SAMOSAFER EXPERIMENTAL FACILITIES: DYNASTY-eDYNASTY

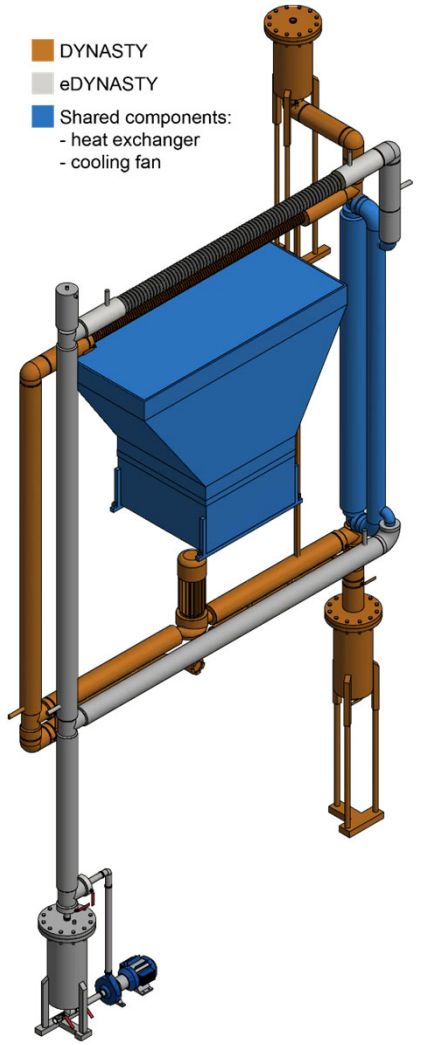
POLITECNICO DI MILANO

Introini C., Benzoni G., Lorenzi S., Cammi, A.

carolina.Introini@polimi.it, gabriele.benzoni@polimi.it, stefano.Lorenzi@polimi.it, antonio.cammi@polimi.it

PURPOSE

- Study the phenomenon of natural circulation under different heating configurations:
  - Fully distributed (DH)
  - Vertical heating source (VHHC)
  - Horizontal heating source (HHHC)
  - Single and coupled loop configuration
- Study the effect of a secondary loop on the NC stability and thermal behaviour of the primary (heated) one:
  - Start-up natural circulation
  - Passive heat removal during cool-down
  - Transition from forced to natural circulation



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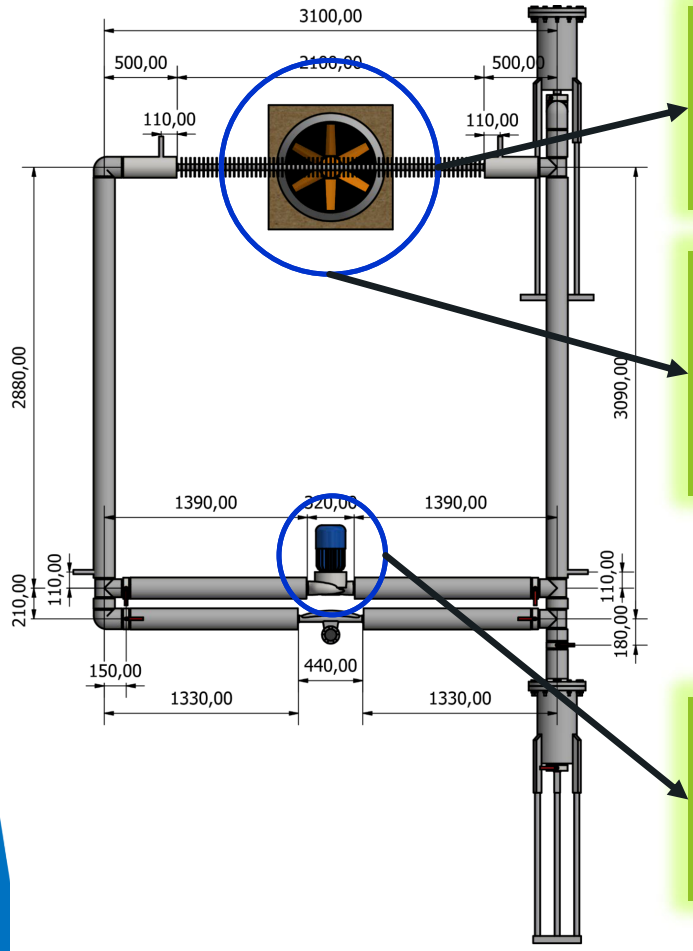
DESIGN PARAMETERS

	DYNASTY CHARACTERISTICS	eDYNASTY CHARACTERISTICS
Size	Height: 3.09 m Width: 3.10 m Piping: φ 42.16 mm Thickness 2 mm	Height: 3.23 m Width: 3.10 m Piping: φ 42.16 mm Thickness 2 mm
Working fluids	Water TYFOCOR LS (propylene glycol)	Water TYFOCOR LS (propylene glycol)
Material	AISI 304/316 L	AISI 304
Heating system	Fibreglass knitted and braided electrical strips (up to 5.5 kW)	Double pipe heat exchanger
Heat exchanger	Finned tube coupled with a cooling fan / Double pipe heat exchanger	Finned tube coupled with cooling fan
Operative Temperature range	20 / 95°C (water) 20 / 120°C (glycol)	20 / 95°C (water) 20 / 120°C (glycol)
Pressure	1 atm (filling tank top)	1 atm (filling tank top)

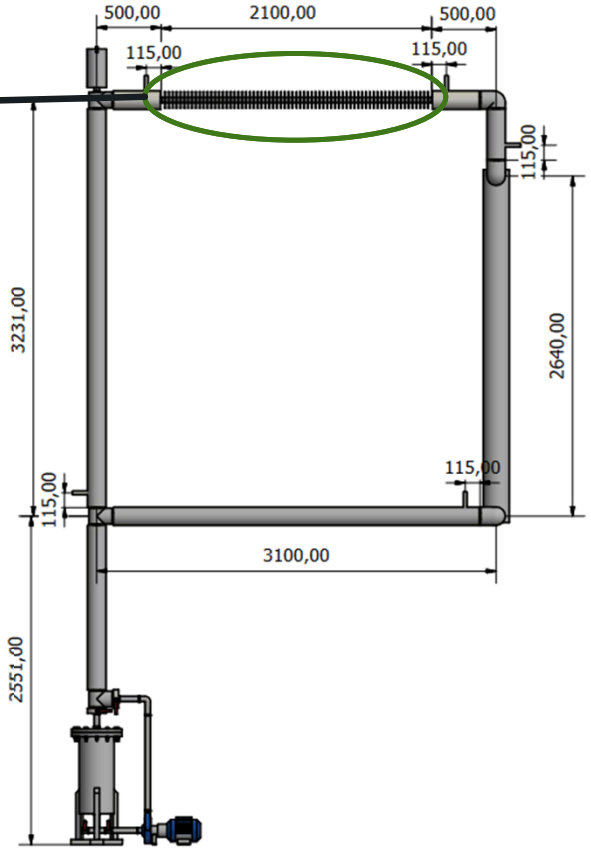
THE FACILITIES



COOLER PIPE
Finned 2500 mm pipe
Fin step 17 mm, height 15 mm

COOLING FAN
Max air flow rate 14500 m^3h^{-1}
Coupled configuration: cooling fan switched on secondary loop

PRIMARY PUMP
Pump head 5 m
Pump max velocity 1450 RPM



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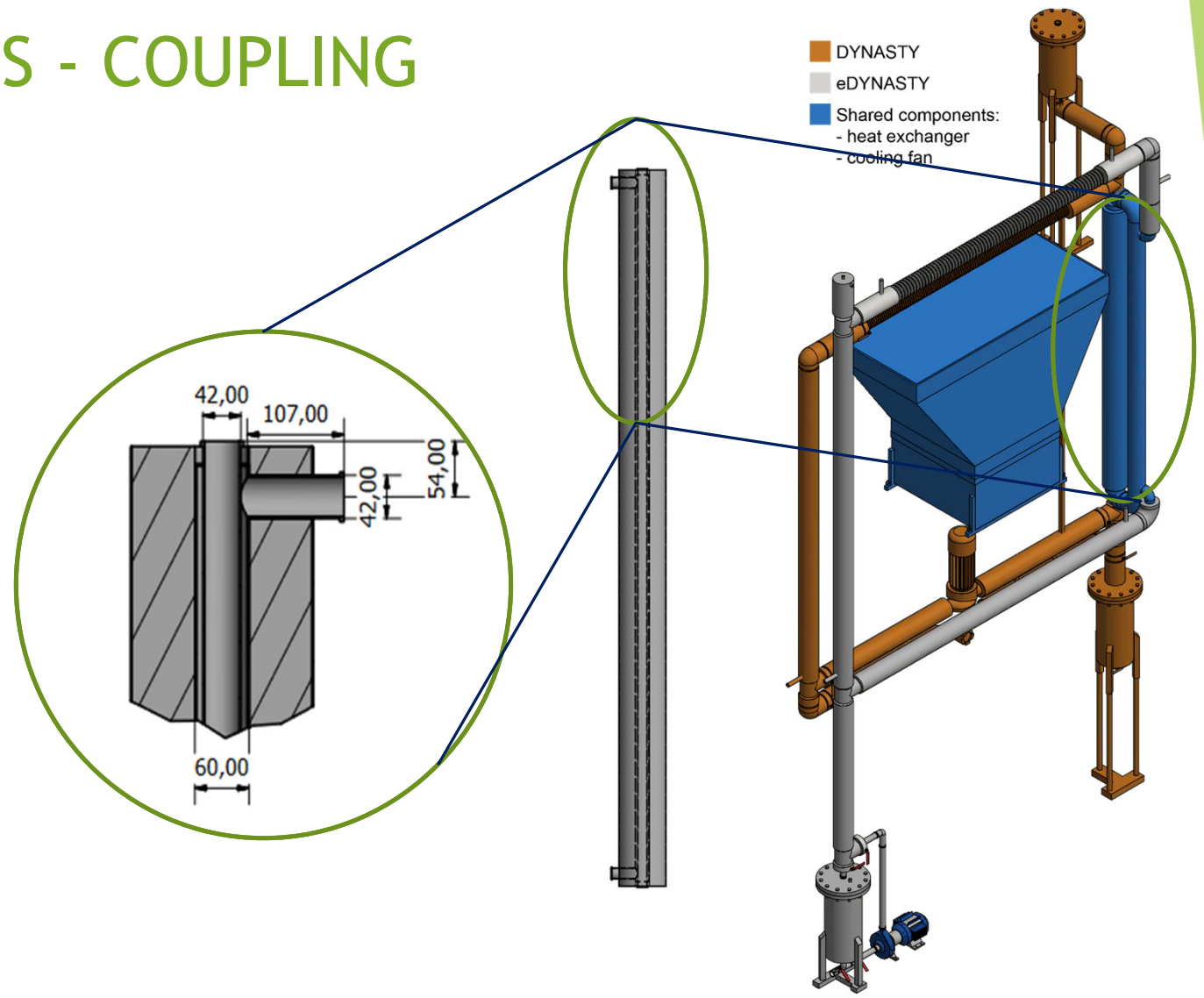
THE FACILITIES - COUPLING

- Coupling HX
  - Double pipe HX
  - DYNASTY is the internal pipe (internal diameter 38 mm)
  - eDYNASTY is the annulus pipe (outer diameter 60 mm)



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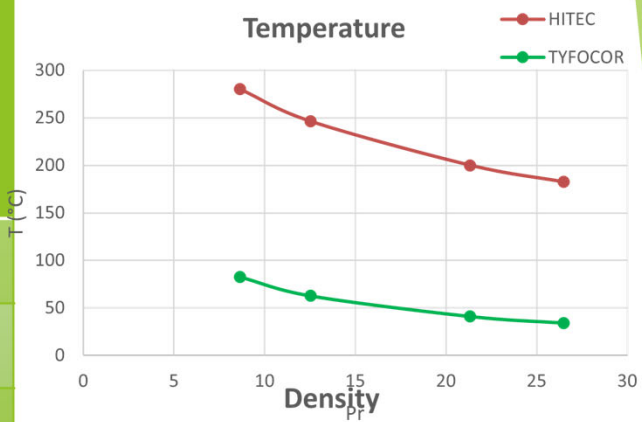
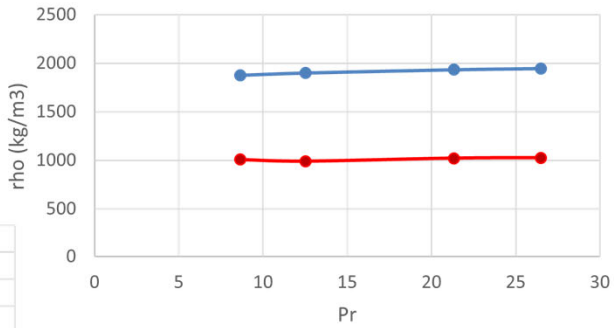
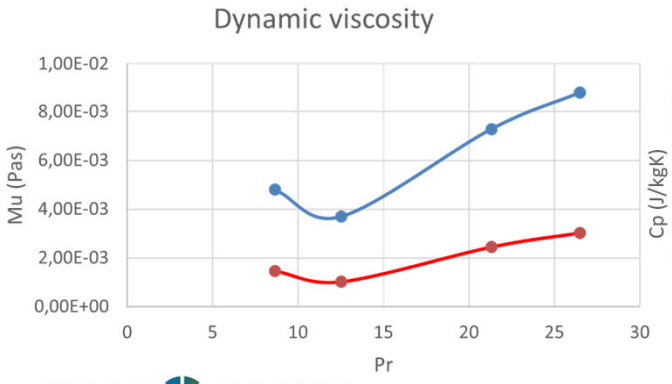
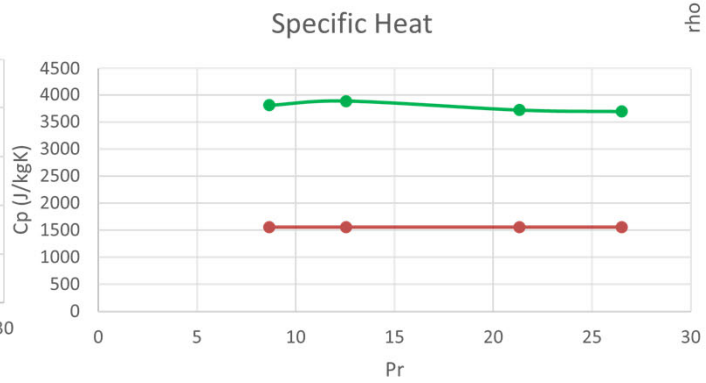
TYFOCOR MAIN CHARACTERS

Temperature (°C)g	Density (kg m^{-3})	Viscosity (Pa s)	Specific heat (J kg^{-1} K^{-1})	Thermal conductivity (W m^{-1} K^{-1})
20	1034	0,0048	3600	0,413
50	1015	0,0018	3720	0,434
90	986	0,0009	3880	0,462
120	959	0,0005	3990	0,483









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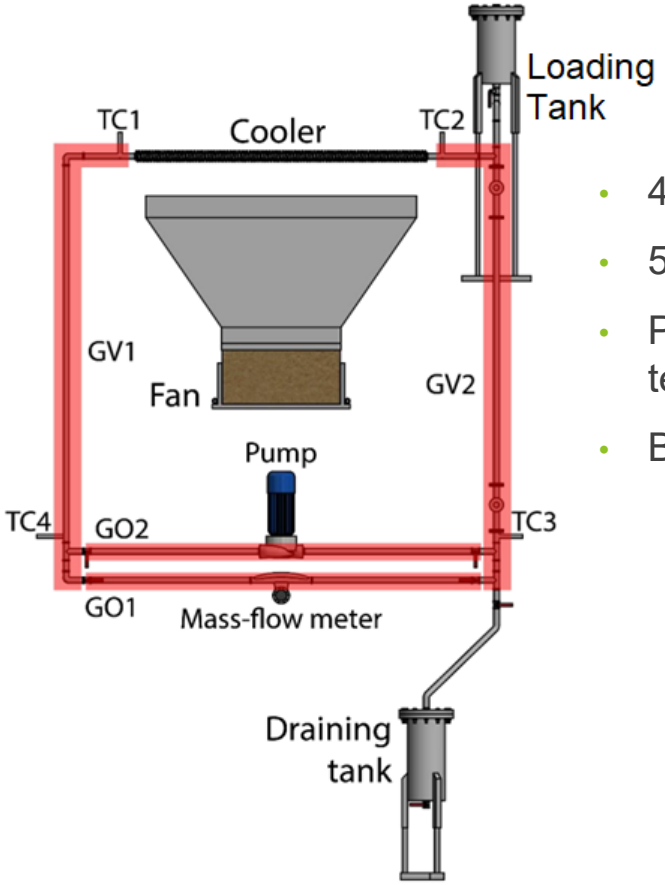
HEATING AND INSTRUMENTATION - DYNASTY



- 4 ELSI J-type thermocouples for the fluid temperature (TC1 to TC4)
- 5 ELSI J-type thermocouples for the wall temperature
- PROMASS F80 DN25 Coriolis mass flow rate meter (with temperature measurement)
- BRISKHEAT heating strips (single strip power 684.5 W)
  - Three strips in the vertical legs
  - Two strips in the horizontal legs
  - In coupled configuration, GV2 is bypassed

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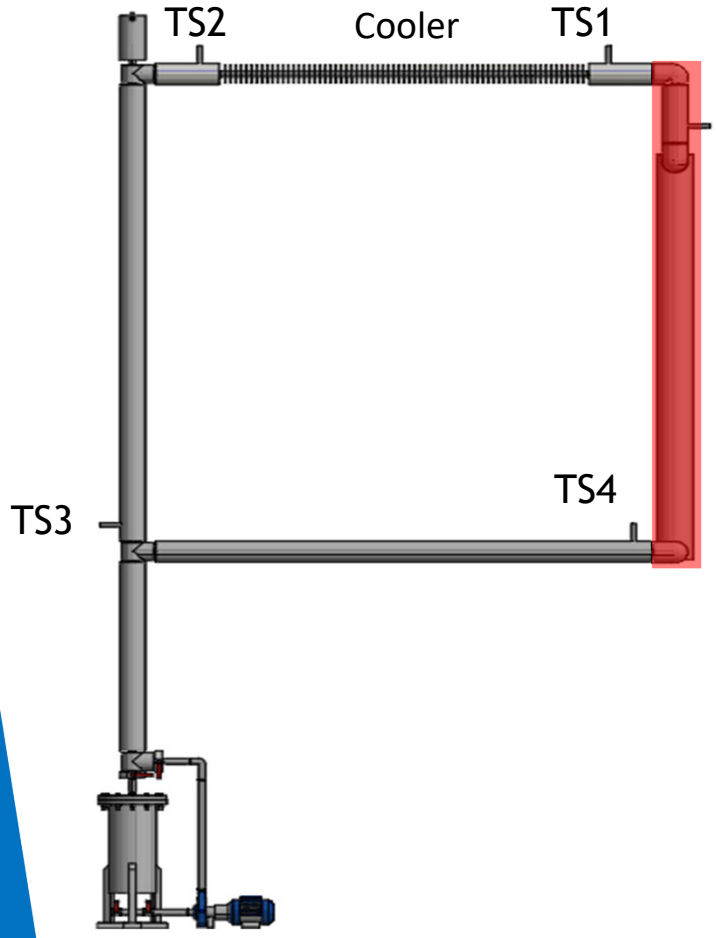
HEATING AND INSTRUMENTATION - eDYNASTY



- 5 ELSI J-type thermocouples
- Bottom pump for load and unload
- Upper expansion vase to control the pressure
- Heating configuration
  - VHHC (DYNASTY as heat source)

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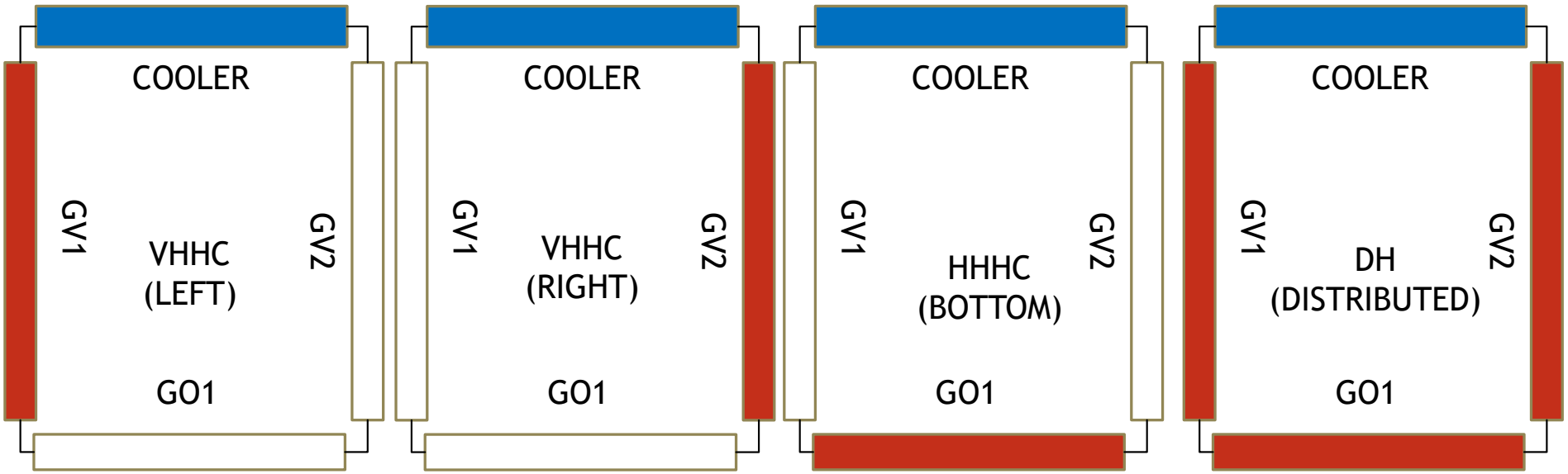
HEATING CONFIGURATIONS - SINGLE



	GO1	GV1	GV2	DH	FAN
P (W)	1369	2068	2071	5508	DYNASTY

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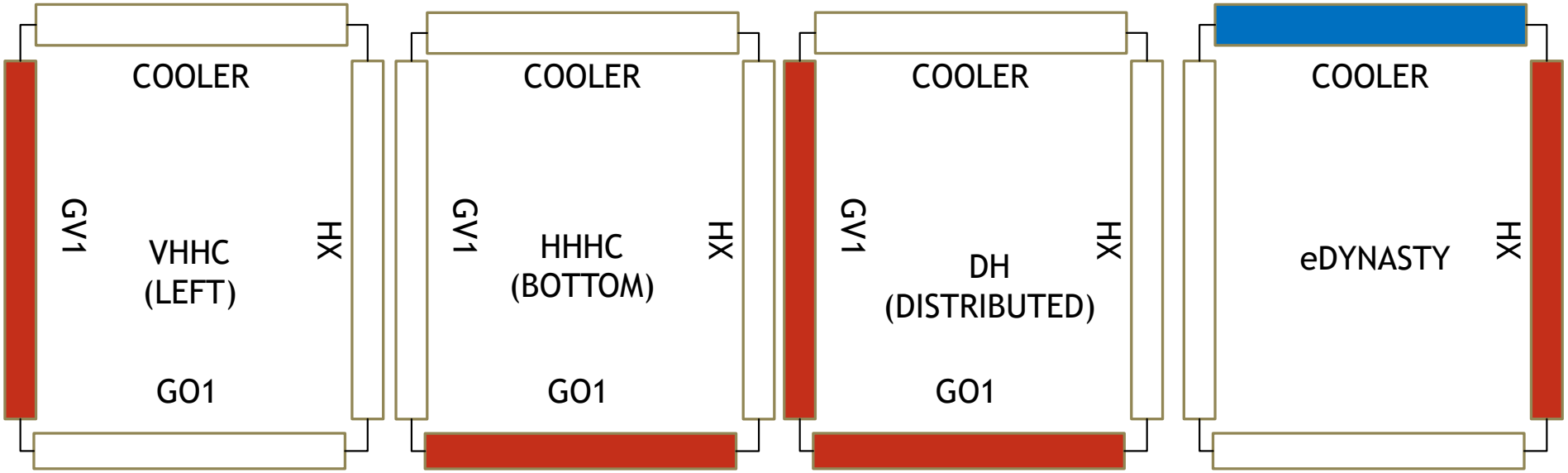
HEATING CONFIGURATIONS - COUPLED



	GO1	GV1	GV2	DH	FAN
P (W)	1369	2068	0	3437	eDYNASTY

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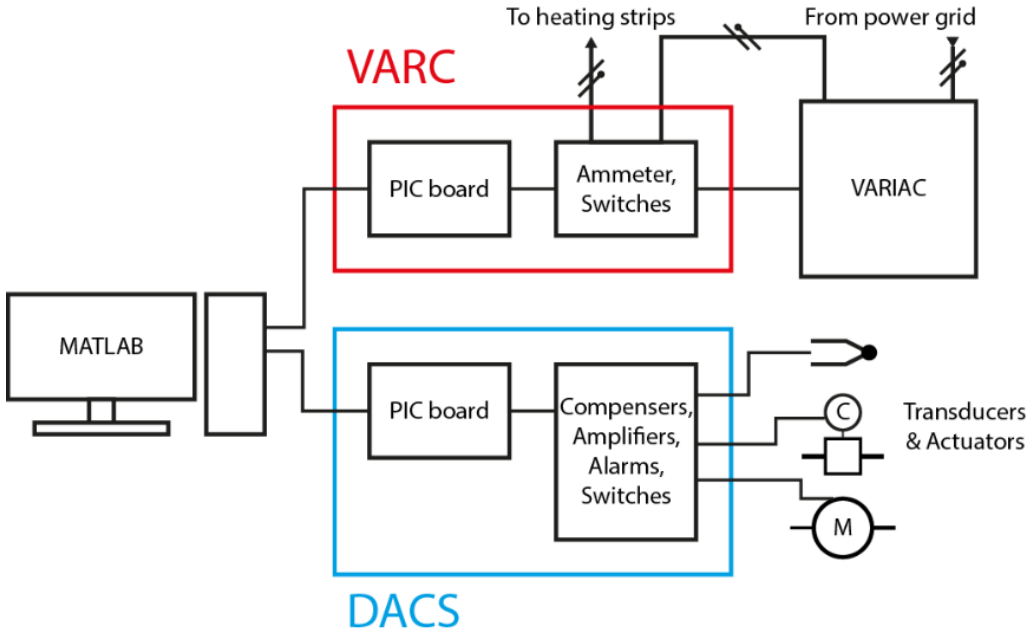
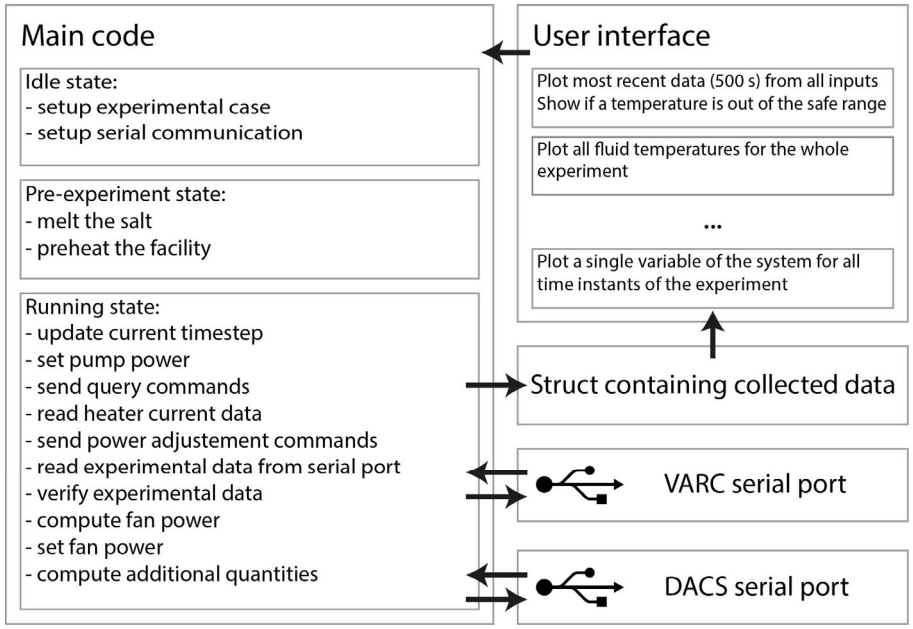
DYNASTY CONTROLLER





VARC (heater control) and DACS (data acquisition) boards are custom designed and built
The PIC boards are a standard PIC18F8723 controller.
A custom-made MATLAB interface is used for monitoring and saving the data

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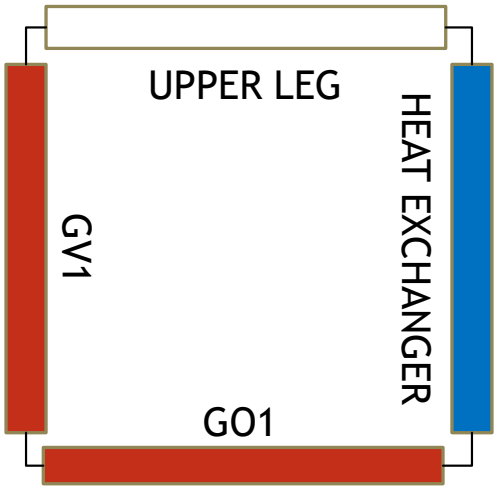
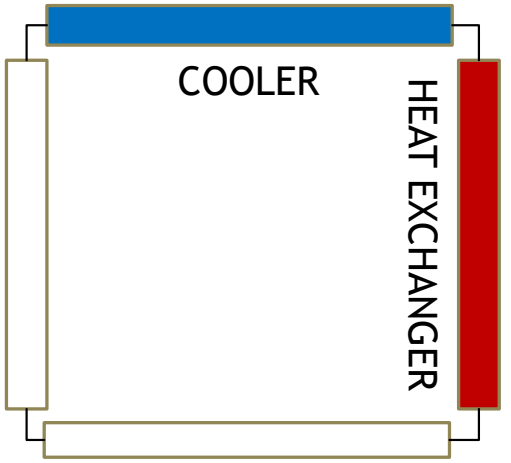
EXPERIMENTAL RESULTS

COUPLED LOOP – DH CONFIGURATION



- DH heating configuration (GV1 + GO1)
- eDYNASTY cooler
- Input power: 2360 W
- Working fluid: WATER / WATER
- Insulation: Yes



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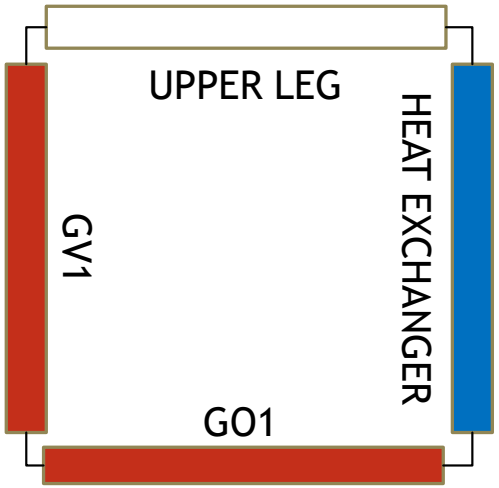
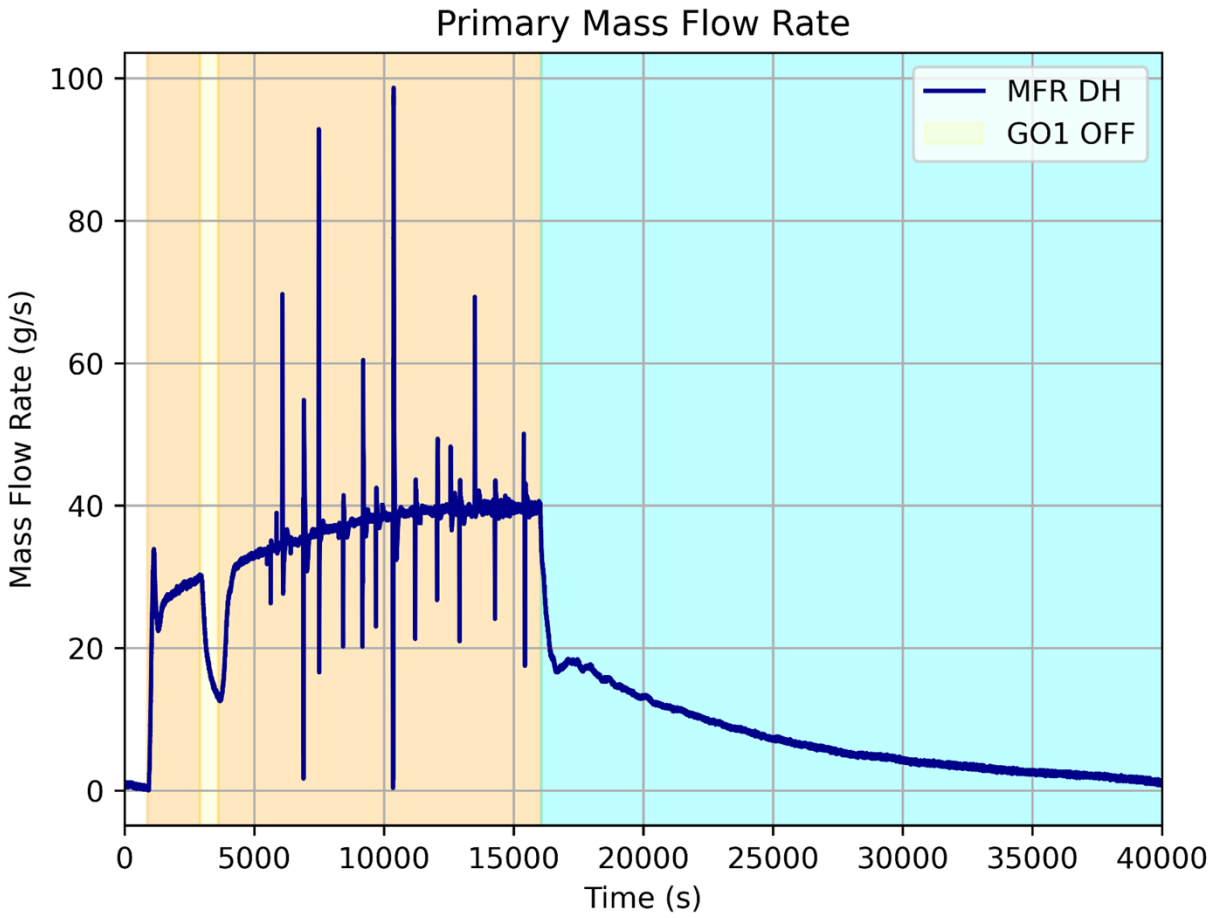
COUPLED LOOP – DH CONFIGURATION (FAN 0%)





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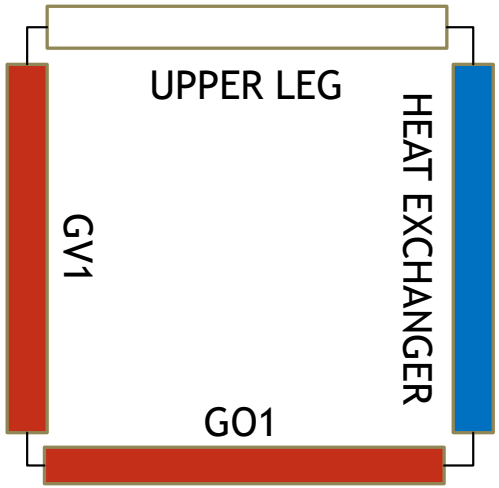
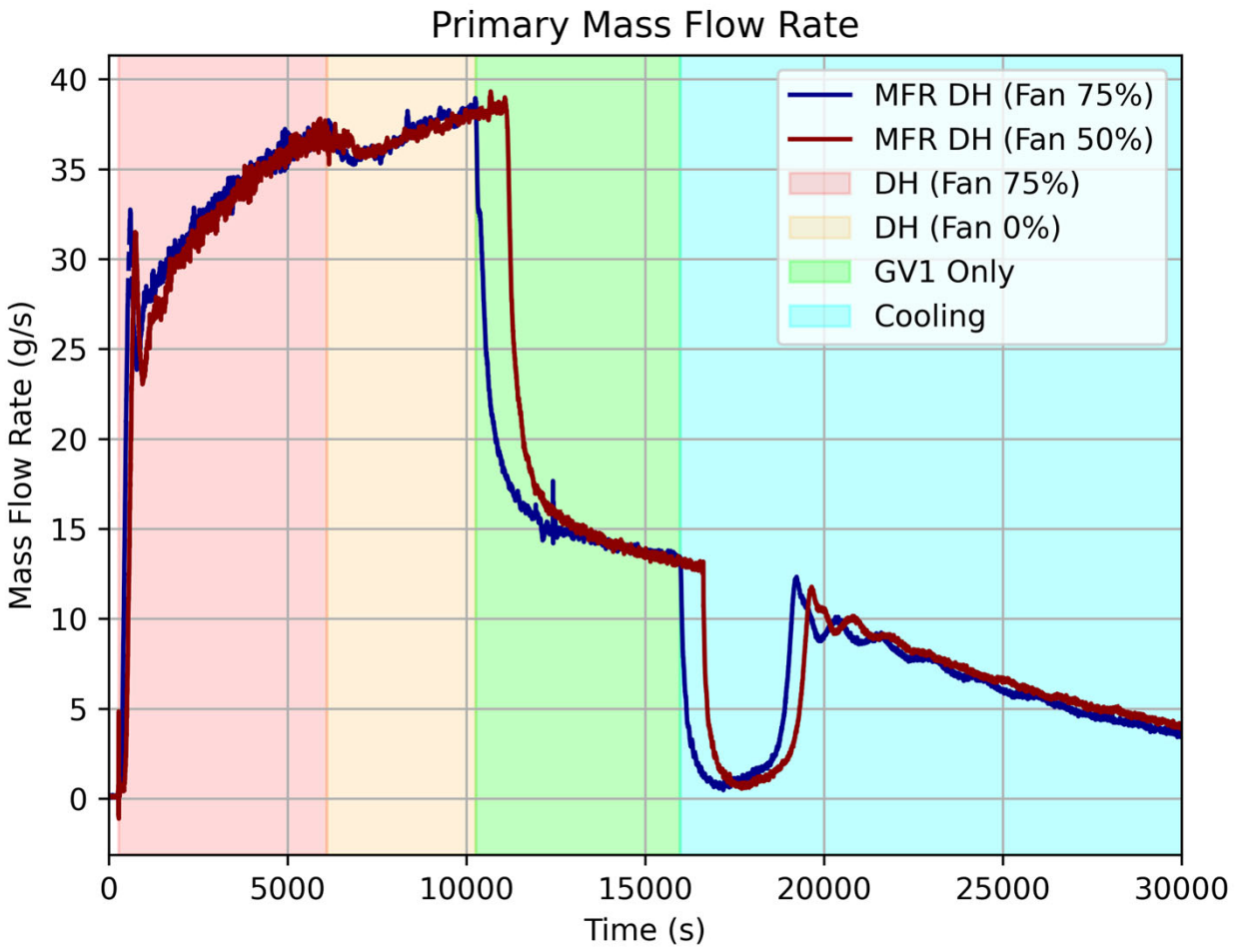
COUPLED LOOP – DH CONFIGURATION (FAN ON)





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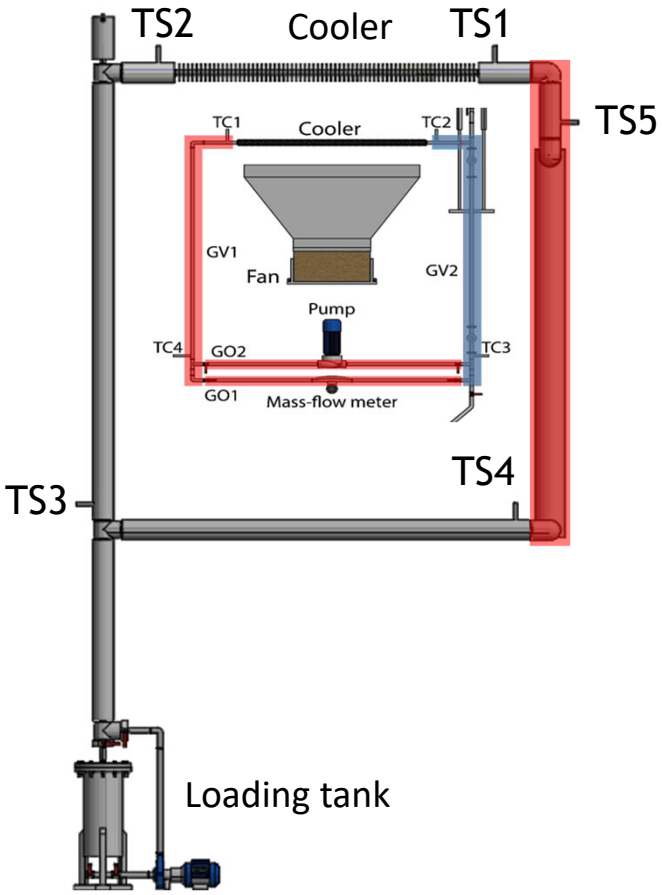
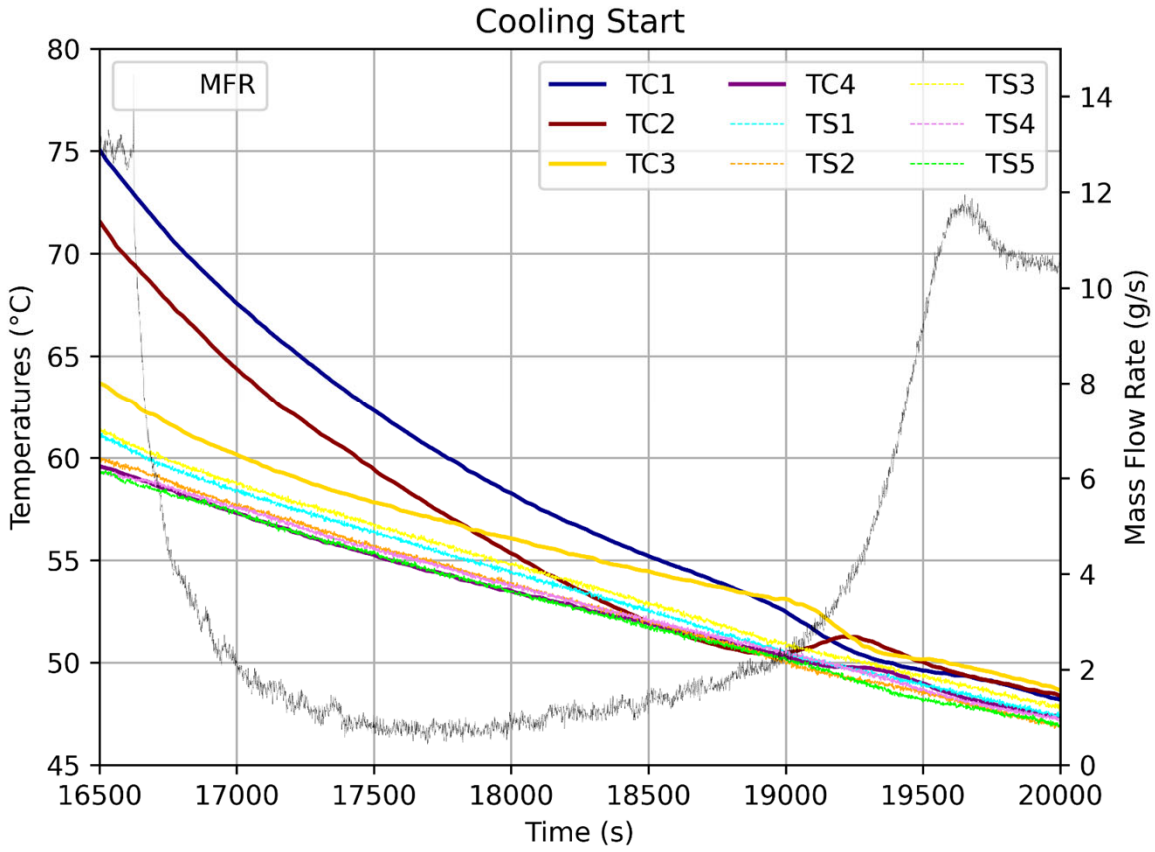
COUPLED LOOP – DH CONFIGURATION (FAN 50%)





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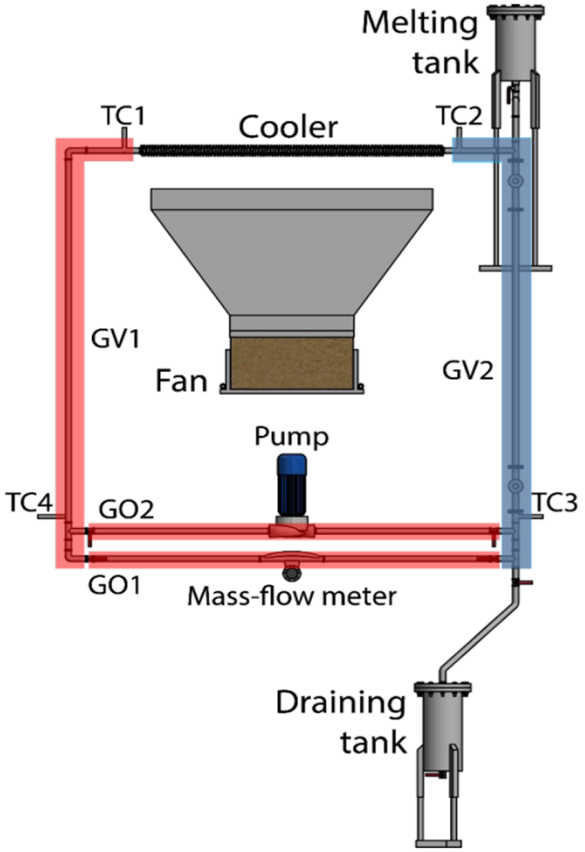
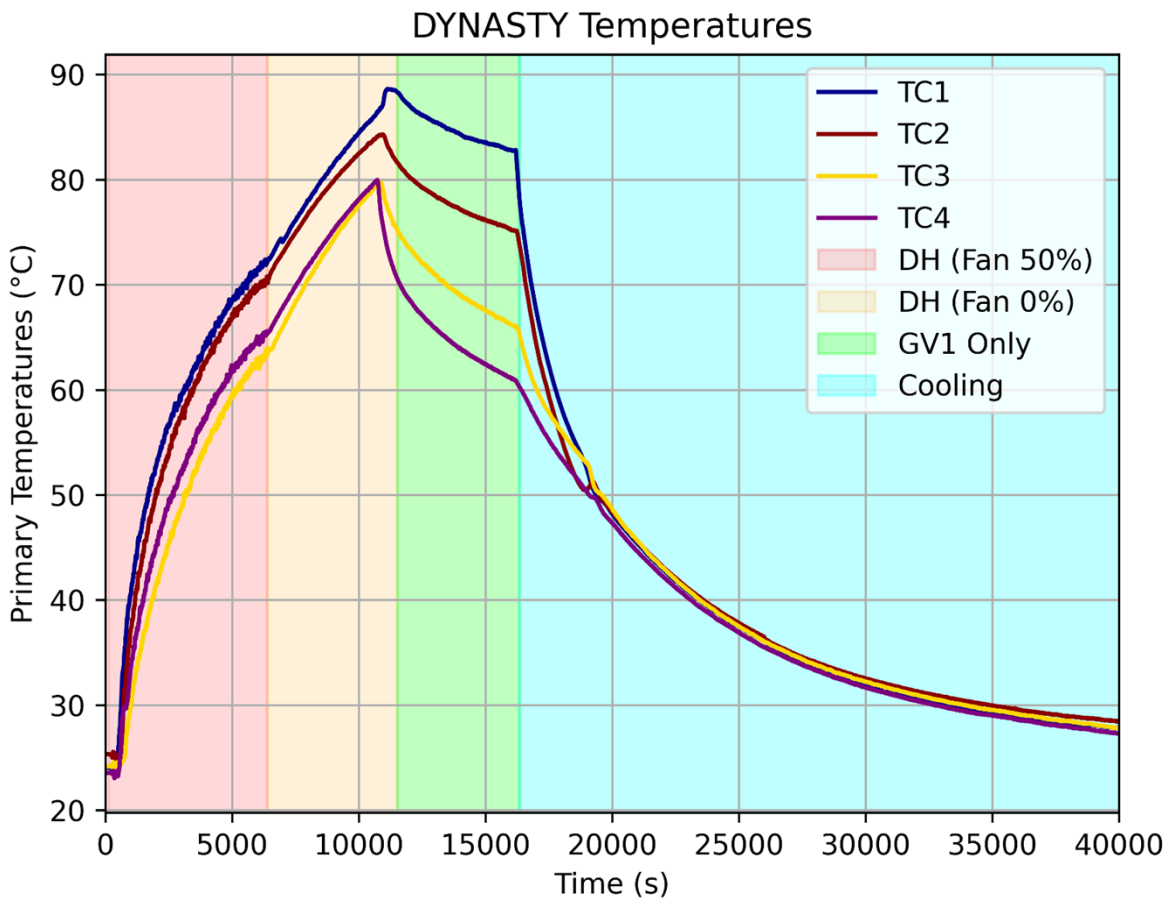
COUPLED LOOP – DH CONFIGURATION (FAN 50%)





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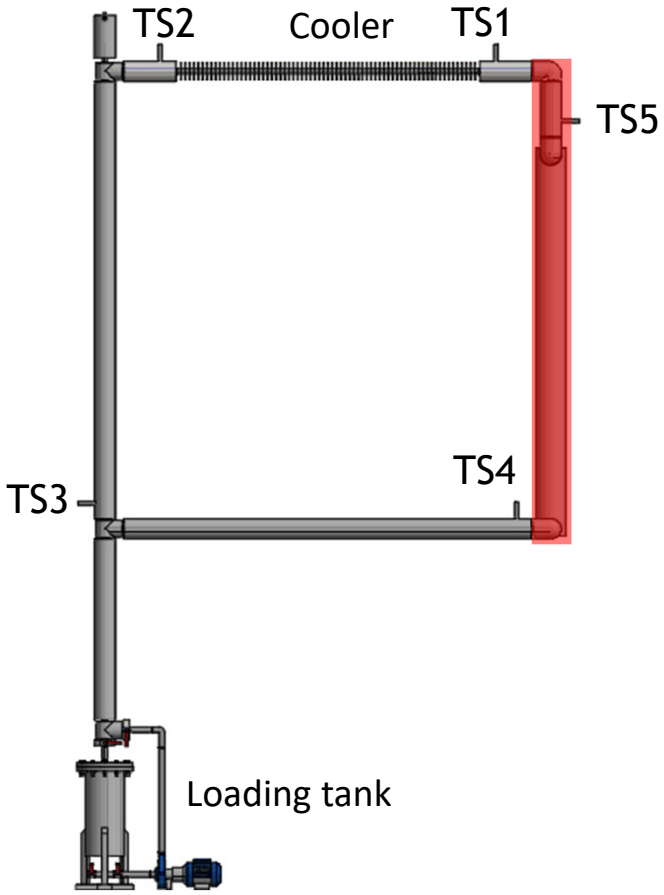
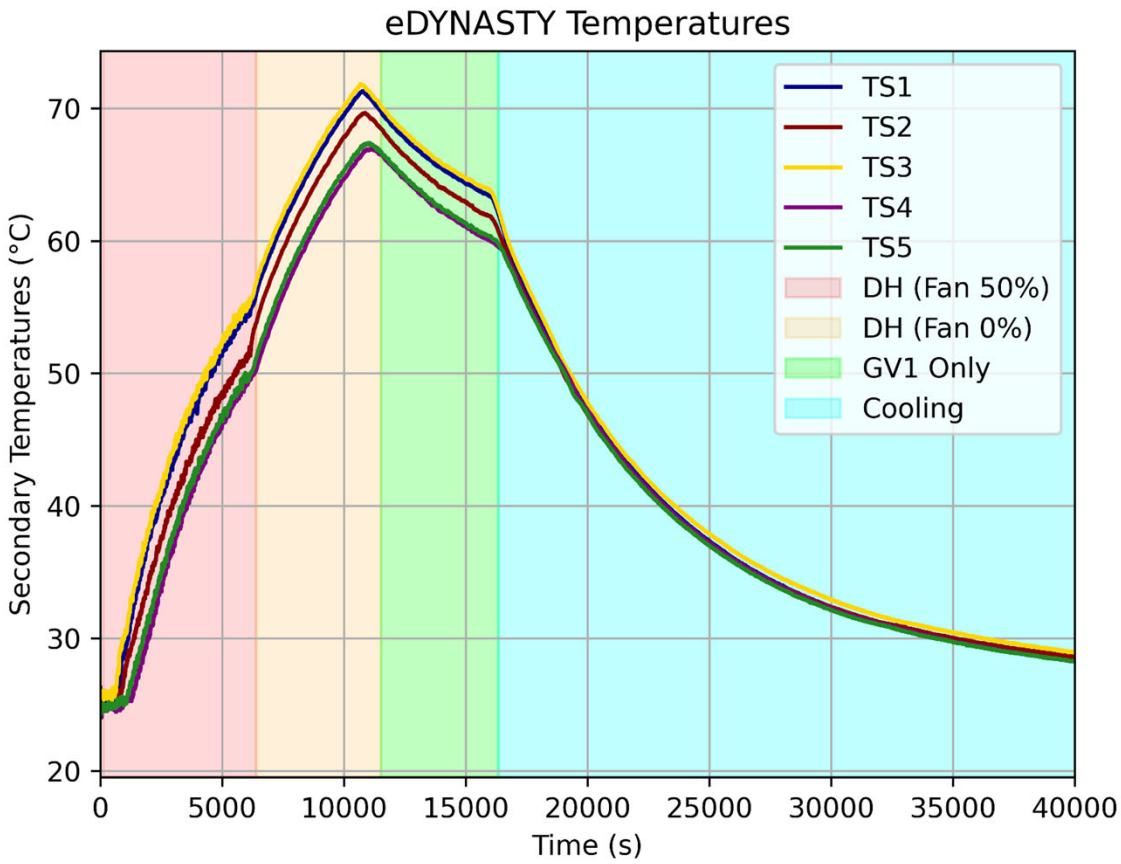
COUPLED LOOP – DH CONFIGURATION (FAN 50%)





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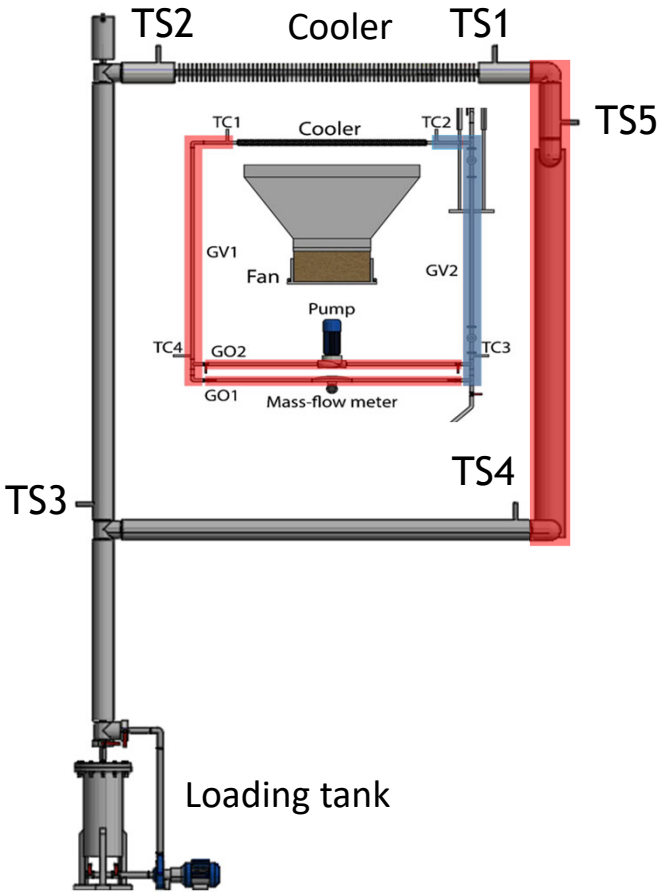
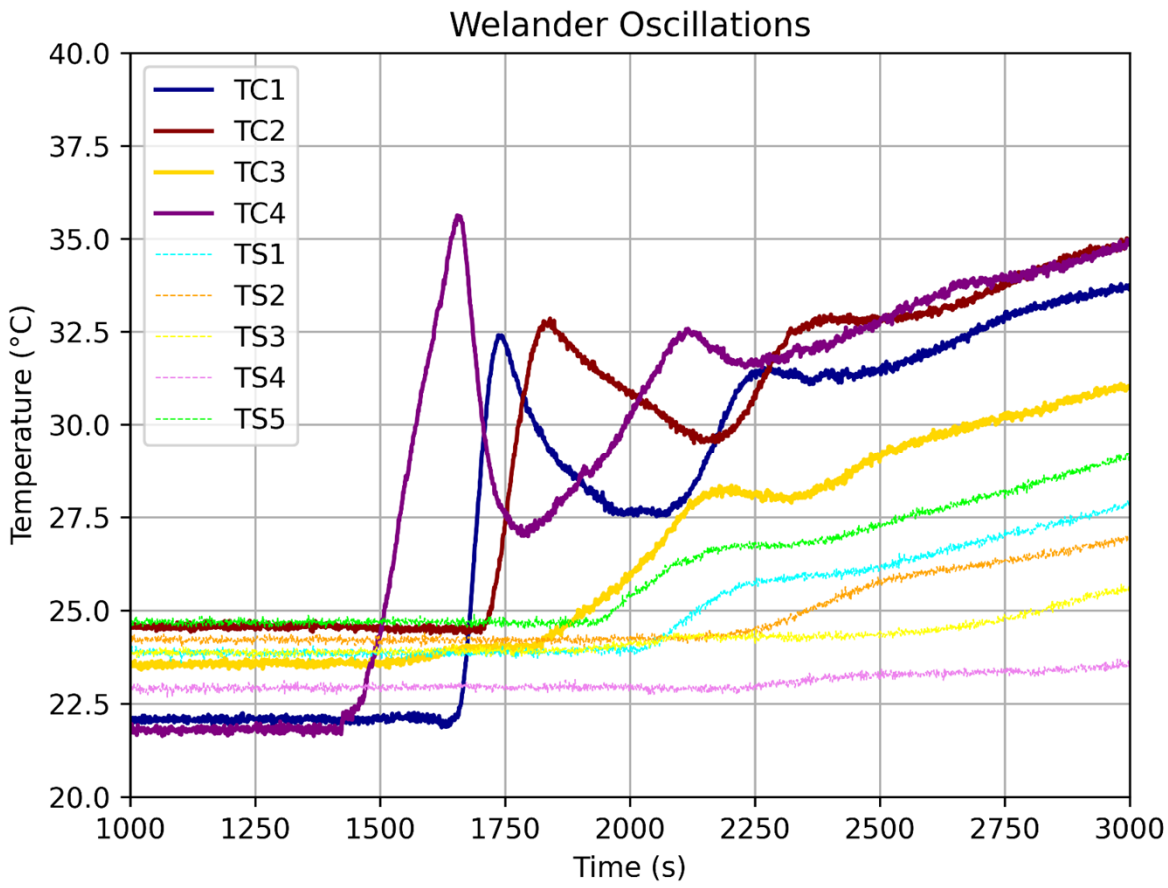
COUPLED LOOP – DH CONFIGURATION





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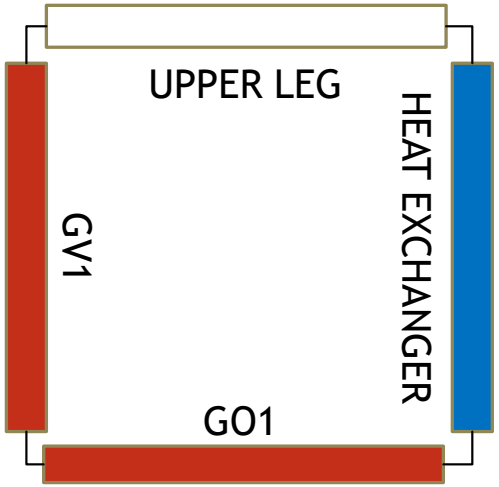
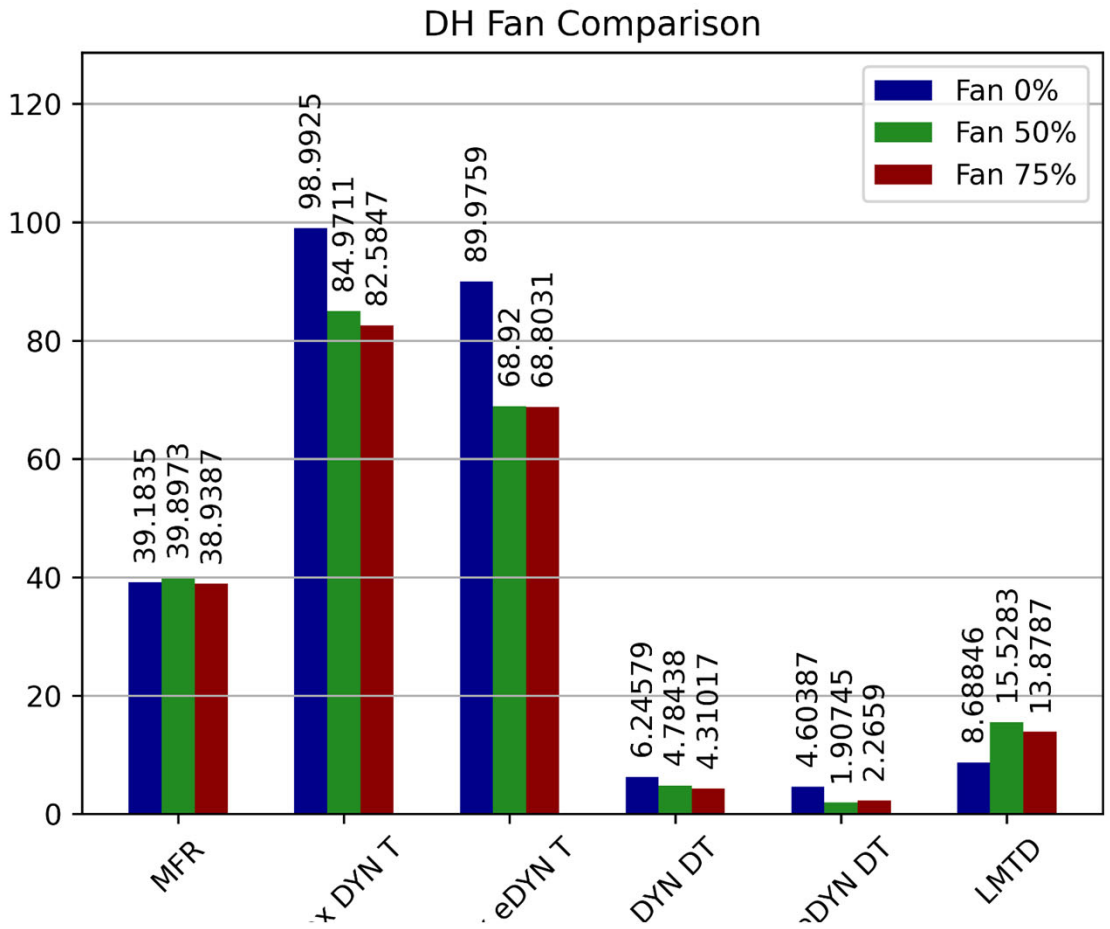
COUPLED LOOP – DH CONFIGURATION





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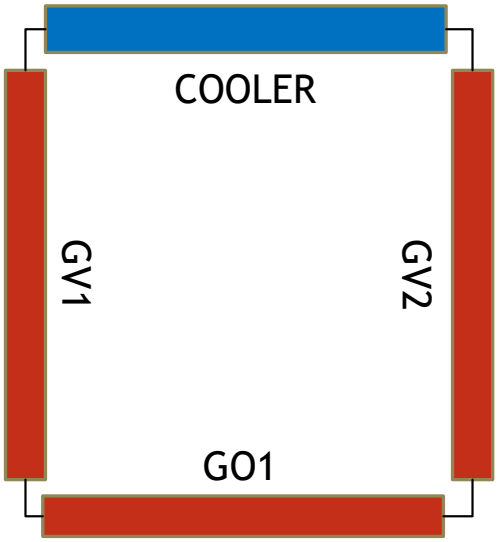
SINGLE LOOP – TRANSIENT INSTABILITY



- DH heating configuration (GV1 + GO1 + GV2)
- DYNASTY cooler
- Input power: 2100 W
- Working fluid: GLYCOL
- Insulation: Yes

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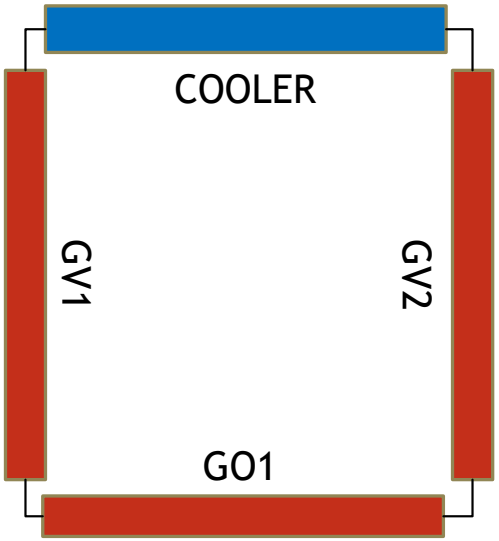
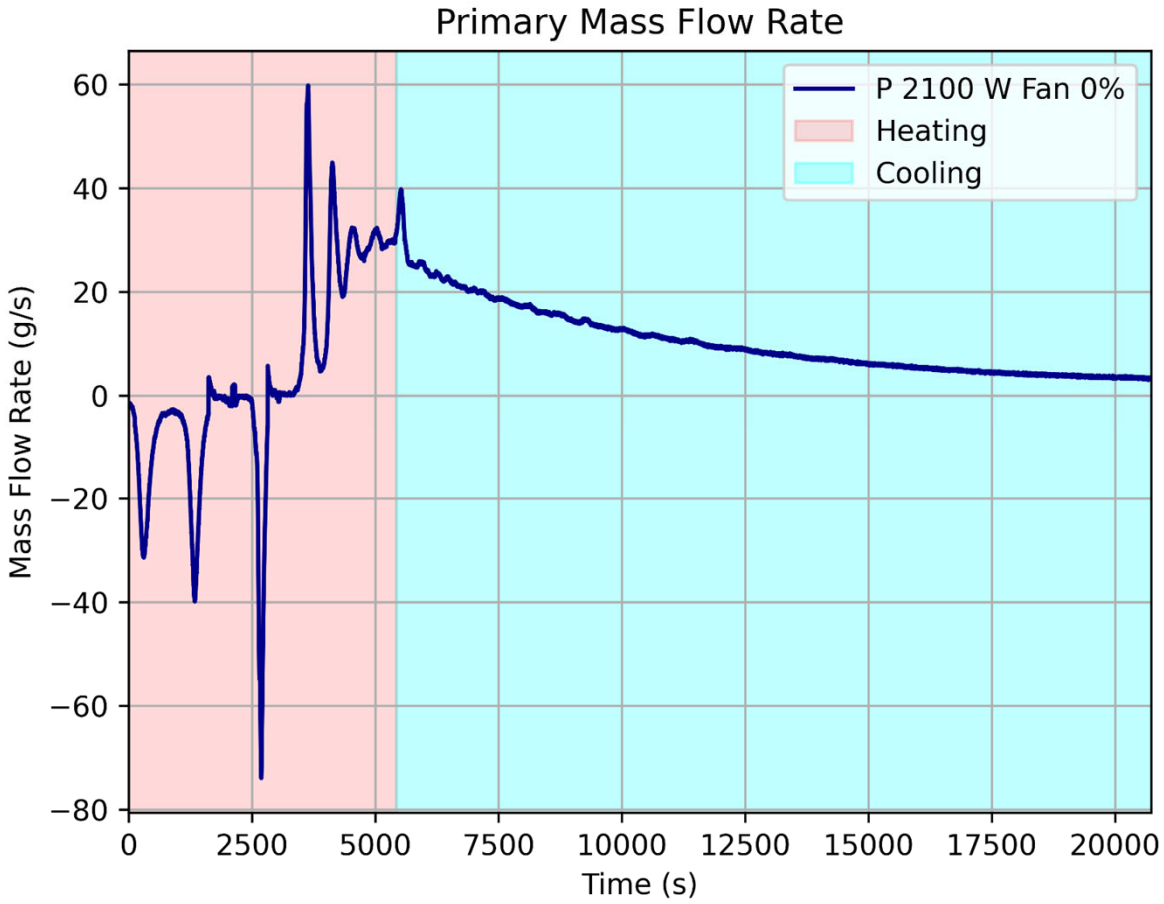
SINGLE LOOP – TRANSIENT INSTABILITY





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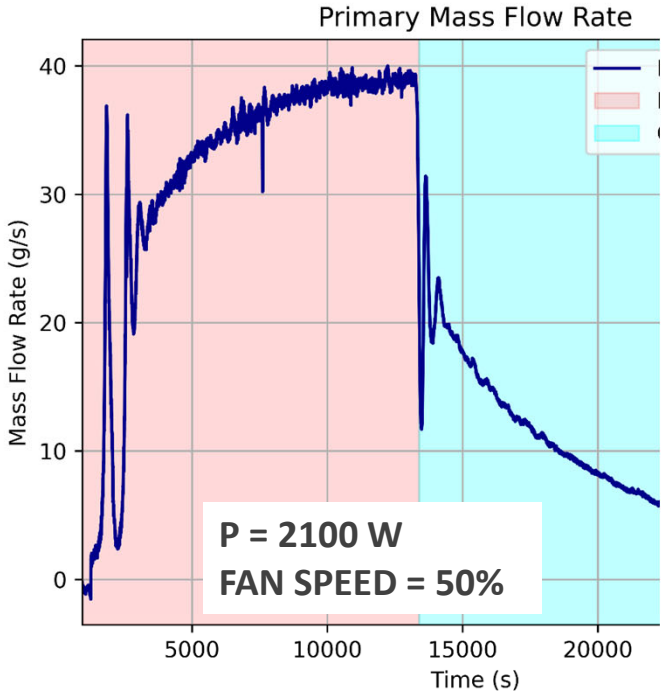

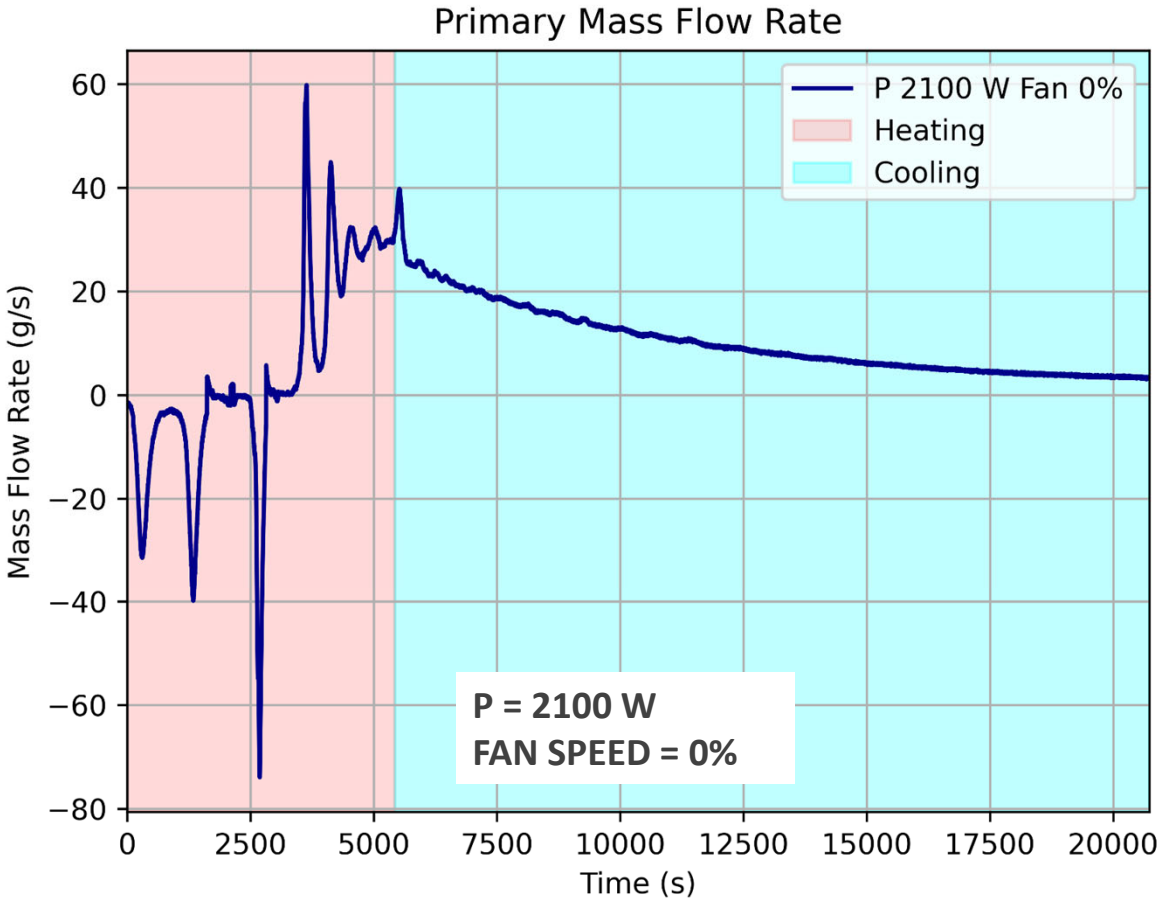

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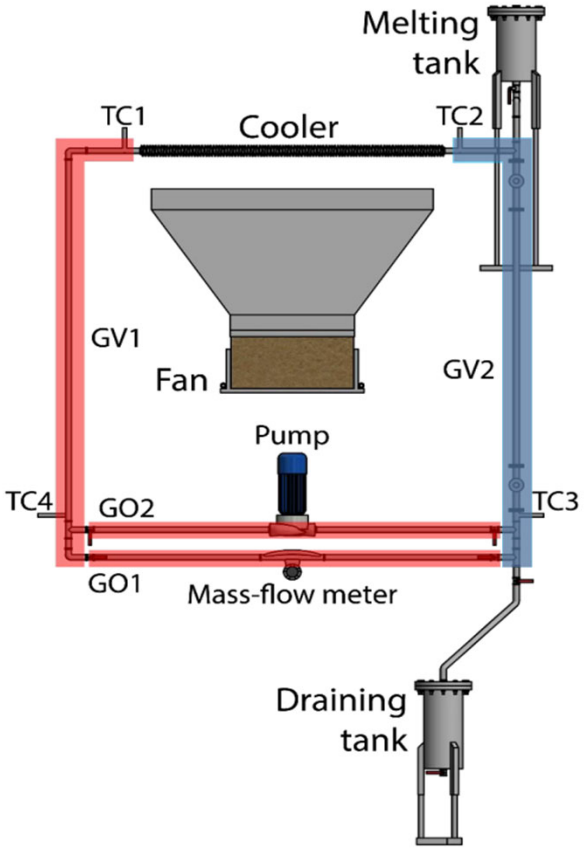

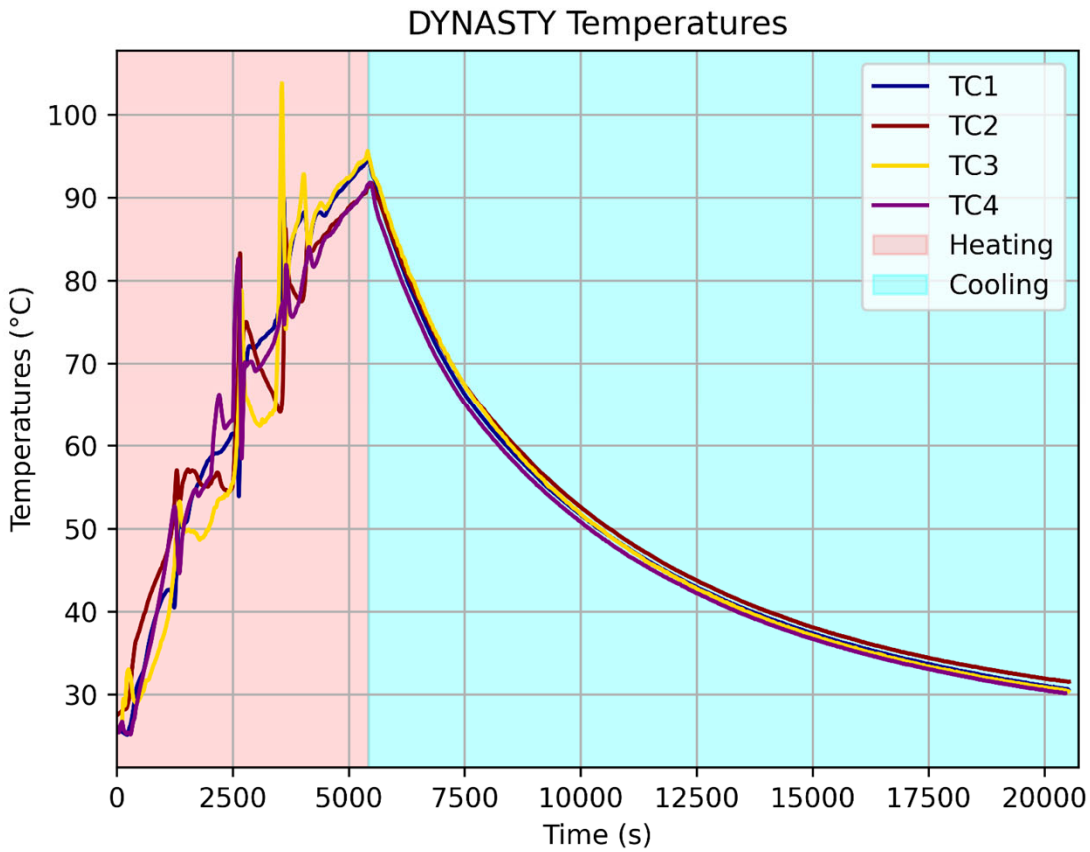

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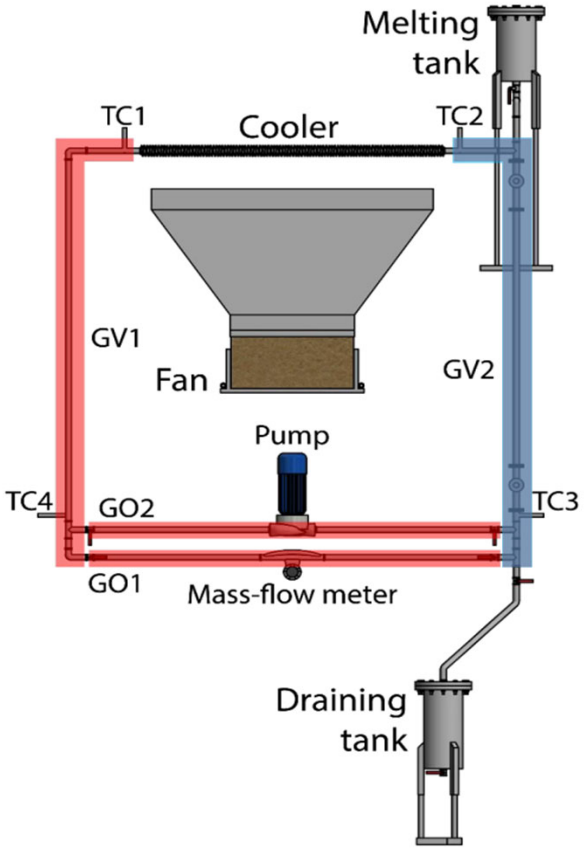
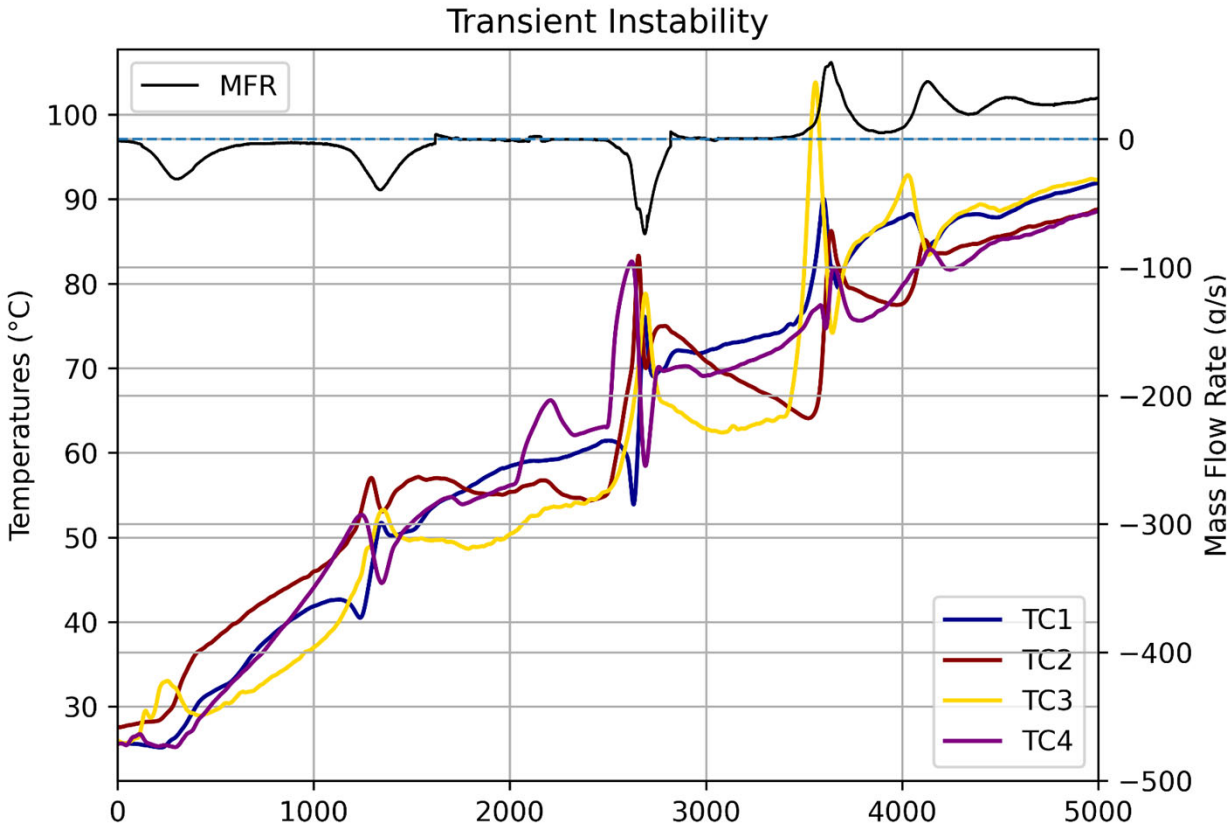
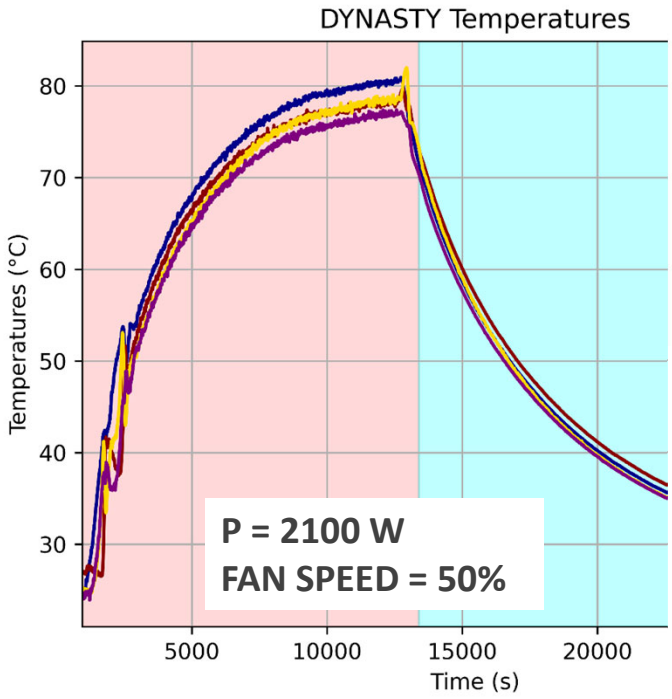
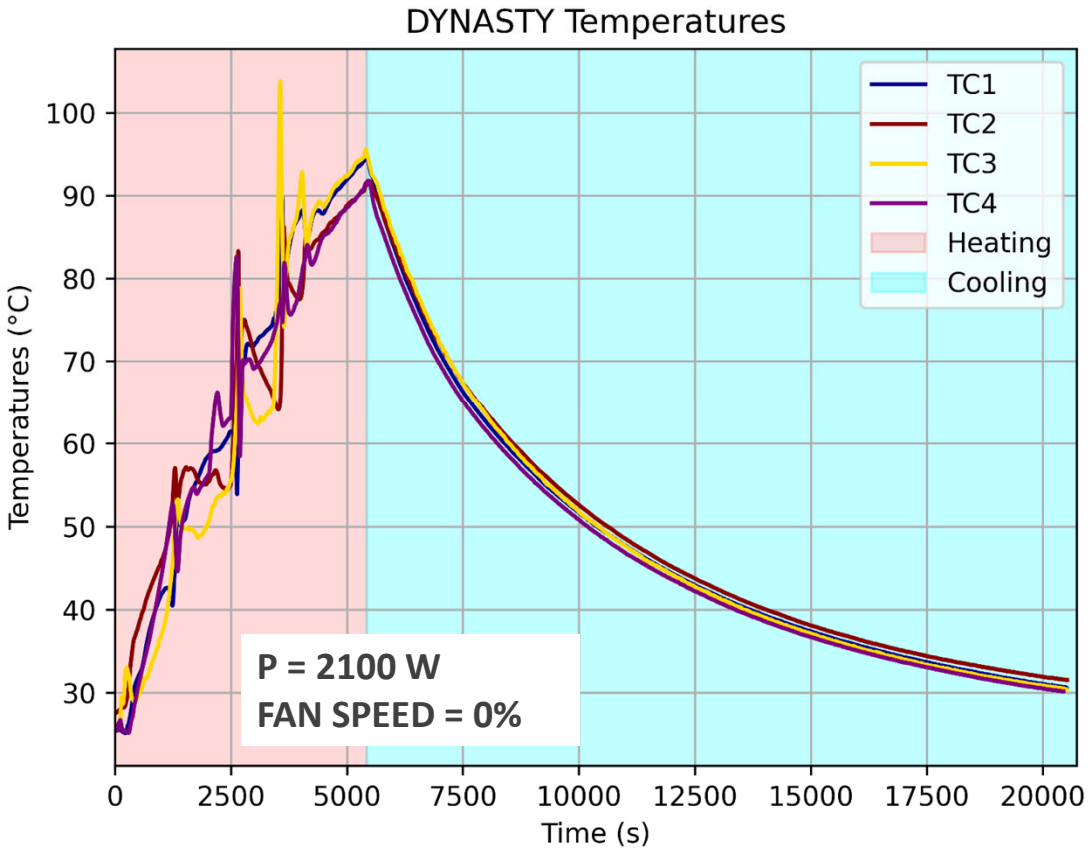
SINGLE LOOP – TRANSIENT INSTABILITY





SINGLE LOOP – TRANSIENT INSTABILITY





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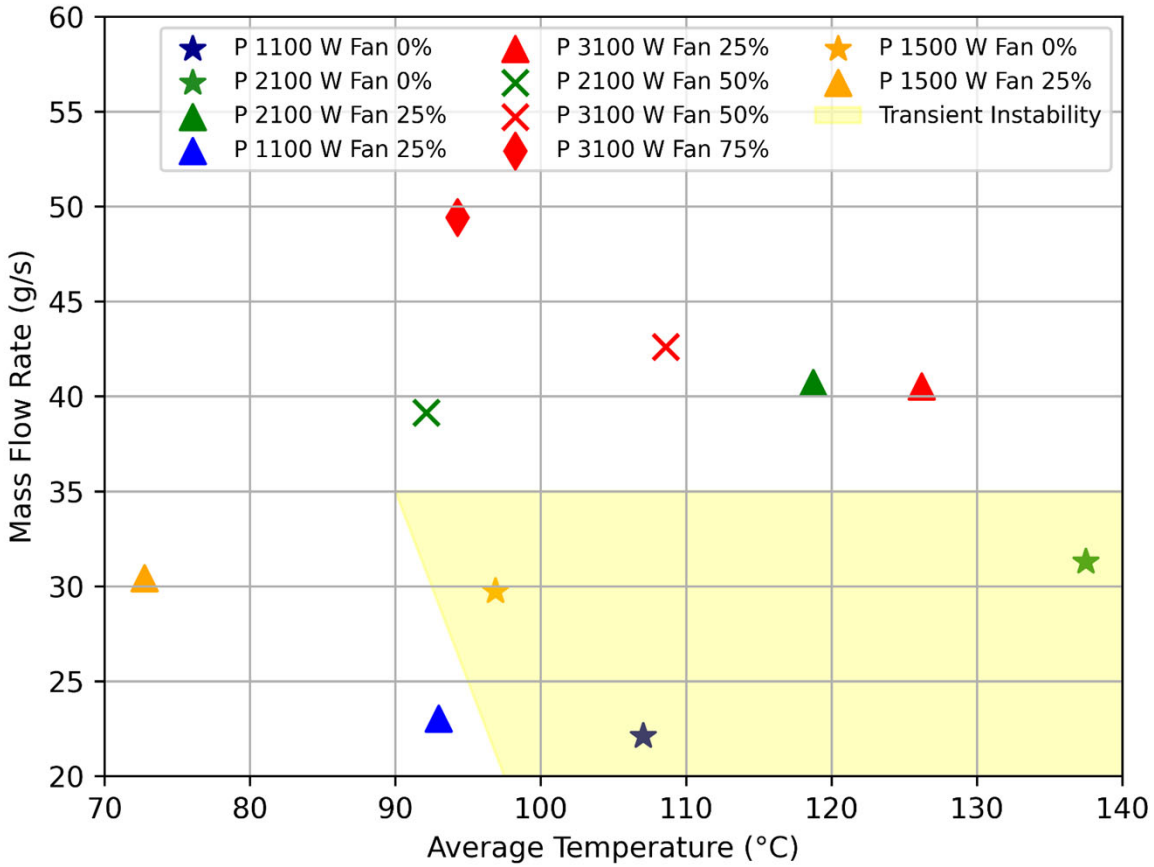
SINGLE LOOP – CASES SUMMARY



Power	Fan	Unstable
1.1 kW	0%	Yes
1.1 kW	25%	No
1.5 kW	0%	Yes
1.5 kW	25%	No
2.1 kW	0%	Yes
2.1 kW	25%	No
2.1 kW	50%	No
3.1 kW	25%	No
3.1 kW	50%	No
3.1 kW	75%	No

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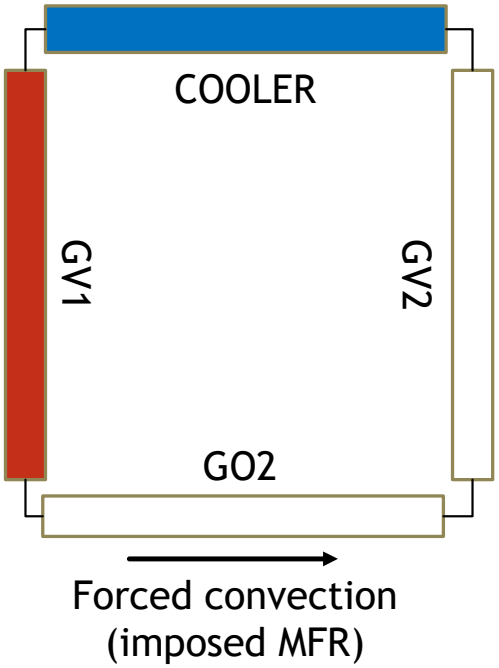
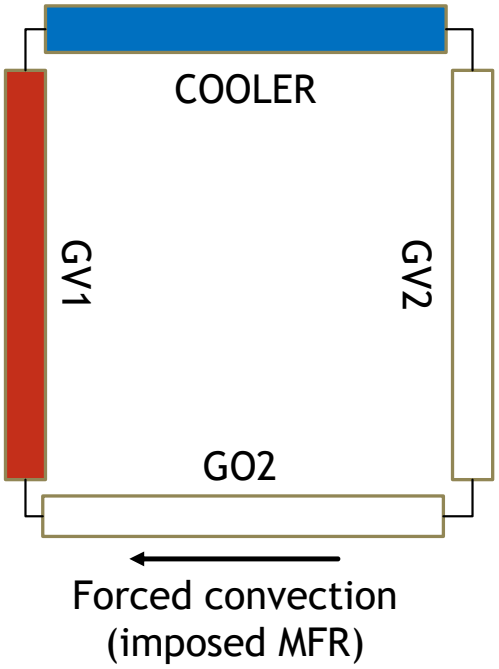
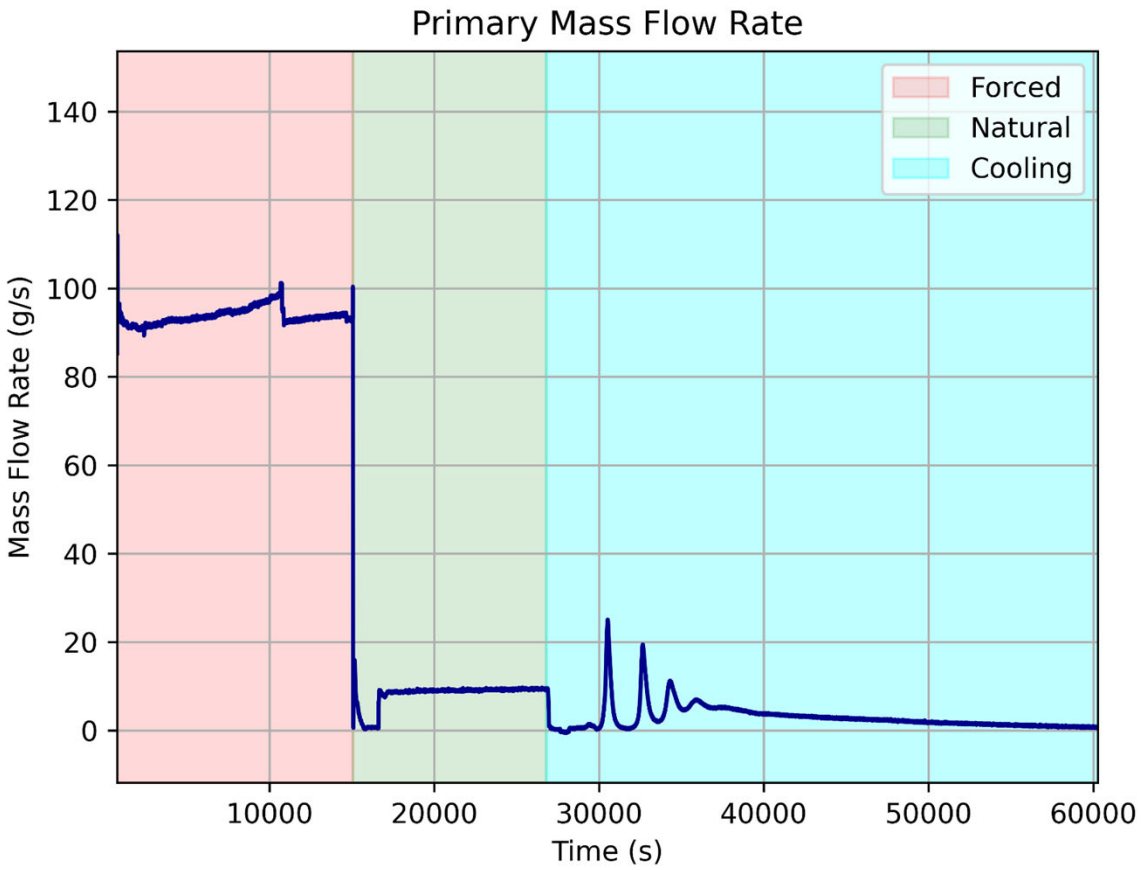
SINGLE LOOP – REGIME TRANSITION



- VHHC heating configuration (GV1)
- DYNASTY cooler
- Input power: 2100 W
- Working fluid: WATER
- Insulation: Yes
- Pump speed: 18 m^3/s
- Imposed MFR: 93 g/s

SINGLE LOOP – REGIME TRANSITION





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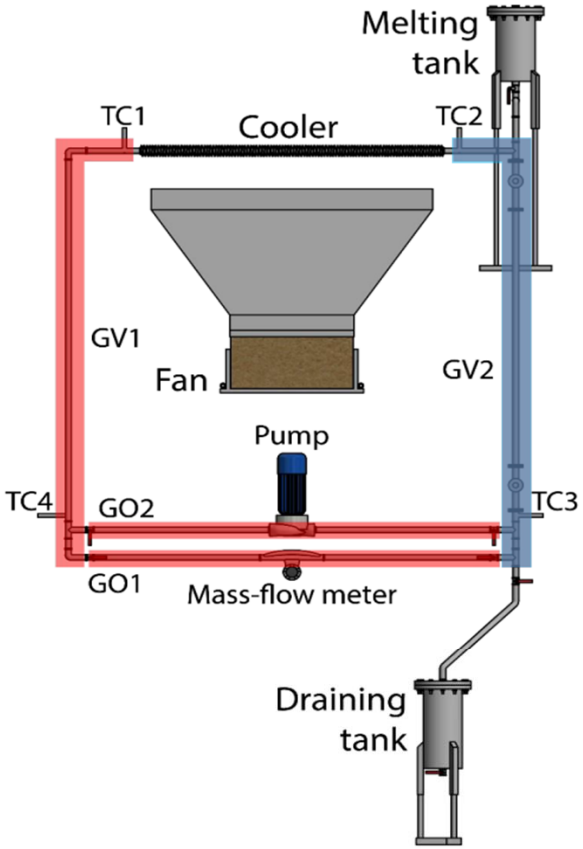
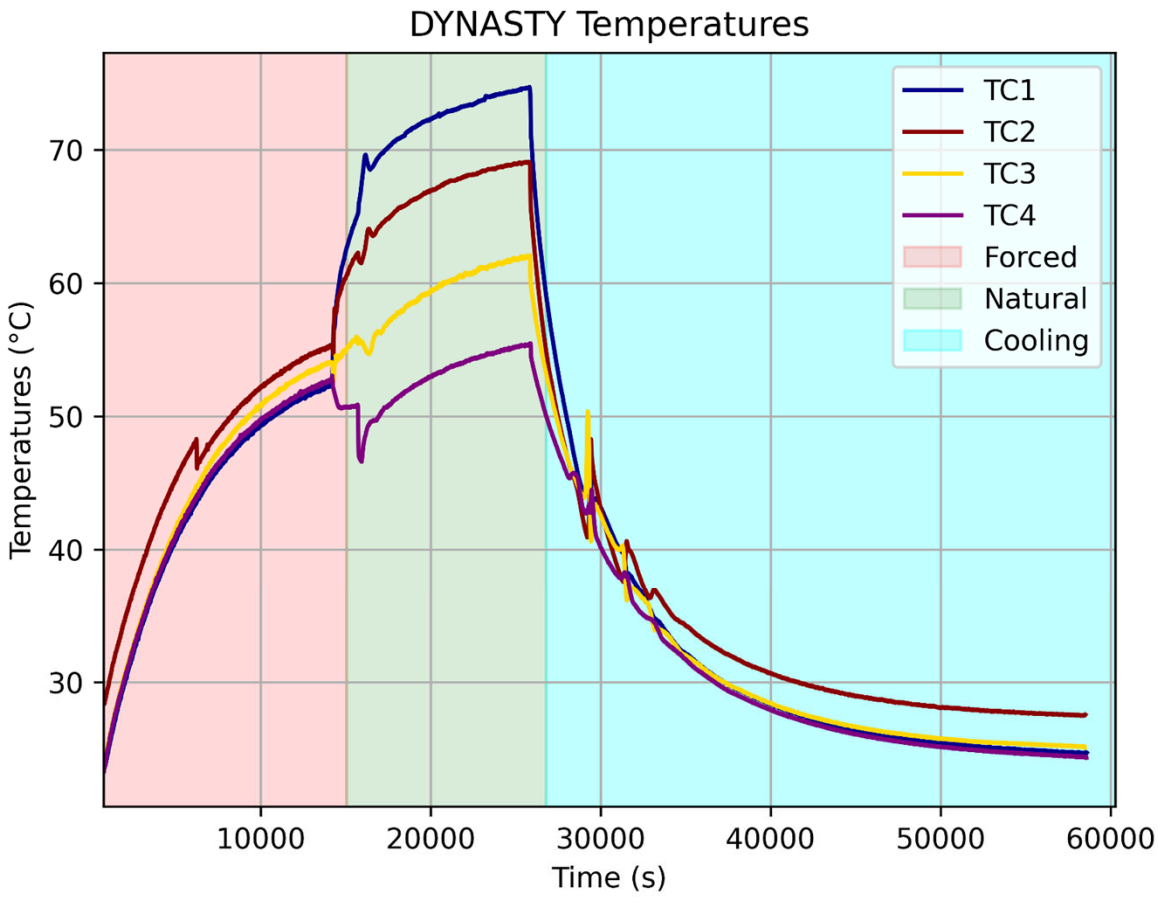
SINGLE LOOP – TRANSIENT INSTABILITY





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THANK YOU FOR YOUR ATTENTION

POLITECNICO DI MILANO

Introini C., Benzoni G., Lorenzi S., Cammi, A.

carolina.Introini@polimi.it, gabriele.benzoni@polimi.it, stefano.Lorenzi@polimi.it, antonio.cammi@polimi.it