The scroll compressor with internal cooling system – conception and CFD analysis

Jozef Rak, Slawomir Pietrowicz, Zbigniew Gnutek

Department of Thermodynamics, Wroclaw University of Technology, Wroclaw, Poland
jozef.rak@pwr.edu.pl
Outline

• Motivation
• Vanes shape comparison
• Heat transfer in working chamber
• CFD simulation
  • assumptions
  • dynamic mesh
  • results
• Summary
Motivation

• Making the compression process more effective
• Study of the modified shape
• Knowledge about a heat-flow phenomena
• Building a device for special applications
Vanes shape comparison

classic

modified
Modified vanes shape (preserved parameters)

- Vanes length reduced up to 42%
- Significant empty space inside the vanes
- Fewer working chambers – friction reduction
- Shorter compression cycle
Heat Transfer

Orbiting

Stationary

$T_1$ $a_1$ $a_2$ $a_3$ $a_4$ $T_2$
Heat transfer coefficient [1]

\[ \alpha = 0.023 \frac{\lambda}{D_h} Re^{0.8} Pr^{0.4} \left( 1 + 1.77 \frac{D_h}{r_{ave}} \right) \]

\[ Re = \frac{\dot{m}D_h}{A_{cr} \mu} \]

\[ D_h = \frac{4V}{A_{ar}} \]

\[ r_{ave} = r_b \left[ \frac{(\phi_k - 0.5\pi) + (\phi_{k-1} - 0.5\pi)}{2} \right] \]
Working chambers

classic

modified
Sinusoidity

\[ S = \frac{L}{l} \]

\[ S = \frac{L_{out} - L_{in}}{l} \]
Sinusoity

\[ S = \frac{L}{l} \]

\[ S = \frac{L_{out} - L_{in}}{l} \]
### CFD simulation

<table>
<thead>
<tr>
<th>Medium</th>
<th>air, ideal gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction pressure</td>
<td>1 bar</td>
</tr>
<tr>
<td>Suction temperature</td>
<td>300 K</td>
</tr>
<tr>
<td>Walls</td>
<td>adiabatic</td>
</tr>
<tr>
<td>Turbulence model</td>
<td>k-epsilon</td>
</tr>
<tr>
<td>Wall function</td>
<td>scalable</td>
</tr>
<tr>
<td>Scroll rotational velocity</td>
<td>750 and 1500 rpm</td>
</tr>
<tr>
<td>Leakage</td>
<td>no leakage</td>
</tr>
<tr>
<td>Vanes deformation</td>
<td>no deformation</td>
</tr>
</tbody>
</table>
Deforming mesh

• User defined node displacement

• Ansys ICEM mesh generation script
  • automatic meshing script
  • separate mesh for each timestep
  • preserved topology
  • density as a function of timestep
Numerical vs analytical results

Average pressure variation

Average temperature variation
Pressure fields
Numerical heat transfer coefficient [2]

\[ h = \frac{\rho c_p u^*}{T^+} \]

where:

\[ u^* = C_{\mu}^{0.25} k^{0.5} \]

\[ T^+ = 2.12 \ln y^* + \beta \]

\[ \beta = \left(3.85 Pr^{\frac{1}{3}} - 1.3\right)^2 + 2.12 \ln Pr \]

\[ y^* = \frac{u^* \cdot \Delta n/4}{\nu} \]
Sinuosity and heat transfer coeff.
Summary

• New shape based scroll compressor development

• Heat transfer coefficient study

• Working chamber geometry influence on the process
References