Ammonia-Salt Resorption Updates

George H. Atkinson | STET | University of Warwick

Monday 4th July 2022| Mission Innovation

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Next-generation ammonia adsorption heat pump cycles and technology

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Why are we interested?

- Emissions from heat are still the biggest contributor to UK emissions (hot water 4% & space heating/cooling 17%.)[1]
- 85% of UK households use natural gas for space heating.[1]

- Sorption heat pumping technologies offer:
  - Potential in reducing CO_2 emissions associated with domestic heating by improving end use efficiency.
  - Consumer familiarity with systems designed with the 'look and feel' of a gas boiler in the UK market.

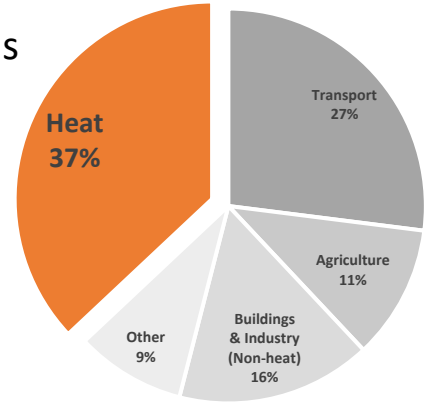
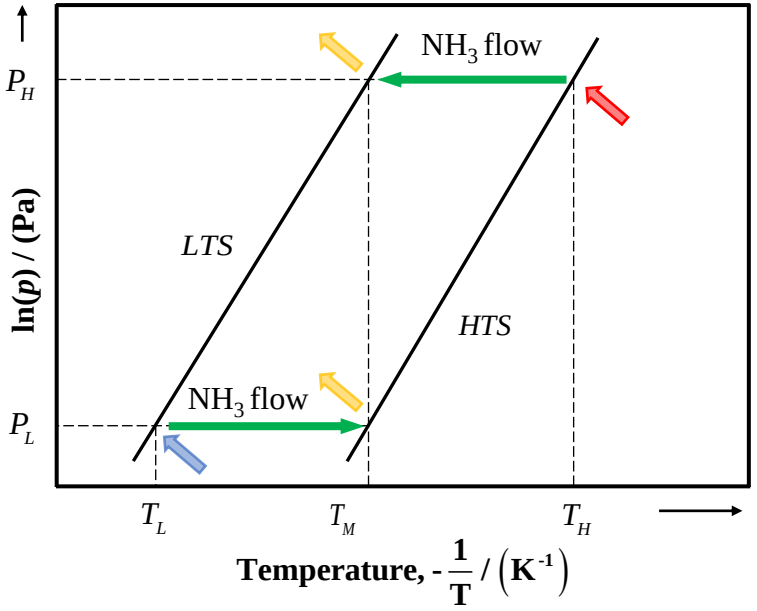
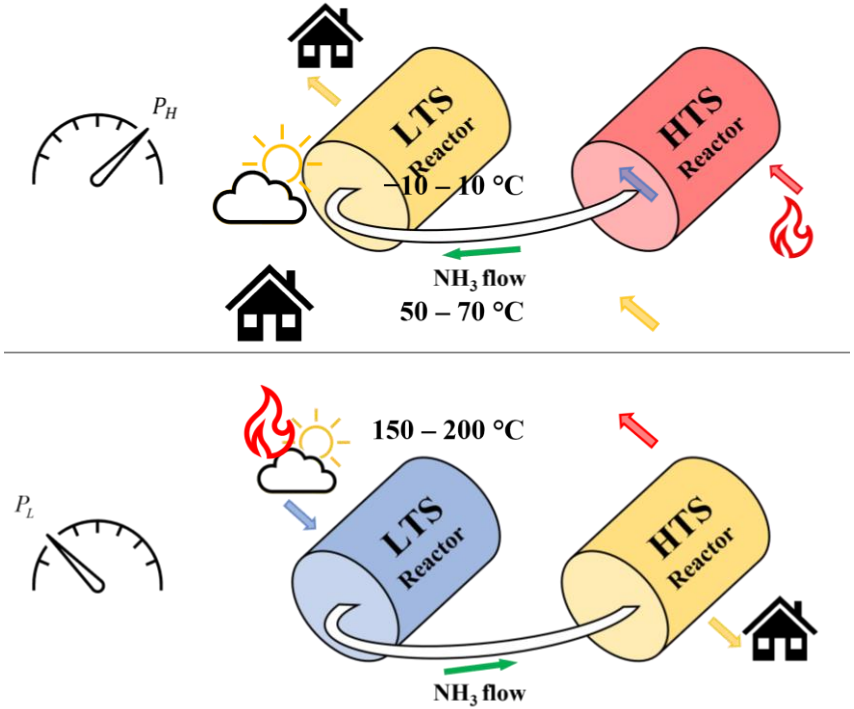


Fig. 1 Estimated UK emissions attributable to heating, 2016 [1].

[1] (2018). Clean Growth: transforming heat - overview of current evidence. [Online] Available: https://www.gov.uk/government/publications/heat-decarbonisation-overview-of-current-evidence-base

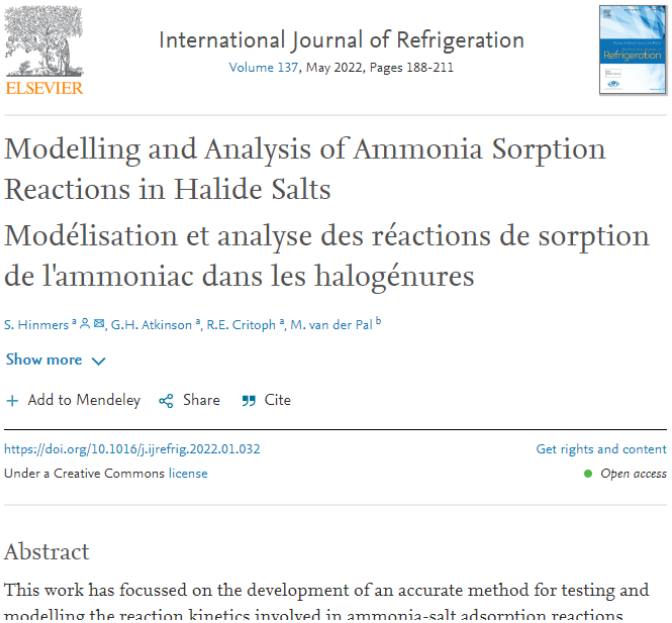
Resorption cycle operation





Paper update #1

- International Journal of Refrigeration (IJR) paper accepted.



ELSEVIER

International Journal of Refrigeration
Volume 137, May 2022, Pages 188-211

Modelling and Analysis of Ammonia Sorption Reactions in Halide Salts

Modélisation et analyse des réactions de sorption de l'ammoniac dans les halogénures

S. Hinmers [a], G.H. Atkinson [a], R.E. Critoph [a], M. van der Pal [b]

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https://doi.org/10.1016/j.ijrefrig.2022.01.032

Abstract

This work has focussed on the development of an accurate method for testing and modelling the reaction kinetics involved in ammonia-salt adsorption reactions

Paper update #2

- Energies paper on generator design written and published.

Open Access Article

Resorption Thermal Transformer Generator Design

by Samuel Hinmers [1,*], George H. Atkinson [1], Robert E. Critoph [1] and Michel van der Pal [2]

[1] Sustainable Thermal Energy Technologies (STET) Research Group, School of Engineering, The University of Warwick, Coventry CV4 7AL, UK

[2] TNO Energy Transition, Westerduinweg 3, 1755 LE Petten, The Netherlands

* Author to whom correspondence should be addressed.

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Energies **2022**, *15*(6), 2058; **https://doi.org/10.3390/en15062058**

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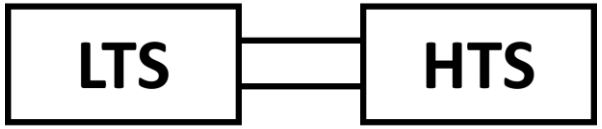
(This article belongs to the Special Issue **Advances on Adsorption Heat Pumps, Stores and Systems**)

View Full-Text | Download PDF | Browse Figures | Citation Export

Abstract

This work takes an empirical and evidence-based approach in the development of a resorption thermal transformer. It presents the initial modelling conducted to understand key performance parameters (coefficient of performance and specific mean power)

Design



- Two reactors with salt, and an ammonia connection between them (+ some fluid flow to each reactor) = simple, **but…**
- For performance analysis we want:
  - Pressure, temperature, flow rates on fluid and ammonia sides
  - As well as flow control to each reactor

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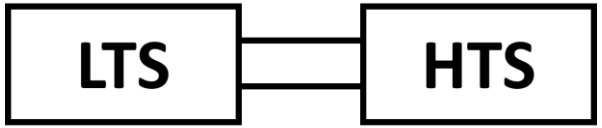
Design



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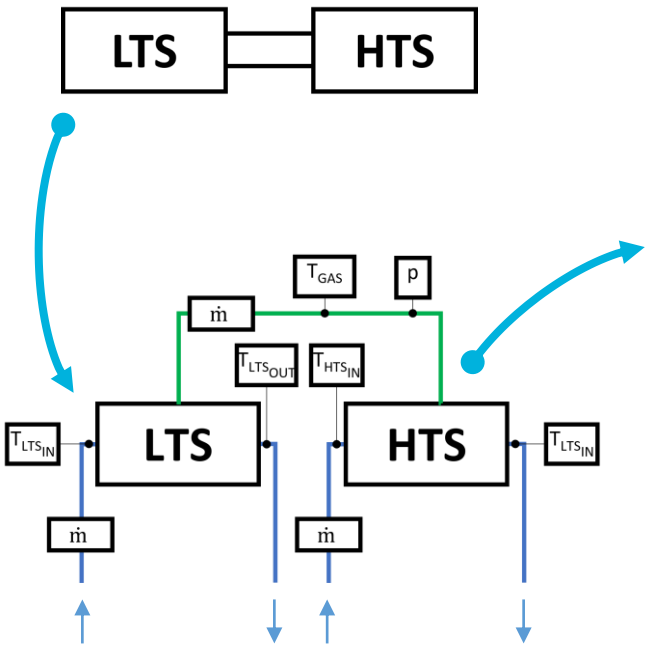
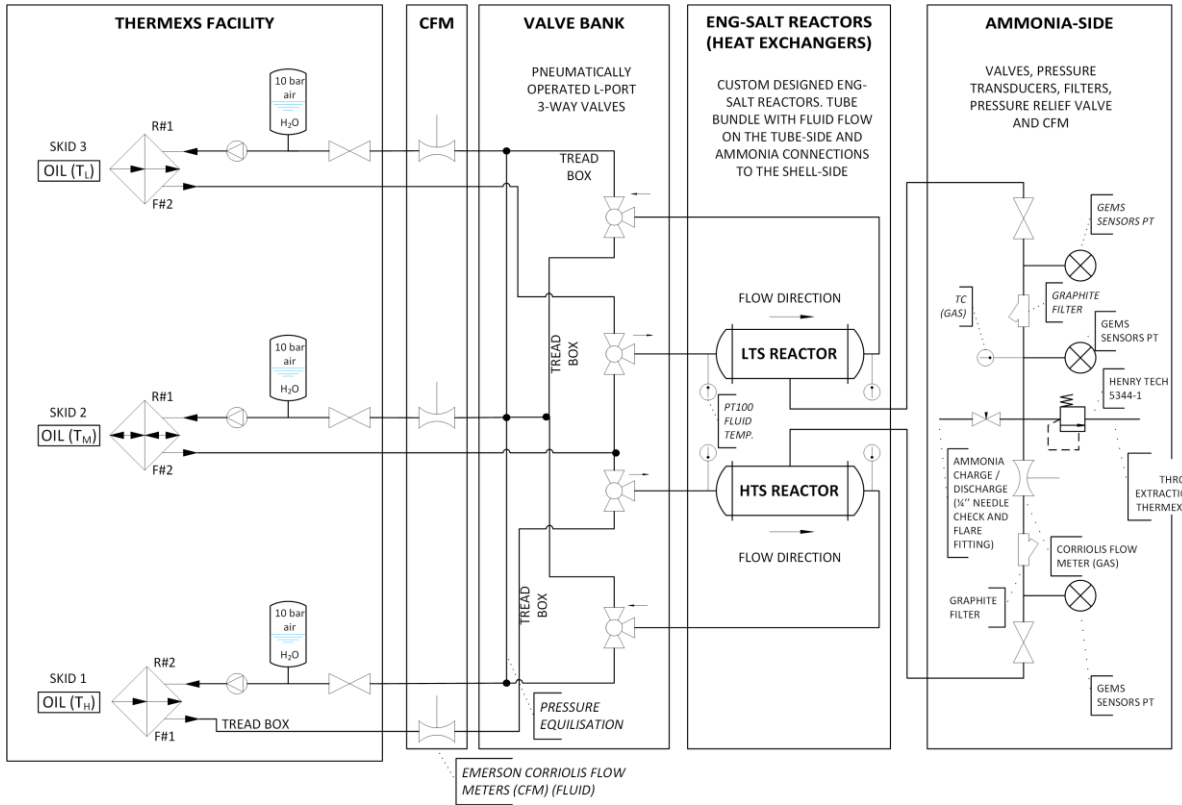
Schematic





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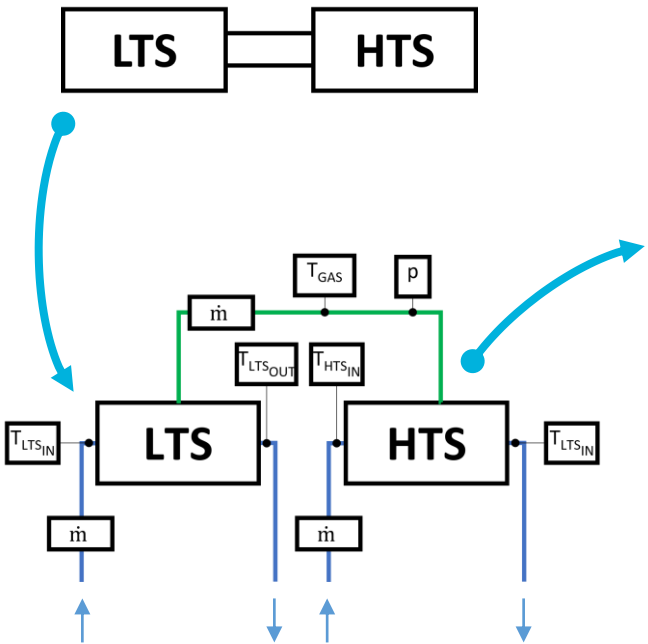
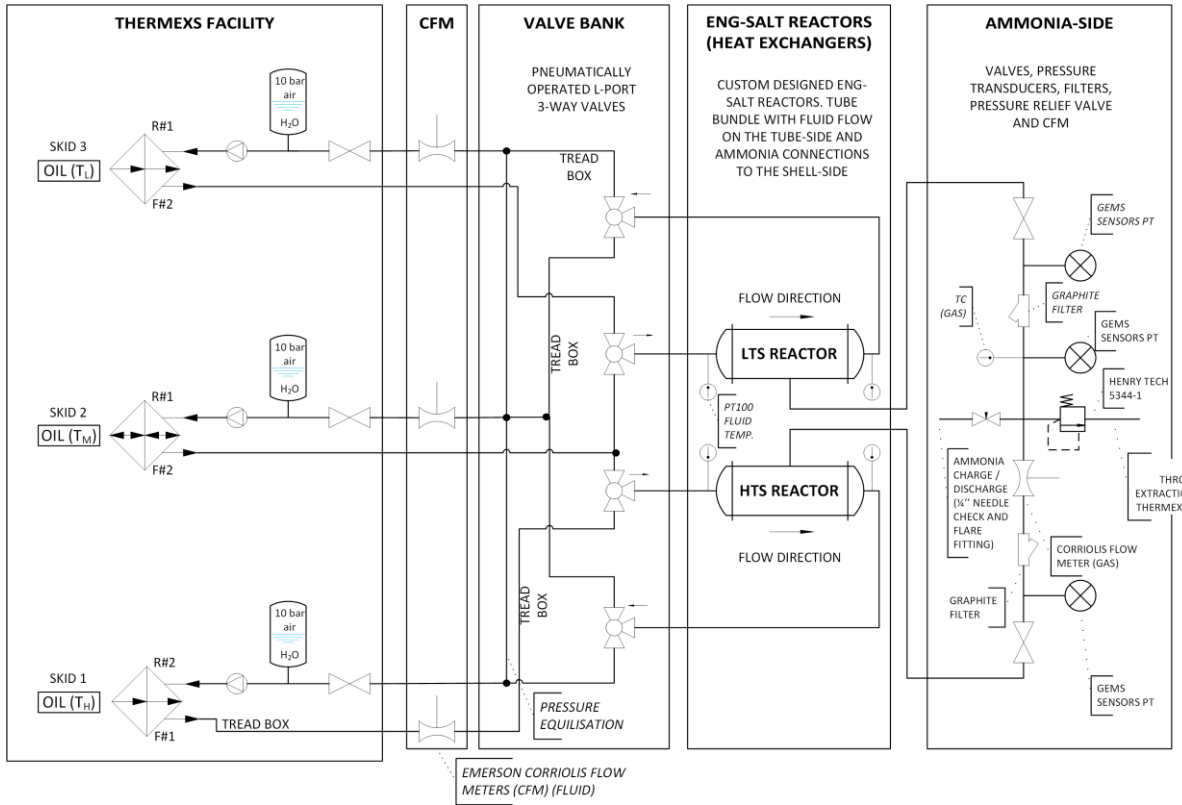
Schematic





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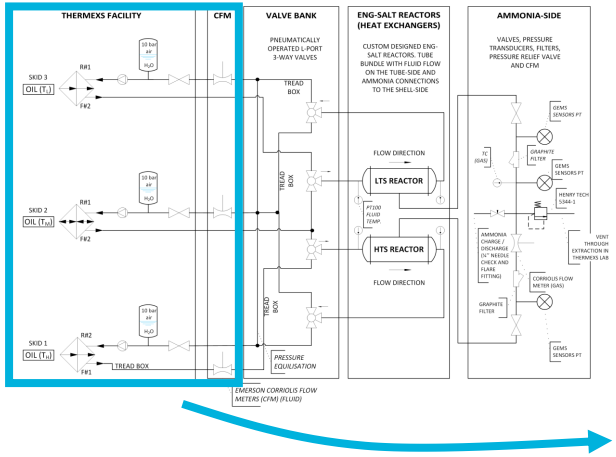
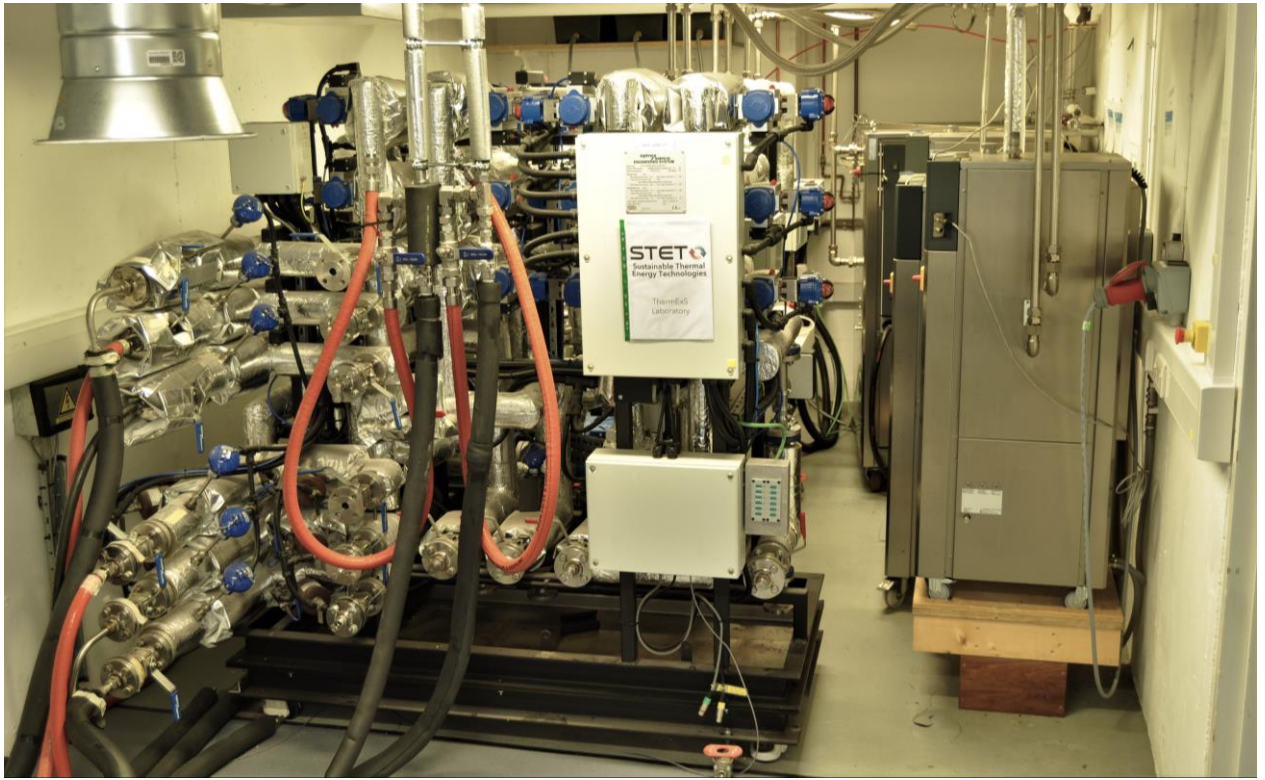
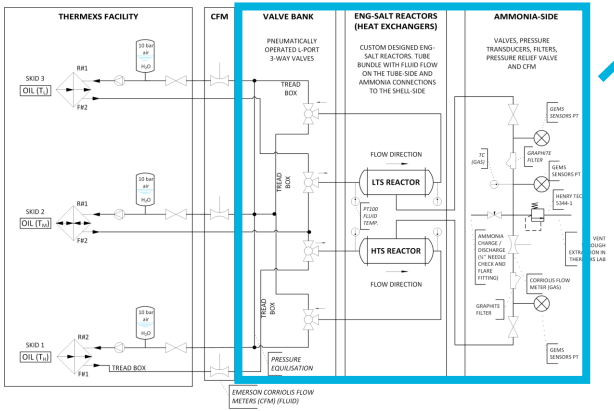
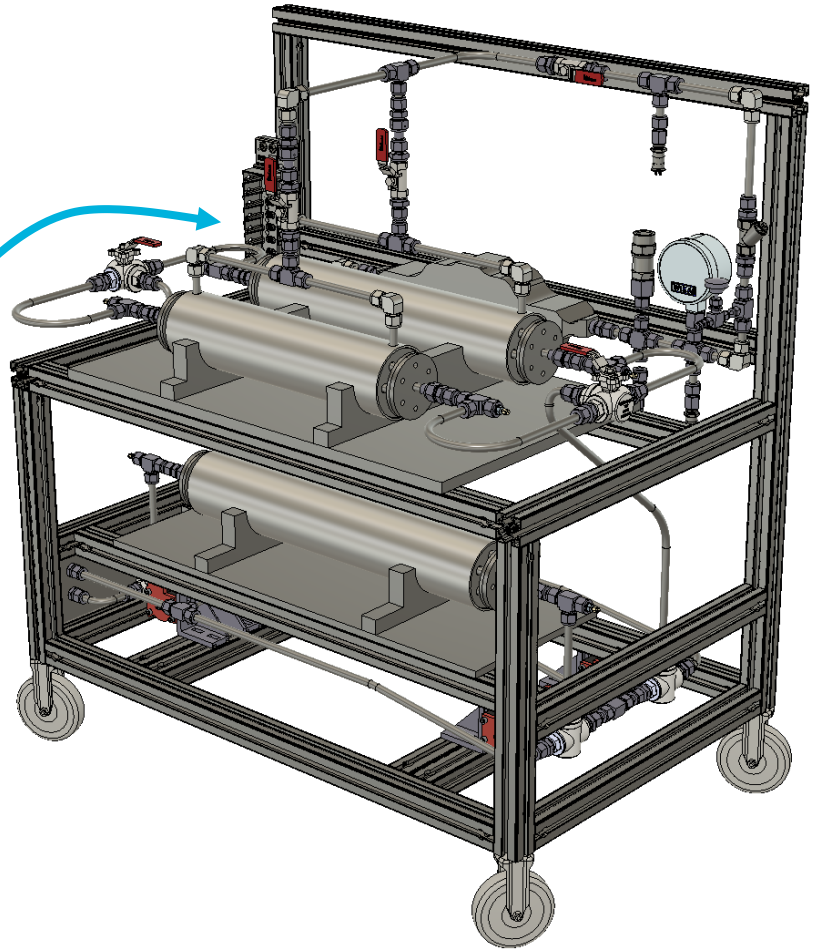
ThermExS



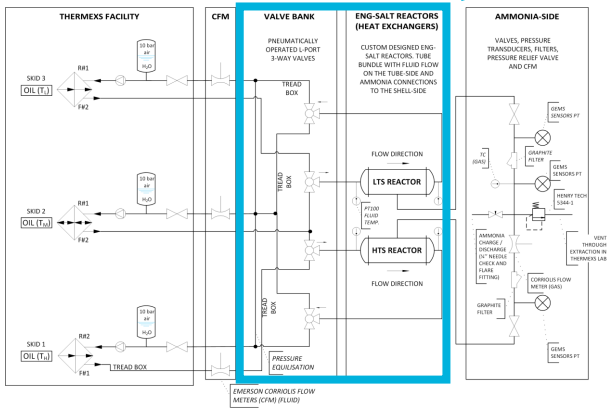


CAD model

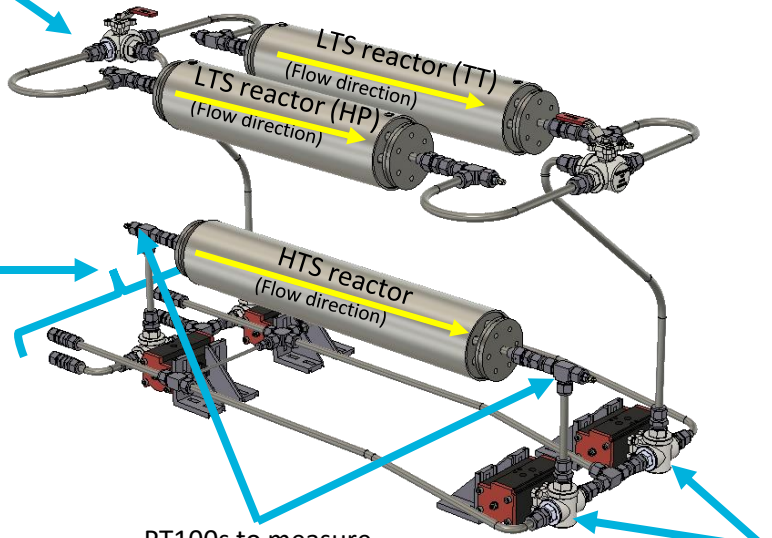

THERMEXS FACILITY
CFM
VALVE BANK
PNEUMATICALLY OPERATED L-PORT 3-WAY VALVES
ENG-SALT REACTORS (HEAT EXCHANGERS)
CUSTOM DESIGNED ENG-SALT REACTORS. TUBE BUNDLE WITH FLUID FLOW ON THE TUBE-SIDE AND AMMONIA CONNECTIONS TO THE SHELL-SIDE
AMMONIA-SIDE
VALVES, PRESSURE TRANSDUCERS, FILTERS, PRESSURE RELIEF VALVE AND CFM
SKID 3
OIL (T3)
SKID 2
OIL (T2)
SKID 1
OIL (T1)
TREAD BOX
FLOW DIRECTION
LTS REACTOR
HTS REACTOR
PT100 FLUID TEMP.
PRESSURE EQUALISATION
EMERSON CORRIOLIS FLOW METERS (CFM) (FLUID)
GEMS SENSORS PT
GRAPHITE FILTER
HENRY TEC 5344-1
CORRIOLIS FLOW METER (GAS)



Fluid-side



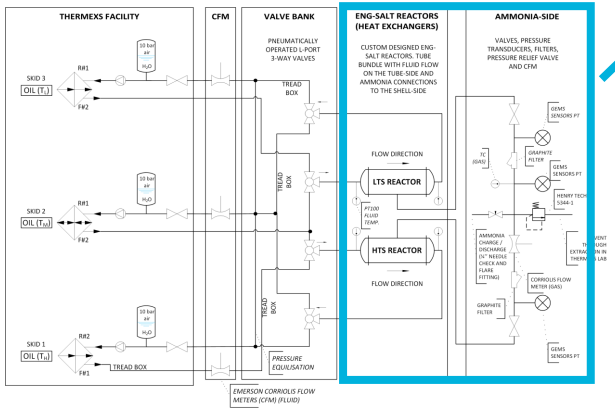
Bulkhead connections to the ThermExS facility

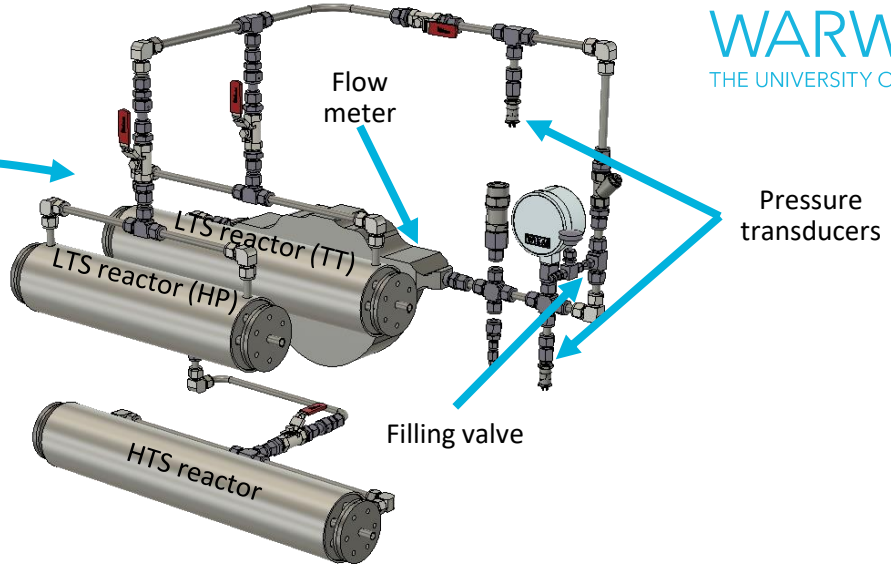


PT100s to measure inlet and outlet fluid temperature

Pneumatically controlled valves to direct the Heat Transfer Fluid (HTF) to the reactor

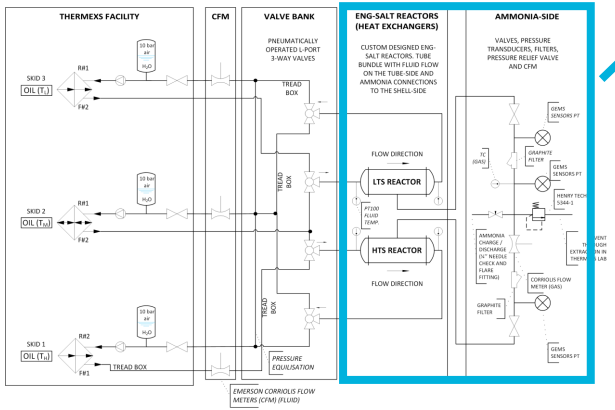
Ammonia-side

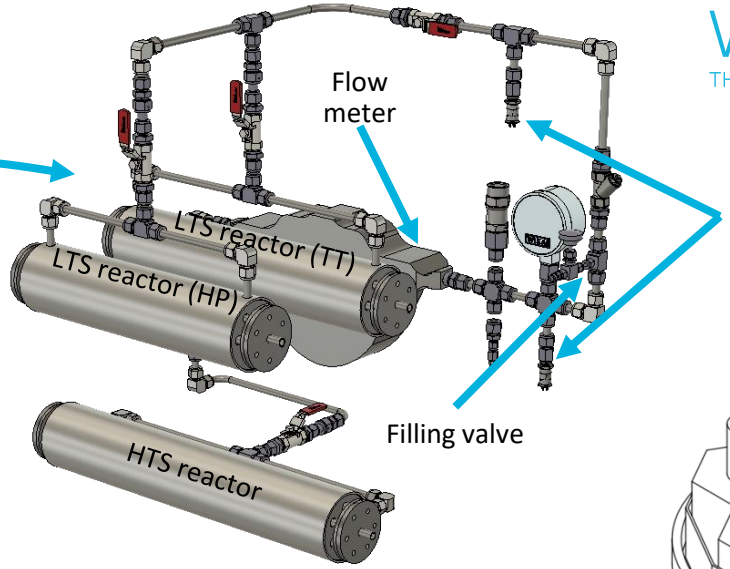


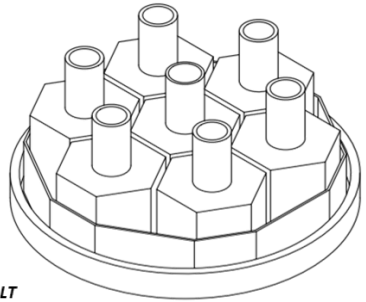


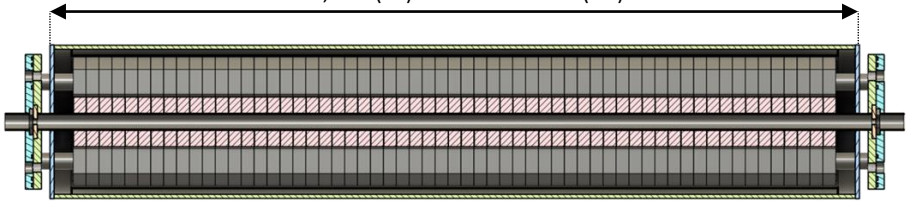
- Expected reactor lengths for 2.5 kW.
- Predicted heat pump (internal) Coefficient of Performance (COP) of 1.3.

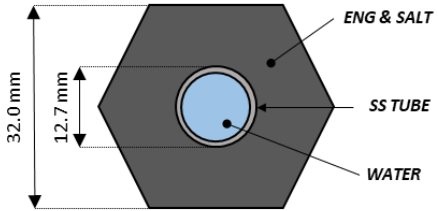
Ammonia-side











Build progress #1

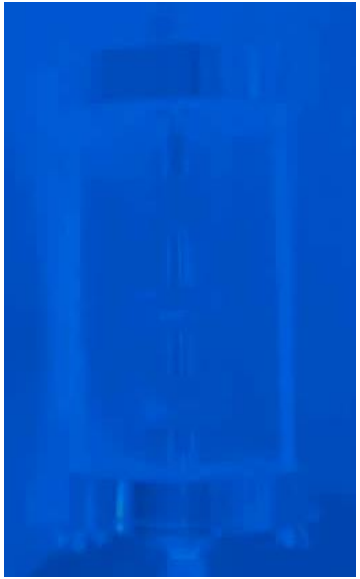
- Frame constructed
- Ammonia-side built
- Fluid-side built
- Connections to ThermExS insulated
- Reactor shells machined
- Bypass lines in position

Build progress #2

- Calibration of sensors / checking data acquisition outputs for:
  - Thermocouples
  - PT100s
  - Pressure Transducers
- Data acquisition system designed and tested in LabView
- Hydraulic lines leak tested and fluid pumped through

Conclusions and further work

- Design and manufacture of a resorption heat pump is ongoing:
  - Hydraulic lines tested
  - Ammonia side to build
- Testing to commence in the coming months, including:
  - Heat transfer investigations to continue and then build each reactor for the laboratory scale proof of concept
  - Run resorption heat pump tests
  - Analysis of results



THANK YOU FOR LISTENING

QUESTIONS?

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