Ammonia - carbon heat pump development at the University of Warwick

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Sorption friends – 15th September 2015 – Milazzo, Italy
Contents

• Heat pump under investigation
  - Generator design
  - Previous and current versions
  - Operating conditions

• Experimental results and analysis

• Conclusions

• New test facilities
Heat pump concept

- Box-for-box exchange for conventional gas boiler – Retrofit market > 90% of annual sales
- Air source
- 30 - 40% reduction in gas consumption

Inside

Outside (evaporator unit)
Schematic drawing

- Final Exhaust Heat Exchanger
  - Warm Exhaust Gases
  - Air-to-Pressurised Water Heat Exchanger
    - Hot Gases
    - Gas Burner
- Cool Exhaust Gases
- Adsorbent Bed 1
  - Heated
- Adsorbent Bed 2
  - Cooled
- Adsorbent Bed 3
- Condenser
- Evaporator
  - Ambient Air to Evaporator
  - Cooled Air from Evaporator
  - Return water to house
- Ammonia

Heated water to house

Inlet Air

Return water from house
Generator design

Shell and tube heat exchanger

1.2 mm
3 mm
0.8 mm
Current version

Version 3 - 2014

- Two bed system
- Flooded evaporator – Water source
Operating conditions

- Driving Temperature: 150 °C
- Evaporating temperature: 0 – 7 °C
- Delivery temperature:
  - Underfloor heating: 36 °C flow – 26 °C return
  - Low temperature radiators: 50 °C flow – 40 °C return
Experimental results

- COPh
- Heating power (kW)
- Underfloor heating
- Low temperature radiators
- Linear (Low temperature radiators)
Experimental results

Example case for model comparison

- Underfloor heating
- Low temperature radiators
- Linear (Low temperature radiators)
## Predicted performance

<table>
<thead>
<tr>
<th>Case</th>
<th>COP</th>
</tr>
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<tbody>
<tr>
<td>Experiment</td>
<td>1.30</td>
</tr>
<tr>
<td>Model – tubes, tube plates and water plenums only</td>
<td>1.38</td>
</tr>
<tr>
<td>Model – added 10 kg steel</td>
<td>1.29</td>
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</tbody>
</table>

- The generator is effectively a thermally driven compressor and is the **most critical** part of the design.
- The generator flanges contained 10 kg of stainless steel which reduced the COP.
Generator thermal mass

New domed end flanges that reduce the mass of steel of the generator from 10 kg to 2 kg have been designed and manufactured.
# Generator thermal mass

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<tr>
<td>Model – added 10 kg steel (previous design)</td>
<td>1.29</td>
</tr>
<tr>
<td>Model – added 2 kg steel (current design)</td>
<td>1.35</td>
</tr>
</tbody>
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Conclusions

• For the example case of underfloor heating at 7 kW heat output, the overall COP (heat output to higher heating value of gas input) could then reach 1.2

• An assessment of the performance with respect to the new Energy Related Products (ERP) labelling scheme is required to determine if our system would be rated A, A+ or A++
New test facilities

• ‘ThermExS Lab’ Thermal storage test facility under construction
• It will also be used as a heat source and sink for testing of the heat pump
• It is expected to be completed in the next few months
Thanks for your attention!