Teaching Thermodynamic Cycles

DLR ThermoFluidStream Community Event
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Content

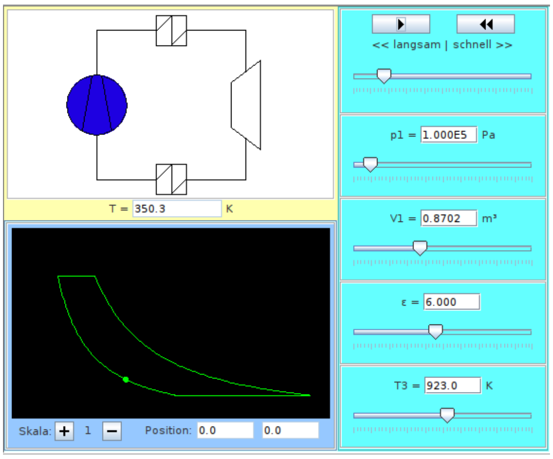
Using Modelica models for teaching thermodynamics

Cyclic processes:

- Otto, Diesel
- Joule-Brayton, Ericsson (ideal gas, dry air)
- Clausius-Rankine (standard water)

Very simple static models:

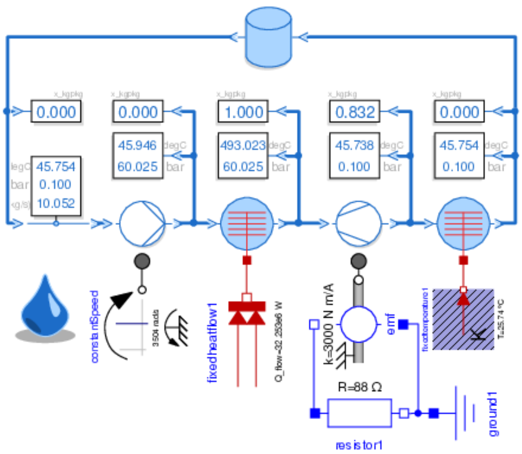
- turbo machines with linear characteristic ($\dot{m} = K\omega$)
- mass flow is given explicitly
- reproduce results from lecture and exercises
- old version with own simple Thermolib
- rebuilt with DLR TFS-Lib 1.0.0



Example Models

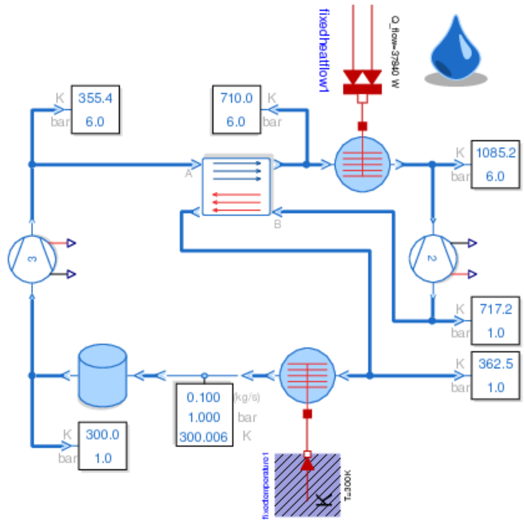
Clausius-Rankine Process:

- looks like simple Joule-Brayton model
- uses IAPWS-IF97 water from MSL media
- compressor (ideal gas) → pump (incompressible fluid)
  - uses simple nominal pump instead of centrifugal pump



Ericsson Process with Ideal Gas:

- simple compressor → line of compressors with intermediate coolers
- similar for turbine
- using excess heat with heat exchanger from ThermoDLR



Problems and Challenges

Special components necessary:

- cylinder model = volume with a mechanical flange
- compressor uses constant c_p
  - instead use constant entropy with $c_p(T)$
  - needs inversion of nonlinear function
- turbine using water (TFS-Lib turbine only uses ideal gas)

Parameter Tuning:

- reverse logic
  - p, T, $\dot{m}$ given
  - compressor, turbine and heater parameters needed
- arbitrary guess values → "Failed to solve nonlinear system"
- solution methods
  - use turbine equations to compute ω or τ manually
  - start with smaller state changes
  - use known state values as initial values
- model runs at least for a short time
  - → apply parameter changes and monitor results
  - → final values can be reached
- more details in
  - "Implementing Thermodynamic Cyclic Processes Using the DLR Thermofluid Stream Library",
SNE 33/4 (2023), 175-182.

Conclusions

- experiments with MSL Thermo/Fluid library unsuccessful
- with DLR TFS library still non-trivial
- but clear path to find working parameters