<td>8</td>
<td>65</td>
<td>29</td>
<td>10</td>
<td>56</td>
</tr>
<tr>
<td>34</td>
<td>27</td>
<td>104</td>
<td>27</td>
<td>15</td>
<td>66</td>
</tr>
</tbody>
</table>
# Schedule of DOAS with Enthalpy Wheel, Cooling Coil and Sensible Wheel

<table>
<thead>
<tr>
<th>Outdoor Air Conditions</th>
<th>Off Wheel Air Conditions</th>
<th>Off coil Conditions</th>
<th>Supply air Conditions</th>
<th>Return air Conditions</th>
<th>Return air on EW Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>29</td>
<td>121</td>
<td>23</td>
<td>16</td>
<td>63</td>
</tr>
<tr>
<td>23</td>
<td>16</td>
<td>7</td>
<td>27</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>9</td>
<td>7</td>
<td>27</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>36</td>
<td>25</td>
<td>11</td>
<td>53</td>
</tr>
<tr>
<td>7</td>
<td>27</td>
<td>18</td>
<td>7</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>27</td>
<td>63</td>
<td>18</td>
<td>7</td>
<td>36</td>
</tr>
<tr>
<td>27</td>
<td>11</td>
<td>121</td>
<td>25</td>
<td>11</td>
<td>53</td>
</tr>
<tr>
<td>104</td>
<td>15</td>
<td>59</td>
<td>16</td>
<td>11</td>
<td>43</td>
</tr>
<tr>
<td>20</td>
<td>9</td>
<td>7</td>
<td>27</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>7</td>
<td>27</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>53</td>
<td>16</td>
<td>11</td>
<td>43</td>
</tr>
<tr>
<td>27</td>
<td>17</td>
<td>17</td>
<td>15</td>
<td>43</td>
<td>15</td>
</tr>
</tbody>
</table>
Schedule of DOAS with Cooling Coil and Active Desiccant Wheel

1. Cooling Coil
2. Active Desiccant Wheels
3. Condenser Unit
## Schedule of DOAS with Cooling Coil and Active Desiccant Wheel

<table>
<thead>
<tr>
<th></th>
<th>Outdoor Air Conditions</th>
<th>Off DX Coil Conditions</th>
<th>Off Wheel Conditions</th>
<th>Off Coil/Supply Conditions</th>
<th>Off Condenser Conditions</th>
<th>Sensible Load</th>
<th>Total Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Flow (m³/h): 5000</td>
<td>47</td>
<td>29</td>
<td>121</td>
<td>13</td>
<td>10</td>
<td>37</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>7</td>
<td>48</td>
<td>18</td>
<td>7</td>
<td>36</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>132</td>
<td>22</td>
<td>44</td>
<td>27</td>
<td>115</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>104</td>
<td>13</td>
<td>9</td>
<td>35</td>
<td>7</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Schedule of DOAS with Enthalpy Wheel, Cooling Coil and Passive Desiccant Wheel

1. Enthalpy Wheel
2. Cooling
3. Cooling Coil
4. PDHC Wheel
5. Enthalpy Wheel
## Schedule of DOAS with Enthalpy Wheel, Cooling Coil and Passive Desiccant Wheel

<table>
<thead>
<tr>
<th>Outdoor Air Conditions</th>
<th>Off Wheel Air Conditions</th>
<th>Off coil Conditions</th>
<th>Supply air Conditions</th>
<th>Return air Conditions</th>
<th>Return air on EW Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>29</td>
<td>121</td>
<td>26</td>
<td>17</td>
<td>71</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>33</td>
<td>16</td>
<td>7</td>
<td>34</td>
</tr>
<tr>
<td>25</td>
<td>11</td>
<td>53</td>
<td>21</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>27</td>
<td>104</td>
<td>24</td>
<td>16</td>
<td>66</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>33</td>
<td>16</td>
<td>7</td>
<td>34</td>
</tr>
<tr>
<td>25</td>
<td>11</td>
<td>53</td>
<td>21</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Design Data for Different DOAS Systems for Doha, Qatar Conditions- Supply Air Flow – 5000 m³/h

<table>
<thead>
<tr>
<th>S.No</th>
<th>Arrangement</th>
<th>Description</th>
<th>Cooling Coil load (TR)</th>
<th>Cooling Coil load (Kw)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ambient Conditions</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>CC</td>
<td>Cooling Coil+Electric Heater</td>
<td>43.3</td>
<td>17.8</td>
</tr>
<tr>
<td>2</td>
<td>EW+CC</td>
<td>Enthalpy Wheel + Cooling Coil</td>
<td>20.2</td>
<td>13.4</td>
</tr>
<tr>
<td>3</td>
<td>ADEW+DX</td>
<td>Desiccant Wheel + DX Coil + Condenser</td>
<td>44.3</td>
<td>14.6</td>
</tr>
<tr>
<td>4</td>
<td>EW+CC+SW</td>
<td>Enthalpy Wheel + Cooling Coil + Sensible Wheel</td>
<td>16.8</td>
<td>10.0</td>
</tr>
<tr>
<td>5</td>
<td>EW+CC+PDHC</td>
<td>Enthalpy Wheel + Cooling Coil + Passive Desiccant Wheel</td>
<td>16.8</td>
<td>10.0</td>
</tr>
</tbody>
</table>

* Cooling kw/tr is assumed 1.2 Kw/tr from S.No. 1 to 5, 0.9 kw/tr for S.No. 6, 7 & 9 and 0.73 kw/tr for S.No. 8
System Load at Doha, Qatar Condition
The unique passive desiccant wheel (Patent Pending) has the ability to be regenerated with the 50% RH room return air allowing for substantial moisture removal through dehumidification of the saturated (100% RH) Fresh Air being supplied to the room. This is intelligently controlled by the DRISmart EMS (Energy Management System) to regulate speed optimization for different load conditions and different outside conditions.
Advantage with G3MA “Passive” Wheel
(Patented)

- Removes moisture from a saturated air stream without heat/thermal regeneration
- High performance in -situ synthesized desiccant
- Fully water washable
- 100% non-flammable
- No washing away of desiccant on continued exposure to saturated/wet air
Working Principle of Heat Recovery Wheel

1. Heating/Cooling Energy (e.g. 80%) is always returned to where it came from

   Heat In → Cooling Energy Out

   Heat Out → Cooling Energy In

2. Moisture and Dry Air (e.g. 80%) is always returned to where it came from

   Moisture In → Dry Air Out

   Moisture Out → Dry Air In
Advantage with EcoFresh Wheel

- **EcoFresh** Molecular Sieve MS 3Å is recommended where there is a need to limit the cross contamination to absolute minimum and ensure exclusion of contaminants in the air streams, while transferring water vapour molecules.

- **EcoFresh** heat wheels are *ARI certified* with 100% Success Rate Performance Award for 7 consecutive years.

- **Certified for Zero Mircobial Growth:** **EcoFresh** Wheels are specially treated for prevention of any microbial growth on its surface and are certified by Shriram Labs. As per the DIN EN ISO 846 standard, showing 0% fungi and bacterial growth.

- **Certified for Zero Flame Spread:** DRI conforms to NFPA–90A certification for 0% Flame spread classification and is tested in accordance with NFPA 225 and ASTM–E84-95 Standard Test Method for Surface Burning.
Operating Principle of the **Desiccant Dehumidifier**

**How does it work?**

[Diagram showing the components and flow of air through a desiccant dehumidifier, with labels for process inlet, reactor inlet, reactor outlet, process outlet, desiccant rotor, top divider, and bottom divider.]
Installation Options

DOAS in Parallel with Terminal Equipment
Installation Options

DOAS in Series with Terminal Equipment

[Diagram showing flow of air from exhaust, outdoor, and treated fresh air into rooms through supply and exhaust systems.]

ULTIMA

E/A (Exhaust Air)

O/A (Outdoor Air)

R/A (Room Air)

Supply Air

Treated Fresh Air

S/A (For Recirculation)

Leakage/Exfiltration
ASHRAE DESIGN GUIDE for Dedicated Outdoor Air Systems

design
installation
operation and maintenance

ANSI/AHRI Standard 920 (I-P)

2015 Standard for Performance Rating of DX-Dedicated Outdoor Air System Units

Approved by ANSI on November 6, 2015
Thank you!