Influence of the configuration of heat exchangers on the performance of ORCs:

a first step towards a system optimization

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Introduction

- Optimization for ORCs:
  - Cycle: temperatures, pressures, …

  or

  - Components: turbine, cooling system, heat exchangers, …

⇒Assumptions

- System optimization:
  - Combine cycle- and component optimization

⇒Eliminate many assumptions

Introduction (2)

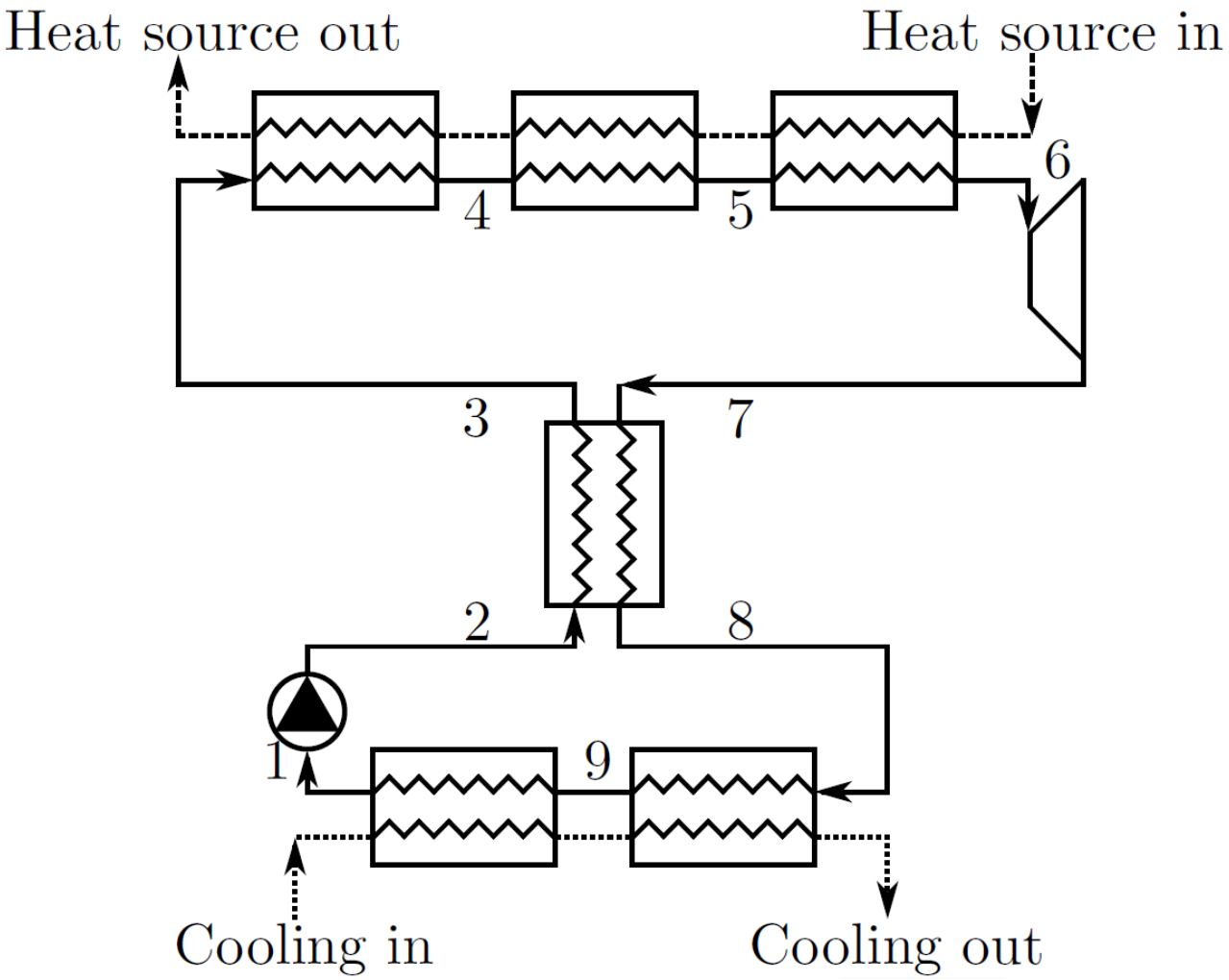
- System optimization with heat exchangers:
  - Shell-and-tube heat exchangers
  - Plate heat exchangers

$\Rightarrow$ Pinch-point ΔT, pressure drop, condenser temperature, … are results

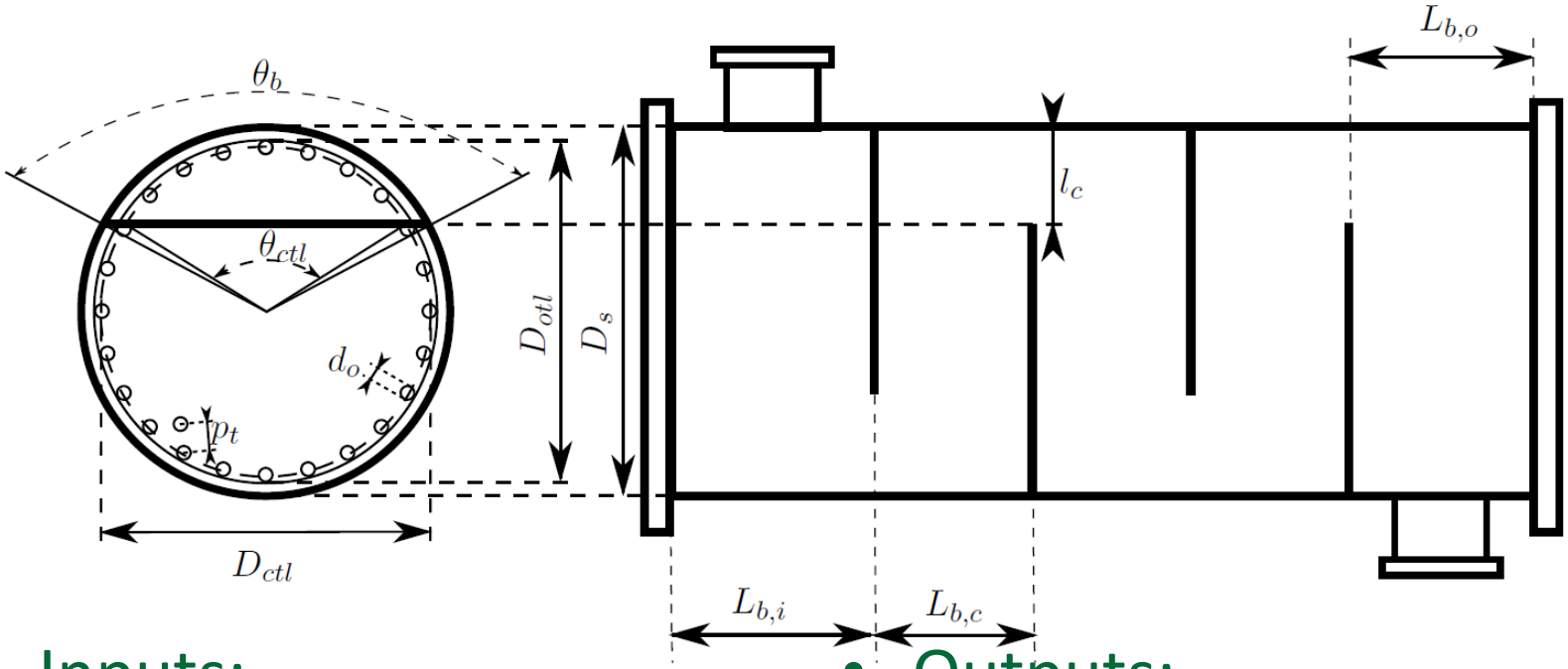
Content

- Introduction
- ORC-model
- Heat exchanger models:
  - Shell-and-tube heat exchanger
  - Plate heat exchanger
- Optimization method
- Results
- Conclusions

Single-pressure ORC

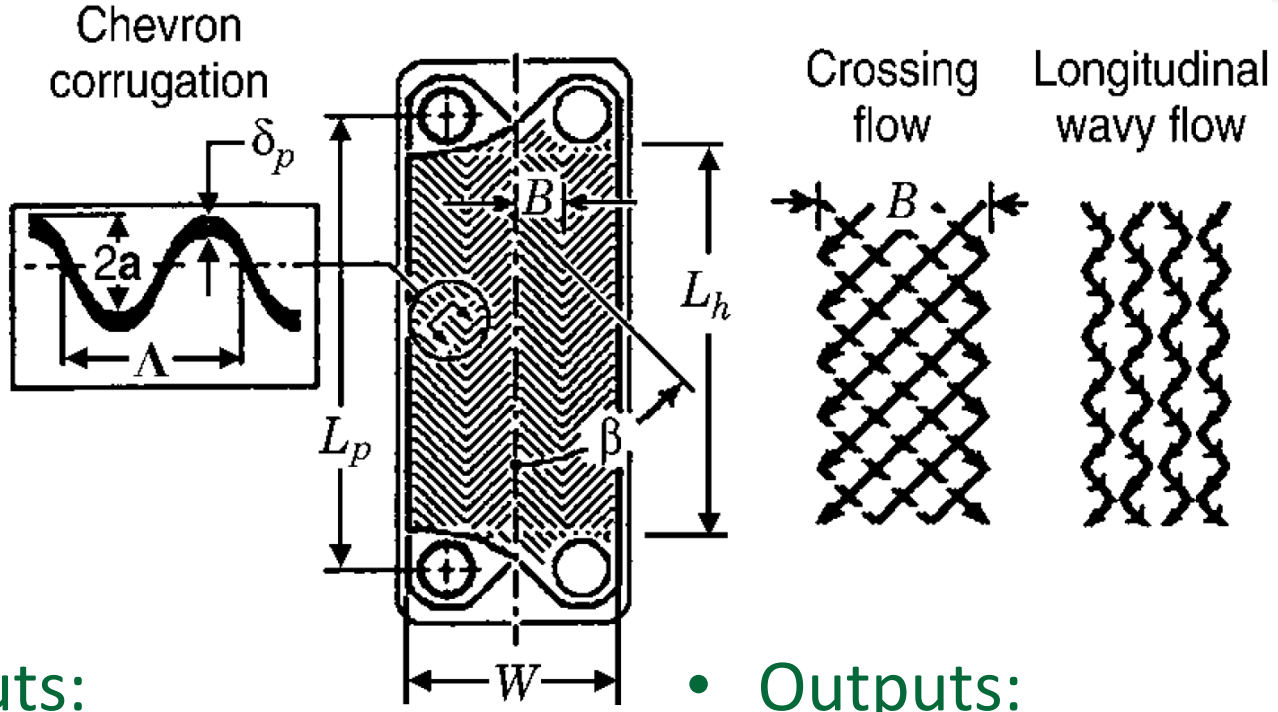


Shell-and-tube heat exchanger: Tema E



- Inputs:
  - Inlet states
  - Requirement outlet state
  - Geometry
- Outputs:
  - Outlet states
  - Size
  - Heat transfer coefficient, ΔT, etc.

Plate heat exchanger: chevron corrugations



- Inputs:
  - Inlet states
  - Requirement outlet state
  - Geometry
- Outputs:
  - Outlet states
  - Size
  - Heat transfer coefficient, ΔT, etc.

Optimization method

- Optimization variables:
  - Cycle:
    - Temperature before turbine
    - Pressure before turbine
    - Pressure before pump
    - Working fluid mass flow
  - Heat exchangers:
    - 4/5 geometrical variables for every heat exchanger

⇒ Computationally difficult

- Gradient-based:
  - Automatic differentiation in reverse mode
  - Adaptation RefProp

- Extra constraint:
  - Maximum total heat exchanger surface

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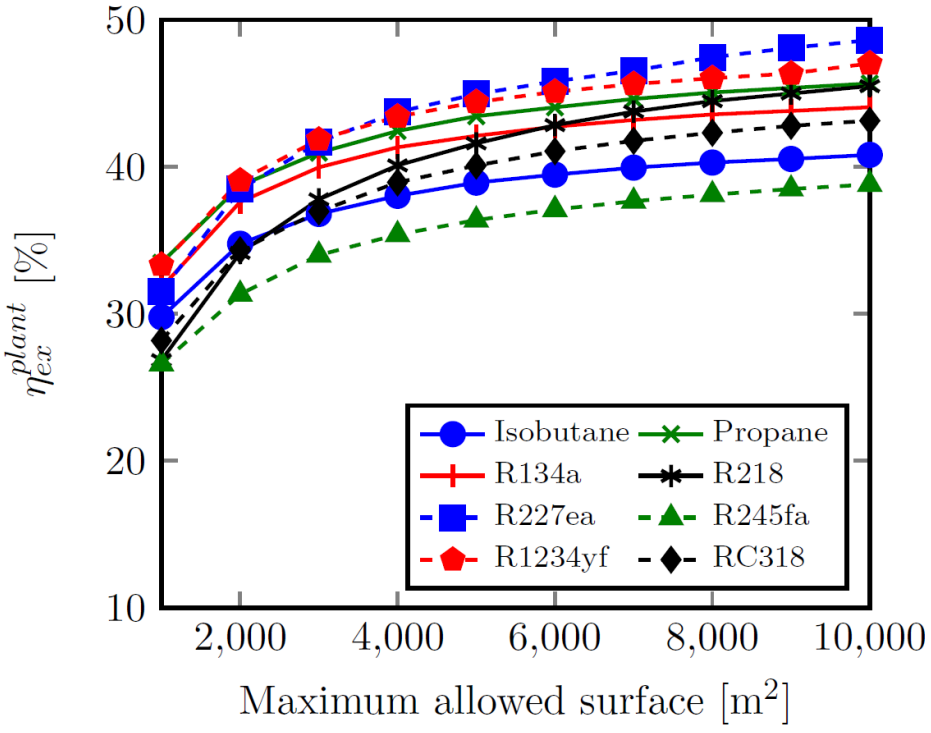
Reference data

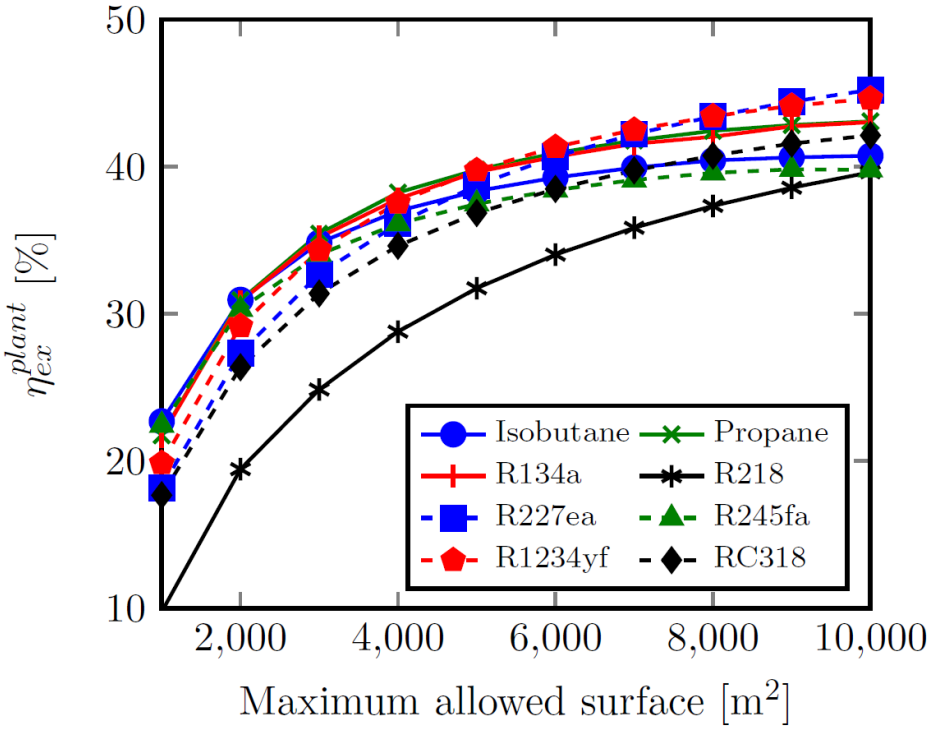
- Heat source:
  - Water
  - 125° C
  - 100 kg/s
- Cooling fluid:
  - Water
  - 20° C
  - 800 kg/s
- ORC:
  - Simple/recuperated
  - 1 pressure level
  - A_{max} = 4000 m²

Influence maximum total heat exchanger surface

- Plate

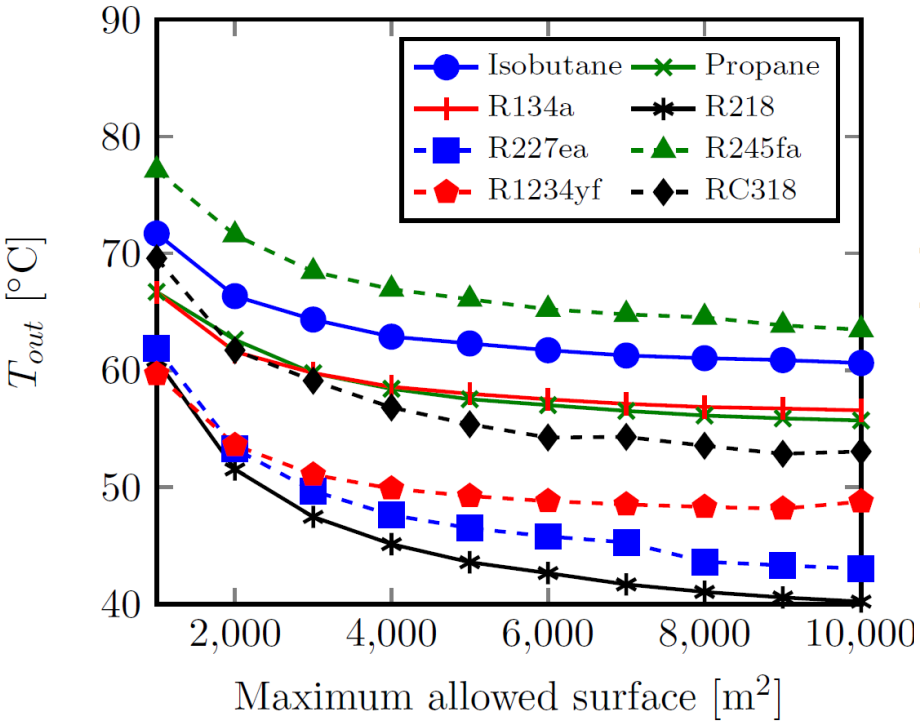


- Shell-and-tube, 90°

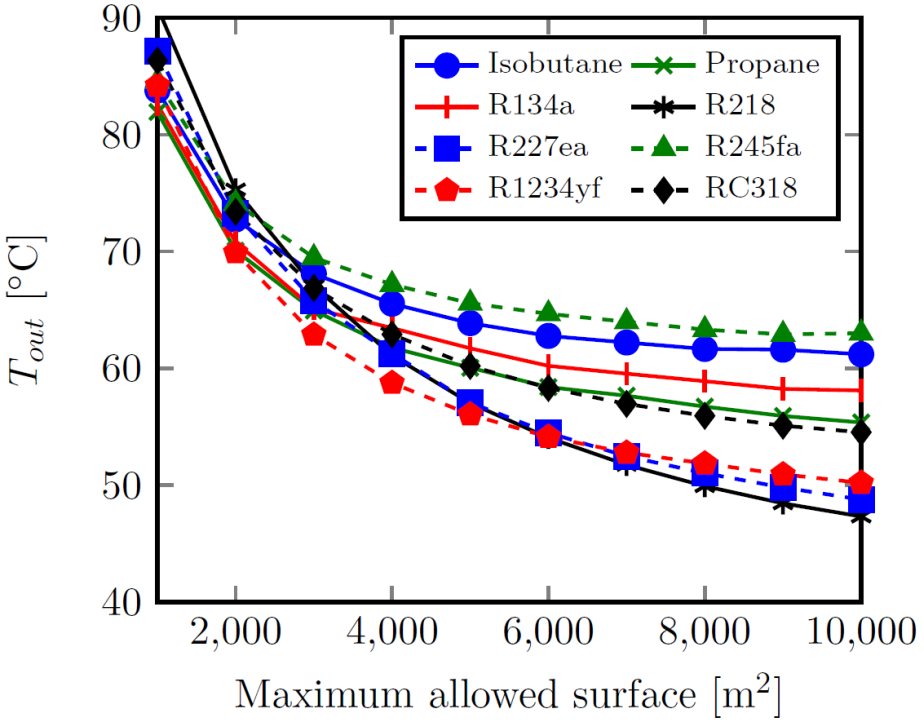


Influence maximum total heat exchanger surface (2)

- Plate

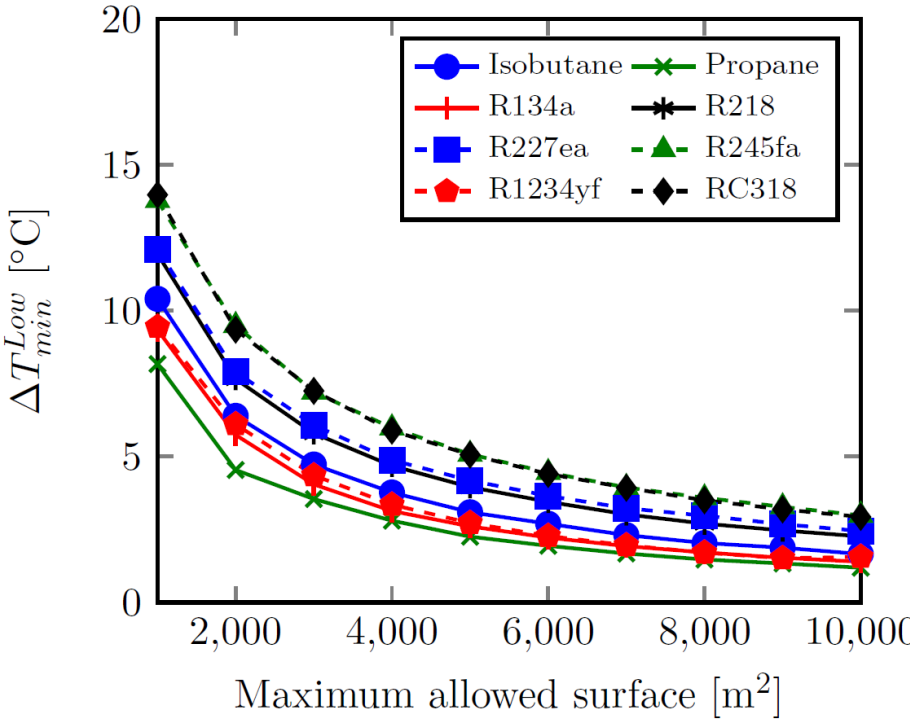


- Shell-and-tube, 90°

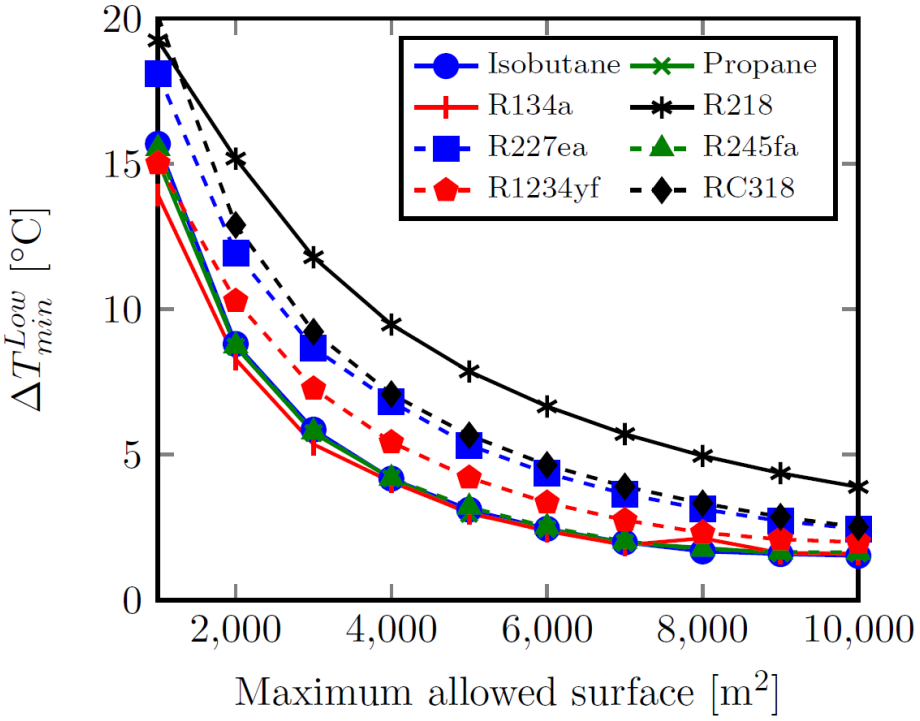


Influence maximum total heat exchanger surface (3)

- Plate

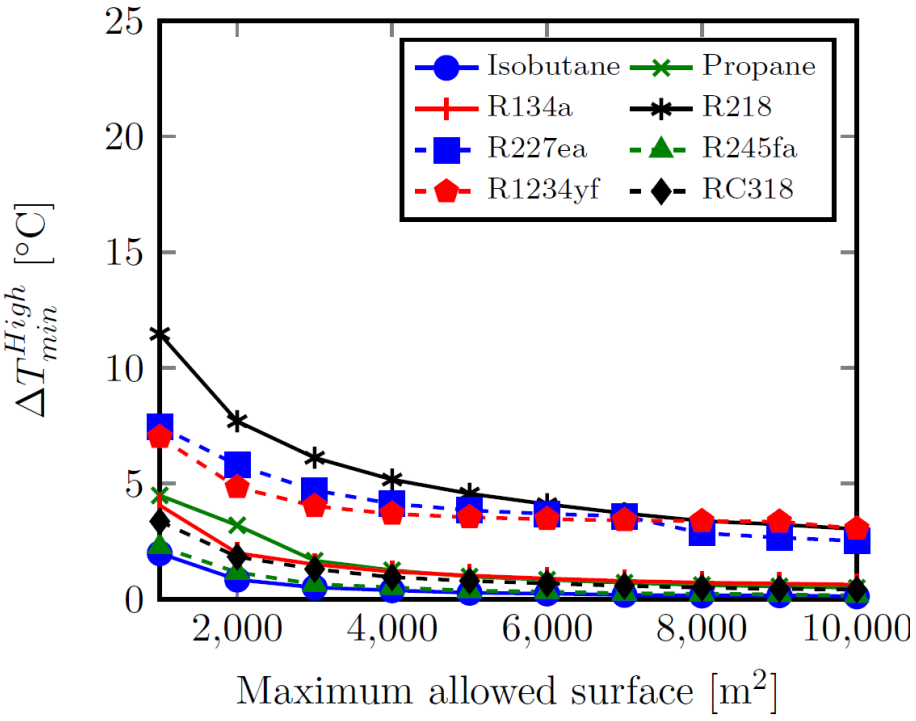


- Shell-and-tube, 90°

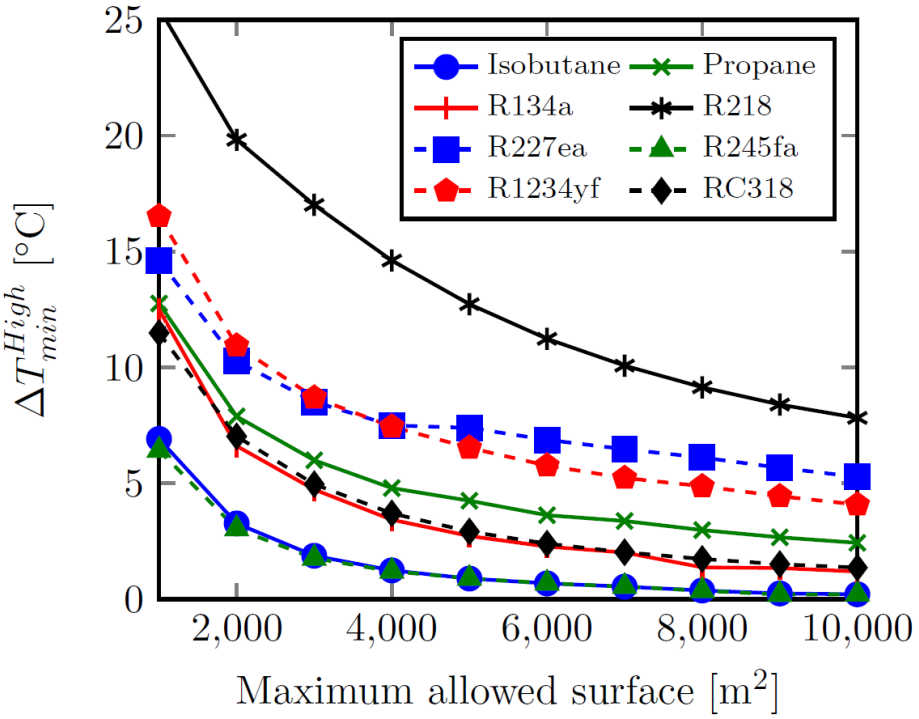


Influence maximum total heat exchanger surface (4)

- Plate

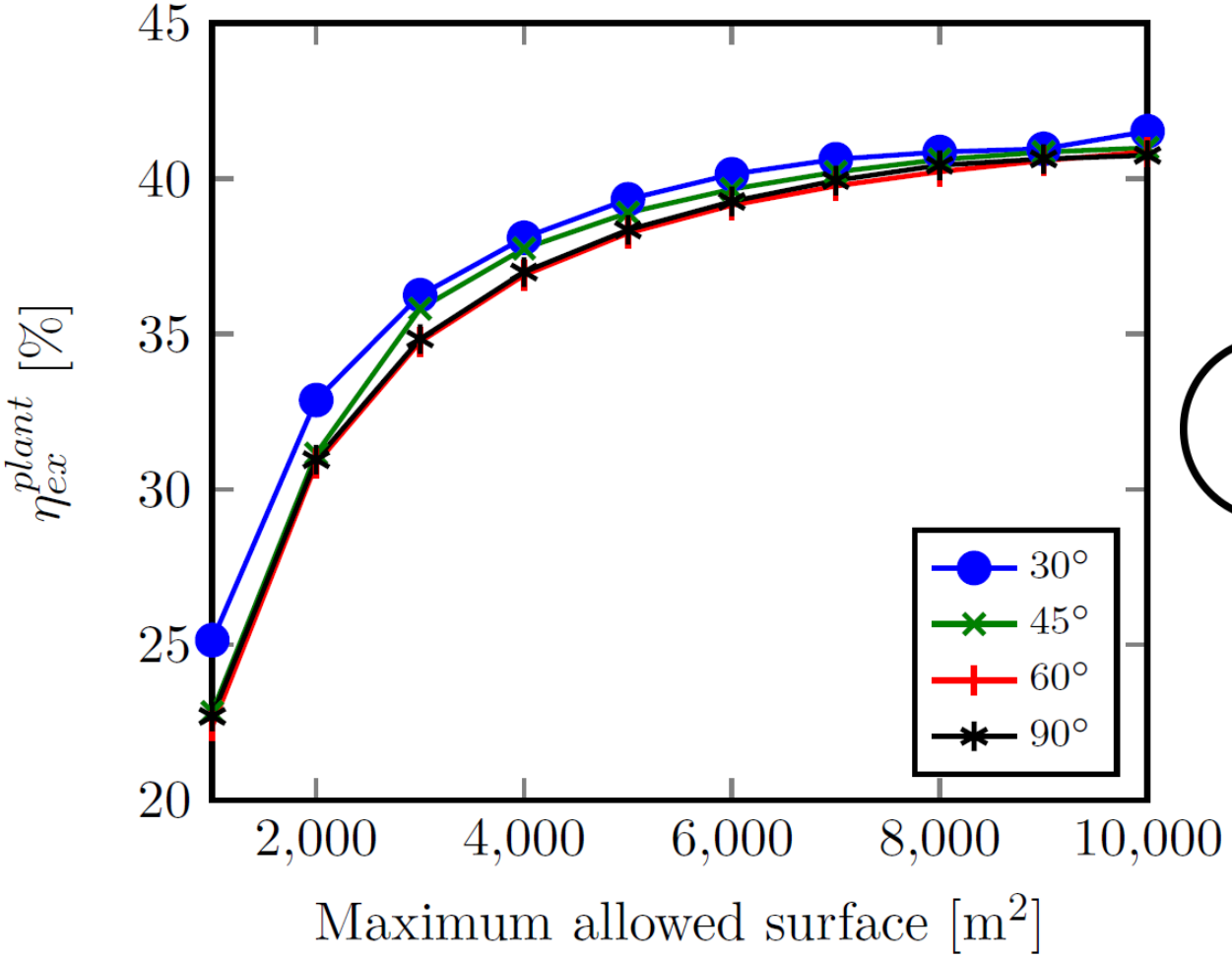


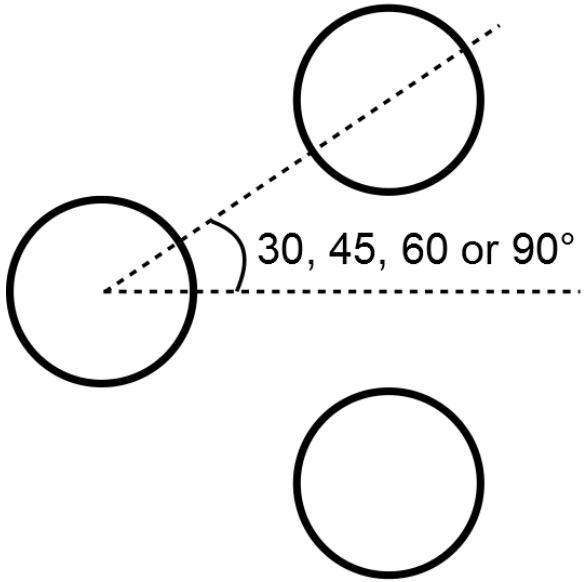
- Shell-and-tube, 90°



Influence configuration tubes

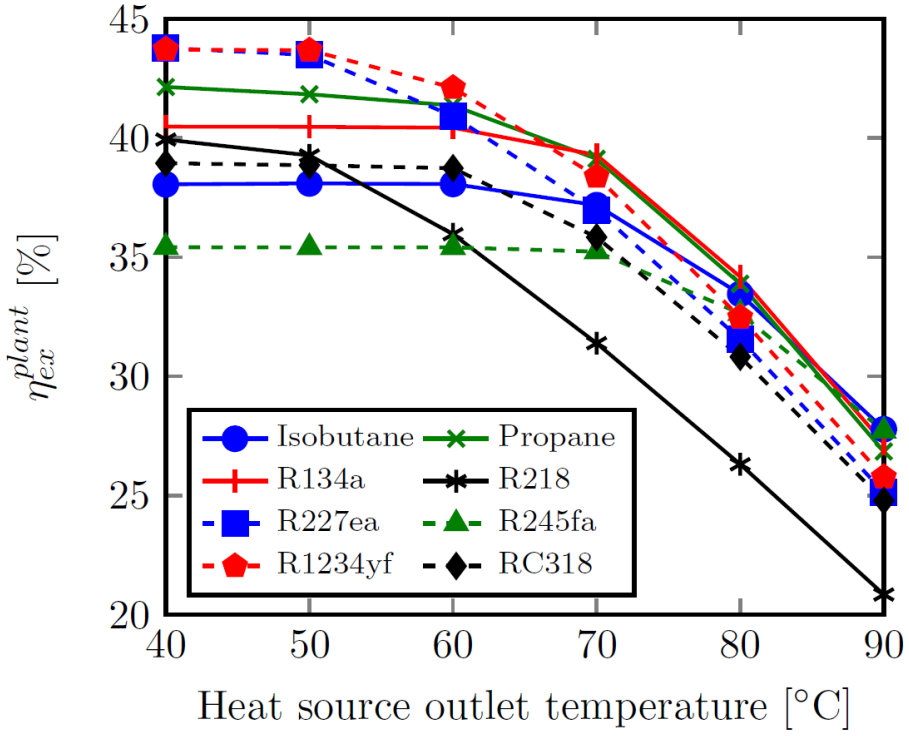
- Isobutane, shell-and-tube



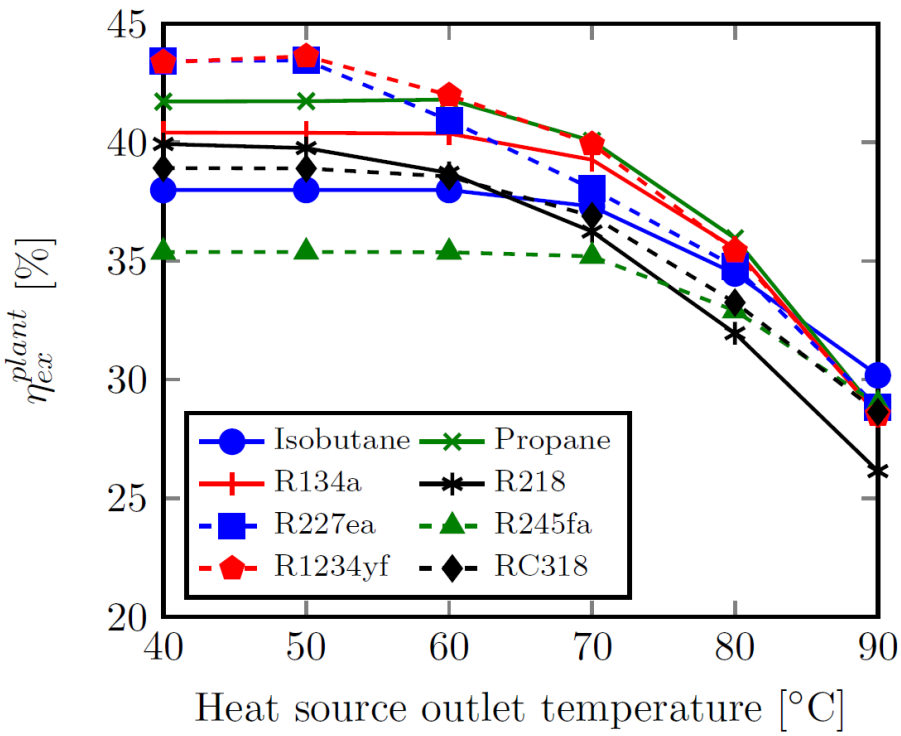


Influence heat source outlet temperature

- Plate heat exchanger, simple

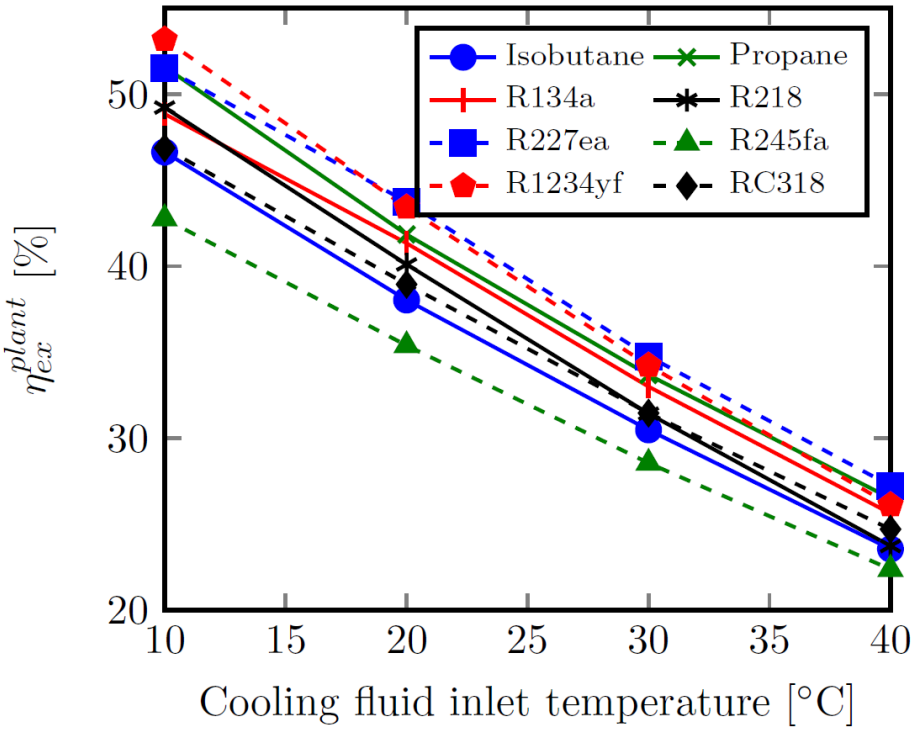


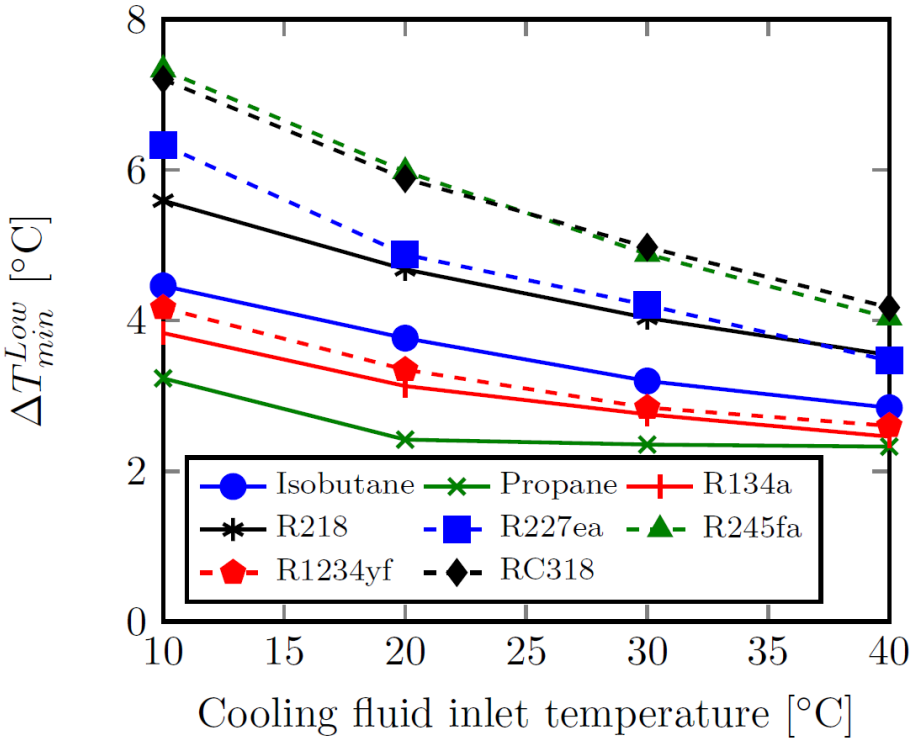
- Plate heat exchanger, recuperated



Influence cooling fluid inlet temperature

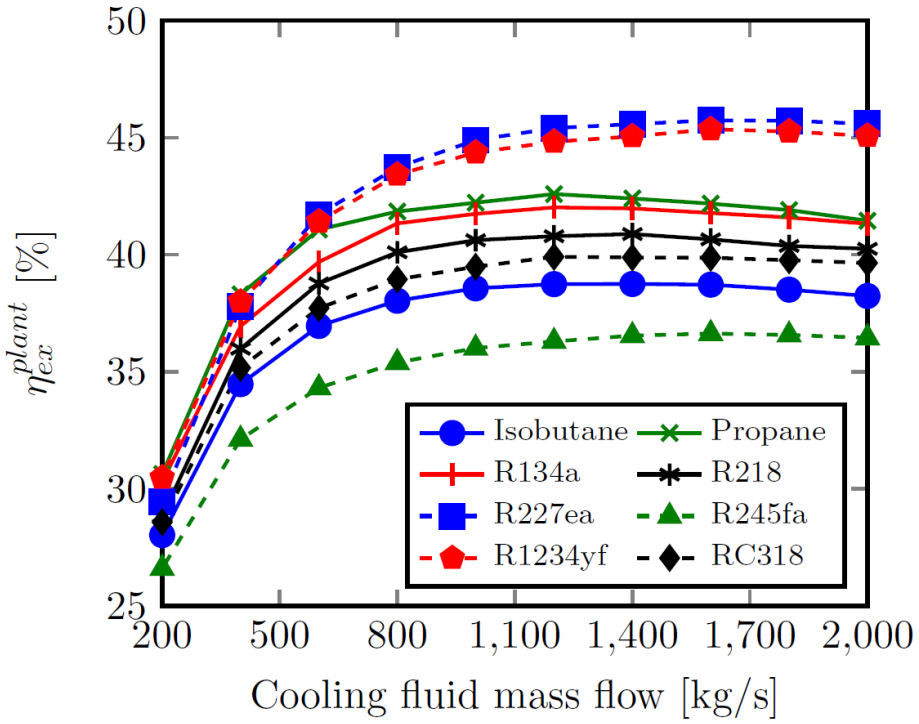
- Plate heat exchanger

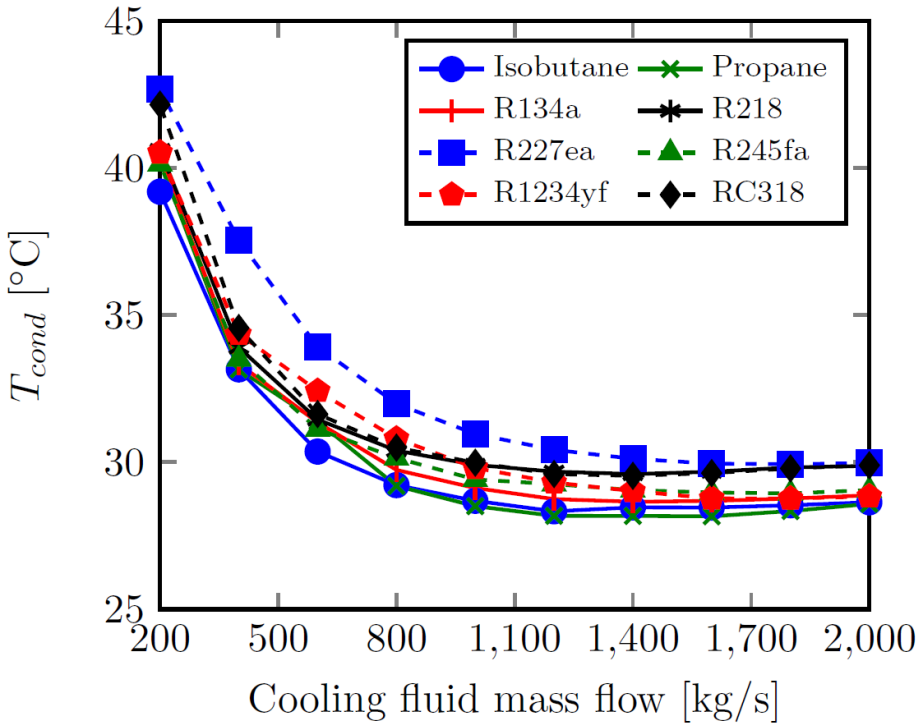




Influence cooling fluid mass flow

- Plate heat exchanger





Conclusions and further work

- System optimization of ORCs is possible
- Plate heat exchangers perform mostly the best

- Strong influence cooling fluid properties

  $\Rightarrow$Include cooling system in optimization

- Strong influence A_{max}

  $\Rightarrow$Economic system optimization