STERG

SOLAR THERMAL ENERGY RESEARCH GROUP

Model development and parametric analysis for SCRAP jet impingement

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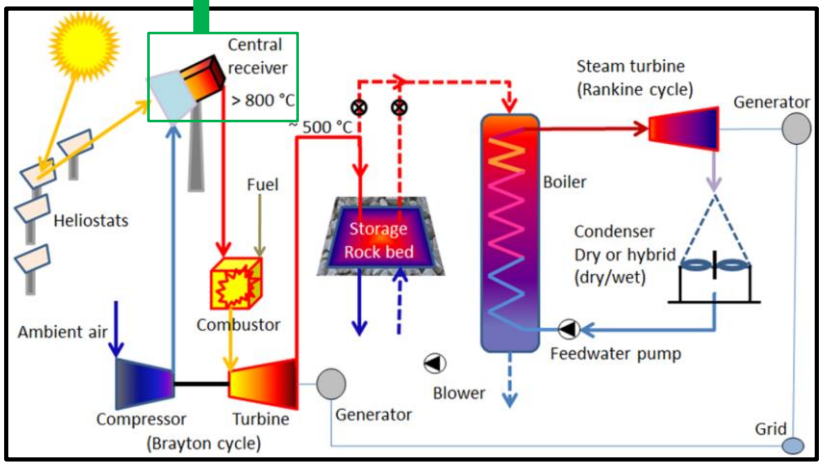
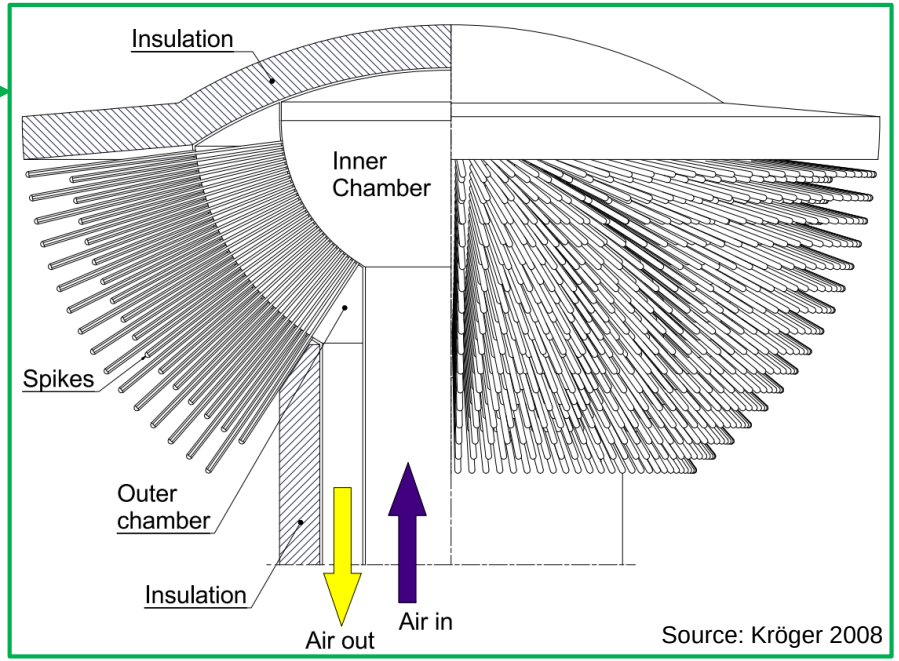
Introduction to SCRAP

Spiky Central Receiver Air Pre-heater



Source: Kröger 2012



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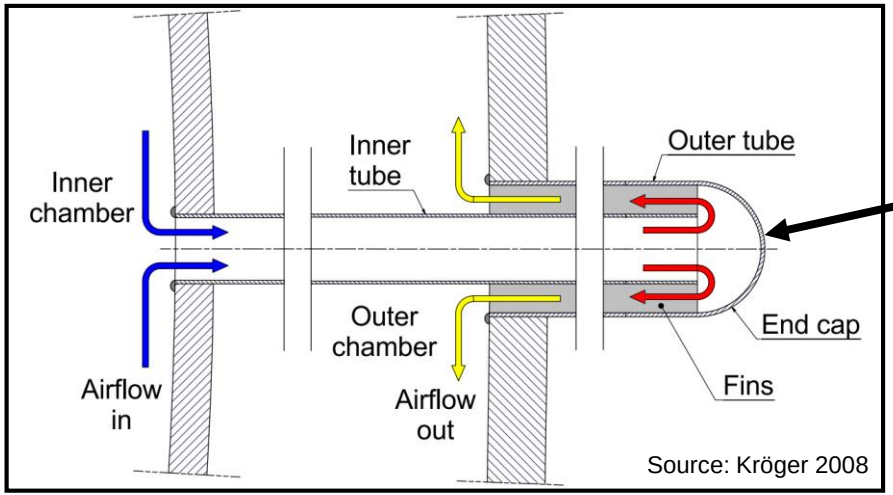

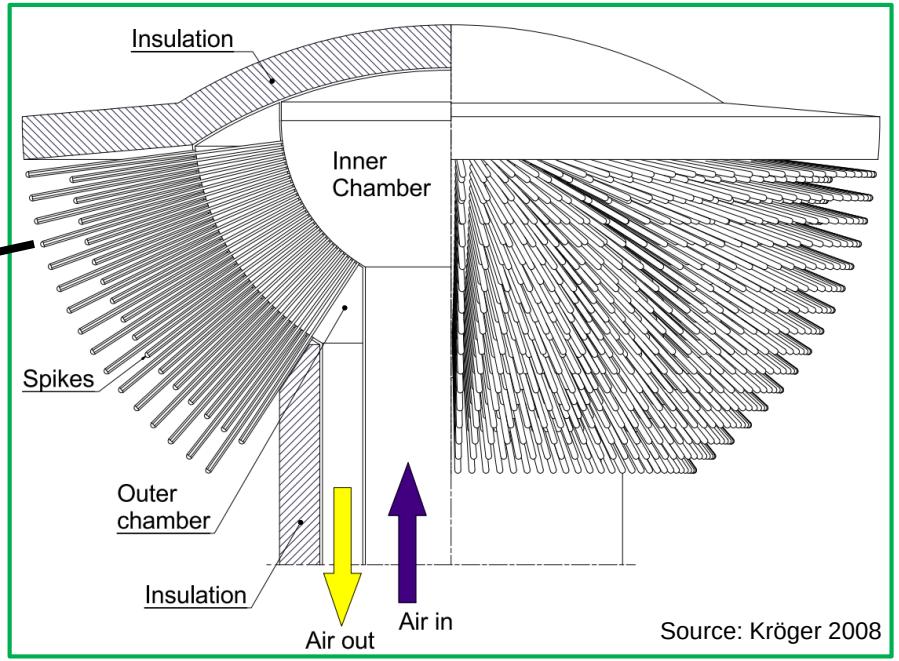

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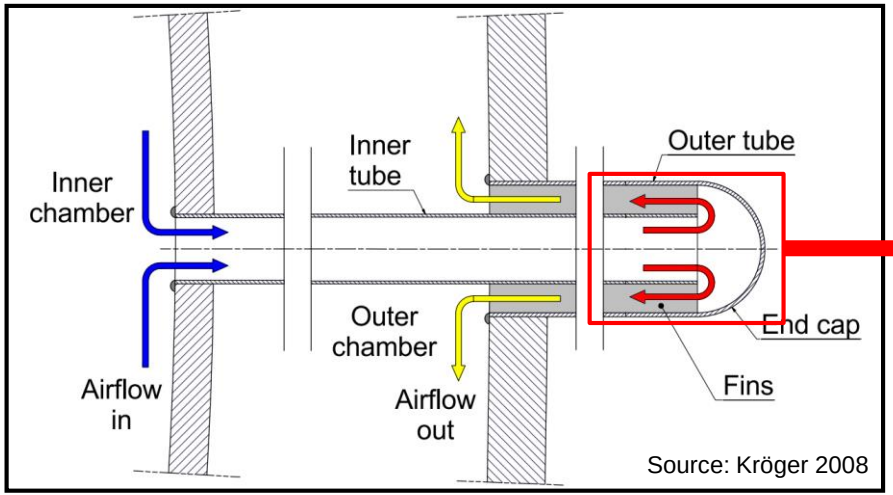
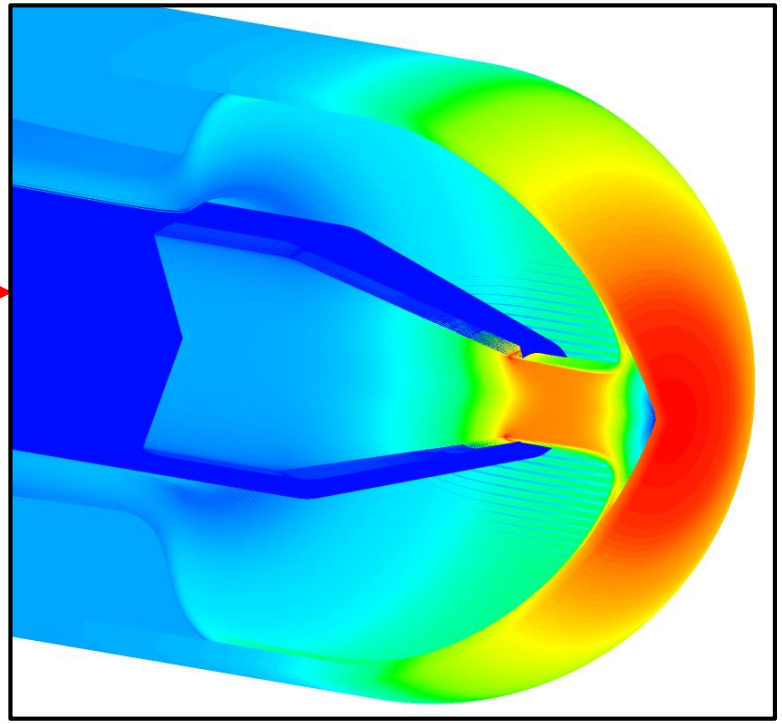
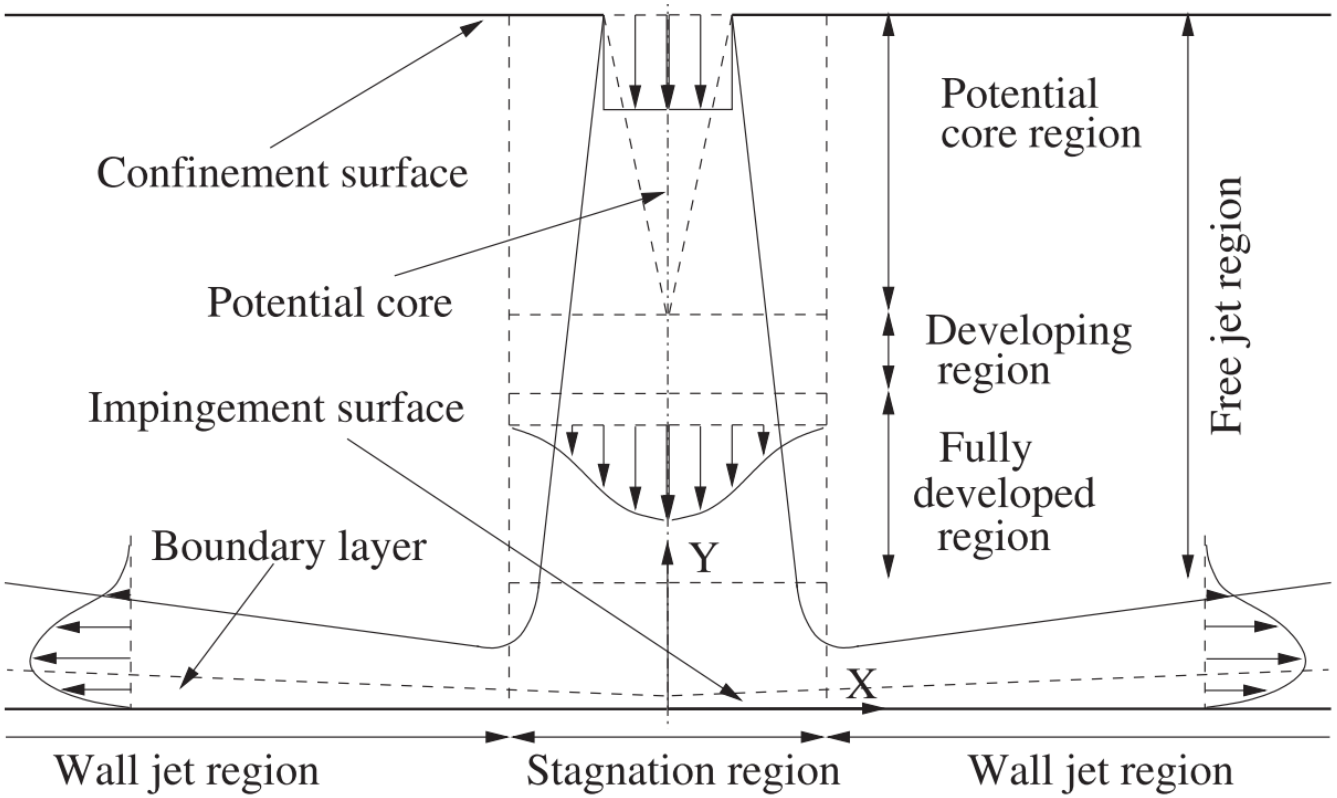
Spiky Central Receiver Air Pre-heater





Jet Impingement

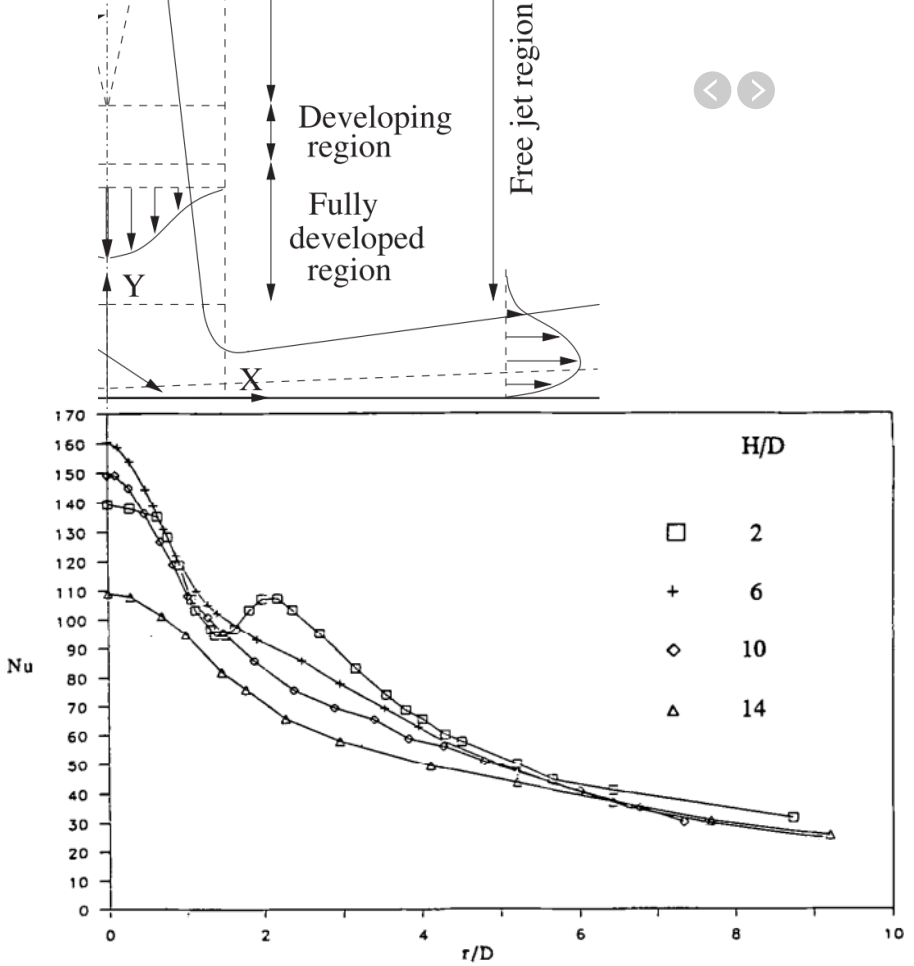


Source: Achari and Das, 2015

Jet Impingement

Secondary peak

- Laminar-transition-turbulent boundary layer
- Flow acceleration
  - ➢ Local maximum

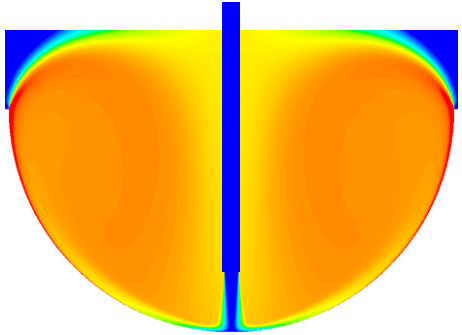


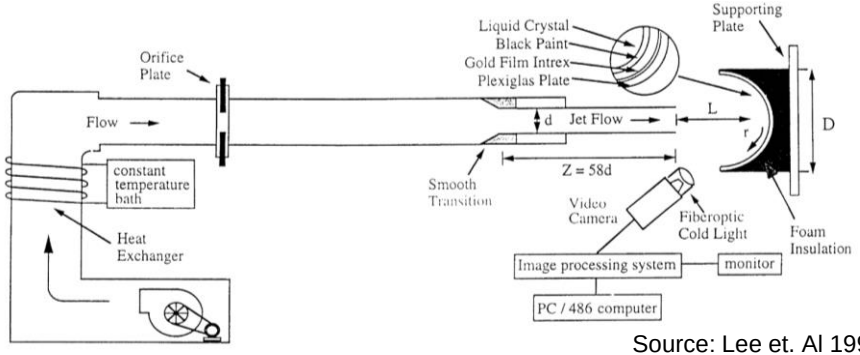
Source: Baughn and Shimizu 1989

Model Validation

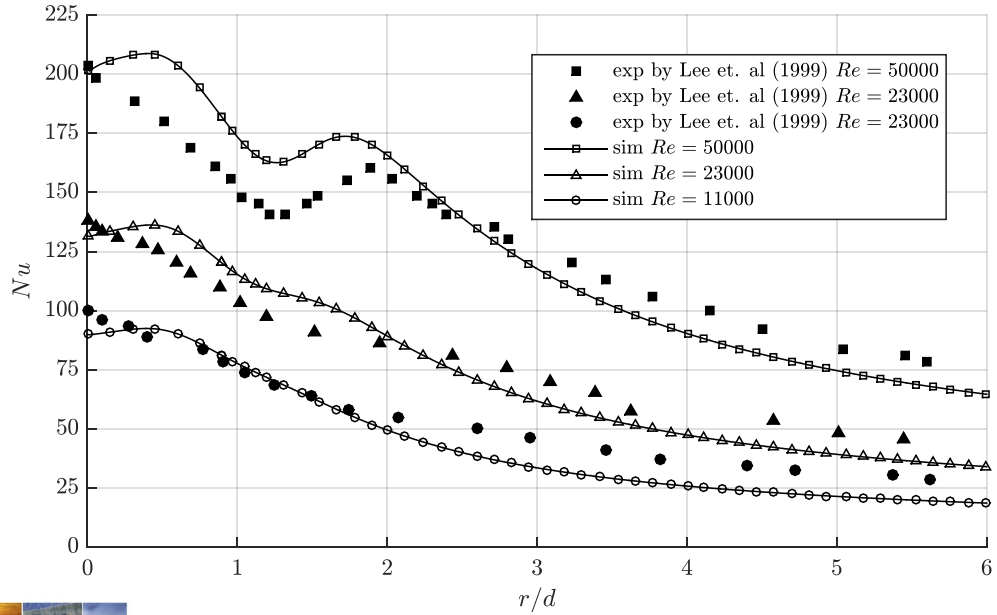
27 published plots

- 2 sensitivities
  - Jet FDF conditions
  - Re-circulation





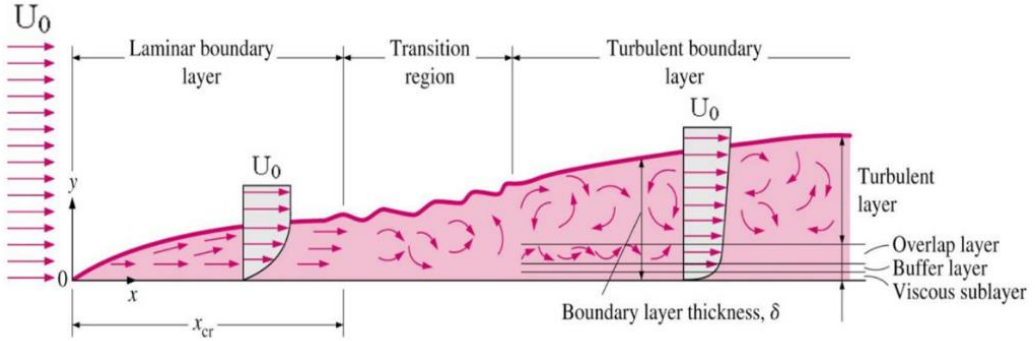
Source: Lee et. Al 1999



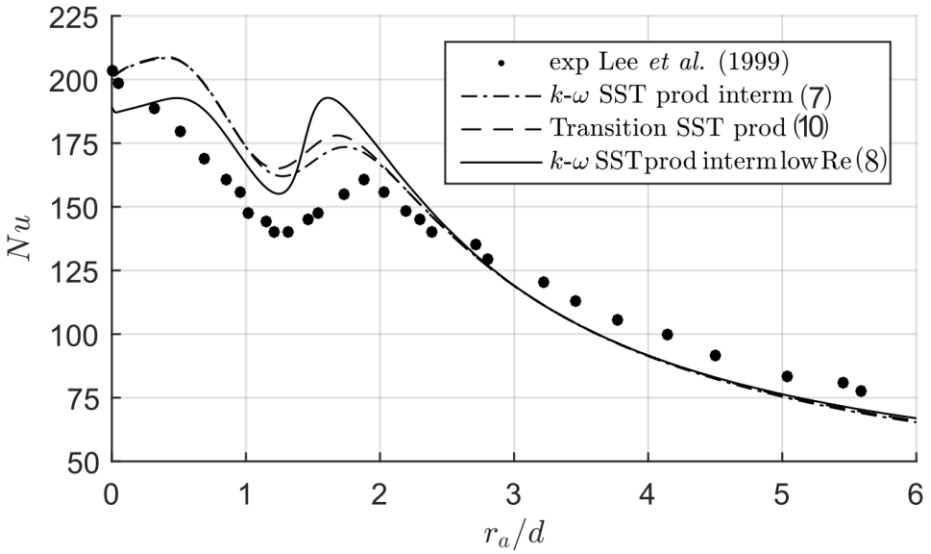
Model Validation

Model selection

- Transition SST
  - 4 equation (zonal)
  - Blending functions
- $k-\omega$ SST Transition
  - 3 equation (zonal)
  - Blending functions



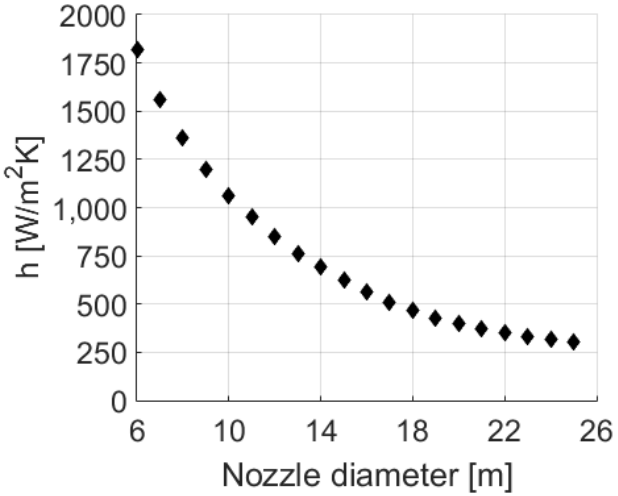
Source: Cengel and Ghajar 2011

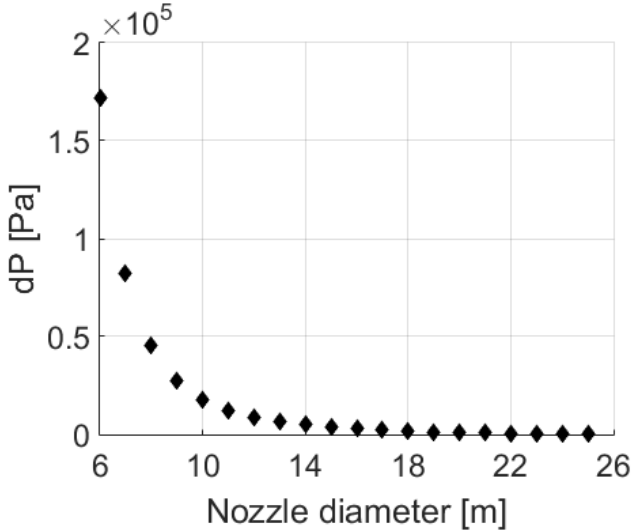


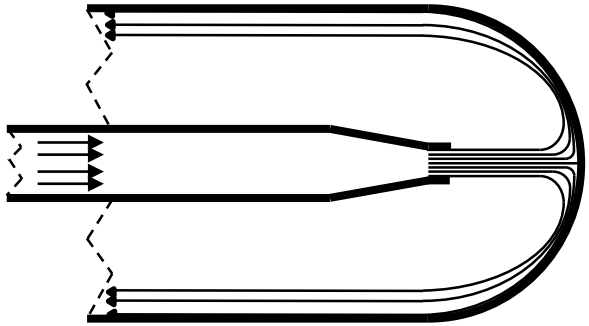
Applicability to SCRAP

Motivation

- Pressure drop, heat transfer trade-off

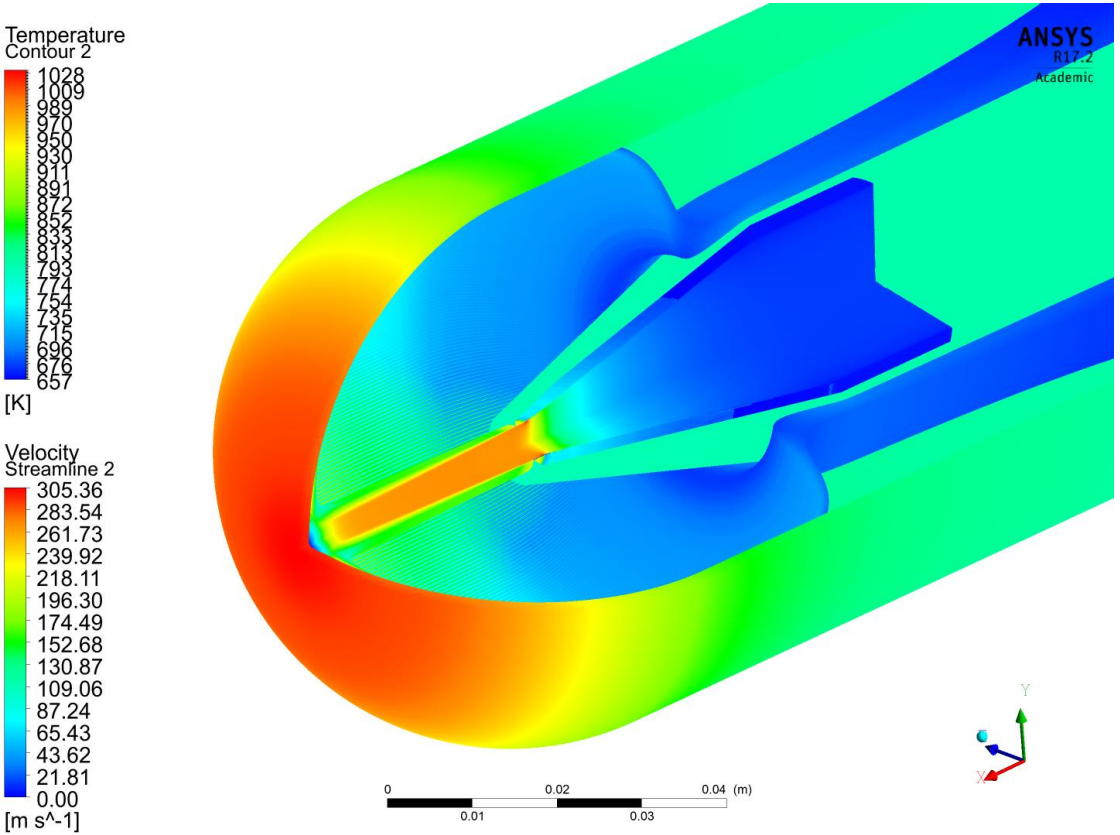






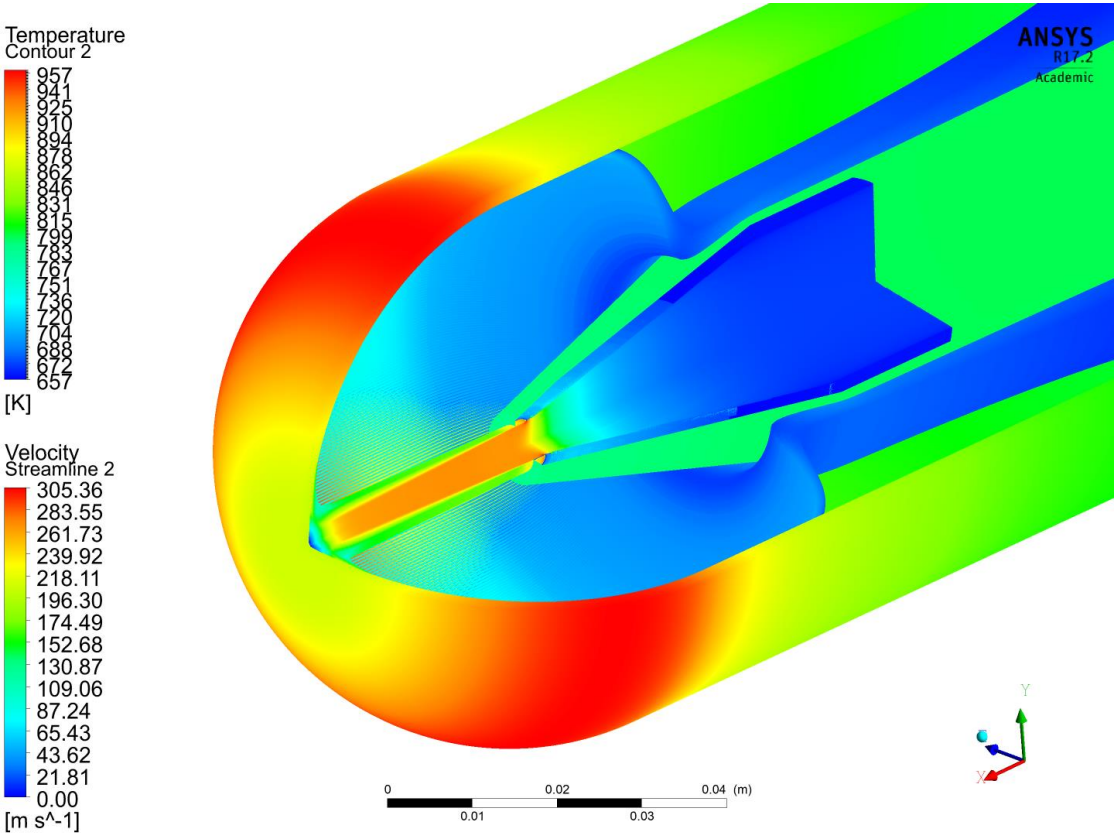
Parametric comparison

6mm nozzle with flux distribution



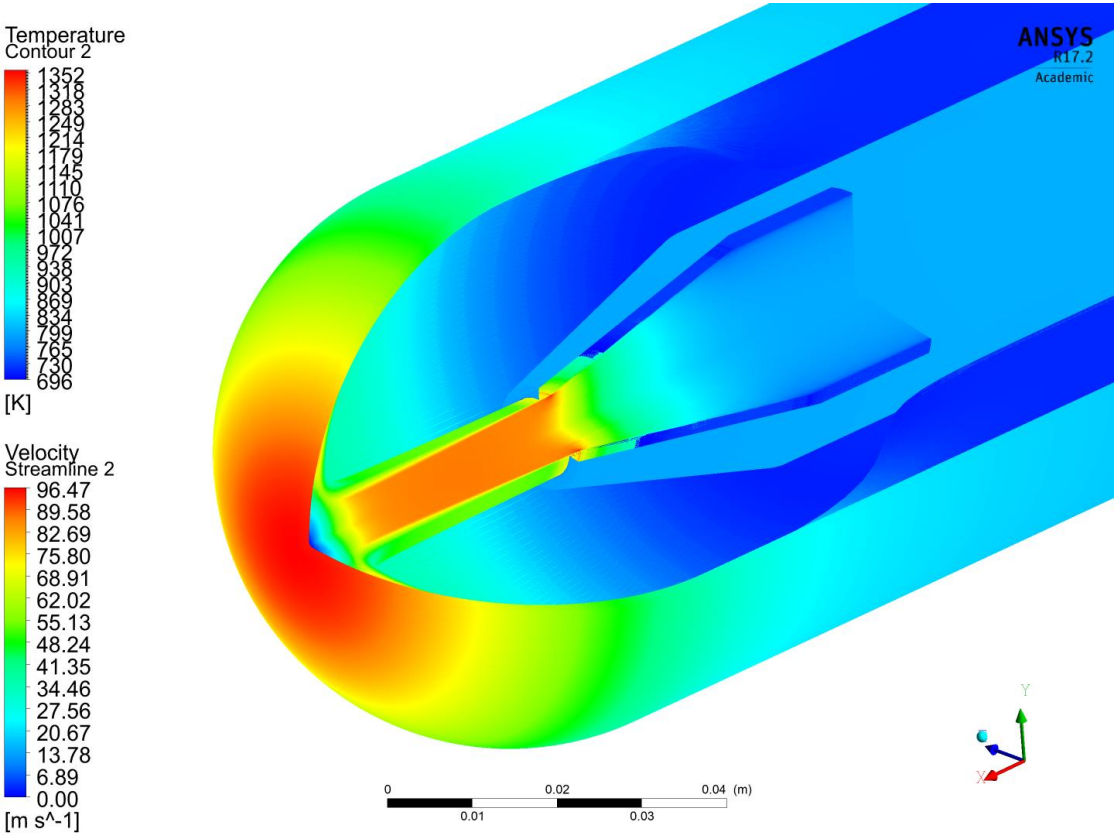
Parametric comparison

6mm nozzle with constant flux



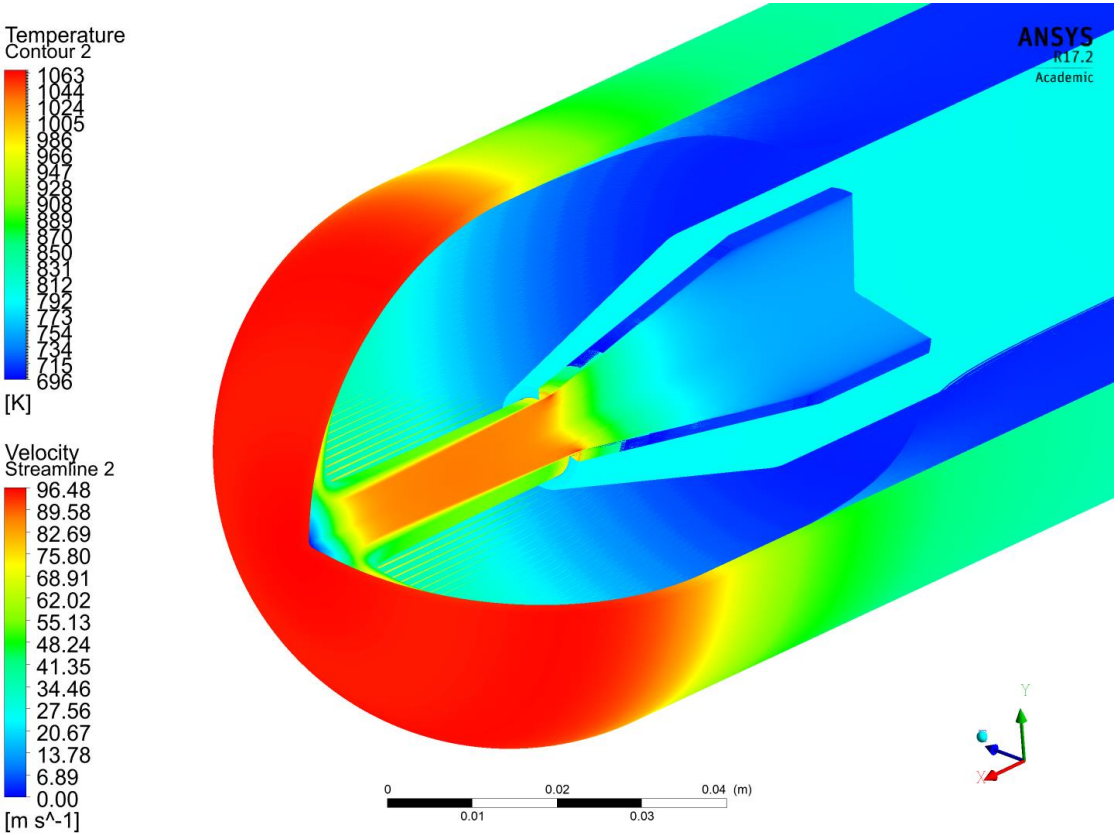
Parametric comparison

$10mm$ nozzle with flux distribution



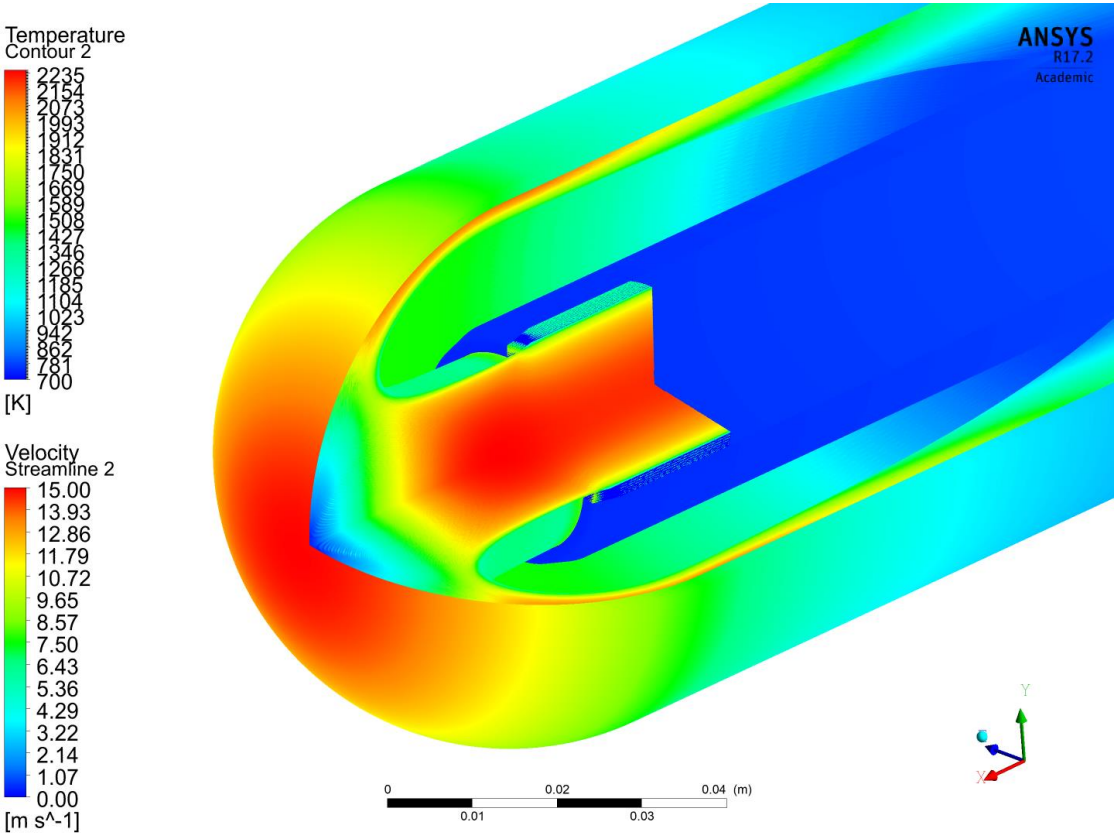
Parametric comparison

6mm nozzle with constant flux



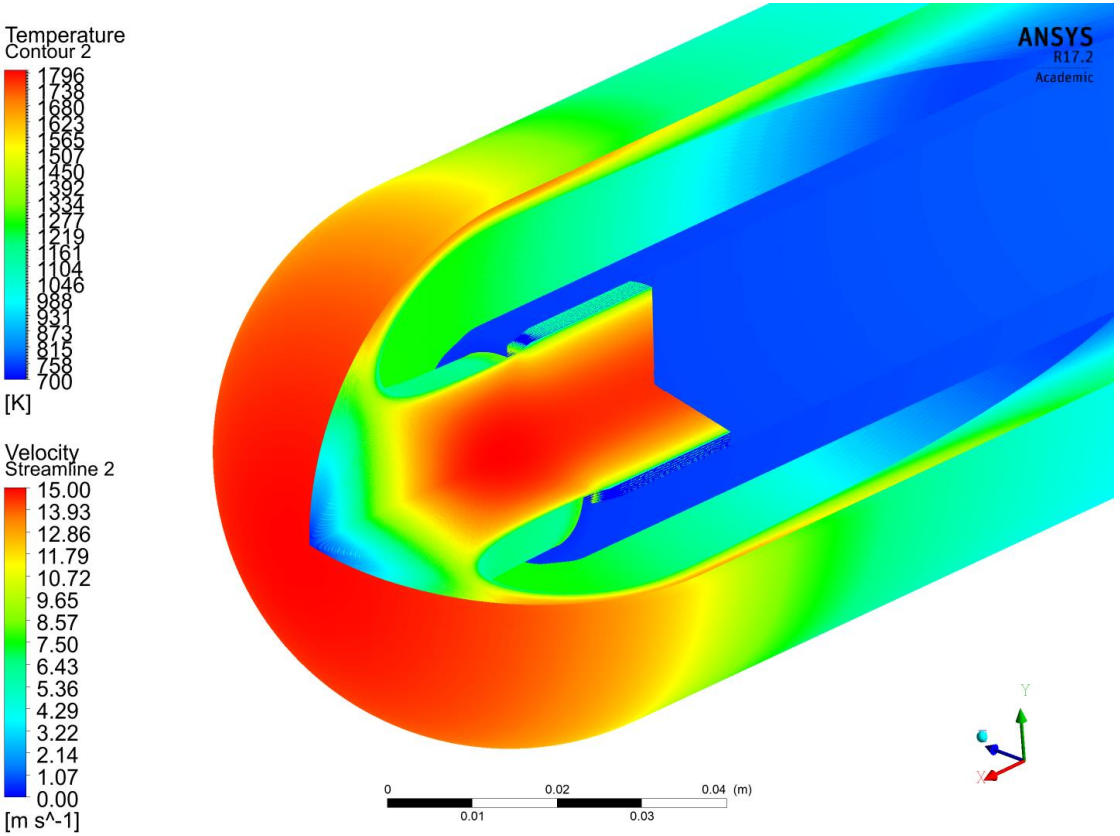
Parametric comparison

25mm nozzle with flux distribution



Parametric comparison

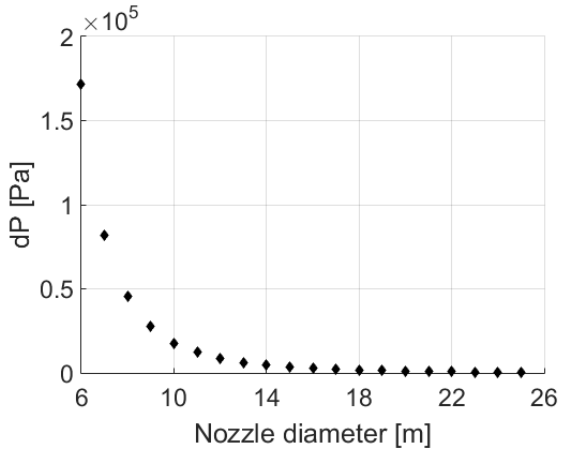
$25mm$ nozzle with constant flux



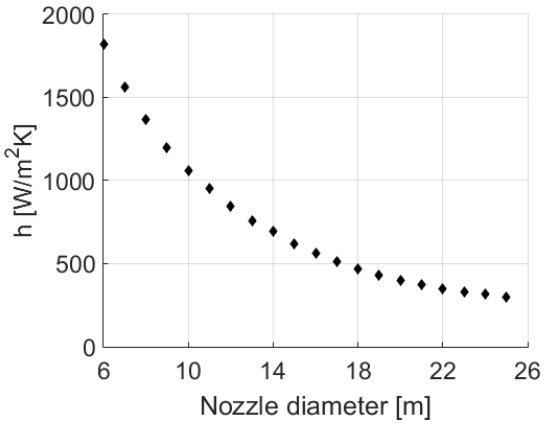
Optimisation study/design improvement

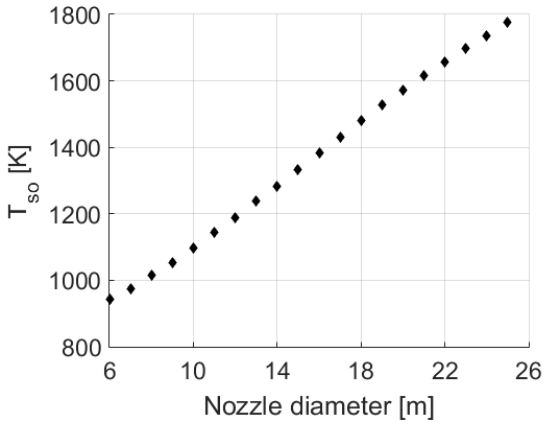
Gas turbine cycle efficiency

Pressure drop



Heat transfer

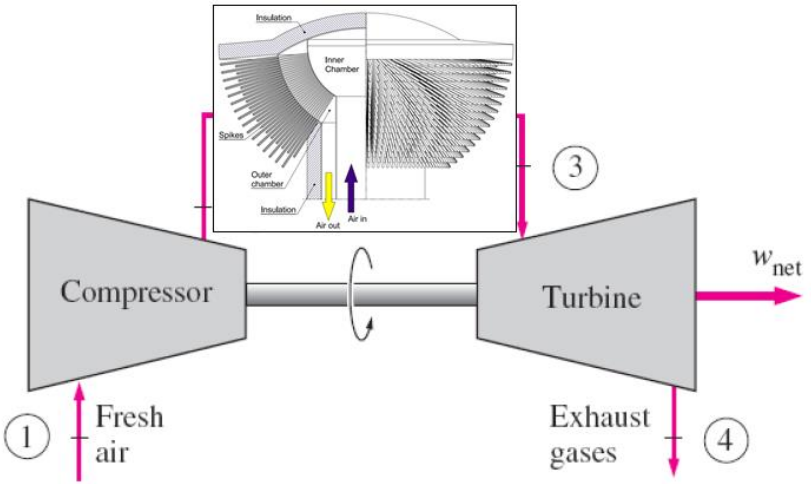




Optimisation study/design improvement

Gas turbine cycle efficiency

- Pressure drop
  - $\Delta P \propto d^4$
- Heat transfer
  - $T_s \propto d$
  - $q_{rad} \propto d^4$



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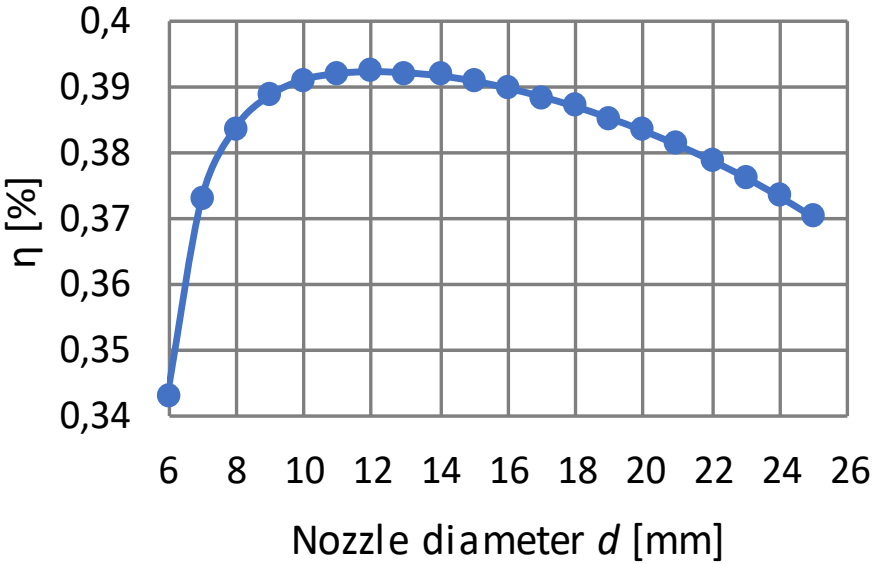

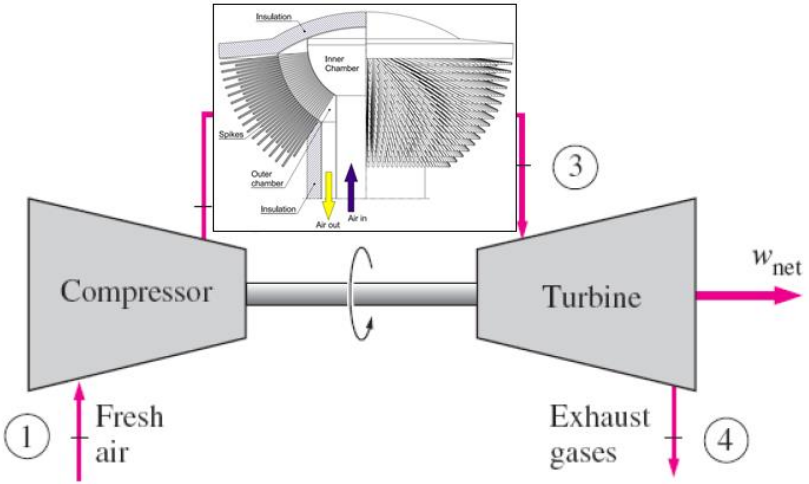

Further model improvements

External effects

- Radiation losses
- External convection losses
  - Natural and forced (wind)
- Internal radiation (S2S)

ACKNOWLEDGEMENTS:

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