Development of R290 Compressor Used for Air Conditioner

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Contents

1. Background
2. Development of R290 compressor
3. Safety issue with R290 compressor
4. Conclusions
R290 is a substance which is naturally occurring in earth’s atmosphere, now it is receiving high attention as a possible candidate replacement refrigerant.
## 1. Background

The property comparison of R22 and R290

<table>
<thead>
<tr>
<th></th>
<th>R22</th>
<th>R290</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular formula</td>
<td>CHClF2</td>
<td>C3H8</td>
</tr>
<tr>
<td>Thermodynamic property</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal boiling point(℃)</td>
<td>-40.81</td>
<td>-42.09</td>
</tr>
<tr>
<td>Critical pressure (MPa)</td>
<td>4.990</td>
<td>4.248</td>
</tr>
<tr>
<td>Critical temperature(℃)</td>
<td>96.15</td>
<td>96.7</td>
</tr>
<tr>
<td>Environmental impact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ODP</td>
<td>0.055</td>
<td>0</td>
</tr>
<tr>
<td>GWP(100y)</td>
<td>1500</td>
<td>&lt;8</td>
</tr>
<tr>
<td>Safety issue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety classification</td>
<td>A1</td>
<td>A3</td>
</tr>
<tr>
<td>Explosive range (volume %)</td>
<td>-</td>
<td>2.1%～9.5%</td>
</tr>
</tbody>
</table>
1. Back ground

The theoretical cycle comparison of R22 and R290

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>R22</th>
<th>R290</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporating temp C</td>
<td>7.2</td>
<td>7.2</td>
</tr>
<tr>
<td>Suction temp C</td>
<td>35.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Condensing temp C</td>
<td>54.4</td>
<td>54.4</td>
</tr>
<tr>
<td>Liquid temp before expansion valve C</td>
<td>46.1</td>
<td>46.1</td>
</tr>
<tr>
<td>Suction pressure MPa</td>
<td>0.625</td>
<td>0.588</td>
</tr>
<tr>
<td>Discharge Pressure MPa</td>
<td>2.146</td>
<td>1.883</td>
</tr>
<tr>
<td>Pressure difference Mpa</td>
<td>1.521</td>
<td>1.295</td>
</tr>
<tr>
<td>Pressure Ratio</td>
<td>3.432</td>
<td>3.205</td>
</tr>
<tr>
<td>Discharge temp C</td>
<td>101.8</td>
<td>84.2</td>
</tr>
<tr>
<td>Cooling capacity per unit volume kJ/m3</td>
<td>3944.8</td>
<td>3430.9</td>
</tr>
<tr>
<td>Compressor work per unit volume kJ/m3</td>
<td>821.0</td>
<td>699.0</td>
</tr>
<tr>
<td>COP</td>
<td>4.805</td>
<td>4.908</td>
</tr>
</tbody>
</table>
2. Development of R290 compressor

- Performance improvement
- Motor optimizing
- Displacement determination
- Lubricant development
- Safety issue
- Reliability
- Material compatibility
- Mechanical structure optimizing
2. Development of R290 compressor

1. Development of lubricant

Miscibility and reliability

![Graph showing pressure vs. R290 wt% in lubricant at different temperatures.](image)

- **Pressure, Kg/cm²**
  - 30
  - 25
  - 20
  - 15
  - 10
  - 5
  - 0
- **R290 wt% in lubricant**
  - 0
  - 20
  - 40
  - 60
  - 80
  - 100

*Viscosity Sensor*
2. Development of R290 compressor

1. Development of lubricant

Compatibility

Material in the compressor

Material during manufacture of compressor
2. Development of R290 compressor

1. Development of lubricant

Performance

- R290/A油
- R290/B油
- R22/C油

![Graph showing performance comparison between R290/A oil, R290/B oil, and R22/C oil.](attachment:image.png)
2. Development of R290 compressor

## 2. Displacement determination

<table>
<thead>
<tr>
<th>Model</th>
<th>SH307HV</th>
<th>PSH307HV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement (cc/rev)</td>
<td>30.7</td>
<td>30.7</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>R22</td>
<td>R290</td>
</tr>
<tr>
<td>Cooling capacity (W)</td>
<td>5249</td>
<td>4627</td>
</tr>
</tbody>
</table>

For the same cooling capacity, the displacement of R290 compressor should be about 12% larger than that of the R22 compressor.
2. Development of R290 compressor

3. Mechanical structure optimizing

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CAE/CFD Simulation
2. Development of R290 compressor

4. Motor optimizing

![Graph showing efficiency comparison between R290 and R22 compressors. The graph illustrates the optimizing points for each compressor and the output power.]
3. Safety issue with R290 compressor

1. Lower the charge amount in compressor

   (1) Reduce the shell internal volume
   (2) Reduce the accumulator internal volume
   (3) Lower the R290 solubility in lubricant
   (4) Lower the lubricant charge amount
3. Safety issue with R290 compressor

1. Lower the charge amount in compressor

(1) Reduce the shell internal volume

G Series → D Series

Diameter: φ112mm → φ107mm

Volume reduced: 60ml

R290 reduced: 2.0g
3. Safety issue with R290 compressor

1. Lower the charge amount in compressor

(2) Reduce the accumulator internal volume

Diameter: φ 70mm → φ 65mm

Volume Reduced: 66ml

R290 reduced: 0.7g
3. Safety issue with R290 compressor

1. Lower the charge amount in compressor

(3) Lower the R290 solubility in lubricant

POE VS Mineral oil

R290 Solubility 15% vs R290 Solubility 20%

R290 reduced by 13g (1HP air conditioner)
3. Safety issue with R290 compressor

1. Lower the charge amount in compressor

(4) Lower the lubricant charge amount

Optimizing the oil supply system,
Lower the oil lever,
Reduce the oil charge amount.

Take 1HP air conditioner as example:
Oil charge amount reduced: 50ml,
POE: R290 reduced by 9.5g
Mineral oil: R290 reduced by 7.5g
3. Safety issue with R290 compressor

1. Lower the charge amount in compressor

(5) Conclusion

To lower the R290 charge amount in compressor, the focus should be kept on lowering R290 solubility in oil and lowering the oil charge amount.
3. Safety issue with R290 compressor

2. Flammability and Explosion Analysis

With the pressure increases, the R290-air mixture flammability concentration limits is narrower than that of R22-air mixture.
4. Conclusions

1. R290 is receiving high attention as a possible candidate replacement refrigerant, especially for high ambient temperature region.

2. The key points to develop R290 compressor include: lubricant development, displacement determination, structure optimizing and motor optimizing.

3. To lower the R290 charge amount in compressor, the focus should be kept on lowering R290 solubility in oil and lowering the oil charge amount.

4. With the pressure increases, the R290-air mixture flammability concentration limits is narrower than that of R22-air mixture.
Thank you for your attention!