Technology Convergence for Post Combustion Capture?

Setting the context
A review of a concept proposal discussed at the IPA meeting
UKCCSRC Bi-annual, Strathclyde University, Glasgow.

Richard P. Smith
UKCCSRC Independent Advisory Panel – Vice Chair
www.ukccsrc.ac.uk

Howden Group
www.howden.com
richard.smith@howden.com
Howden is a subsidiary of Colfax Corporation, as are ESAB and Colfax Fluid Handling.

<table>
<thead>
<tr>
<th>Colfax Fluid Handling</th>
<th>ESAB</th>
<th>Howden</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Precision pumps and systems</td>
<td>• Welding and cutting equipment</td>
<td>• Fans, heat exchangers and compressors</td>
</tr>
<tr>
<td>• Sales in 2014 – $0.7bn</td>
<td>• Sales in 2014 – $2.3bn</td>
<td>• Sales in 2014 – $1.7bn</td>
</tr>
<tr>
<td>• Associates – 2,500 approx</td>
<td>• Associates – 10,000 approx</td>
<td>• Associates – 6,000 approx</td>
</tr>
</tbody>
</table>
Founded 1854, Howden now employ over 6000 people in 27 Countries
Sales are made throughout the world to key process industries

By industry
- Industrial 17%
- Oil, gas, petrochem 17%
- Mining 11%
- Power 49%

By region
- Europe 16%
- N America 21%
- China 19%
- Africa 14%
- Other Asia 18%
- RoW 12%

New equipment plus aftermarket
Howden operate in a wide range of industries, which underpin today's modern industrial society.
High integrity fans, heat exchangers and compressors
Providing the highest levels of efficiency, reliability and availability.
Extensive installed base of experience underpins our applications knowledge

<table>
<thead>
<tr>
<th>Product</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugal fans</td>
<td>25,000</td>
</tr>
<tr>
<td>V.P Axial fans</td>
<td>4,000</td>
</tr>
<tr>
<td>Cooling fans</td>
<td>10,000</td>
</tr>
<tr>
<td>Heat exchangers</td>
<td>4,000</td>
</tr>
<tr>
<td>Screw compressors</td>
<td>35,000</td>
</tr>
<tr>
<td>Reciprocating compressors</td>
<td>12,500</td>
</tr>
<tr>
<td>Turbo compressors</td>
<td>1,250</td>
</tr>
<tr>
<td>Roots blowers</td>
<td>150,000</td>
</tr>
</tbody>
</table>
Power Products and Services
C-85.6, Worlds Largest API 618 Compressor
Howden ČKD Compressors

15 MPa CO₂ Compressor for an Urea Plant
Current CCS Activities

• **Fossil Fuel power Generation can’t be replaced overnight!**
  • Active support for transitional CCS
    • Involved with several confidential technology developments partnerships.
    • Supplied balance of plant items to contractors for low carbon technologies.

• **Equipment provided for Worldwide CCS Project demonstrations:**
  • Karlshamn    Gas Fired CCGT with PC    Sweden
  • Ferrybridge  Conventional Coal Fired with PC    UK
  • Donguaan    IGCC    China
  • Hua Dian    Conventional Coal Fired with PC    China
  • Kemper County    IGCC (585MW)    USA
    • Six Howden 7000HP Coal drying Fans
    • Six Howden 900HP Coal Mill Feed Fans
    • One Howden 1630HP Combustor Air Fan
    • One Howden 450HP Stack Gas blower
    • One Howden 3100HP Cooling Air Blower
    • Eight Howden 4000HP refrigeration Screw compressors.

*Installed Total    84,500HP    (63.4 MW)*
• A leading global Balance of Plant (BOP) supplier for Energy Intensive Industries

• Dance with all the girls!
  • Customer confidentiality is always respected!

• Provide consultancy and experience for large scale solutions

• Generates a broad perspective of practical issues and trends
• How can we get CCS going and reduce costs?
  – Basis: PCC amine and variations!
  – Possible to modularise????
    • Example – SoCo Plant Barry / MHI
      – Small Scale 25MW
  – Would suit mass production in China
    • UK links to some Chinese potential supply chain
    • Largest fleet of modern power stations
    • Geographic Distribution
    • Targets largest market

>>>>> Proven transferable technology?
Ferrybridge CC Pilot 100+

- PCC using Doosan’s HTC technology
- 5MWe slip stream
  - 100 tpd CO2 capture
- Operation in late 2011
- Two year test program
- Project partners include:
Moderation 1

• **Scale too large for transportable modules to be practical!**
  – potentially suited to general industry
• **Target optimum plant size**
  – Interested Parties Push /Pull
    • Boiler Unit size  300/600/900 MWe
    • EOR Unit Demand  250MW
    • Process Performance
    • Practical / Cost effective manufacture & transportation
      – General rule of thumb for BOP equipment
        » BOP items - Double capacity can approach only 25% cost increase
        • Other extreme produces exponential cost increase
        » Different thresholds for different types of equipment so...

>>> **What is practical unit size to get ‘maximum’ size sweet spot ?**
Moderation 2

• “Dancing” with most major suppliers for BOP
  – PCC Technologies have converged
    • No major differences in requirements between amine plants (temperatures, pressure etc.)
  – Many other process industries –
    • Maximum flexibility, reliability vs. critical reliability.
      – Option 3 x 50% units or 3 x 40% standby/assist
      – Critical service vs. general industry = 3 x cost for same duty/power etc.

• Process Developers
  • 800 Mwe >> “Rather large” 25 m diameter absorber
  • Gas / Liquid distribution issues
  • Thermal mass limitations – response times
  • Factors are limitations on sensible vessel sizes
    – (2MtCO2/year coal / 1MtCO2/year gas)
Objective / Questions:

- Reality is that only amine based solutions are ready to go!
  - Rapid deployment & retrofit
- Can these principle be applied to accelerate CCS?
  - Is it Practical at scale?
  - Can it provide serious cost reduction?
- Why incorporate standby capacity?
  - Does this really matter?
    - Venting to atmosphere acceptable at low frequency
  - How much time at full load anyway?
**Objective / Questions:**

- Does standard size produce mismatch on flow & efficiency?
  - Turndown to 60% generally achievable
  - Power Generation variation in demand
  - Suitable for wider industry applications

- Reliability will be reduced?
  - In contrast, less chance of losing total Capture system
  - Increased flexibility
  - Potential increased efficiency at part load
    - Trend >> fossil fuel Power generation for increased flexibility
    - maximise renewable energy

- Condition monitoring
Rationalisation 3

Objective / Questions:
• Peripheral Cost Impacts?
  • Sourcing Materials – large items e.g. forgings
  • Manufacture
  • Delivery Cycles
• Civils
• Transportation
• Damage in Transit
• Site Erection Costs
• Site Erection Schedule
• Commissioning
  > >> >>> Continuous improvement!
Summary 1

• Direction > Standardised rather than Modular
  • 1 GW Power Plant requiring say 4 Standard lines
  • Maintain element of flexibility
    – Site layouts and Industries
    – Process variations and development <> CONVERGENCE!
    – Response to failure and development in discrete part of module

• Drivers for cost reductions
  – Design & Manufacturing Costs
  – Footprint defined & Speedy Civils
  – Transportation, Site Erection & Scheduling
  – Commissioning Procedures Established

• Will it be more inviting for Investor Interest?
  • Proven Performance and both CAPEX & OPEX Understood
    • Upgradable

• Reduced Risk!
Technology Convergence for Post Combustion Capture?

Setting the context
A review of a concept proposal discussed at the IPA meeting
UKCCSRC Bi-annual, Strathclyde University, Glasgow.

Richard P. Smith
UKCCSRC Independent Advisory Panel – Vice Chair
www.ukccsrc.ac.uk

Howden Group
www.howden.com
richard.smith@howden.com