APPLICATION OF MODERN ABSORPTION “NEW NORMAL” TECHNOLOGY IN CAMPUS DISTRICT ENERGY SYSTEMS WITH LIFE CYCLE ANALYSIS

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Agenda

- Basics of Absorption Cycle
- Modern Absorption “New Normal” Technologies
- Case Study of Absorption Technologies Application in Campus Energy District System
- Q&A
Introduction of Absorption Cycle

How Burning gas (Steam/Waste heat) produces cooling?
Introduction of Absorption Cycle

- Absorption Cycle
  - Similarity:
    - Heat removal through refrigerant evaporation at low pressure side
    - Heat rejection through refrigerant condensation at high pressure side
  - Differences:
    - VCC uses mechanical compressor to create pressure differences necessary to circulate the refrigerant
    - Absorption cycle uses thermal energy source as the driving force with a generator and an absorber
Introduction of Absorption Cycle

- Absorption Cycle
  - Refrigerant H$_2$O and Absorbent Lithium Bromide

Distilled Water + Lithium Bromide (LiBr)

**Refrigerant: distilled water R718**
- Stable
- Nontoxic
- Low cost
- Readily available
- Environmentally friendly
- High latent heat of vaporization

**Absorbent: LiBr**
- High affinity for water
- Nontoxic
- In solution, higher boiling point **2309°F** compared to that of water **212°F**
- Time tested 60 plus years of commercial use in HVAC
Introduction of Absorption Cycle

- **Absorption Cycle**
  - Evaporator with water as refrigerant
    - Refrigerant water sprays on tubes of chilled water system
    - Changes state (boils) and absorbs large amounts of energy
      - Water evaporates at 212°F at 0 psig
      - Water evaporates at 39°F at -14.58 psig

<table>
<thead>
<tr>
<th>Boiling point</th>
<th>pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>212°F</td>
<td>0 psig (atmosphere pressure)</td>
</tr>
<tr>
<td>39°F</td>
<td>-14.58 psig</td>
</tr>
</tbody>
</table>

- **VCC cycle**
  - CFC refrigerant changes state and absorbs large amounts of energy for ex. R134 evaporates at 40°F at 35 psig

- Vacuum, Vacuum, Vacuum for Absorption Cycle!
Working Principle of Absorption Cycle

- **Direct Fire**
- **Steam**
- **Hot Water**

1. **Generator**
   - Refrigerant Vapor
   - LiBr Solution (LiBr + H₂O)
   - Concentrated LiBr

2. **Absorber**
   - Concentrated LiBr
   - Refrigerant Vapor
   - Diluted LiBr solution

3. **Evaporator**
   - Condensed Refrigerant
   - Refrigerant Vapor
   - Expansion Valve
Working Principle of Absorption Cycle

1. LiBr solution absorbs heat from heat source
2. The refrigerant (water) boils and separates from solution
3. The generated refrigerant vapor travels to the condenser
Working Principle of Absorption Cycle

1. Refrigerant vapor produced in the evaporator is absorbed by LiBr solution
2. Refrigerant vapor condenses back to liquid
3. Heat generated is rejected to the cooling (condenser) water

Absorption of refrigerant vapor results in low pressure inside the absorber, which induces a continuous flow of refrigerant vapor from the evaporator side.
Modern Absorption Technology – New Normal

- **Corrosion** and degradation of performance was an issue with absorbers in the past.
- **Old Absorption technology** requires operators to periodically run a vacuum pump to insure operation and to maintain chilled water set point.
- **Oxygen** is the source of corrosion inside an Absorber. If proper vacuum can be maintained for the absorbers life there is no opportunity to have corrosion form inside the Absorber.
Modern Absorption Technology – New Normal

- Titanium Tube Material: Best Corrosion Resistant Metal for long life and low life cycle cost
Modern Absorption Technology – New Normal

- “Big Ten”, “State”, “Ivy League” and universities all across North America and Canada are using “Modern Absorption” to lower the cost of proving chilled water on campus.
Why BROAD Absorption Chiller - Technology

- Titanium Tube Material: Best Corrosion Resistant Metal for long life and low life cycle cost

<table>
<thead>
<tr>
<th>Tube Materials</th>
<th>Pure Copper</th>
<th>Copper-Nickel</th>
<th>Stainless Steel</th>
<th>Titanium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution Media</td>
<td>Resist corrosion under low temp &amp; low concentration</td>
<td>Resist corrosion under low and medium temperature</td>
<td>Resist corrosion differs by types of stainless steel</td>
<td>No corrosion</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1.2 m/s</td>
<td>3.6 m/s</td>
<td>5-7 m/s</td>
<td>No limitation</td>
</tr>
<tr>
<td>salt water (speed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>Serious corrosion</td>
<td>Corrosion</td>
<td>No corrosion</td>
<td>No corrosion</td>
</tr>
<tr>
<td>Polluted air &amp; water</td>
<td>Corrosion</td>
<td>Slight corrosion</td>
<td>No corrosion</td>
<td>No corrosion</td>
</tr>
</tbody>
</table>
Why BROAD Absorption Chiller - Technology

- Titanium Tube Material: Best Corrosion Resistant Metal for long life and low life cycle cost

Titanium is low density, light weight and high strength element.

Titanium does not corrode when exposed to salt water, acid & chlorine..... or in absorber.

A Titanium tube in an Absorbers will likely never need to be re-tubed
Modern Absorption Technology – New Normal

- Tube selection can be a significant factor to and Absorbers life cycle & should be considered with each application for use based on project goals and specifics.
- As tubes become stronger and less resistant to deterioration wall thickness can be reduced to gain or overcome thermal efficiency differences between material choices.
- Less weight can reduce installation costs.
- Materials that are stronger and resistant to corrosion will reduce life cycle cost.
- Economics of materials and tubes technology changes such as enhancements, cross hatching-rifleling allow for numerous choices for tube selection to improve life cycle costs and the efficiency of the chiller.
Case Studies

- Steam absorption chiller application at University of Minnesota
Case Studies

Steam absorption chiller application at University of Minnesota
Case Studies

- Steam and Hot water absorption chiller application at the University of Maryland Upper Chesapeake

EPA Energy Star
CHP award winner

CCHP 2 MW with multi-energy absorption
Case Studies

- Steam and Hot water absorption chiller application at the University of Maryland Upper Chesapeake

  - With an operating efficiency of 75 percent, the system requires approximately 34 percent less fuel than would be used by conventional electricity and steam production, and also avoids emissions of air pollutants, including an estimated 4,700 tons of carbon dioxide annually (equal to the emissions from the generation of electricity used by more than 630 homes). The system saves the University an estimated $300,000 each year.
THANK YOU!

Q&A

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