Transforming our Approach to Waste Heat

LoT-NET AB 9th September 2020

WP3.7 Ammonia-Salt Resorption for Thermal Transformations

ENERGY RESEARCH ACCELERATOR

EPSRC
Engineering and Physical Sciences Research Council

TNO

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Overview

- Problem statement
- Resorption and Thermal Transformers
- Experiments and Tests to date
- What is next?

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Government reports identify 48TWh/yr of waste heat sources from industry
Equivalent to a 1/6th of industrial energy use
Element Energy (2014) Imperial College London for DECC

Resorption Thermal Transformers

- Recovers waste heat by upgrading to useful temperature
- Simple concept and design, no pump, no evaporator or condenser
- Components can be cheap to manufacture
- Use of solid salts enables an endless list of possible operations and alternative applications

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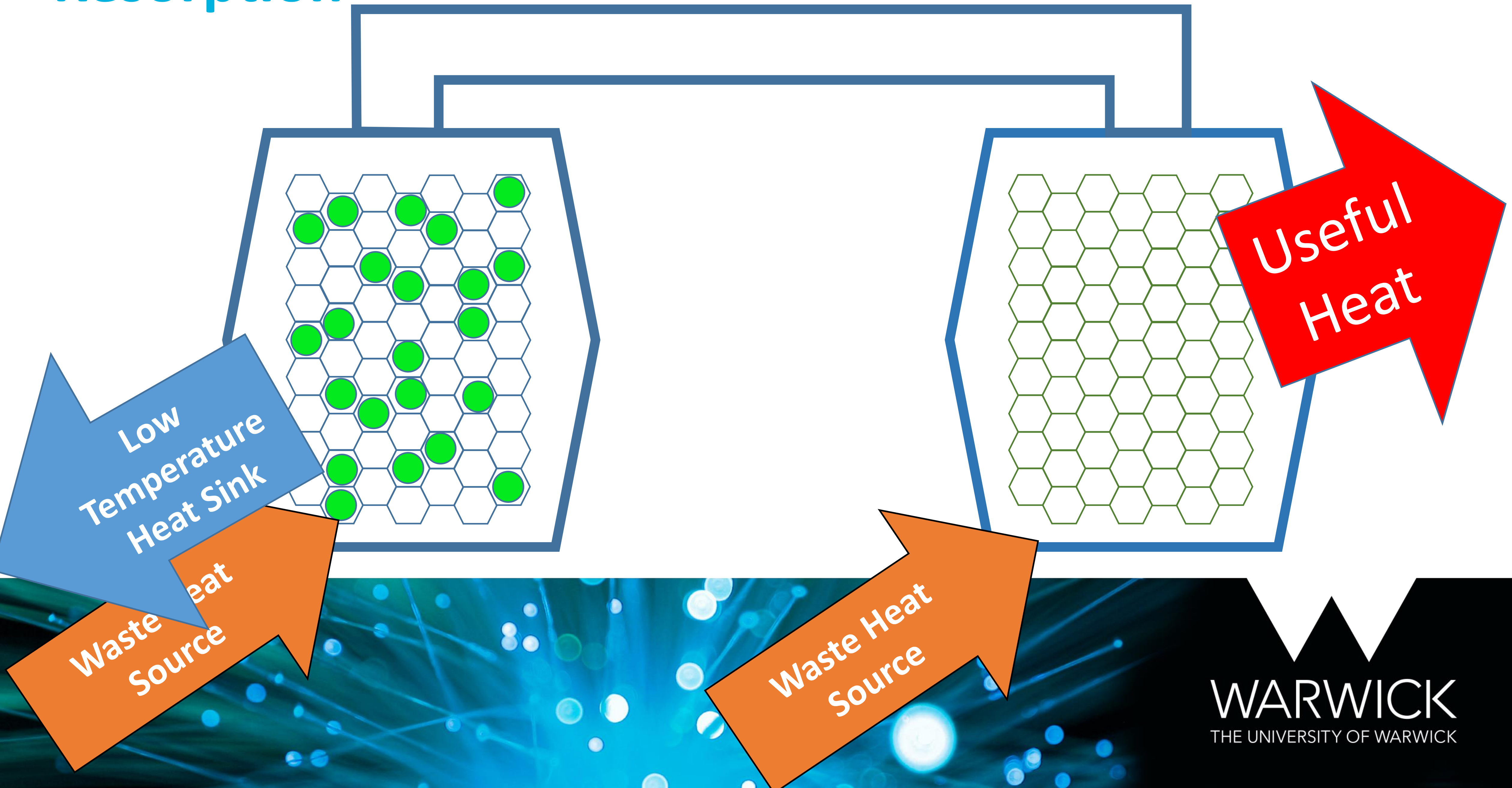
Resorption



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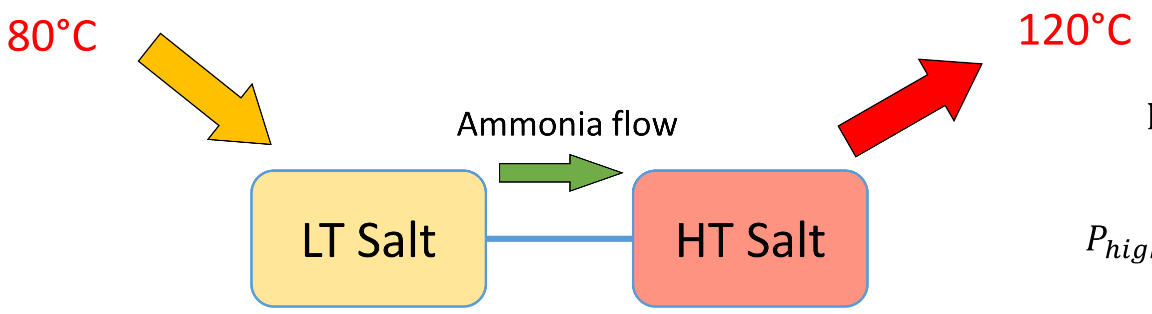
2-Salt resorption cycle thermal transformer

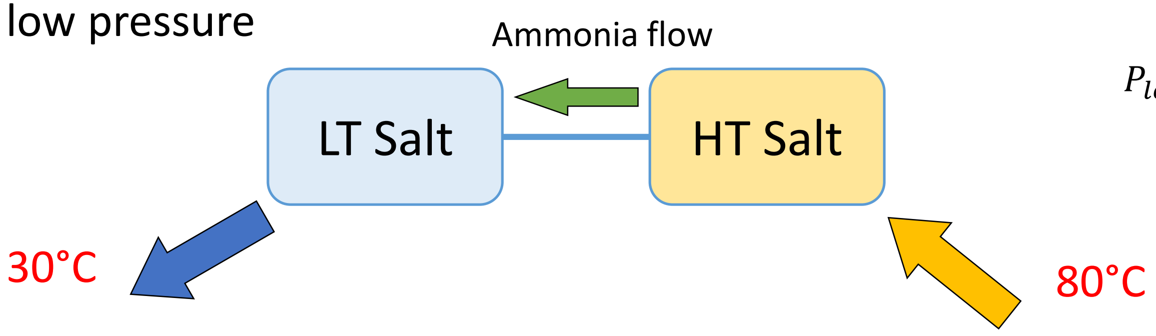
Phase 1
high pressure



Endothermic **desorption** at medium temperature

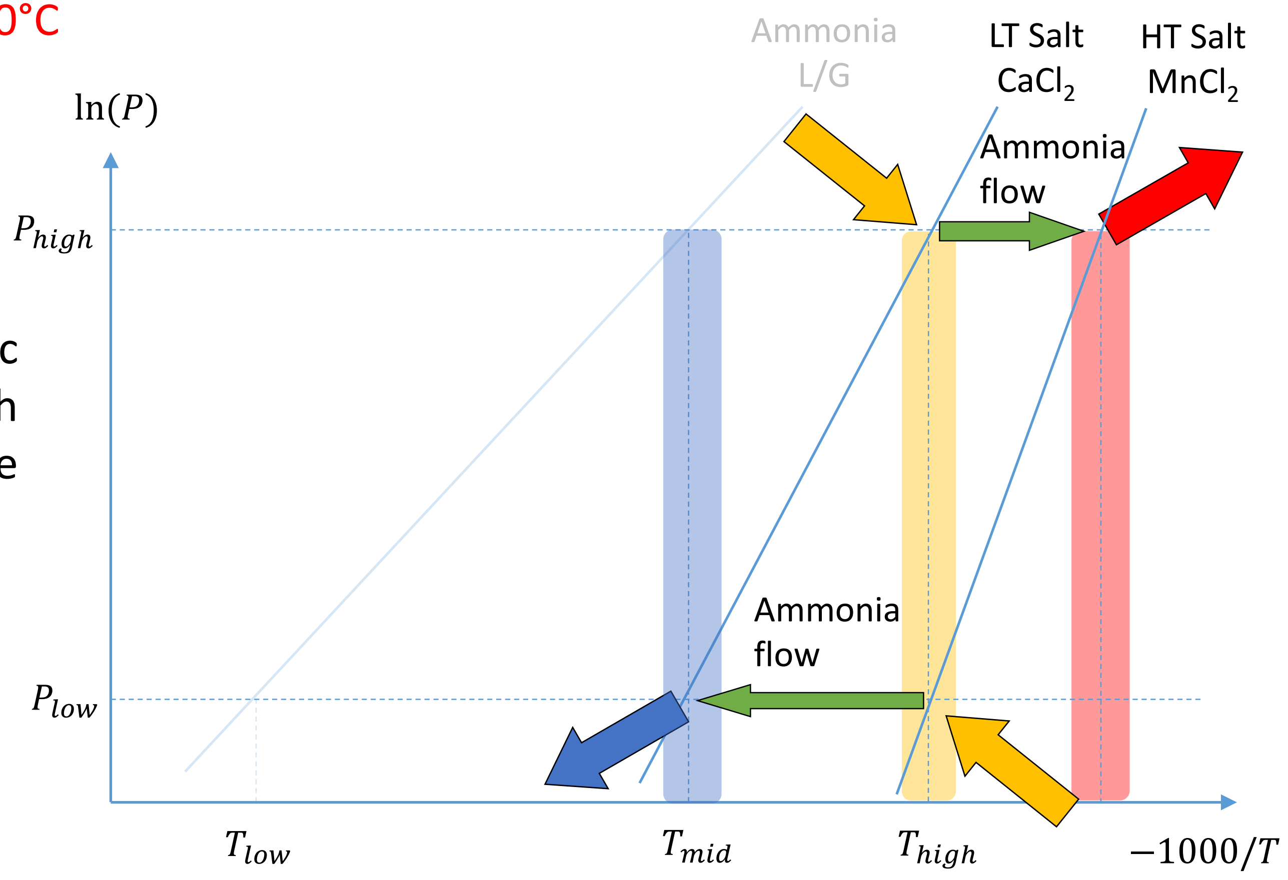
Exothermic **adsorption** at high temperature

Phase 2
low pressure



Exothermic **adsorption** at low temperature

Endothermic **desorption** at medium temperature



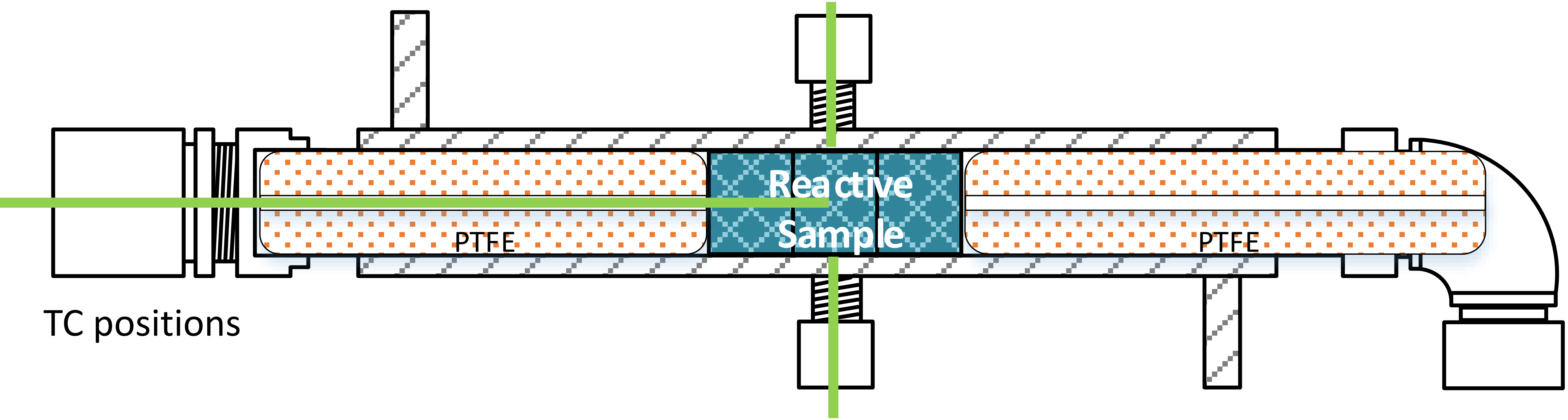
Research plan

- Samples implanted in a conductive matrix of ENG
- Large Temperature Jump tests, to test the material under real working conditions
- Model the composite material behaviour
- Design a working transformer

Main tested samples with a content:

- 0.317kg salt/kg composite
- 0.531kg salt/kg composite

Large Temperature Jump Reactor



TC positions

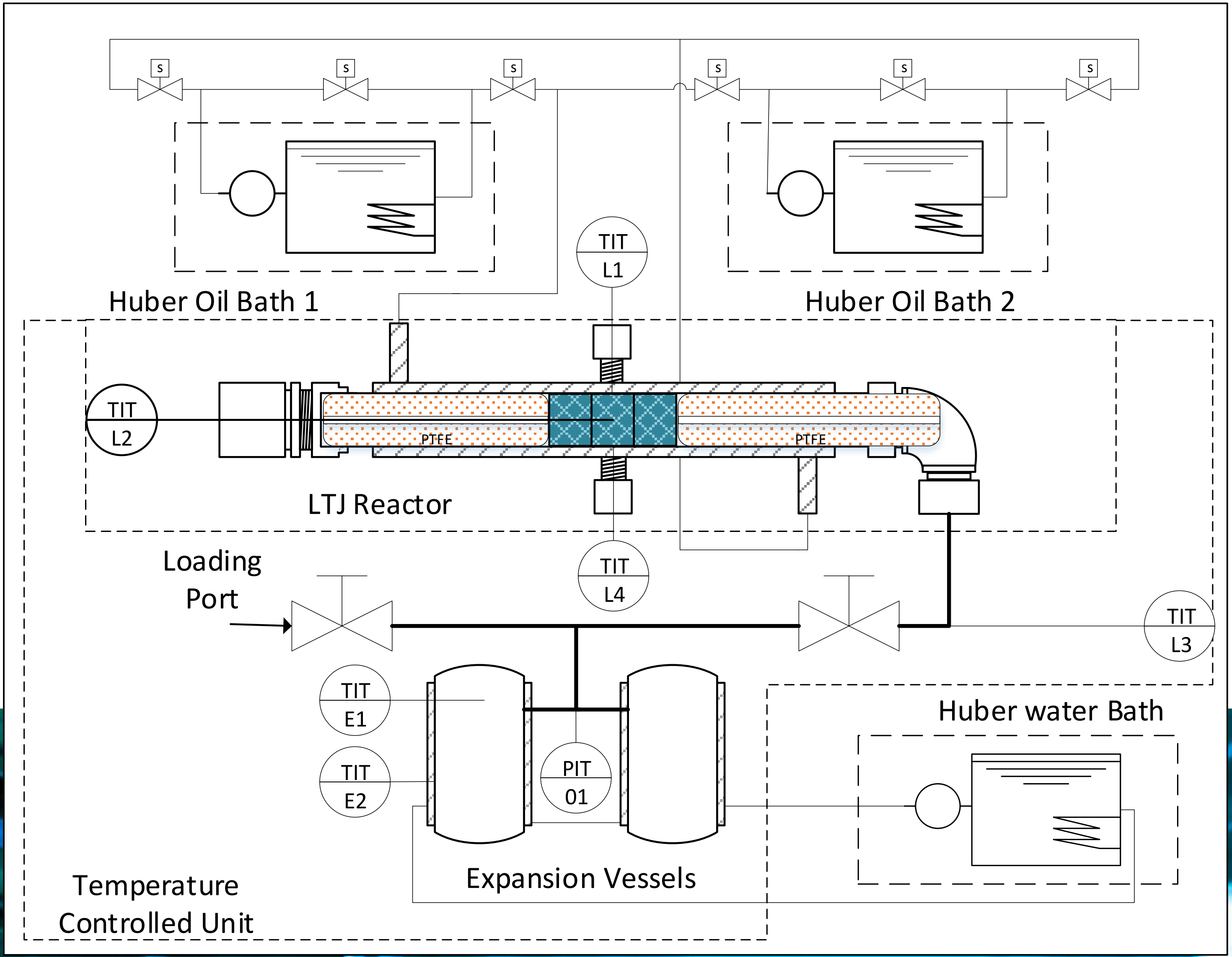
½ inch pipe centre

1 inch pipe jacket

PTFE to fill heated volume

O-ring Swagelok face seal fitting

Large Temperature Jump Reactor



- ~12litres expansion vessels
- Huber baths with silicone oil
- Operate from -5 to 170°C
- Water bath controls expansion vessels and unit temperature

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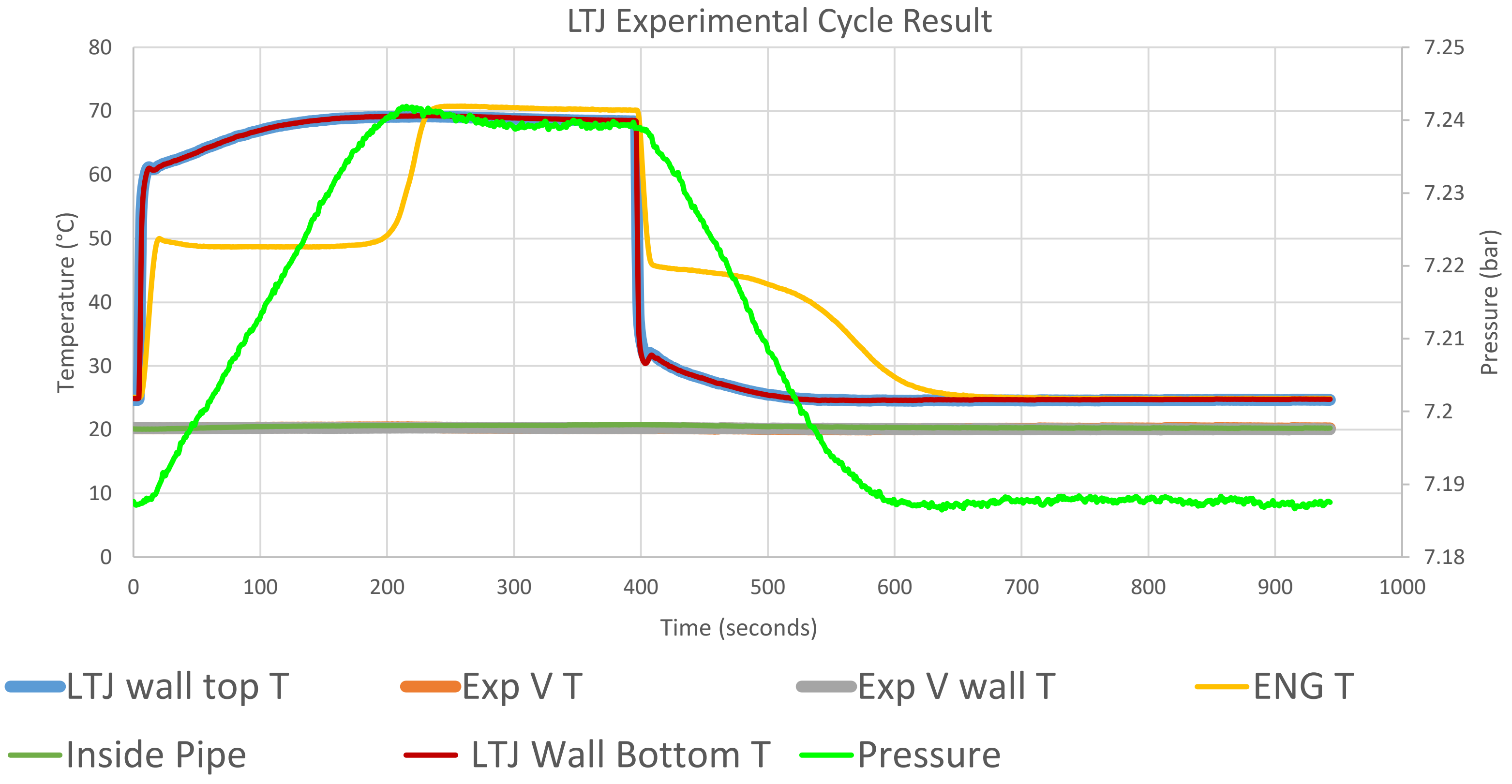
PUSH THE LIMITS
PUSH THE LIMITS

Results, full LTJ cycle



- Two scales on graph
- Repeated for different cases
- A new equilibrium line has to be calculated first based on position of phase change

Empirical reaction mode

$$\frac{dx}{dt} = [1-x]^{y0} \cdot Ar \cdot \frac{P - P_{eq}(T)}{P}$$

Order of reaction y0= 2

Arrhenius term Ar= 3.5

Pressure

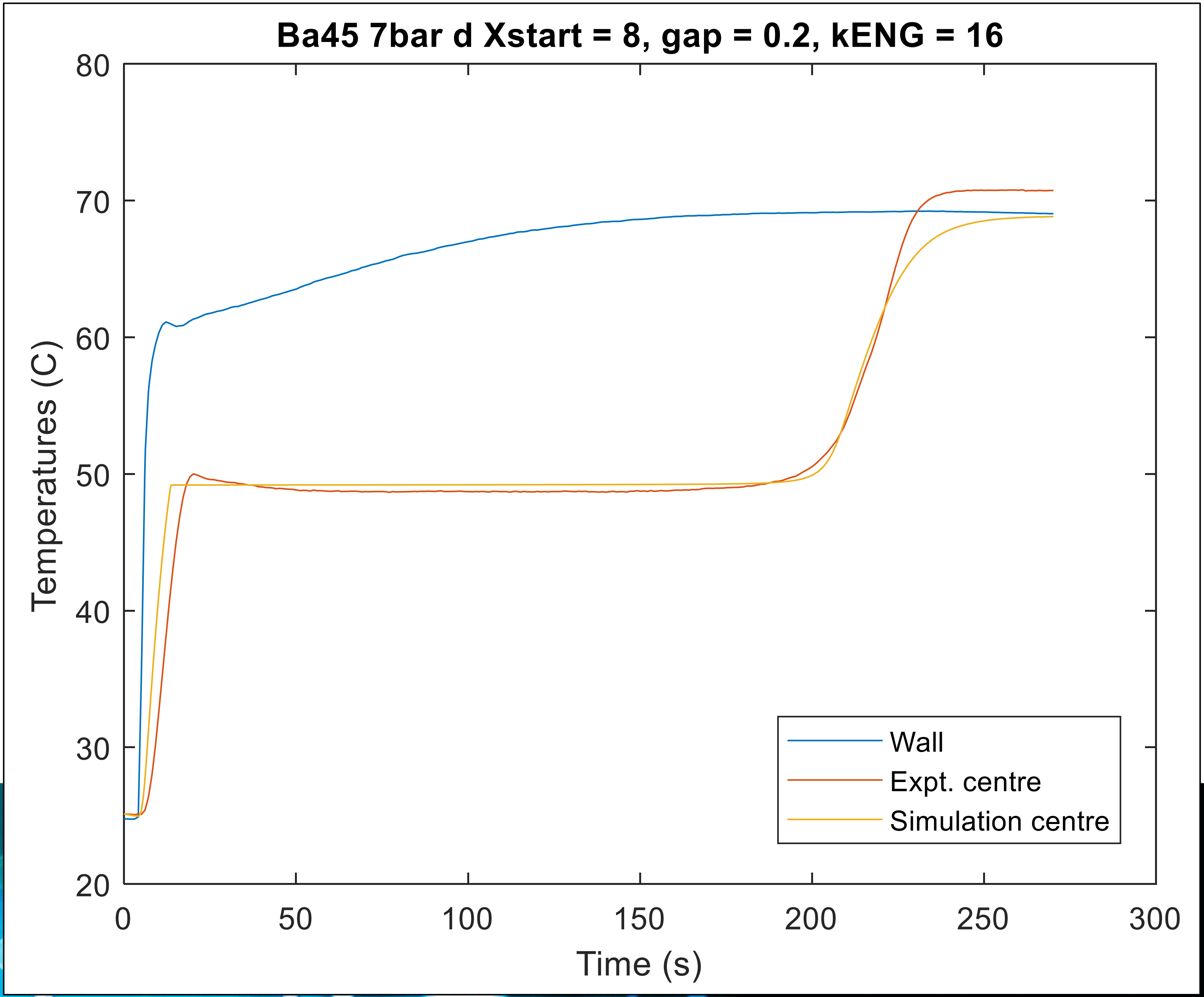
7bar

Mass Salt

0.759g

Mass Fraction of Salt

O.53g/g



Model Results

Order of reaction y0= 1
Arrhenius term Ar= 0.1

Pressure

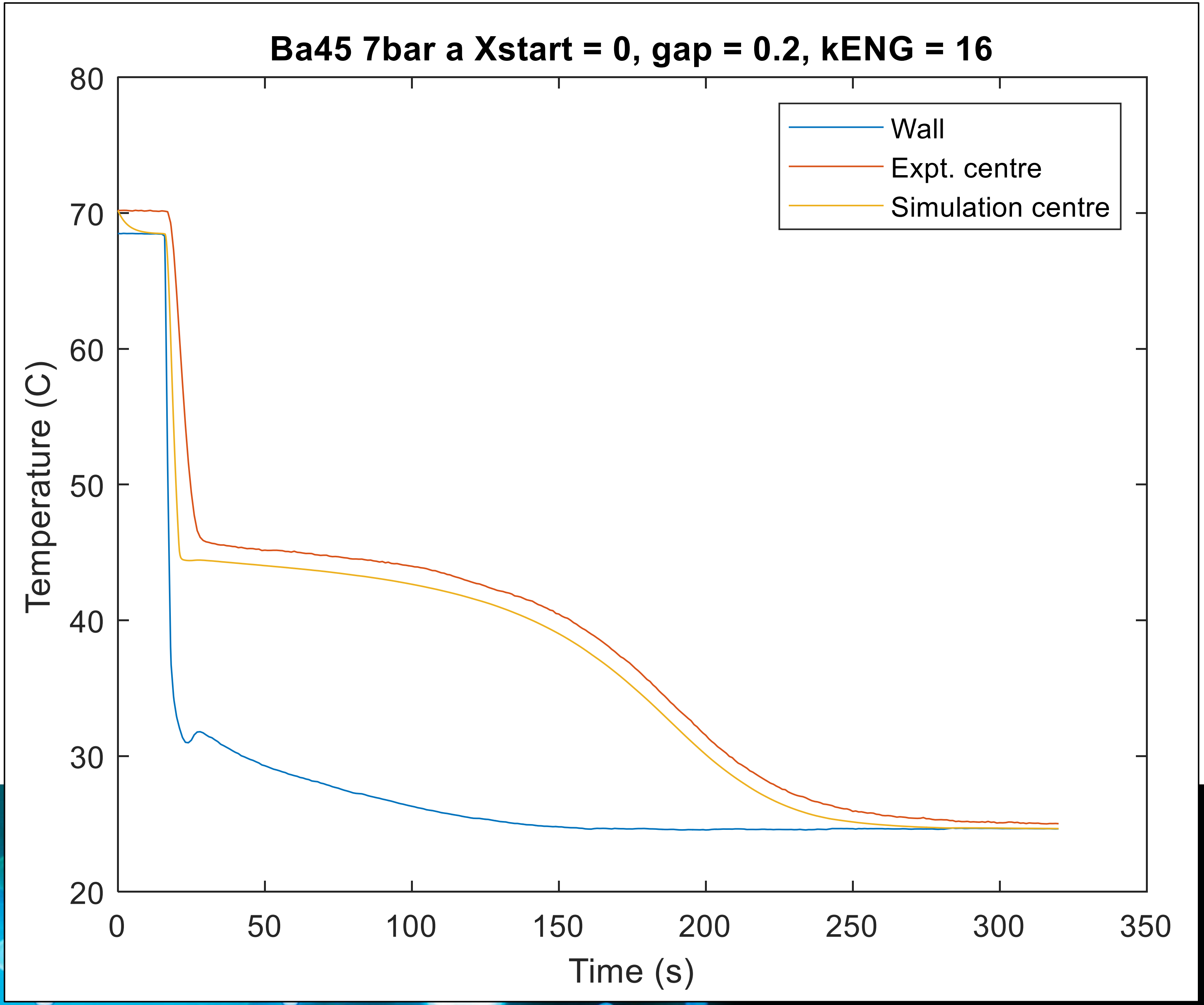
7bar

Mass Salt

0.759g

Mass Fraction of Salt

O.53g/g



To conclude..

Questions?

- Salts and resorption enable effective utilisation of heat
- LTJ testing shows materials behaviour under real working conditions
- Modelling tests gives reaction data that enables development of working machines