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Compressors and Compressor Technologies

August 2, 2012
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Today’s speakers...
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Rajan Rajendran is the Vice President of Engineering Services and Sustainability at Emerson Climate Technologies in Sidney, Ohio, USA. He has worked at Emerson since 1990 in various capacities and is the spokesperson for Emerson Climate in technical communications with the media, customers, and industry organizations primarily in the United States.
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Mike Saunders is the Director of End User Technical Sales and Support at Emerson Climate Technologies, Inc. in Sidney, Ohio. He has over 18 years of experience in refrigeration product development and support. Mike's current roll is educating and supporting supermarkets on refrigeration trends and compressor technologies.

Mike holds a B.S. in Mechanical Engineering and a M.S. in Mechanical Engineering from the University of Idaho.
Compressor & Compressor Technologies

EMERSON
Climate Technologies
Compressor Technologies

Agenda

• Compressor Introduction
  – Typical Applications
  – Common Types
  – Compression Mechanisms

• Compressor Features
  – Efficiency
  – Modulation
  – Reliability
**Typical Applications**

### Markets
- **Industrial**
- **Transport**
- **Food Retail**
- **Food Service**
- **A/C Commercial**
- **A/C Residential**

### Compressors
- Screw Reciprocating
- Scroll Units
- Semi-Hermetic (Rack) Scroll (Distributed)
- Scroll Hermetic Units
- Scroll Hermetic Semi-Hermetic
- Scroll Hermetic

### Refrigerants
- NH₃
- R134a
- R404A/507 R290
- R404A
- R404A/507 R407A R134a CO₂
- R404A/507 R407A R134a
- R410A
- R410A R407C
- R410A
Key Industry Needs

Total Cost Of Ownership

- Supermarket Refrigeration Accounts For 60-65% Of Total Energy Costs
- Reliability Costs - Varies

Maintenance Solutions (Reliability/Uptime)

Sustainability

- Refrigerant Containment
- System Architecture
- Low GWP Refs. & Natural Alternatives
- Energy Efficiency

Number Of Qualified Techs (000)

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<th>Year</th>
<th>Number</th>
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<td>244</td>
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<td>2015</td>
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Compressor Types

- Hermetic
- Semi-Hermetic
- Open-Drive
Compression Mechanisms

Scroll

Screw

Reciprocating

Rotary Vane

Single

Dual

Air Flow Direction
How The Scroll Compressor Works

1. Fixed Scroll
2. Orbiting Scroll
3. Suction Pocket
4. Intermediate Pocket
5. High Pressure Pocket
6. Discharge
Compliant Scrolls

Axial Compliance

Radial Compliance
Semi-Hermetic Reed vs. Discus Technology

- The geometry of a Reed compressor does not allow all the discharge gas to exit when the piston is at top dead center, leading to re-expansion volume.
- Re-expansion in the Discus design is virtually zero, providing higher efficiency.
Single Screw Compression Cycle
Rotary Vane Compressor

Information Sources: Samsung.com & Pilot Light Newsletter, FSCC Summer 2000
Compressor Efficiency & Technology

- Compressor Rating Conditions
  - LT: -25°F/105°F/65°RG/0°SC
  - MT: 20°F/120°F/65°RG/0°SC

- AEER

- Peak Loads

- Factors Affecting Efficiency
  - Evaporating Temperature
  - Condensing Temperature
  - Return Gas or Superheat Temperature

**Table 1. Standard Rating Conditions for Compressors and Compressor Units for Commercial Refrigeration Applications (Based on 95°F [35°C] Ambient Temperature)**

<table>
<thead>
<tr>
<th>Suction Dew Point Temperature °F</th>
<th>Compressor Type</th>
<th>Discharge Dew Point Temperature °F</th>
<th>Return Gas Temperature °F</th>
<th>Subcooling °F</th>
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<tr>
<td>45 7.2</td>
<td>All</td>
<td>130 54.4</td>
<td>65 18</td>
<td>15 8.3</td>
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<tr>
<td>20 -6.7</td>
<td>All*</td>
<td>120 48.9</td>
<td>40°/65°</td>
<td>4.4/18°</td>
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<tr>
<td>-10 -23</td>
<td>Hermetic</td>
<td>120 48.9</td>
<td>40 4.4</td>
<td>0 0</td>
</tr>
<tr>
<td>-25 -32</td>
<td>All*</td>
<td>105 40.6</td>
<td>40°/65°</td>
<td>4.4/18°</td>
</tr>
<tr>
<td>-40 -40</td>
<td>All*</td>
<td>105 40.6</td>
<td>40°/65°</td>
<td>4.4/18°</td>
</tr>
</tbody>
</table>

*Note: If airflow across the compressor is used to determine ratings, it shall be specified by the compressor manufacturer.

*1) For hermetic type compressors, 40°F [4.4°C] return gas temperature shall be used.

*2) For external drive and accessible hermetic type compressors, 65°F [18°C] return gas temperature shall be used.

AHRI 540
What Is AEER Using Bin Analysis?

- Annual EER (AEER) is the EER weighted averaged by the condensing temperature for the whole year
  - \( AEER = \frac{1}{\text{sum}} \sum (\%\text{time} \times \text{EER}) \)
- If the cost of energy consumed is required, that can be calculated as well
- Weather data used is data from U.S. National Weather Service
- AEER is useful for comparison purposes

\[
\text{Load} \frac{\text{Btu}}{\text{hr}} \times \text{AEER} \frac{\text{Btu}}{\text{W-hr}} \times 8.76 \times \text{Energy Cost} \frac{\text{\$/hr}}{\text{kWh}}
\]

AEER is a better efficiency metric
Methods To Improve Efficiency

- Enhanced Vapor Injection (EVI)
- Variable Capacity
- Floating Head
- System Architecture (Close Coupled Systems)
- Refrigerant
- etc
Economized Vapor Injection For Scroll Compressors
- Similar To A 2 Stage Cycle, But Accomplished With A Single Scroll Compressor
  - 40% Capacity Gain At LT ARI Condition
  - 20% Efficiency Gain At LT ARI Condition

Subcooling increases net cooling capacity
Capacity Modulation Improves Efficiency & Reliability

- Modulation Allows Capacity To Precisely Match The Load
- Simple & Effective Modulation Results In Important Benefits
  - Suction Pressure Stability
  - Tight Temperature Control
  - Energy Efficiency
  - Reduced Compressor Cycles

- Modulation Methods
  - Blocked Suction
  - Variable Speed
  - Pulse Width Modulation (Digital)
Scroll Digital Capacity Modulation

- Takes Advantage Of Scroll Axial Compliance
- When Scrolls Are Separated Axially (0.5 – 1.0 mm), Little To No Gas Flow
- When Scrolls Are In Contact, 100% Gas Flow
- Modulate 10 – 100% By Pulsing

Unloaded Scrolls
Separated Zero Capacity

Loaded Scrolls
Together Full Capacity

20% Output

50% Output

Full Capacity
Zero Capacity

4 Sec | 16 Sec

10 Sec | 10 Sec
1. Enters Compressor
2. Passes Through Body
3. Into Valve Plate
4. Compressed by Pistons
5. Exits Compressor
Discus Digital Refrigerant Gas Flow

1. Enters Compressor
2. Passes Through Body
3. 4 Unloader Pistons Block Gas Before Entering Valve Plate

Valve assembly routes discharge gas above unloader pistons.

Unloader pistons block suction gas flow into valve plate.
Capacity Modulation

- Copeland Digital Results
Other Capacity Modulation Options

Unloaders

- Unloaders & Blocked Suction
- Discrete Capacity Steps

Variable Speed
- Continuous Capacity Control
- Requires External Inverter Drive

Blocked Suction

Variable Speed

EMS

Inverter

Compressor
Industry Pain Points Are Evident

- Reliable performance in the HVACR markets is key
- Need for equipment that can diagnose and protect itself
- Critical pain points: maintenance cost, system downtime, call-backs
- Value Proposition:
  - “Compressor electronics enhances compressor and system performance by sensing, monitoring and interpreting electrical and mechanical information within the compressor to provide advanced capabilities, such as system diagnostics, protection, verification and communication.”
Compressor Reliability

- Common Compressor Failure Modes

- Heat (High Comp. Ratio, Return Gas, etc.)
- Liquid Refrigerant (Flooded Start Or Running)
- Contamination
- Motor Burn
- No Defect Found
Electronics Have Proven To Increase Accuracy, Even For Experienced Technicians

Problem-Solving Accuracy

Entry-Level Technicians

- Without Electronics
- With Electronics

Experienced Technicians

- Without Electronics
- With Electronics
Compressor Reliability & Technology

- Compressor Electronics Identify & React To System Problems

Benefits:
- Lower Maintenance Costs
- Less System Downtime
- Faster Troubleshooting
- More Accurate Diagnosis
- Reduced Contractor Callbacks
- Service Root Cause vs. Replace Compressors. “open the system”
Questions?
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