MI Research in Sorption Heat Pump Systems – Kick Off Meeting

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30th June 2020

Background, introduction and deliverables

Timeline:

- Abu Dhabi, November 2017
- Pisa, July 2018
- Road map for Sorption Research, September 2018
- …..

Timeline:

- Abu Dhabi, November 2017:

  Affordable heating and cooling challenge
  - Thermal Energy Storage
  - Heat Pumps
  - Non-Atmospheric Heat Sinks and Sources
  - Predictive Maintenance and Optimization
  - Physiological Studies for Thermal Comfort

Timeline:

- Abu Dhabi, November 2017:

  Affordable heating and cooling challenge

  Key activities in ‘heat pumps’:
  1. Converting low grade heat to power (Target 60 °C waste heat)
  2. Efficient gas to heat and cold (Target Gas Utilisation Efficiency of 1.6 (air source), 1.7 (water source) and 2.0 (in lab))

Timeline:

- Abu Dhabi, November 2017
- Pisa, July 2018

BEIS commissions a roadmap on Sorption Technologies for heating and cooling from the IEA Annex on Thermally Driven Heat Pumps.

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Country / Organisation – Collaboration Matrix	UK	NL	Germany				Italy				CAN	USA
	UW	TNO	ISE	TUB	OTH-R	THN	POLIMI	Ariston	ICCOM	ITAE	SFU	SMTI
Domestic heat pump application Action Areas:												
1. Demonstration programmes to increase product acceptance.												
2. Refinements to the existing ammonia-water cycle.												
3. Further evaluation of alcohol based absorption pairs.												
4. Ammonia adsorption with salts (lower TRL) or active carbon (higher TRL)												
5. Development of compact and cost effective zeolite-water based adsorption systems												
Water refrigerant air conditioning/heat pumping Action Areas:												
6. Reducing the possible cooling temperature using novel evaporator designs.												
7. Hybrid compressor/sorption systems, multistage cycles particularly useful in large commercial applications.												
8. Novel ad/ab sorber designs with improved heat/mass transfer, compact, economic												
Waste heat powered heat transformers Action Areas:												
9. Lithium Bromide absorption systems					*							
10. Ammonia-salt resorption which also offers energy storage												

The main question was – how do we make this technology affordable/desirable???

Final proposal was a compromise:

- Budget from UK £300k
- Duration 27 months from June 2020
- No direct funding of overseas partners, so only voluntary contributions! – but we can fund meetings.
- Deliverables:

D1 (Month 10) Report on equilibrium and dynamic data for a range of salt and salt mixtures for heat pumping, refrigeration and storage measured by UW, SJTU, ICCOM and compiled by UW.

D2 (Month 12) Report on design and expected performance of 2-salt resorption heat pump (UW)

D3 (Month 12) Report on design and expected performance of advance 3-salt system (SJTU).

D4 (Month 27) Report on 2-bed heat pump performance (UW).

D5 (Month 27) Report on 3-bed cascaded heat pump simulation (UW)

D6 (Month 27) Report on 3-bed system performance (SJTU)

D7 a,b,c,d,e,f. UW will organise the kick-off, 6-monthly meetings (4) and Final Workshop, as above. The last will be extended to include a 3rd ‘Sorption Friends’ meeting, maximising the dissemination opportunity.

D8 (Month 31) The final ‘Sorption Friends’ meeting will be used to generate a final experts report to cover technical and economic potential, policy implications etc.

Other activities that are not deliverables:

CNR-ICCOM (Pisa) characterization of ammonia adsorption into salt mixtures by NMR and FTIR techniques, including the verification of any degradation process due to aging.

CNR-ITAE (Messina) will model alternative applications of the technology to higher temperatures (for use in industry) and storage as well as simulating and optimising different reactor designs.

Other activities that are not deliverables:

SJTU (China)

- Share in experience of ammonia – salt systems and combatting long-term cycling degradation.
- When material equilibrium and dynamic properties are characterised by UW (4th quarter 2020) they will use them to simulate the realistic machine performance that can be expected of a number of advanced 3-bed cycles and will build a 3-salt prototype by 2022.
- Host a project meeting in 2021 linked to ICCR2021.

Other activities that are not deliverables:

SFU (Canada)

- Assist in developing a long-lasting composite sorbent materials
- Graphite heat exchangers for sorption reactors
- Analytical model that can be used for design and optimization.
- SFU will also host a mid-term (Summer 2021) workshop / meeting for all participants.

Other activities that are not deliverables:

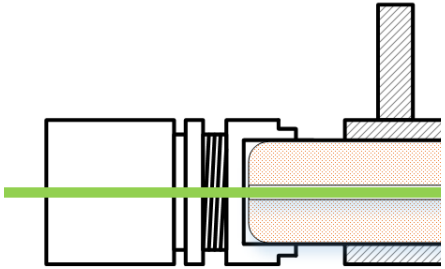
TNO ????

Any questions before 5 minute presentations from each institution?

Relevant research and capabilities

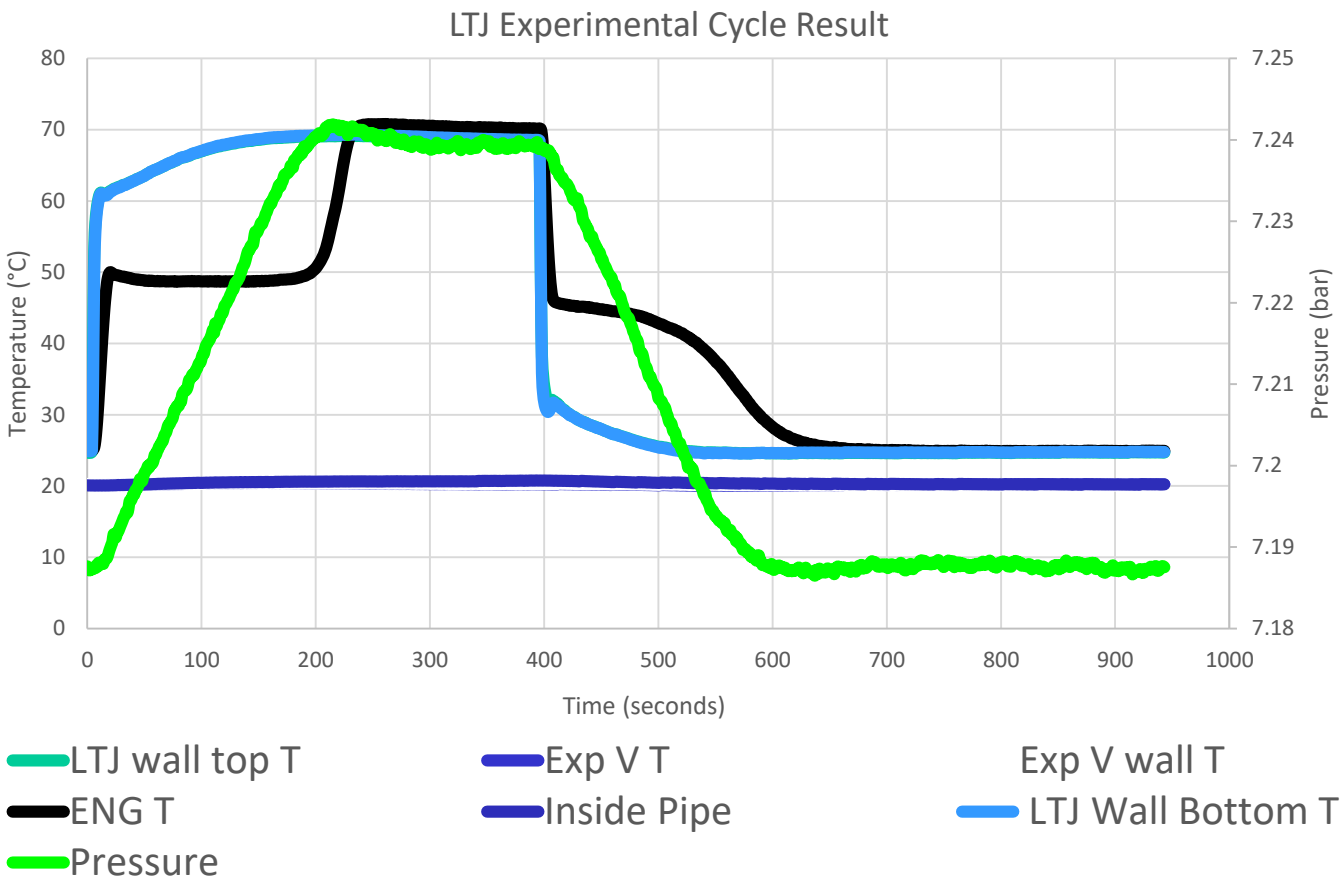
LTJ Tests:

Large Temperatur



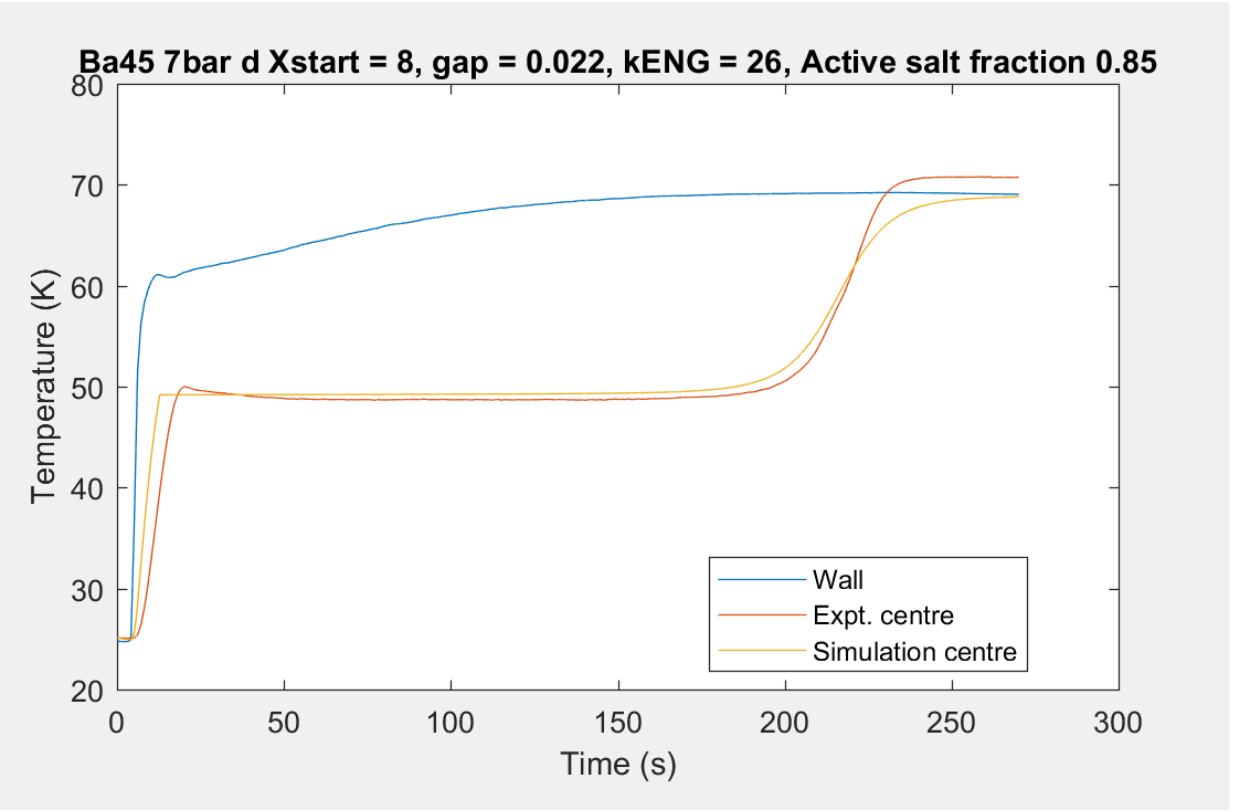
TC positions

½ inch pipe centre



Modelling:

1. LTJ



Modelling:

2. Cycles

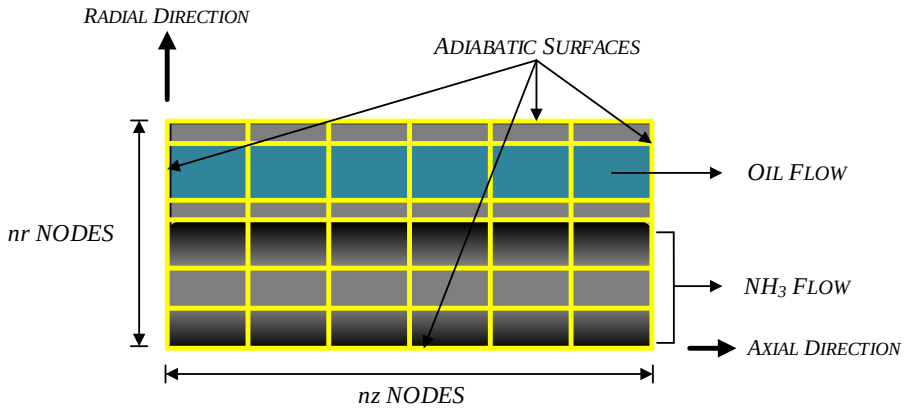
Fluid to wall H.T

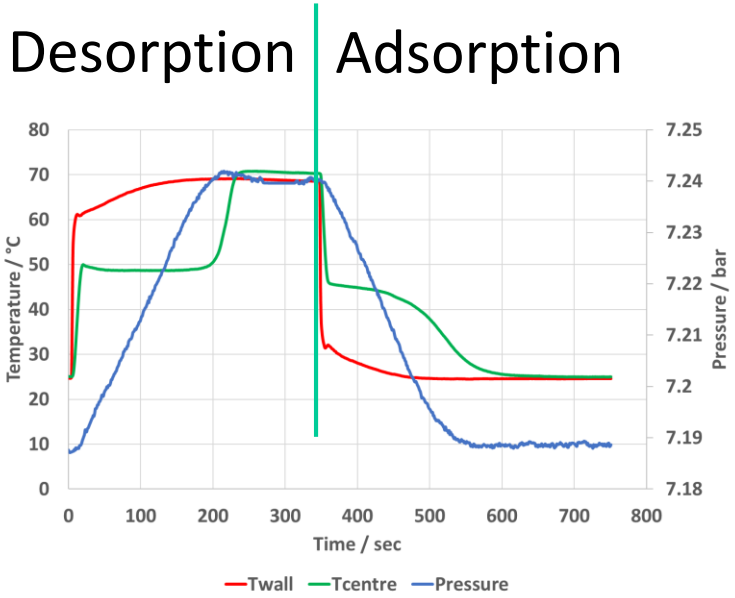
2-d model

2 reactors (Resorption)

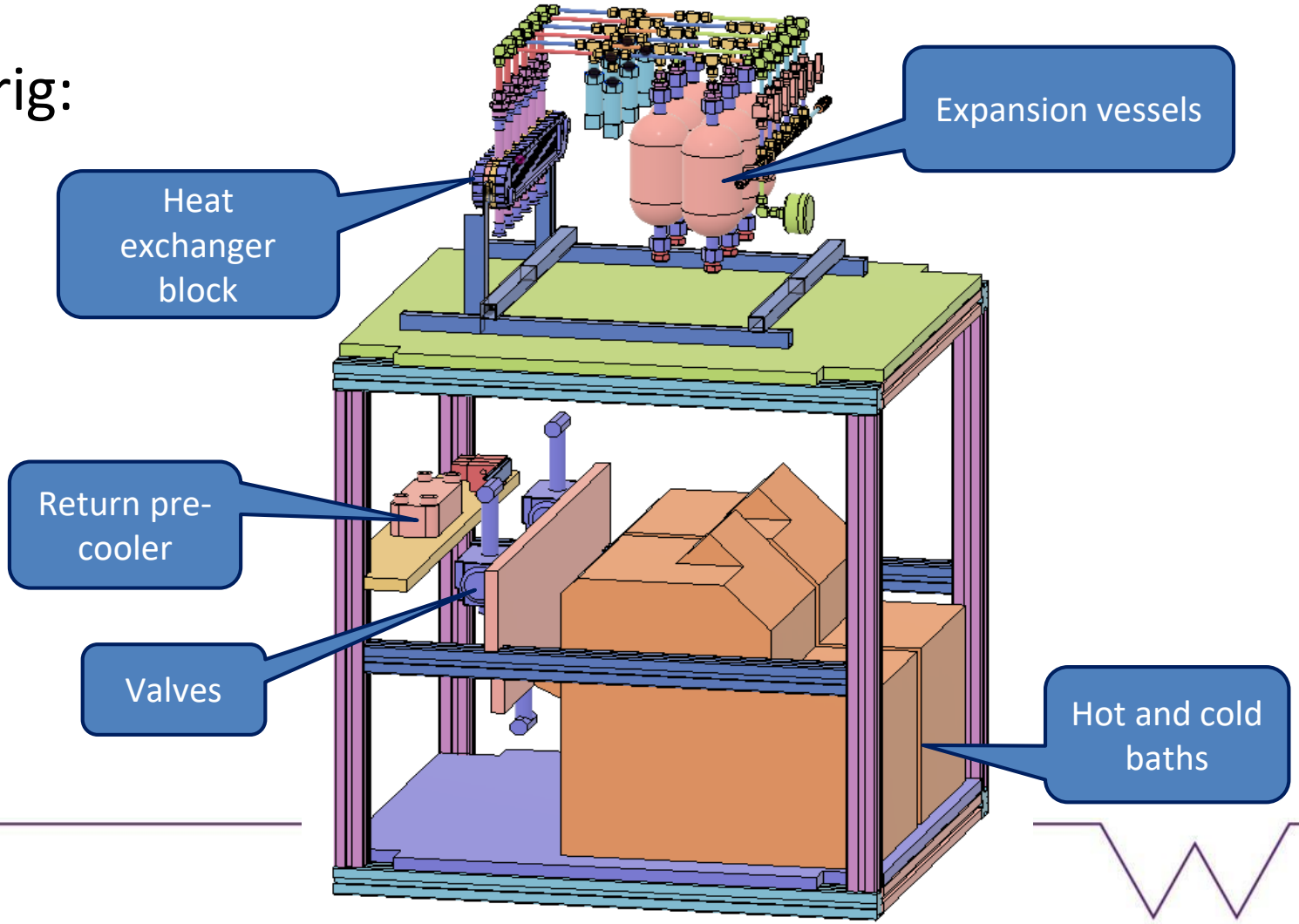
2 reactions, e.g. $CaCl_2$, 8-4 and 4-2

Modelling:

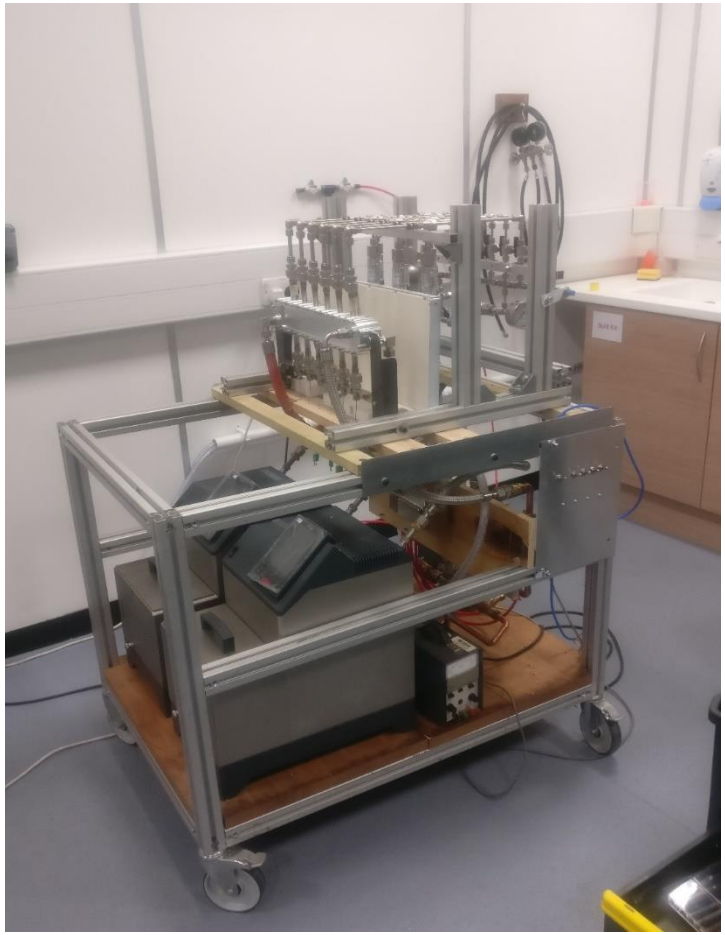

RADIAL DIRECTION
ADIABATIC SURFACES
OIL FLOW
nr NODES
NH_3 FLOW
AXIAL DIRECTION
nz NODES


Desorption
Adsorption
Temperature / °C
Pressure / bar
Time / sec
0
100
200
300
400
500
600
700
800
10
20
30
40
50
60
70
80
7.18
7.19
7.2
7.21
7.22
7.23
7.24
7.25
Twall
Tcentre
Pressure

Cycling rig:


Heat exchanger block
Expansion vessels
Return pre-cooler
Valves
Hot and cold baths

Cycling rig:



Analytical equipment:

- Rubotherm magnetic suspension balance
- High pressure DSC for sorbate properties
- Thermal conductivity
- STA high pressure ammonia

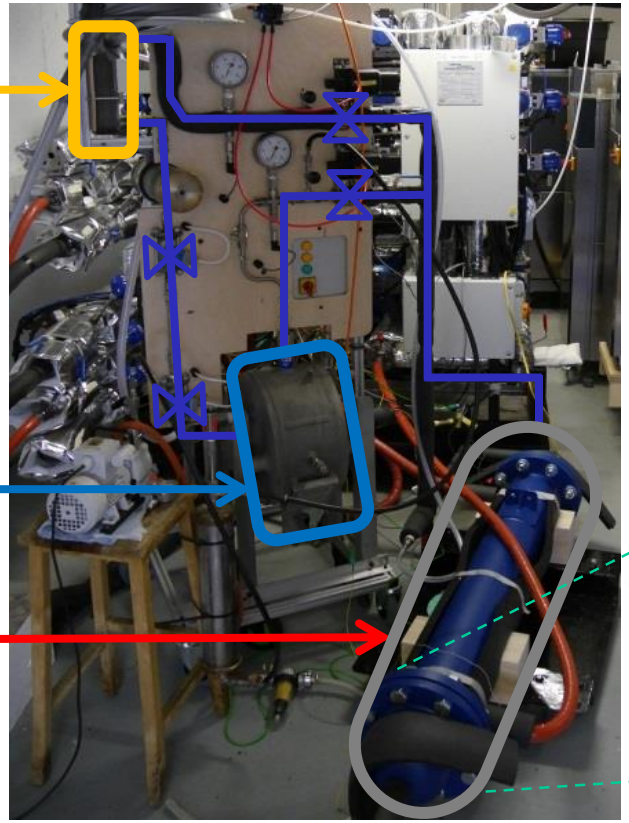
ThermExS Lab:

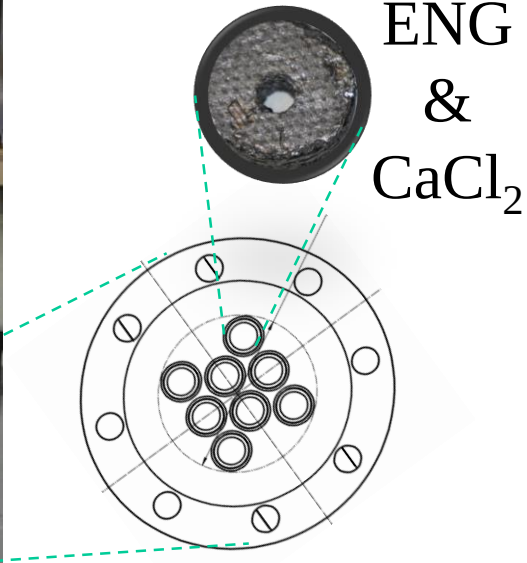
Condenser

Michel van der Pal's $CaCl_2$ - NH_3 reactor under test

Evaporator

Reactor





Thank you!

Questions??