Laboratoire d'Electronique Industrielle

ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

# Modeling and Simulation of a Three-stage Air Compressor Based on Dry Piston Technology

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# Outline

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3. Meshing
4. Inlets and outlets
5. Module used
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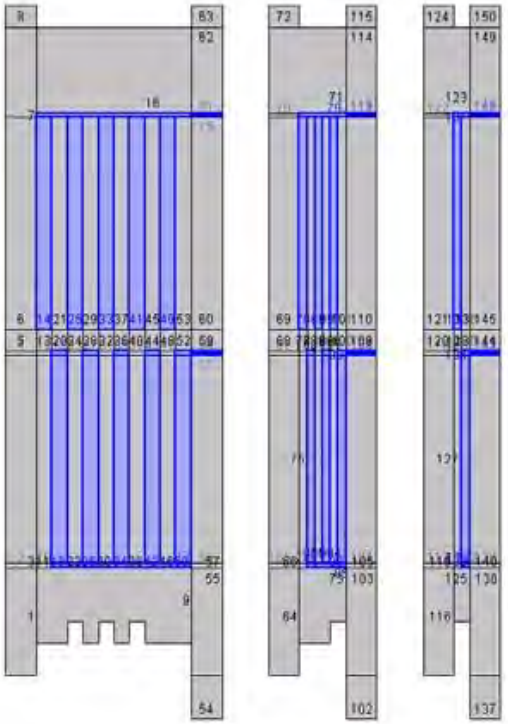
# Introduction

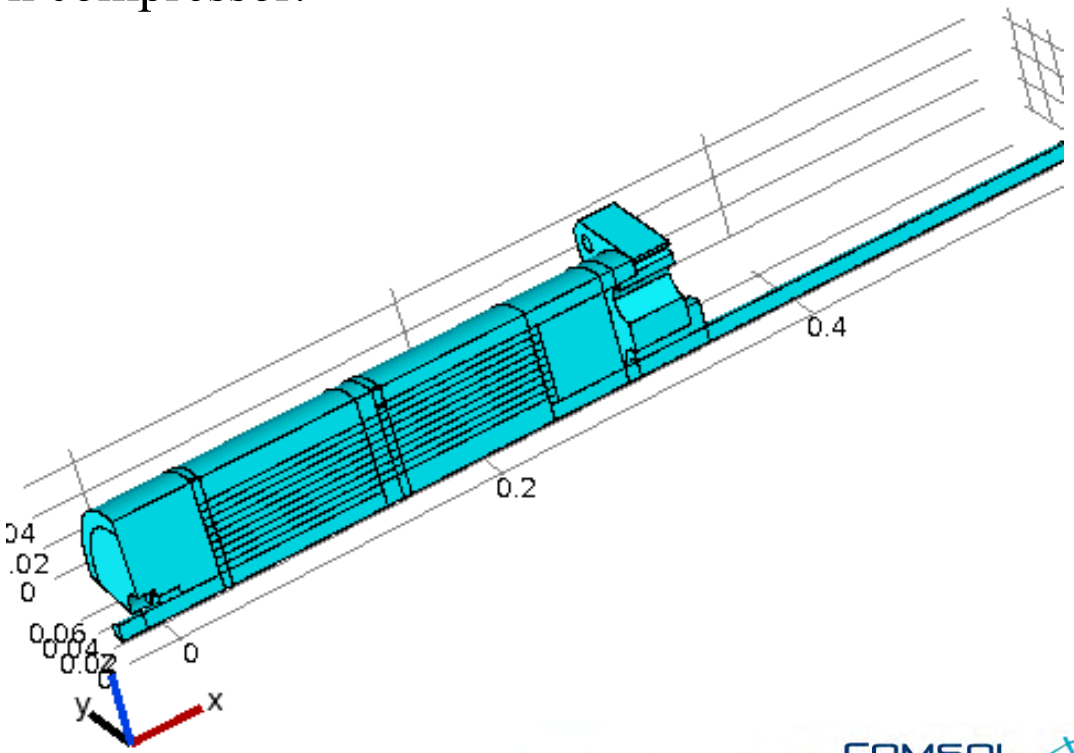
- Compressed Air Energy Storage (CAES)
  - A way to store energy generated at one time for use at another time.
  - Energy generated during periods of low energy demand (off-peak)

  can be released to meet higher demand (peak load) periods.

# Concept

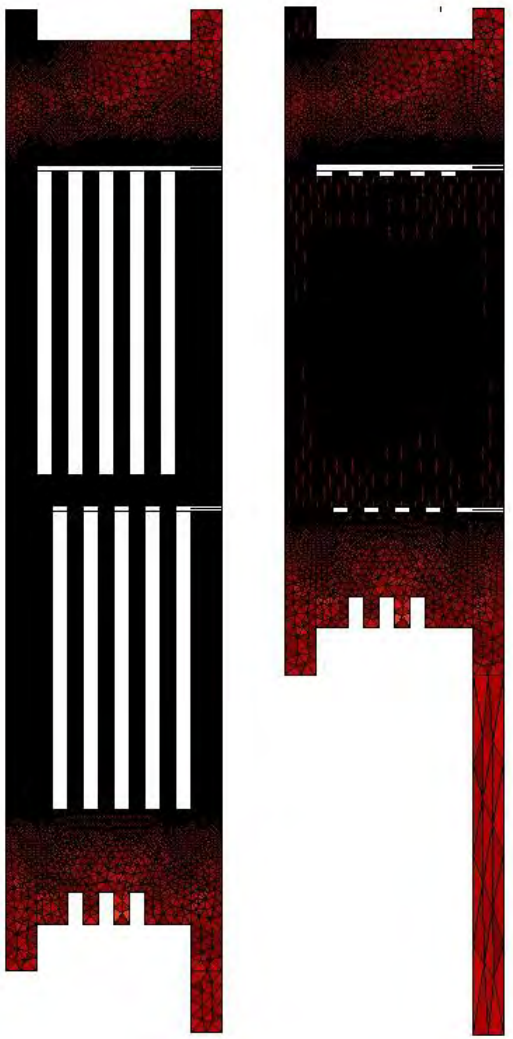
- Concept of Dry Piston
  - Definition of a new near-Isothermal compression and expansion machine, based on a three-stage dry piston compressor.





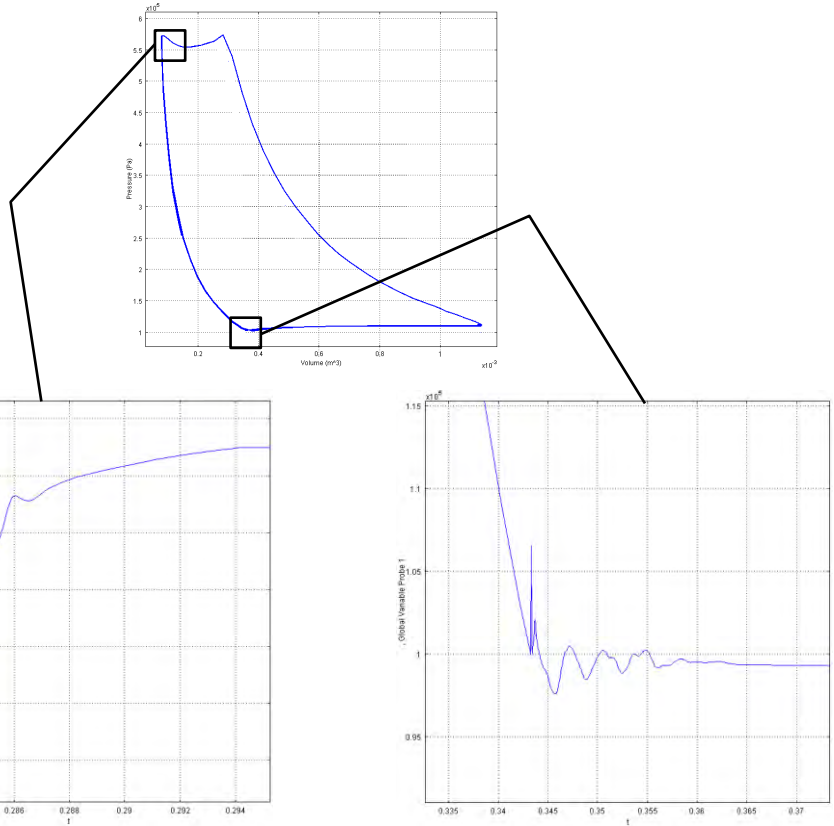
# Meshing

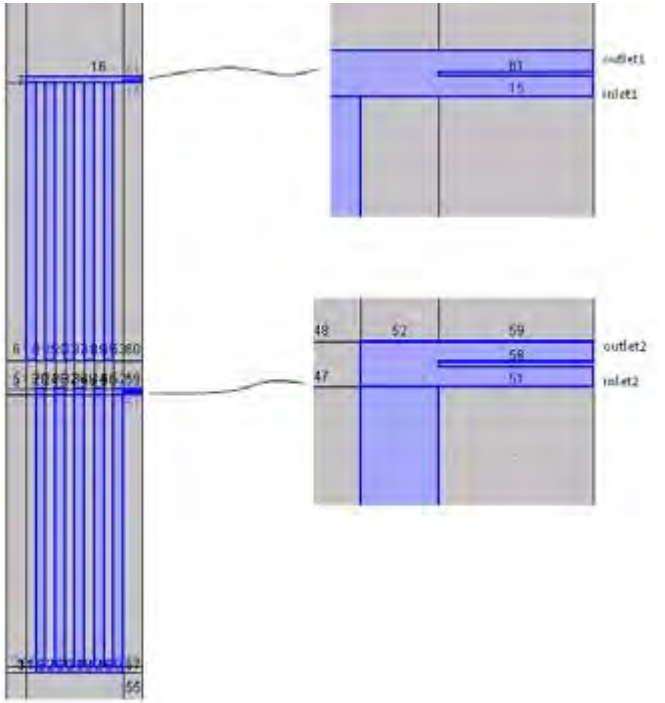
- User Controlled Mesh
- Free triangulare
  - Fine in the middle
  - Coarse in top and bottom



# Inlets and outlets

- Implementing valves using logical terms:
  - ((Pout>=Pr) and (t<τ/2)) => outlet valve is open
  - ((Pin<=Pa) and (t<τ)) => inlet valve is open
- Effect of valve flutter
  - Can be seen in model with very small time scales a fine mesh.

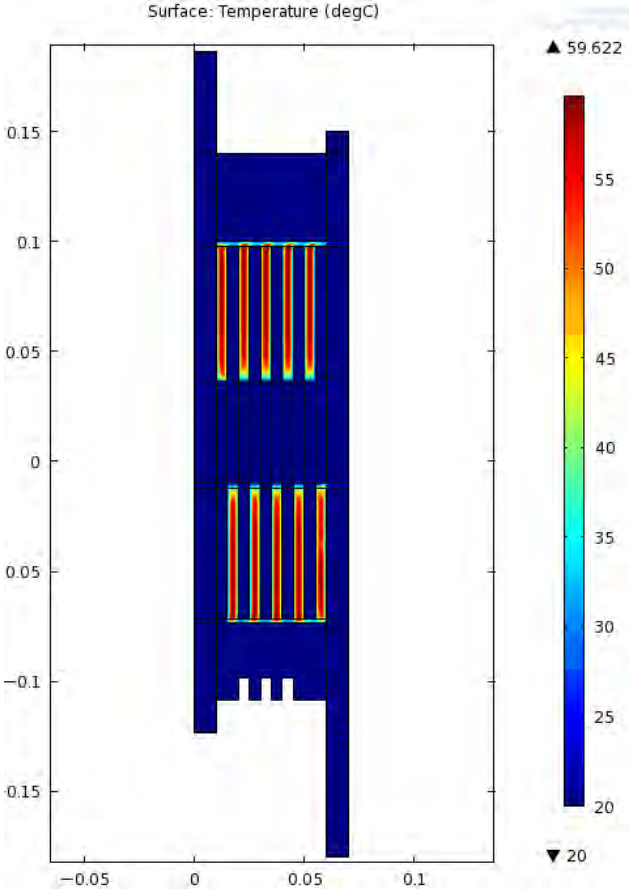


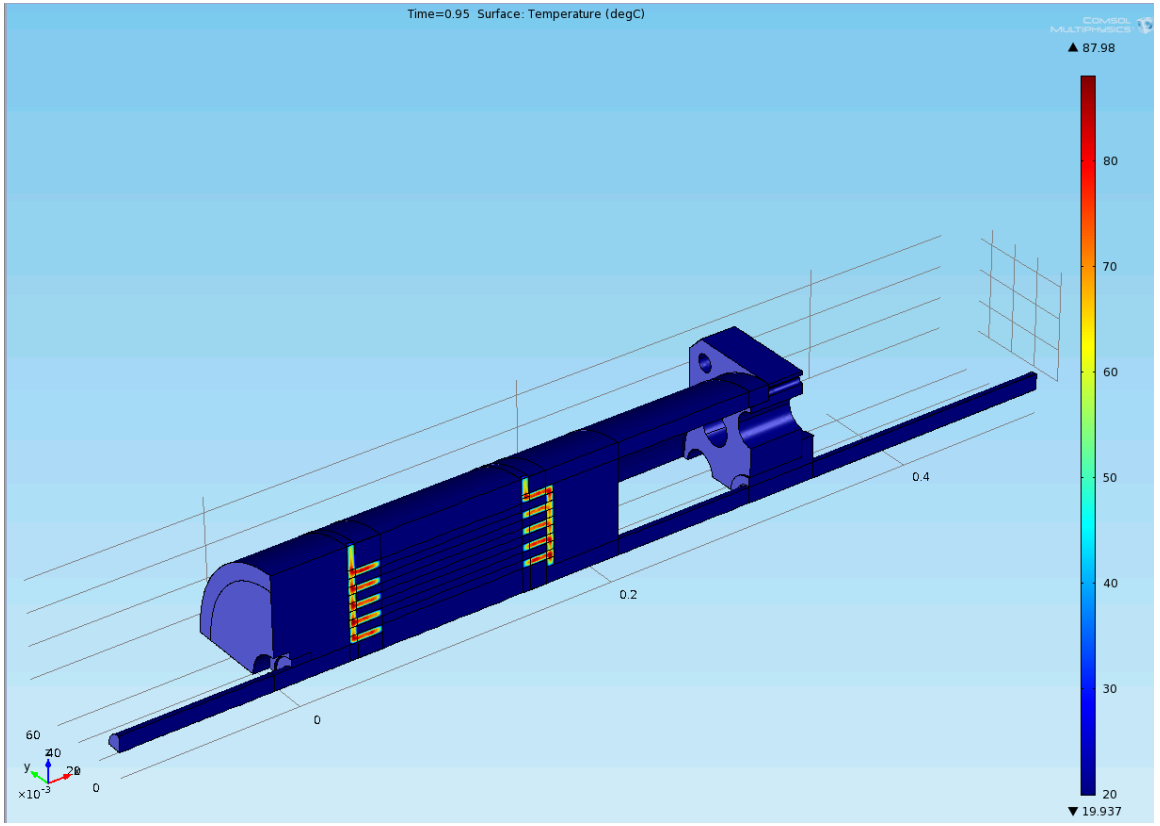


# Module used

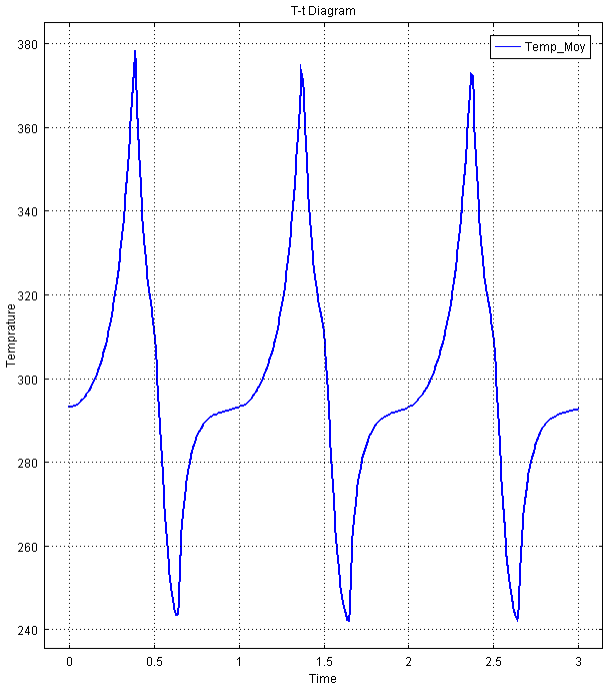
- Moving Mesh(ALE)
  - Fixed part
  - Moving parts, …
- Fluide flow
  - Initial values
  - Walls, …
- Heat transfer
  - Heat transfer in solid
  - Heat transfer in fluid
  - Translational motion
  - Convecting cooling
  - Moving walls, ...

# 2D vs. 3D Model

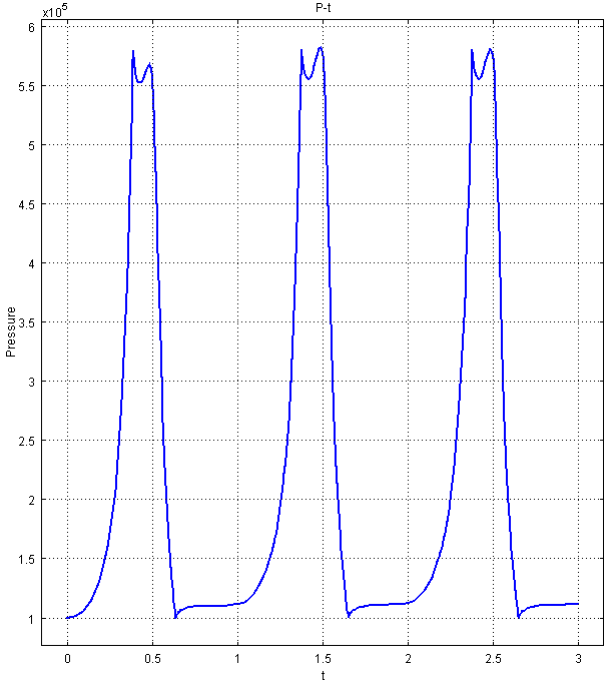


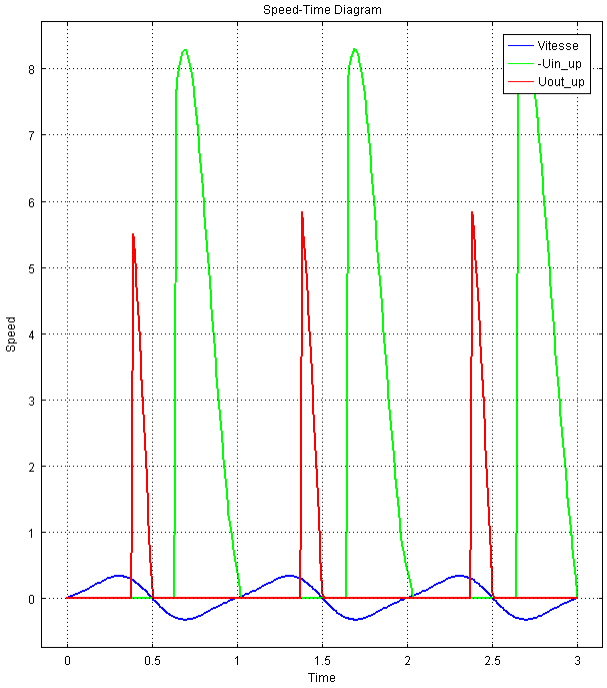
# Diagrams




T-t

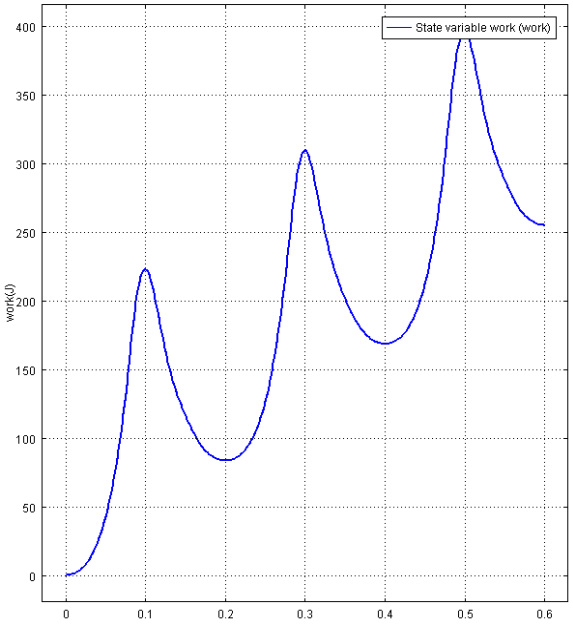



P-t

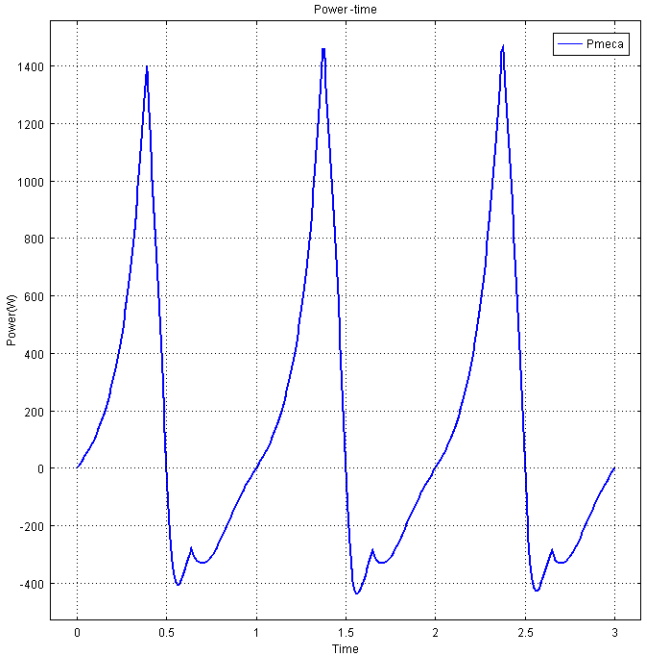



V-t

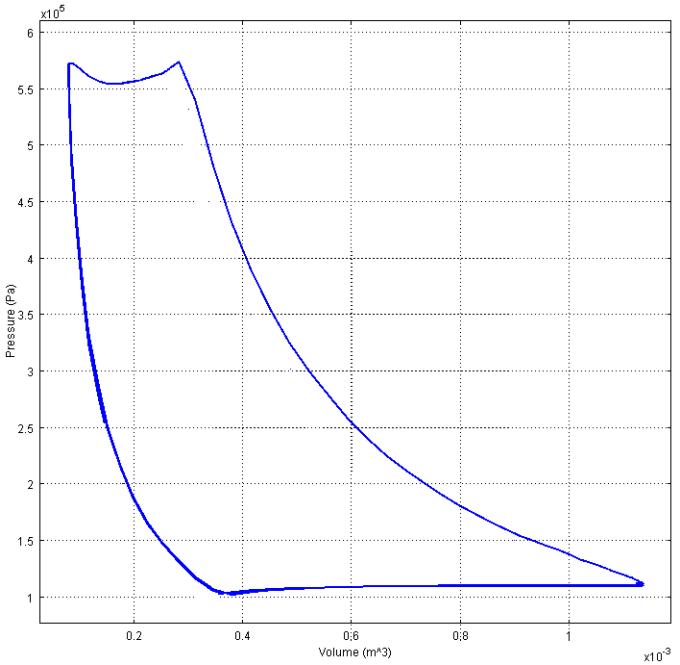
# Diagrams




Work-t

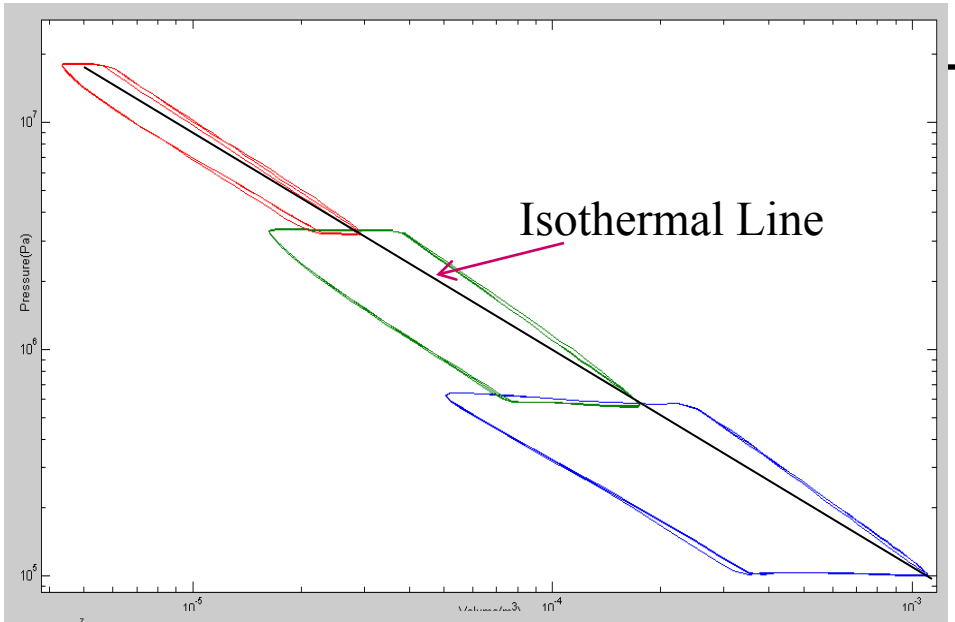


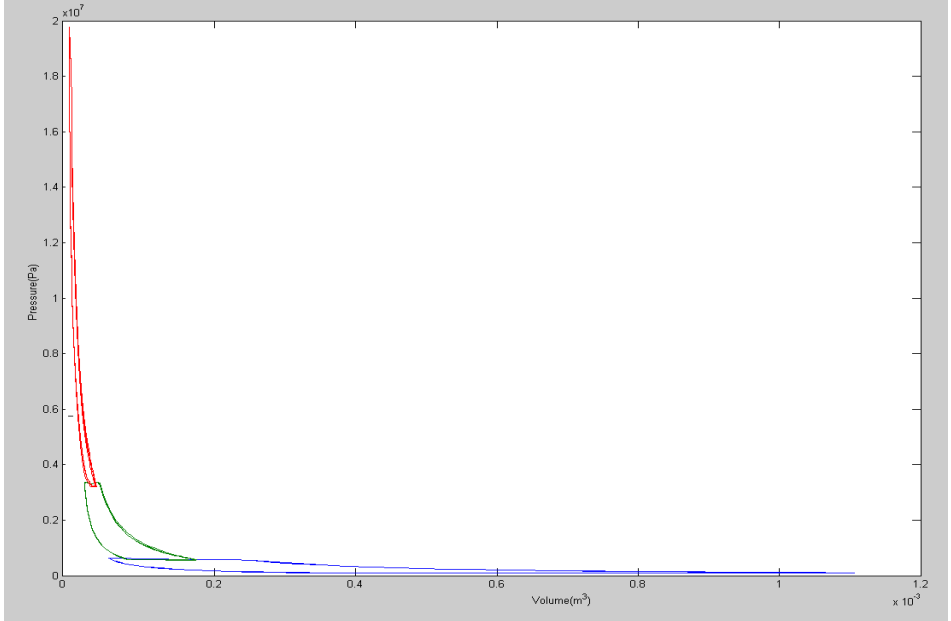

Power-t




P-V

# Results

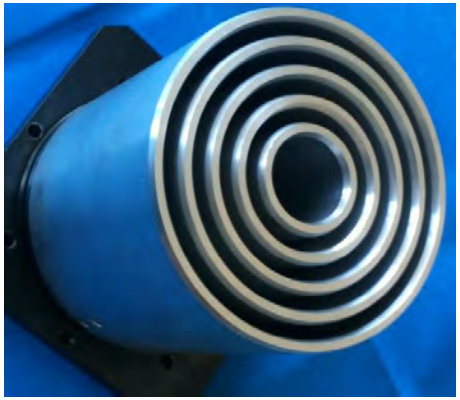


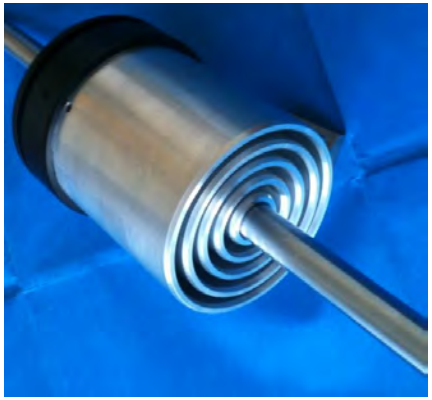




| | stage 1 | stage 2 | stage 3 |
|---|---|---|---|
| $\eta_v$ | 0.75 | 0.65 | 0.41 |
| $n_{comp}$ | 1.164 | 1.168 | 1.06 |
| $w_{net}$ (kJ/kg) | 166 | 168 | 157 |
| $w_{Isoth}$ (kJ/kg) | 146 | 148 | 149 |
| $\eta_{Isoth}$ | 0.88 | 0.87 | 0.94 |

# Experimentation

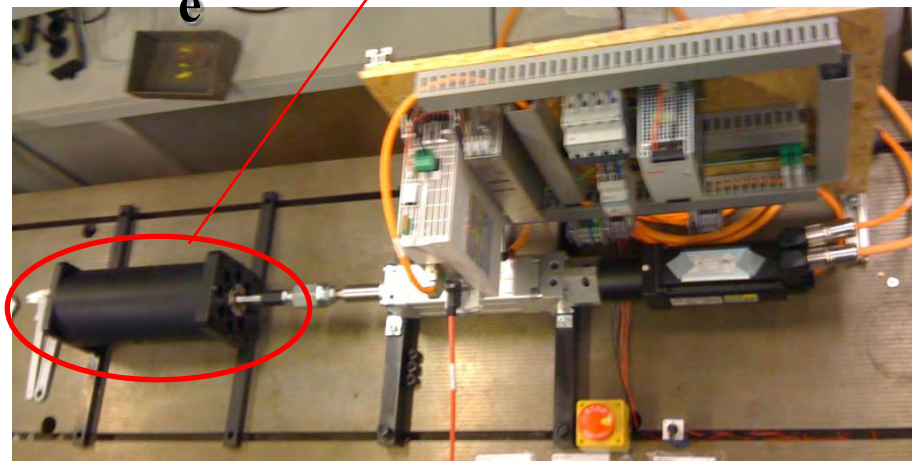
## Experimental set-up





**Fix**
**e**

**Mobie**



**Parts of the new "Dry Piston" Compression/Expansion Chamber**

**New test setup just completed**

**Experimental Verifications will be done soon.**

# Perspective & Conclusion

- Stress analysis, valve vibration and noise control will be implemented in the model soon.

- A multi-objective optimization of geometry will be done with COMSOL optimization toolbox, to maximize both volumetric and isothermal efficiency.

- COMSOL is a Powerful tool for multidisciplinary design and complicated geometries.

# Q&A

- Thanks for your attention