The Influence of the Accumulator and Internal Heat Exchanger Design as separate and combined Components on the System Behavior of a R744 A/C System

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- Design criteria accumulator
  - functions
  - influence of control strategy
  - storage volume
- Design criteria internal heat exchanger
  - functions
  - performance
  - efficiency
- Design criteria combined component design
Accumulator - functions

- Store non-active refrigerant due to:
  - changing operating conditions
  - changing ambient conditions
  - leakage protection
- Reduce equilibrium pressure during high load conditions
- Ensure oil return to compressor
- Separate liquid and gaseous refrigerant during load changes
## Accumulator – influence of control strategy

<table>
<thead>
<tr>
<th>Temperature</th>
<th>EXV-system</th>
<th>Orifice tube system</th>
</tr>
</thead>
<tbody>
<tr>
<td>45°C</td>
<td>370 g</td>
<td>370 g</td>
</tr>
<tr>
<td>30°C</td>
<td>292 g</td>
<td>289 g</td>
</tr>
<tr>
<td>20°C</td>
<td>323 g</td>
<td>255 g</td>
</tr>
<tr>
<td>5°C</td>
<td>361 g</td>
<td>212 g</td>
</tr>
</tbody>
</table>
## Accumulator – required storage volume

<table>
<thead>
<tr>
<th></th>
<th>EXV-system</th>
<th>Orifice tube system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum charge in accu</strong></td>
<td>70 ml</td>
<td>150 ml</td>
</tr>
<tr>
<td><strong>Condition</strong></td>
<td>25°C</td>
<td>5°C</td>
</tr>
<tr>
<td><strong>Leakage protection</strong></td>
<td>to be added</td>
<td>to be added</td>
</tr>
</tbody>
</table>
**Internal heat exchanger - functions**

- Transfer heat from high pressure side to low pressure side
- Enhance system performance at high ambient temperatures
- Reduce required high pressure for optimum COP at medium ambient temperatures
- Increase COP at low and medium ambient temperatures
Internal heat exchanger - efficiency

IHX efficiency:

\[ \eta_{IHX} := \frac{\Delta h_{IHX \text{ real}}}{\Delta h_{IHX \text{ ideal}}} \]

\[ \Delta h_{IHX \text{ ideal}} := h(\vartheta_{GCout}, LP) - h(\vartheta_{IHX LPin}, LP) \]
Internal heat exchanger - efficiency

Relative AC performance at 45°C vs. IHX efficiency.

- Without IHX: 58%
- With IHX: 83%
- Visteon Accu / IHX: 95%

IHX with infinite surface
• Accu:
  - Store non-active refrigerant due to:
    - changing operating conditions
    - changing ambient conditions
    - leakage protection
  - Reduce equilibrium pressure during high load conditions
  - Ensure oil return to compressor
  - Separate liquid and gaseous refrigerant during load changes

• IHX:
  - Transfer heat from high pressure side to low pressure side
  - Enhance system performance at high ambient temperatures
  - Reduce required high pressure for optimum COP at medium ambient temperatures
  - Increase COP at low ambient temperatures

• Combined component: avoid influence of heat transfer into accumulator
Validation of risk that heat transfer from HPside evaporates Accu charge

Assumption:
Accu charge is completely evaporated!

- during transcritical operation the evaporated refrigerant causes significant higher discharge pressure
- AC system operates with decreased COP

EXV-system

\[
\begin{align*}
  p_s &= 35 \text{ bar} \\
  p_d &= 80 \text{ bar} \\
  t_{GC,\text{Out}} &= 33^\circ\text{C} \\
  m_{\text{Accu}} &= 78 \text{ g} \\
  \text{COP} &= 2,59
\end{align*}
\]

EXV-system + heat transfer into Accu

\[
\begin{align*}
  p_s &= 35 \text{ bar} \\
  p_d &= 130 \text{ bar} \\
  t_{GC,\text{Out}} &= 33^\circ\text{C} \\
  m_{\text{Accu}} &= 0 \text{ g} \\
  \text{COP} &= 1,86
\end{align*}
\]

⇒ Avoid any heat transfer in Accu for max COP
## Requirements for combined accu / ihx

<table>
<thead>
<tr>
<th>for EXV system</th>
<th>for Orifice tube system</th>
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</thead>
<tbody>
<tr>
<td>Accumulator storage volume needed at</td>
<td></td>
</tr>
<tr>
<td>25 °C</td>
<td>5 °C</td>
</tr>
<tr>
<td>70 ml + charge protection</td>
<td>150 ml + charge protection</td>
</tr>
<tr>
<td>Internal heat exchanger performance is needed at high ambient temperatures</td>
<td></td>
</tr>
<tr>
<td>Heat transfer from IHX into Accu should be minimized to achieve maximum COP</td>
<td></td>
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</tbody>
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