LUT
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University of Technology
Numerical Sensitivity Analysis for Supercritical CO$_2$ Radial Turbine Performance and Flow Field

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Outline

- Introduction
- Numerical methods & studied case
- Real Gas Properties (RGP)
- Result - Performance
- Result – Flow field
- Extended studies

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• Motivation
• Present study
Numerical simulations with ANSYS CFX 17.0
Structured mesh by using Turbo Grid (about 1.4 million cells)
$k – \omega$ SST Turbulence model
Sandia radial turbine (main)*
Boundary conditions: $p_t, T_t$ & $p_s, T_s$ - $p_t, T_t$ & $\dot{m}$
Unsteady state simulation (Time Transformation)

1. Improved cubic EOS models Peng-Robinson (PR)
2. Soave-Redlich-Kwong (SRK)
3. Span & Wagner (SW)
4. Ideal
Introduction

Numerical methods & studied case

Real Gas Properties (RGP)

Result Performance

Result Flow fields

Extended studies

<table>
<thead>
<tr>
<th>Case name</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\omega$ (RPM)</td>
<td>25000</td>
<td>35069</td>
<td>39140</td>
<td>75000</td>
</tr>
<tr>
<td>$m$ (kg/s)</td>
<td>0.973</td>
<td>1.631</td>
<td>1.630</td>
<td>2.58</td>
</tr>
<tr>
<td>$T_{11}$ (K)</td>
<td>421.25</td>
<td>420.75</td>
<td>476.75</td>
<td>810.15</td>
</tr>
<tr>
<td>$T_{14}$ (K)</td>
<td>411.1</td>
<td>403.3</td>
<td>455.3</td>
<td>749.2</td>
</tr>
<tr>
<td>$p_{t1}$ (MPa)</td>
<td>8.284</td>
<td>9.125</td>
<td>9.365</td>
<td>13.5</td>
</tr>
<tr>
<td>$\tau$</td>
<td>1.089</td>
<td>1.203</td>
<td>1.235</td>
<td>1.711</td>
</tr>
<tr>
<td>$\Delta h_i$ (kJ/kg)</td>
<td>8.6</td>
<td>12.91</td>
<td>17.98</td>
<td>68</td>
</tr>
<tr>
<td>$Z_{in/out}$</td>
<td>0.879/0.876</td>
<td>0.867/0.866</td>
<td>0.923/0.921</td>
<td>1.01/1.005</td>
</tr>
</tbody>
</table>
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1- Specific entropy
2- Specific enthalpy
3- Speed of sound
4- Specific volume
5- Specific heat at constant pressure
6- Specific heat at constant volume
7- Dynamic viscosity
8- Thermal conductivity
9- Partial derivative of pressure with respect to specific volume at constant temperature.
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CPU time second per time step

Ideal  RGP 100  RGP 250  RGP 500

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CPU time second per rotor rotation

Ideal  RGP 100  RGP 250  RGP 500

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Real gas assumption

Ideal gas assumption

Mach Number in Stn Frame

0.0

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Undergoing researches:

- Design a centrifugal compressor with current and modified loss models.

- Sandia Supercritical CO₂ Radial compressor
Efficiency (%) vs Flow coefficient

- Experimental
- CFD
- 1D model

Real Gas Properties (RGP)

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Thank you for your attention!