Speicherung von thermischer Energie durch Flüssigssorption mit Natronlauge
Herausforderungen bei der Entwicklung eines Absorptionsspeichers

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Seasonal Solar Thermal Energy Absorption Storage with Aqueous Sodium Hydroxide Sorbent and Water Vapour Sorbate

Storage System

1. External side view
2. View though the door

View 1.
View 2.

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**Motivation & Challenge**

- Seasonal thermal energy storage - **low thermal losses and high volumetric energy density**
- **High renewable energy fraction** by using solar collectors and environment heat
- Thermochemical storage based on **water absorption/desorption in sodium hydroxide**

**Content**

- **Funktionsprinzip - Absorption**
- **Fallfilm-Technologie**
- **Messresultate: Absorption & Desorption**
- **Bewertung**

- **Frame of the development work** -

**EU project COMTES lines A (adsorption), B (absorption), C (super-cooling of PCM)**
Liquid sodium lye sorption energy storage concept:

Thermal heat pump principle:
- **discharging**: absorption process

→ separation of capacity (energy) & power units

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**Capacity**

Tanks

**Power**

heat & mass exchangers

building (floor heating)

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A-D unit

E-C unit

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Vacuum

ambient (ground source)
Absorption: Function / Effect of a Absorption

- **Simple experiment:** Mixing of two transparent liquids / Sorbate & Sorbent
- **Observation:** Release of heat: $\Delta h_B$ – heat of dilution / “binding energy”
- **Result:** Temperature increase $\Delta T \sim 7$ K

- **Extension:**

$$\Delta h_A(l) = \Delta h_v(v) + \Delta h_B(l)$$

Kondensationswärme
(Verdampfungsenthalpie)

Video: temperature increase
Liquid sodium lye sorption energy storage concept:

Thermal heat pump principle:
- charging: desorption process

→ separation of capacity (energy) & power units

Capacity
Tanks

Power
heat & mass exchanger

solar energy (collector field)

A-D unit
E-C unit

Ambient (ground source)
Tube bundle falling film heat and mass transfer concept:

- Successful application in absorption chillers (but fixed operation point)
- High heat transfer rates - mass transfer(?)
- Process steps combination (seasonal sequential running, costs reduction, compact)
- Tube bundle technology for the two heat an mass exchangers (A&D and E&C)
- Suitable for vacuum application
- Simple design & low costs

Schematic of the charging process step
Introduction

Heat & mass transfer units

Experimental results

Conclusion & outlook

Modelling of the tube bundle falling film / the heat and mass transfer unit:

- Model set-up and results

Schematic of a single tube bundle row model

Daguenet-Frick et al., Solar Energy, 2015

Desorber modelling

Daguenet-Frick et al., Solar Energy, 2015

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Components description (E/C heat and mass exchanger)

- Vapour feed through: low pressure losses, radiative disconnection
- Manifold: designed to ensure an homogeneous fluid distribution
- Tube bundle unit: - A/D sized without fluid recirculation, E/C with the lower rate possible
  - most of the connections/sensors placed on the flange
Overview A/D and E/C unit:

- Vacuum tight containers (operation under exclusion of non-condensing gasses)
- Process stages combination (sequential running, costs reduction, compactness)
- Choice of the tube bundle technology for the two heat and mass exchangers (compactness)
Heat storage discharging mode (absorption process)

- Power in function of temperature difference

\[ \Phi = -61.616 \Delta T + 1007.7 \]

- Exchanged power far away from numerical predictions
- Dependence of the exchanger power on the temperature difference between the evaporator and the absorber

- but in the small scale experiment the temperature lift is \(~25°C\)
**Heat storage discharging mode (absorption process)**

**Power in function of flow rate (surface wetting)**

- Absorber flow rate: $0.4 \text{ l(NaOH-H}_2\text{O)/min @ wt}=50 \%$, $T=22 \degree\text{C}$

- significant influence of the mass flow rate $\Gamma$ on the absorption power as the wetting is poor at low mass flow rates.
Heat storage charging mode (desorption process)

Power in function of temperature difference

\[ \Phi = 8789.8 \ln(\Delta T) - 26524 \]

- Logarithmic dependence of the exchanged power on the temperature difference between the desorber and the condenser.
## Heat storage charging mode (desorption process)

- Tube bundle surface wetting

### Experimental results

**Condenser maximum flow rate:**
- $12 \, l(H_2O)/min \text{ @ } T=20 \, ^\circ C$

**Desorber flow rate:**
- $0.4 \, l(NaOH-H_2O)/min \text{ @ } wt=30 \% \text{, } T=50 \, ^\circ C$

- No significant influence of the mass flow rate $\Gamma$ on the desorption power as the wetting is good already by low mass flow rates.
Conclusion & outlook

Experimental results & assessments:

✓ Heat and mass exchanger design complies with the desorption process (charging)
✓ No heat transfer limitations due to the E & C unit
   ○ Absorption process (discharging) has to be improved

Outlook – further work:

✓ Absorption process improvement:
   - Increasing surface wetting fraction (surfactants, hydrophilic surface)
   - Increasing surface area (texturing, other geometry)
   - A/D unified component concept questionable
✓ Improvement of the heat and mass transfer model for the desorber tube bundle
Conclusion & outlook

Experimental results & assessments:

- Tilted surface: increasing residence time
  
- Test fluid: surfactant solution 1wt%, approx. 1000 μL

Video: wetting

**COMTES:** Combined development of compact thermal energy storage technologies

**Development Line B:** Thermal energy storage in a aqueous sodium lye.

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