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FACULTY OF ENGINEERING
AND ARCHITECTURE

DEPARTMENT OF FLOW, HEAT AND COMBUSTION MECHANICS
RESEARCH GROUP APPLIED THERMODYNAMICS AND HEAT TRANSFER

HEAT TRANSFER MEASUREMENTS IN HORIZONTAL FLOW OF R-125 AT SUPERCRITICAL PRESSURES TESTED UNDER ORGANIC RANKINE CYCLE CONDITIONS

Marija Lazova [31-08-2018]

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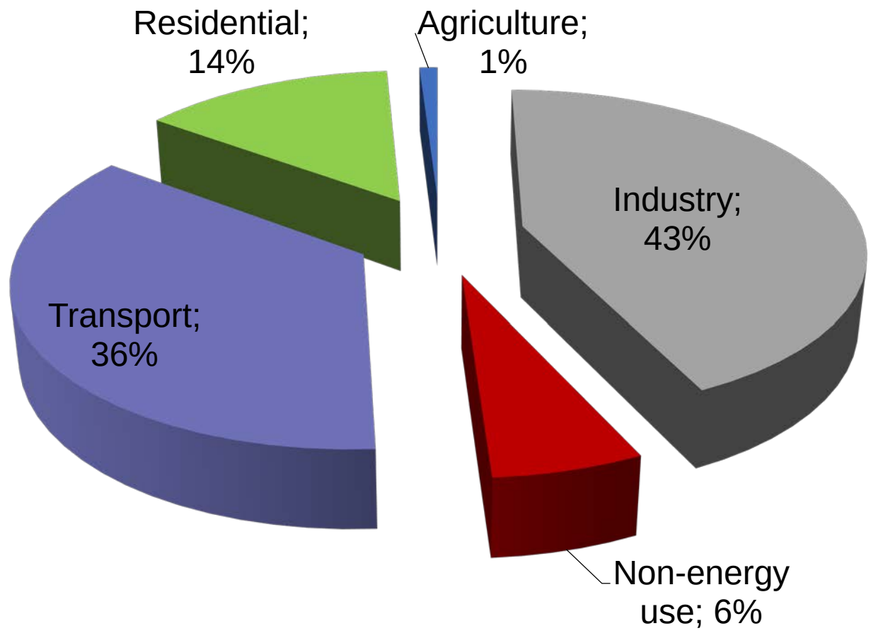
LOW-TEMPERATURE HEAT RECOVERY

Renewable Energy Sources

- low-temperature waste heat <250°C

Energy Use by Different Sectors



- 40 % of the total energy use belongs to the Industry sector
- Up to 50% is accounted as a low-grade waste heat <250°C

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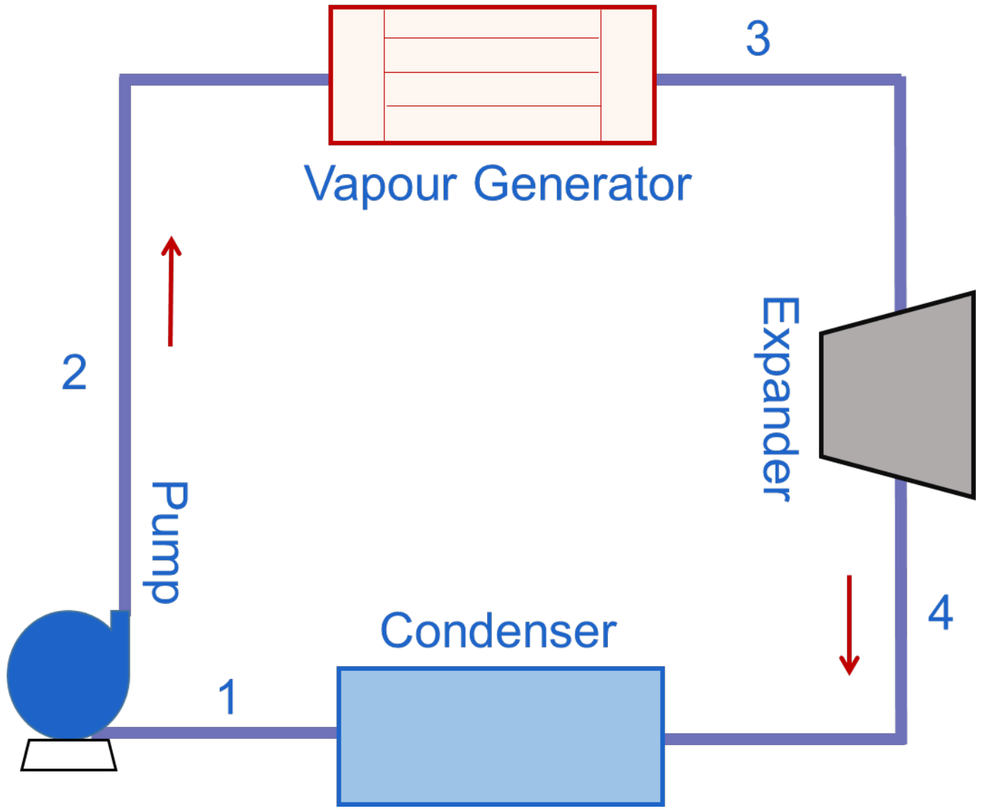
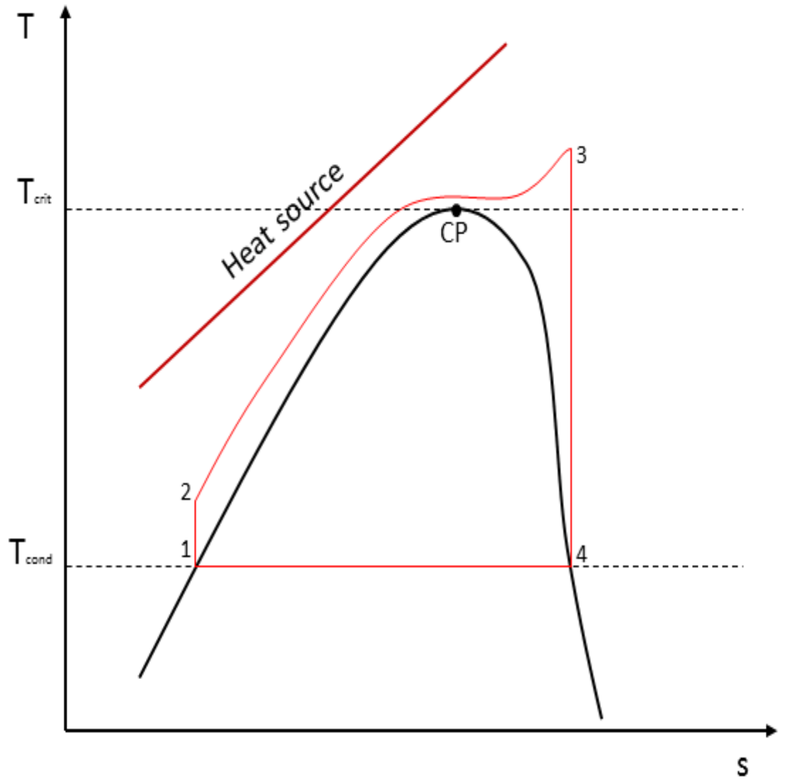
TRANSCRITICAL ORGANIC RANKINE CYCLE





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POTENTIAL WORKING FLUIDS

Organic fluid	p_{cr}	T_{cr}	GWP	ODP
R-125	36 bar	66 °C	3500	0
R134a	41 bar	101 °C	1430	0
R1234yf	33 bar	94 °C	4	0

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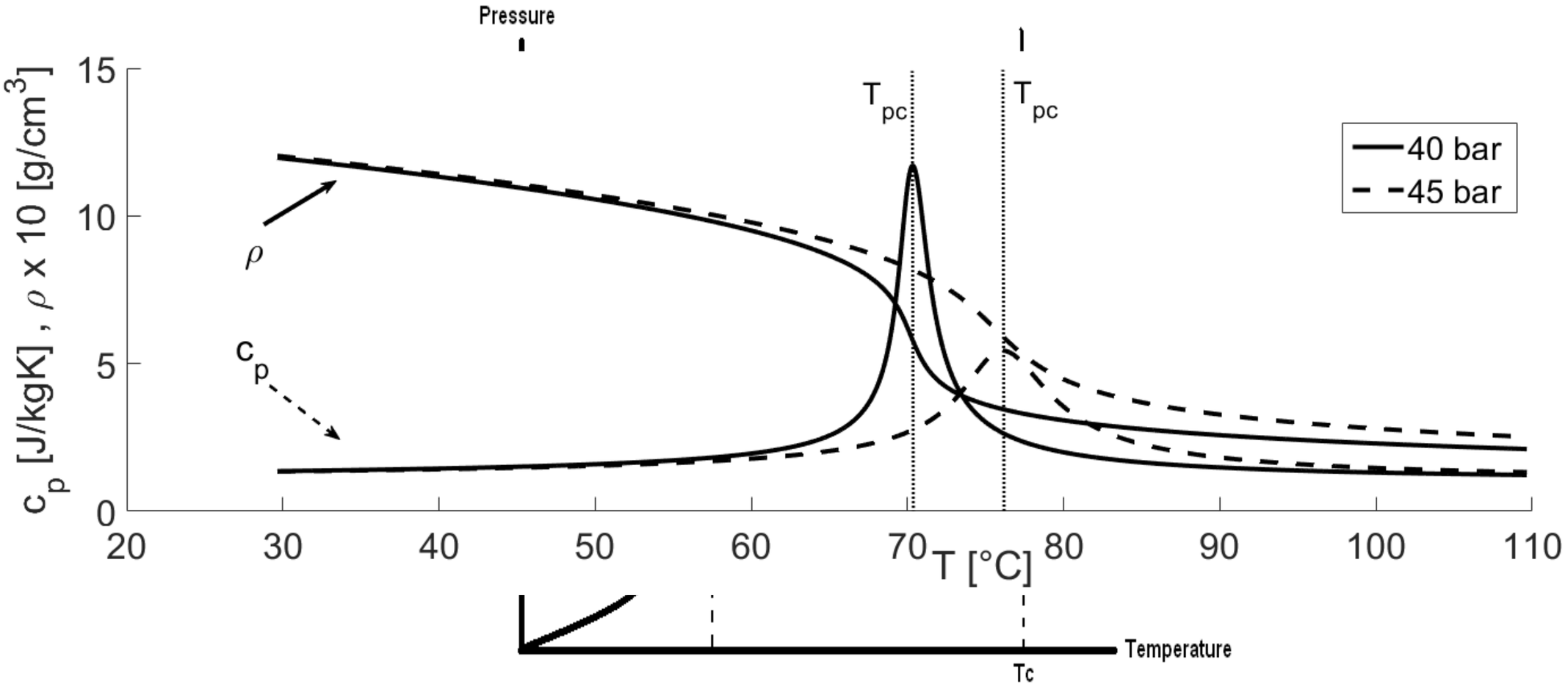
THERMOPHYSICAL PROPERTIES OF R-125



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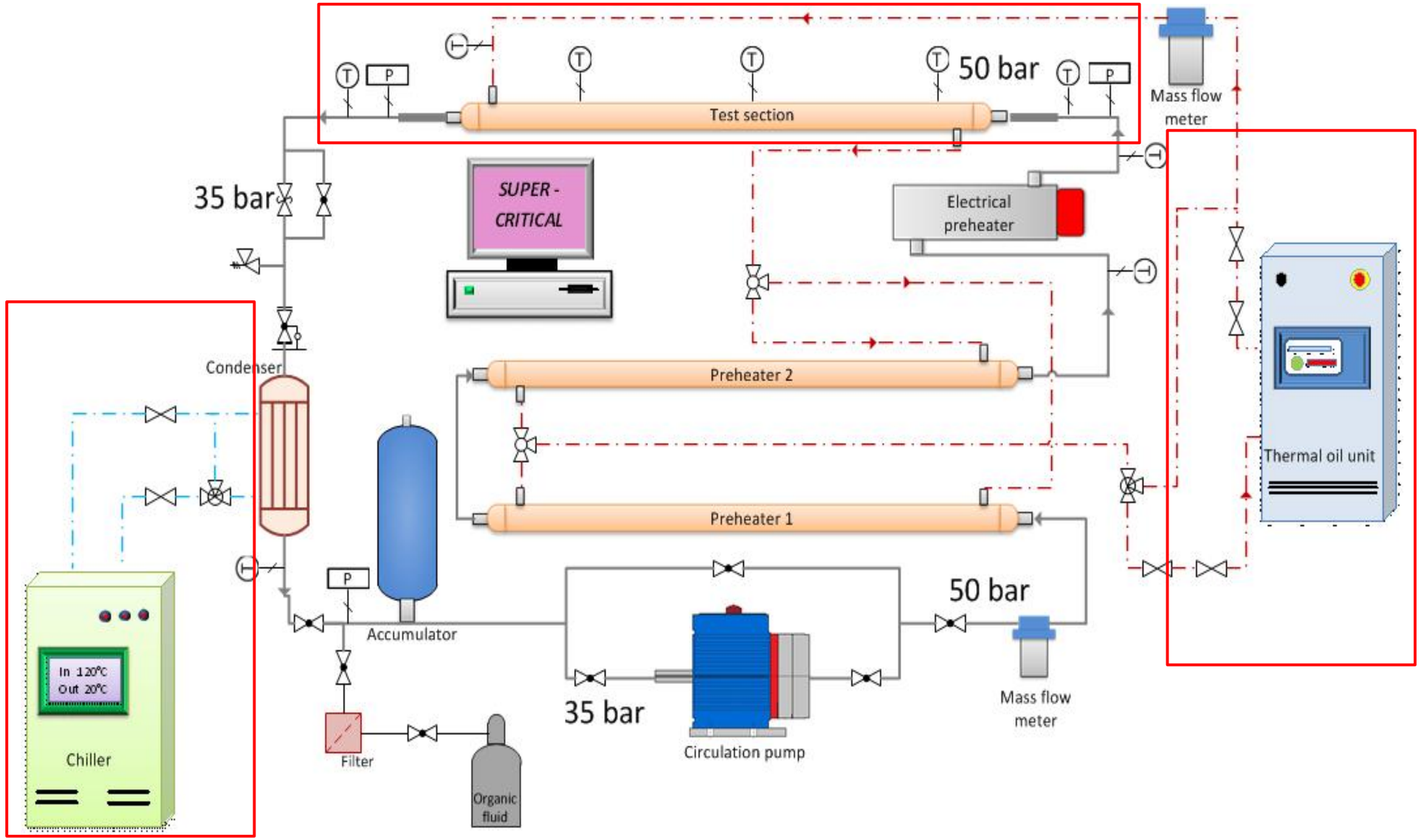
EXPERIMENTAL FACILITY



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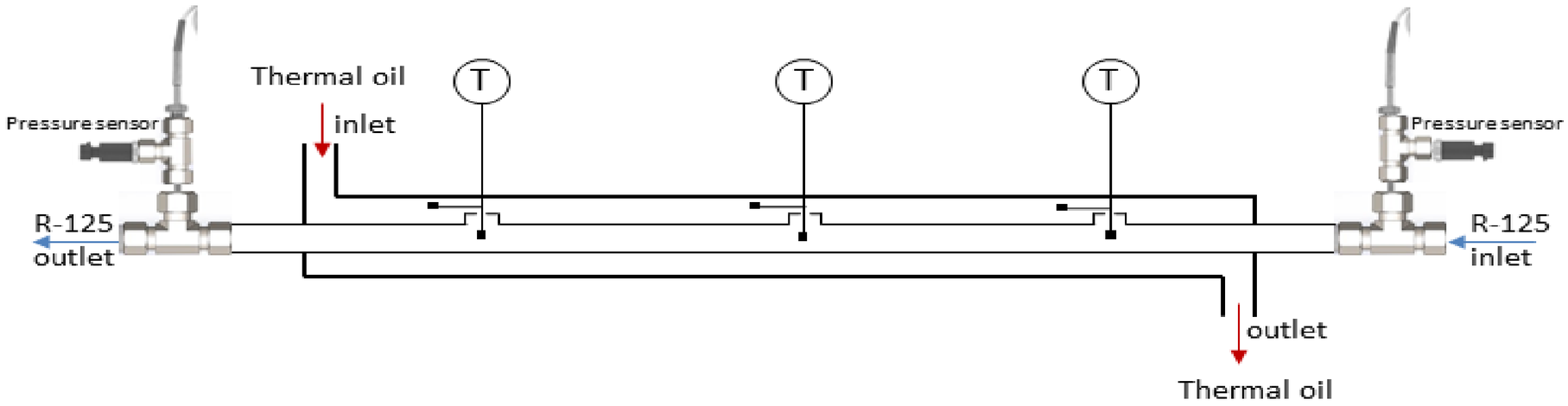
TEST SECTION

Dimensions	Unit	Value
Tube diameter	[mm]	28.6
Tube thickness	[mm]	1.9
Length	[m]	4
Total heat transfer area	[m²]	0.36



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“ISCORE” TEST FACILITY

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MEASUREMENT CONDITIONS

Parameters	Unit	Heating fluid Terminol ADX10	Working fluid R-125
$\dot{m}_{wf}$	[kg/s]	2.1	0.19 – 0.3
T_{in}	[°C]	80 – 100	45 – 60
T_{out}	[°C]	~78 – ~98	66 – 80
p	[bar]	2	37.5 – 46

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DATA REDUCTION

Overall heat transfer coefficient → LMTD method

$$Q = U \cdot A \cdot LMTD$$

$$U = \frac{Q}{A \cdot LMTD}$$

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UNCERTAINTY ANALYSIS

Parameter	Range	Relative error (%)
Heat input	5–10 kW	2.62
Pressure	37.5–46 bar	1.5
Temperature	45–100 ° C	3.71
Mass flow rate	0.2–2.1 kg/s	2.00

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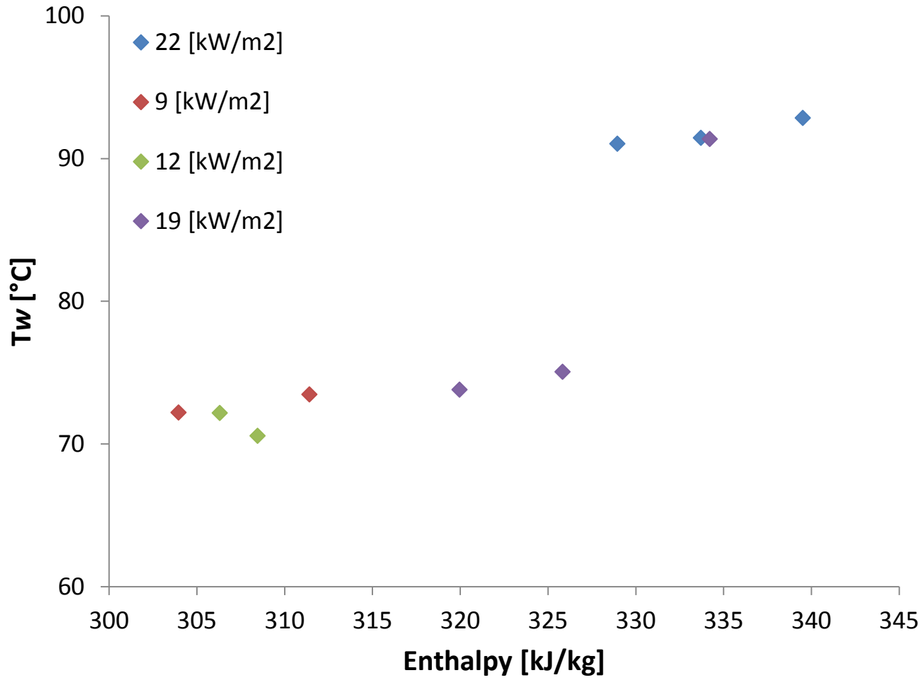
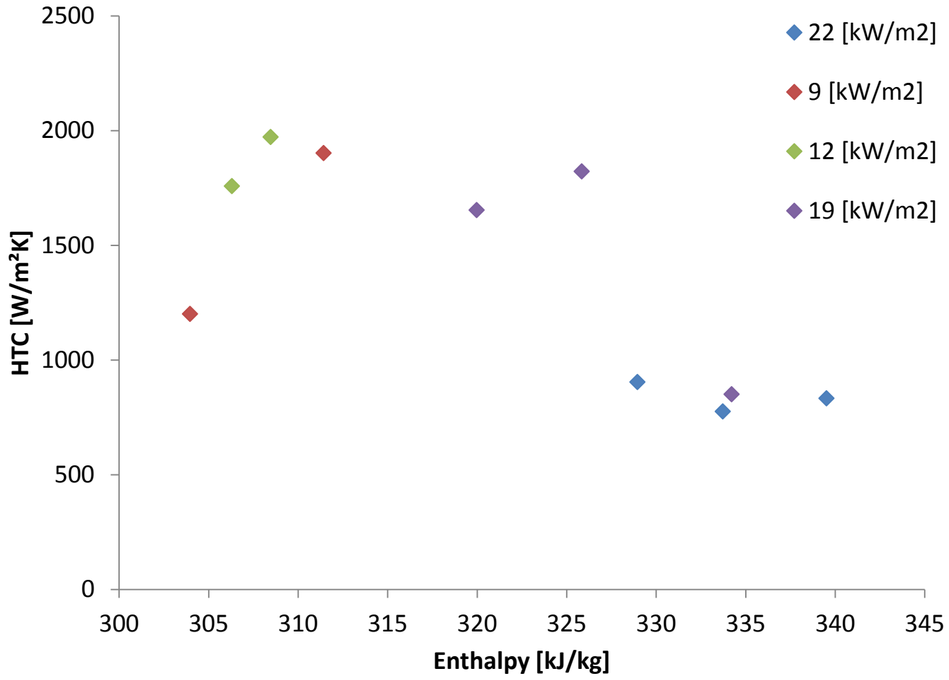
RESULTS AND DISCUSSION 1

– **Influence of the wall temperature to the convective heat transfer coefficients at various heat fluxes**





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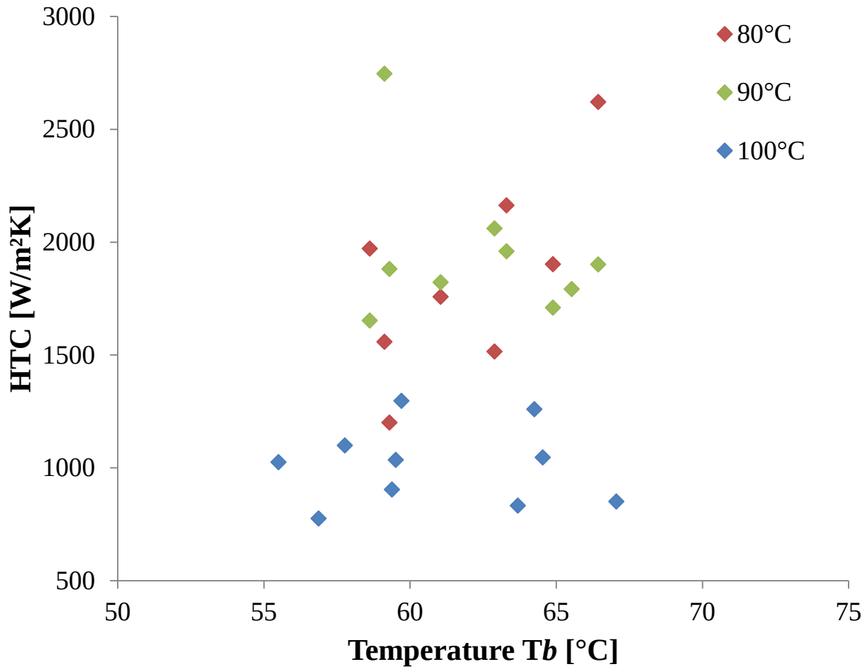
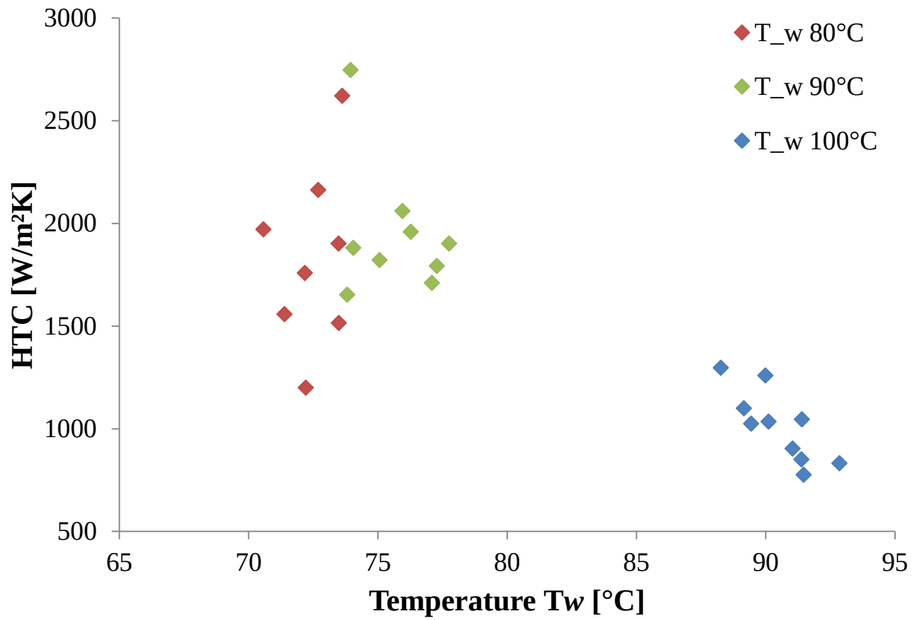
RESULTS AND DISCUSSION 2

– **Comparison of the heat transfer coefficient with different heating fluid temperatures and the respective bulk and wall temperatures**





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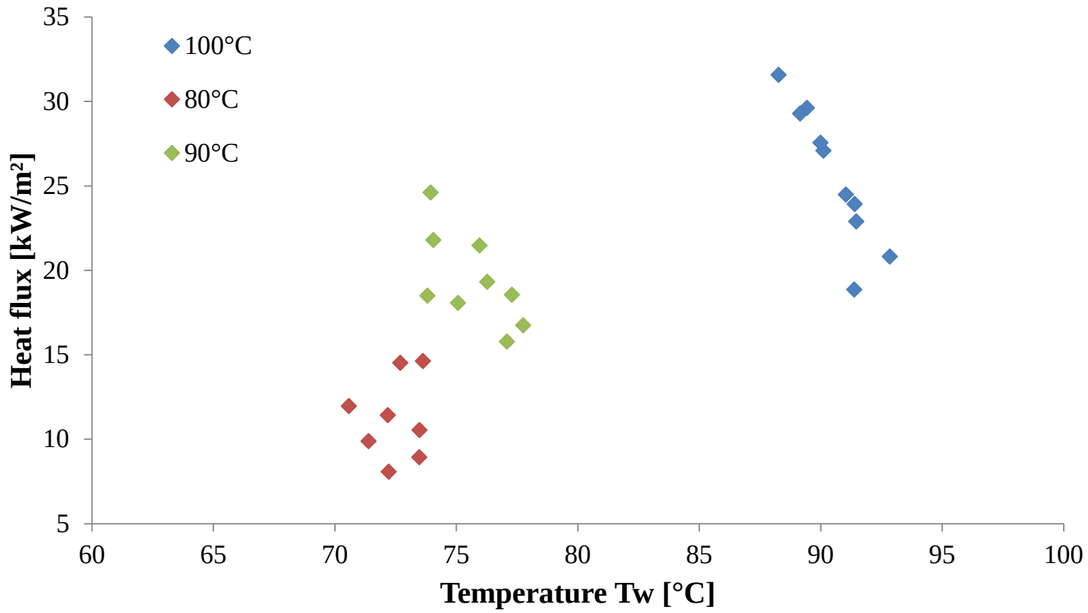
RESULTS AND DISCUSSION 3

– **Determining the effects of the wall temperature to the deteriorated heat transfer**



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CONCLUSION

Results from the forced convection heat transfer measurements at supercritical state

- Higher mass flow rate yields higher values of the overall heat transfer coeffiicent but close the critical pressure reaches maximum values
- Deteriorated heat transfer is not likely to occur at these operating conditions ~100 °C
- Next step → obtaining local measurements and deriving new heat transfer correlation proper for designing heat exchangers suitable to operate under ORC conditions

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ORCNext
The next generation Organic Rankine Cycles

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GHENT UNIVERSITY

FACULTY OF ENGINEERING
AND ARCHITECTURE

Marija Lazova

Research fellow

FLOW, HEAT AND COMBUSTION MECHANICS

E marija.lazova@ugent.be
T +32 9 264 32 50

Ghent University
@ugent
Ghent University

www.ugent.be/ea/floheacom/en

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