Cost efficient R744 AC System for Compact Vehicles

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Motivation

cost efficient R744 AC System
  • Targets

Test vehicle
  • Vehicle
  • R744 Components
  • R744 Compressor

Results
  • AC Performance
  • Driveability (AC-Stumble)

Conclusions
Motivation

- Today's R134a AC-Systems could be classified in three types

<table>
<thead>
<tr>
<th>Class</th>
<th>Compressor Type</th>
<th>Sys. Cost (no currency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper class</td>
<td>external controlled Compressor</td>
<td>550 – 500</td>
</tr>
<tr>
<td>Middle class</td>
<td>external &amp; internal controlled Compressor</td>
<td>480 – 430</td>
</tr>
<tr>
<td>Compact class</td>
<td>fixed displacement &amp; internal controlled Compr.</td>
<td>410 – 380</td>
</tr>
</tbody>
</table>
Motivation

- majority of realized R744 Vehicle cooling systems use external controlled compressor

<table>
<thead>
<tr>
<th></th>
<th>R134a</th>
<th>R744</th>
</tr>
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<tr>
<td><strong>Compressor Type</strong></td>
<td><strong>Sys. Cost</strong></td>
<td><strong>Compressor Type</strong></td>
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<tr>
<td>Upper class</td>
<td>external controlled C.</td>
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<td>ext. &amp; int. controlled C.</td>
<td>480-430</td>
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<tr>
<td>Compact class</td>
<td>fixed &amp; int. controlled C.</td>
<td>410-380</td>
</tr>
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⇒ the cost increase of more than 50% is not acceptable at least for compact class vehicles
Motivation

- internal controlled R744 Compressor is not feasible
  (high pressure difference, needed high pressure control)

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<tr>
<th>Class</th>
<th>Compressor Type</th>
<th>Sys. Cost</th>
<th>R744</th>
<th>Compressor Type</th>
<th>Sys. Cost</th>
<th>Cost increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper class</td>
<td>external controlled C.</td>
<td>550-500</td>
<td>external controlled C.</td>
<td>726-660</td>
<td>132%</td>
<td></td>
</tr>
<tr>
<td>Middle class</td>
<td>ext. &amp; int. controlled C.</td>
<td>480-430</td>
<td>Ext. contr. C.</td>
<td>726-660</td>
<td>152%</td>
<td></td>
</tr>
<tr>
<td>Compact class</td>
<td>fixed &amp; int. controlled C.</td>
<td>410-380</td>
<td>Fixed C.</td>
<td>550-490</td>
<td>115%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fixed displac. C.</td>
<td>550-490</td>
<td>134%</td>
<td></td>
</tr>
</tbody>
</table>

⇒ cost efficient R744 AC System with fixed displacement Compressor is needed at least for compact vehicles.
**cost efficient R744 AC System**

**Targets:**

- Cooling performance equal to R134a cost efficient AC systems (similar to R134a internal controlled and fixed Systems)
- driven by fixed displacement compressor
- system control by clutch cycling
  - EVAP icing avoided by EVAP air outlet temperature sensor
  - pressure switch at Comp. outlet (System protection)
  - temperature sensor at Comp. outlet (System & Oil protection)
- minimized AC stumble
- NVH equal with R134a Systems
cost efficient R744 AC System

realized by Visteon exemplarily in test vehicle:

- Citroen C3
- 1,4 liter petrol engine
- manual gear shift
- climate control by EATC
### Test vehicle

<table>
<thead>
<tr>
<th></th>
<th>Current R134a Citroen C3</th>
<th>Cost efficient R744 AC System in Citroen C3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Condenser / Gascooler</strong></td>
<td>460 * 380 * 17 mm</td>
<td>460 * 380 * 12 mm</td>
</tr>
<tr>
<td><strong>Compressor</strong></td>
<td>120cc internal controlled</td>
<td>15cc fixed displacement</td>
</tr>
<tr>
<td><strong>Evaporator</strong></td>
<td>240 * 200 * 60 mm</td>
<td>240 * 200 * 45 mm</td>
</tr>
<tr>
<td><strong>Accu / IHX</strong></td>
<td></td>
<td>Visteon combined R744 Accu/IHX</td>
</tr>
<tr>
<td><strong>Expansion-Device</strong></td>
<td>(TXV System)</td>
<td>high Pressure Orifice</td>
</tr>
</tbody>
</table>
**R744 fixed displacement Compressor**

- Fixed displacement (15cc)
- Lug distance 121/55mm (small VDA)
- Internal oil separator
- Low rotational inertia
  \[\Rightarrow\text{low engagement torque}\]
- Low weight: < 5,0 kg (incl. clutch)
Test vehicle – AC Performance

climate Wind chamber test:

- 40°C / 40% rh
  no sun load
- 15 Minutes
  50 km/h
  3. gear (2000rpm)
- EATC setting “Lo”
- full blower
- recirc mode
Conclusions:

- any compressor clutch off during pull down phase has deep impact on cooling performance
- in first phase of pull down with low pressure differences the expansion device needs to be wide open to avoid clutch cycling because of high pressure or high temperature
- for later phase the refrigerant mass flow has to be limited to avoid clutch of signals because of potential EVAP icing

⇒ variable mechanical Orifice is needed

    either difference pressure or high pressure driven
Test vehicle – AC Performance

Climate Wind chamber test:

- baseline test with R134a current AC system before rebuild

⇒ R744 AC Performance with 15cc fixed compressor is similar to current R134a System (120cc) inside Citroen C3.
AC Stumble Test at mild ambient:

- beside the performance is the driveability the main comfort criteria for fixed displacement compressor Systems

- AC-Stumble is compared with R134a fixed displacement AC system by subjective ratings

⇒ AC Stumble of R744 cost efficient AC System competitive.
Conclusion

• For a 100% penetration of the mobile AC Systems with R744 cost efficient fixed displacement Compressor Systems are strictly required

• The shown AC performance is similar with the replaced R134a internal controlled compressor system

• The negative impact of AC Stumble is competitive to current R134a Systems

• R744 System is fully integrated in current AC control
Thanks for your attention.

Questions ?