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

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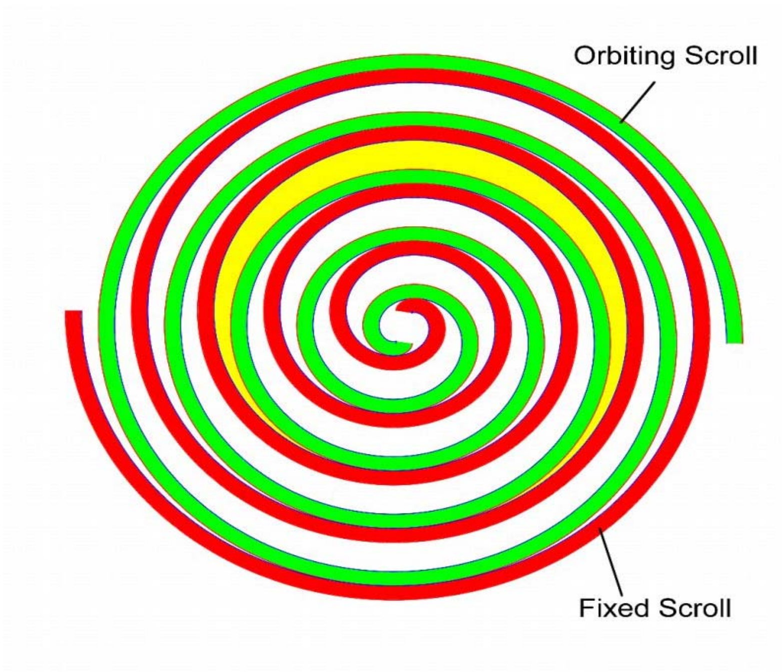
Outline

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

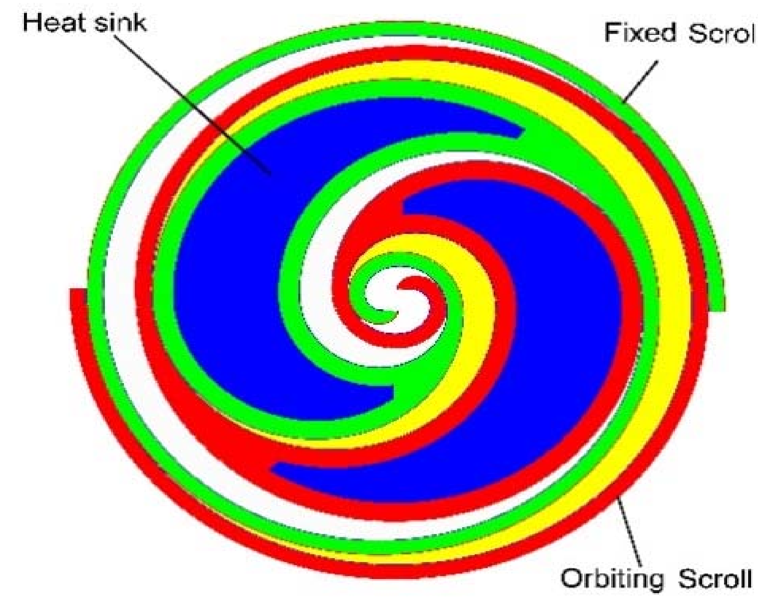
Motivation

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

Vanes shape comparison



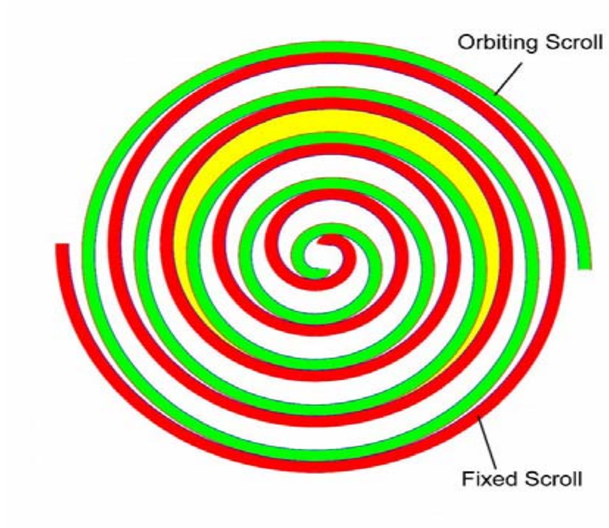
classic

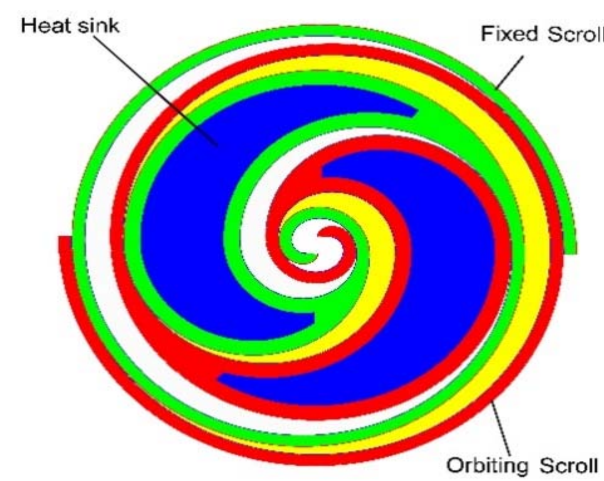


modified

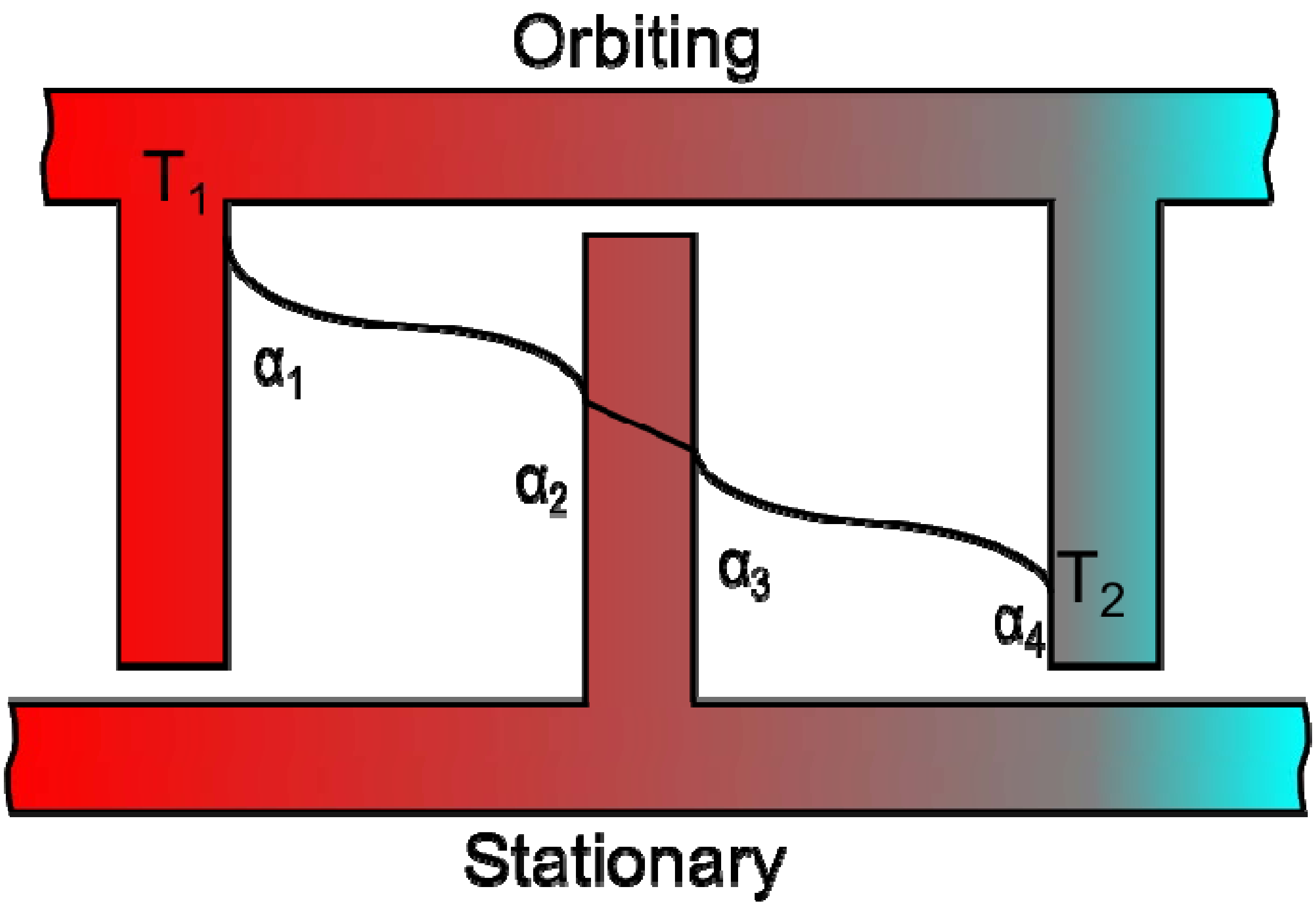
Modified vanes shape (preserved parameters)

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





Heat Transfer



Heat transfer coefficient [1]

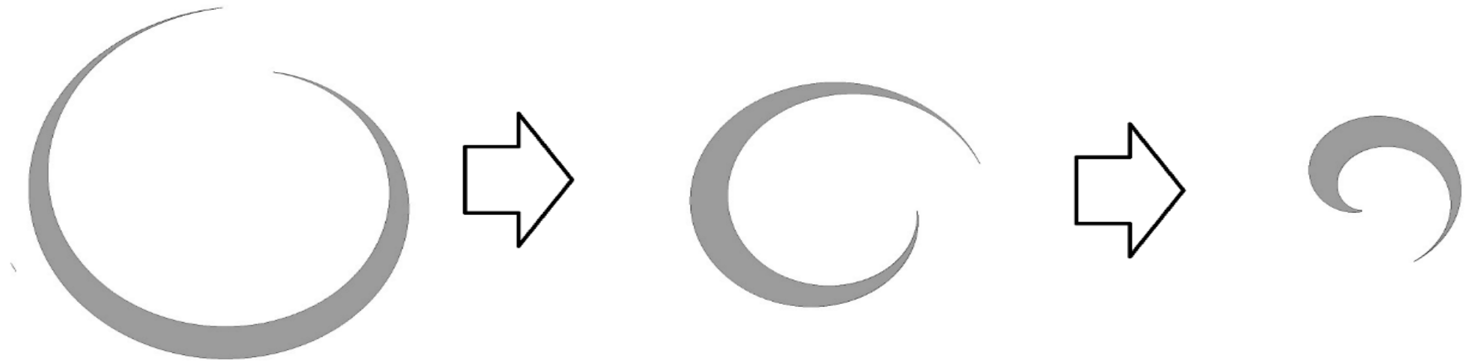
$$\alpha = 0.023\frac{\lambda}{D_h}Re^{0.8}\,Pr^{0.4}\left(1 + 1.77\frac{D_h}{r_{ave}}\right)$$

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

$$D_h = \frac{4V}{A_{ar}}$$

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

Working chambers



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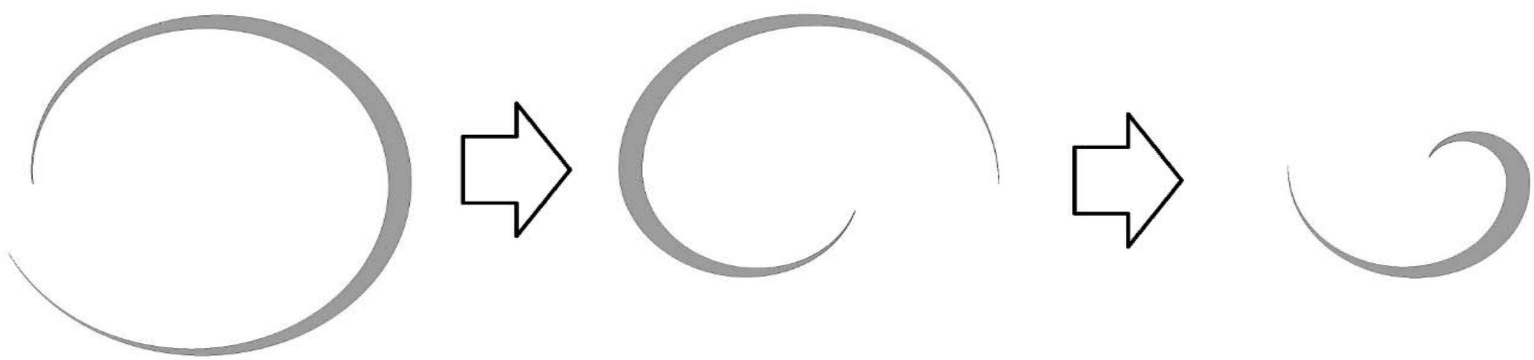
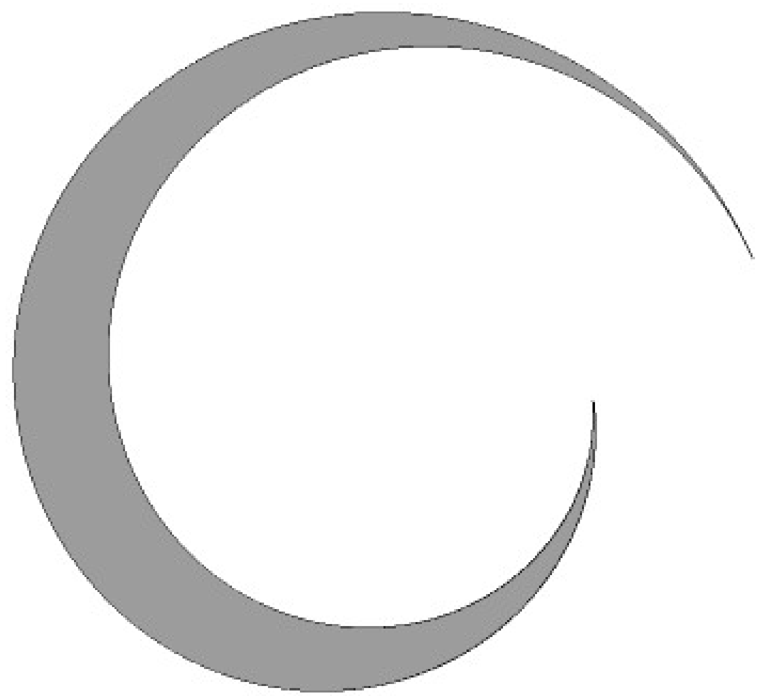


modified

Sinusoity

$$S = \frac{L}{l}$$

$$S = \frac{L_{out} - L_{in}}{l}$$



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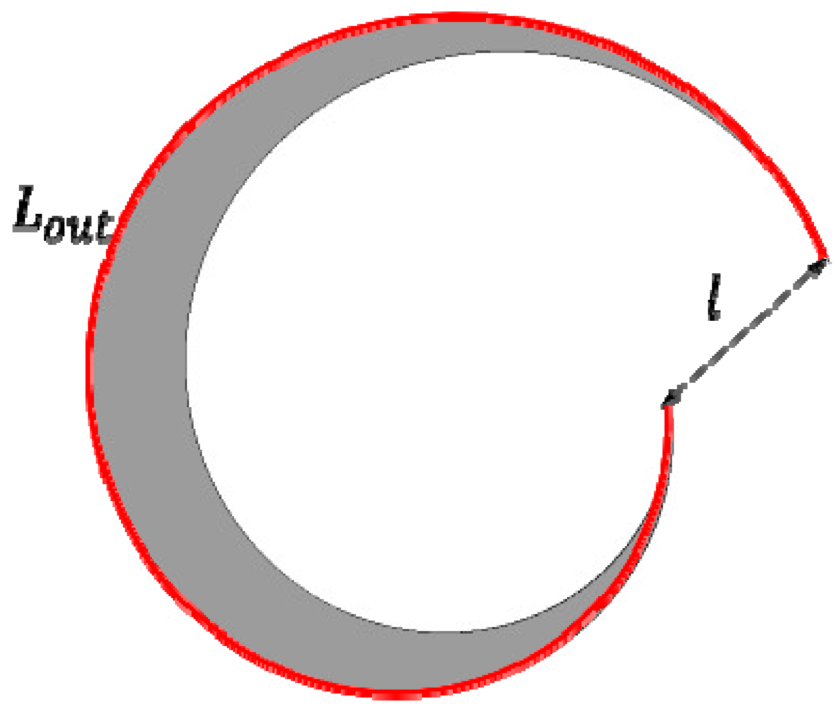


CFD simulation

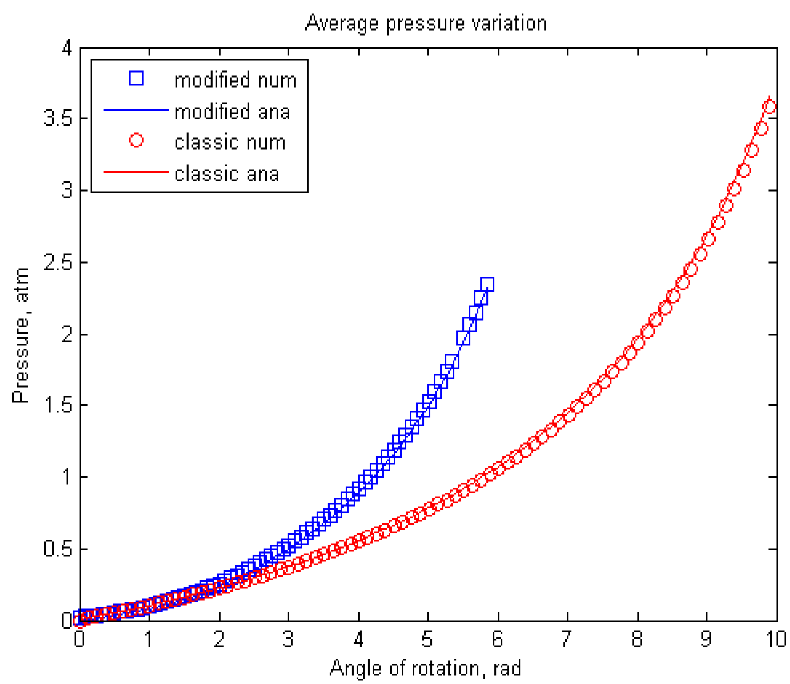
Medium	air, ideal gas
Suction pressure	1 bar
Suction temperature	300 K
Walls	adiabatic
Turbulence model	k-epsilon
Wall function	scalable
Scroll rotational velocity	750 and 1500 rpm
Leakage	no leakage
Vanes deformation	no deformation

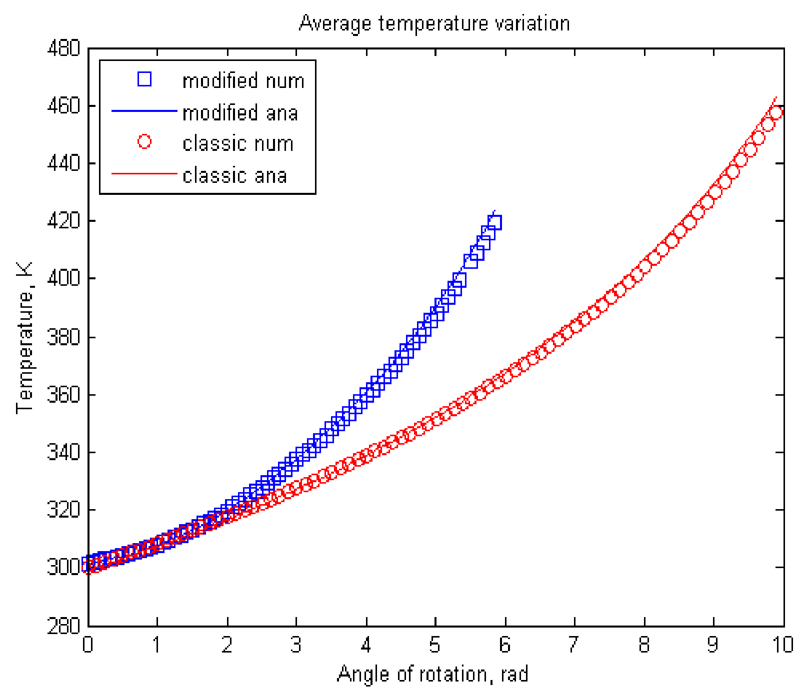
Deforming mesh

- User defined node displacement

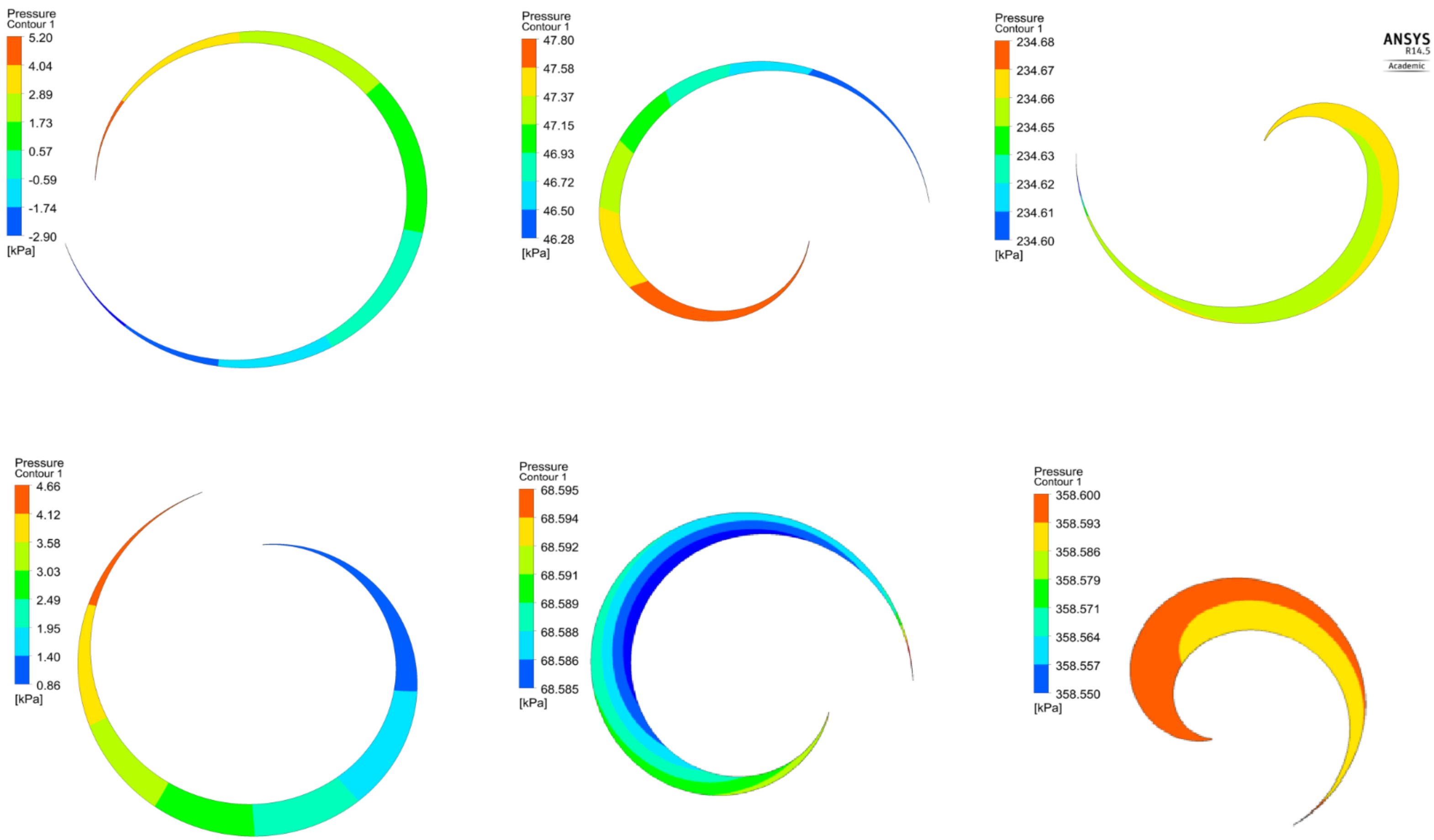
- Ansys ICEM mesh generation script
  - automatic meshing script
  - separate mesh for each timestep
  - preserved topology
  - density as a function of timestep

Numerical vs analytical results





Pressure fields



Numerical heat transfer coefficient [2]

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

where:

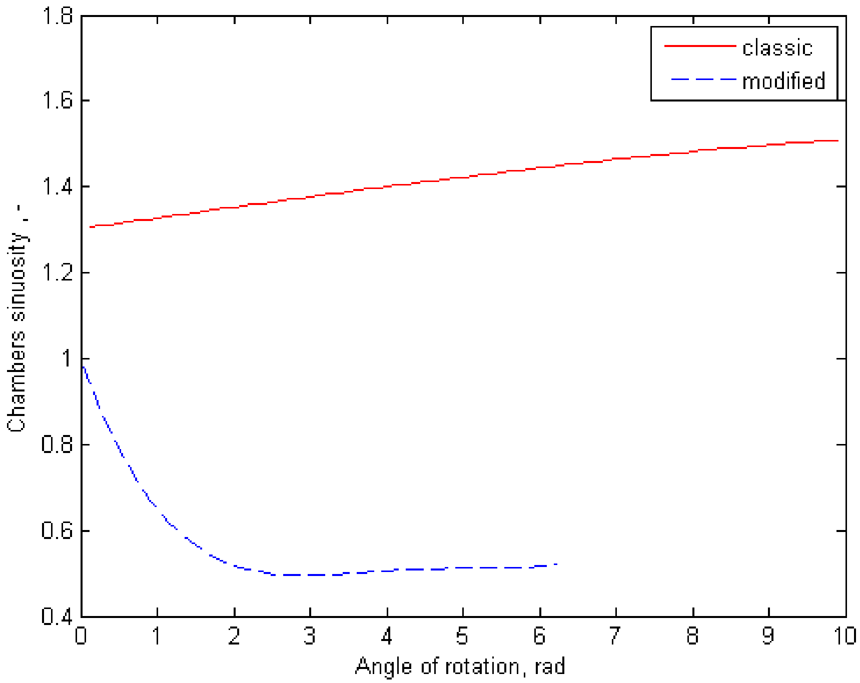
$$u^* = C_\mu^{0.25} k^{0.5}$$

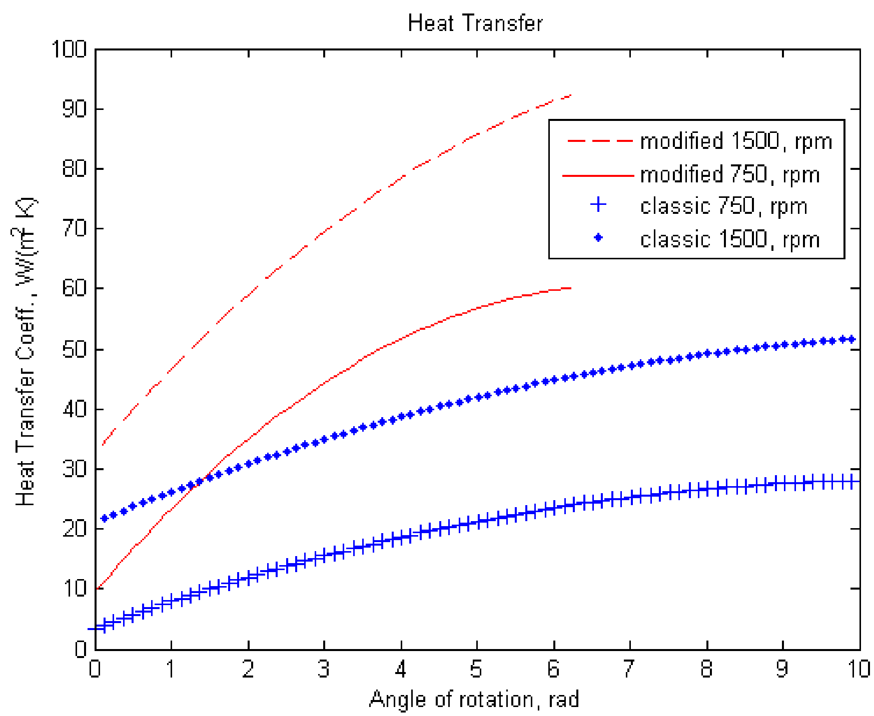
$$T^+ = 2.12 \ln y^* + \beta$$

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

$$y^* = \frac{u^* \cdot \Delta n/4}{\nu}$$

Sinuosity and heat transfer coeff.





Summary

- New shape based scroll compressor development
- Heat transfer coefficient study
- Working chamber geometry influence on the process

References

[1] L.C. Burmeister, Convective Heat Transfer, Wiley, New York, 1983

[2] Ooi K.T., Zhu J., 2004, *Convective heat transfer in a scroll compressor chamber: a 2-D simulation*, International Journal of Thermal Sciences, vol. 43, no. 7, p. 677-688