Impact of Refrigerants on Compressor Design

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• Describe the major market and regulatory trends impacting chiller and compressor design.

• Explain how design choices for compressor, heat exchangers and other major components are inter-related.

• Define how compressor design is impacted by part load efficiency focus. Including modulation via speed and mechanical means.

• **Describe the impact of new refrigerants on compressor design.**
Outline

• Refrigerants Landscape
• Compressor Design Considerations
  • Performance
  • Thermal Management
  • Oil Selection
  • Envelope
• Conclusion
• Questions
Refrigerant Landscape

Pressure

- R-410A Like
  - R410A
  - CO2
  - R32, R452B, HFO Blends
  - 400-675

- R407 / R22 Like
  - R22 / R407C
  - NH3
  - R290
  - HFO Blends
  - 150 - 300

- R134a Like
  - HFO 1234yf
  - HFO 1234ze
  - ~600

- R123-Like
  - HFC/HFO Blends
  - ~600

Refrigerant Composition

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>R32</th>
<th>R125</th>
<th>R1234yf</th>
</tr>
</thead>
<tbody>
<tr>
<td>R410A</td>
<td>50%</td>
<td>50%</td>
<td>---</td>
</tr>
<tr>
<td>R32</td>
<td>100%</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>R452B</td>
<td>67%</td>
<td>7%</td>
<td>26%</td>
</tr>
<tr>
<td>R454B</td>
<td>69%</td>
<td>---</td>
<td>31%</td>
</tr>
</tbody>
</table>

GWP Level

- HFC/HFO Blends
  - <1500
- R134a
  - <150
- R452B
  - <750
- R410A
  - <1500
- R22 / R407C
  - >1500
Compressor Design Considerations

✓ Capacity
✓ Efficiency: EER, IEER, IPLV, SEER and HSPF
  • Field Life / Reliability
✓ Envelope Capability
✓ Discharge Temperature Management
✓ Chemical Compatibility
✓ Oil: Selection and Circulation Rate
  • Capacity Modulation
  • Sound, Vibration, Gas Pulsation
  • Motor Protection
  • Pressure Vessel
  • Cost
  • Complexity Management
  • And More...

✓ = Discuss Today
Capacity Varies with Refrigerant

Potential changes in scroll elements influence key design areas: counterweights, motors, seals, and more.

![Three Ton Compressor Drop-In Testing](chart)

- **Capacity Ratio (Relative to R410A)**
- **Operating Condition [T Evap / T Cond °F]**
- **R410A**
- **R452B**
- **R454B**
- **R32**
Efficiency Varies with Refrigerant

Refrigerant changes may require compressor modifications to optimize EER

Optimizing volume ratios with valves can help mitigate compression losses

Regulation shifts to part load ratings may require new scroll and motor design strategies

Motor optimization can be tuned to favor multi-point ratings
Discharge Temperature Management

New refrigerants may drive changes in scroll elements, system superheat control, material selection, and more to manage increased temperatures.

3 Ton Compressor Drop-In Testing
Many Solutions Exist for Discharge Temperature Management

There are several viable technologies for reducing discharge temperatures including the examples shown here.

**Objective:** Select the right technologies to meet applications needs

- **Scroll discharge valves can help mitigate compression losses**
- **Managing scroll suction inlet temps can help reduce discharge temps**
- **Reducing system superheat can help reduce discharge temps**
- **Vapor / liquid injection schemes help mitigate heat of compression**
Refrigerant selection requires selecting oils that remain miscible for intended applications.

Refrigerant selection requires selecting oils that satisfy many requirements:

- Viscosity
- Solubility
- Chemical compatibility
- Thermal stability
- And more...
Operating Envelope

The resulting envelope is a composite result of all technical concerns, often spread across multiple applications.
Conclusions

• New refrigerants will drive compressor design changes
  • Particularly when coupled with higher system efficiency requirements

• The impacts of new refrigerants on compressor design are challenging but manageable
  • Known technologies can be improved, optimized, and deployed in new ways
  • New technologies and control solutions beyond the compressor continue to evolve
Questions?

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