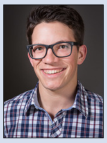
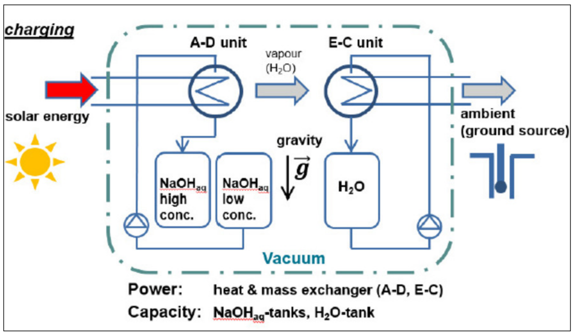


Loris
Laib

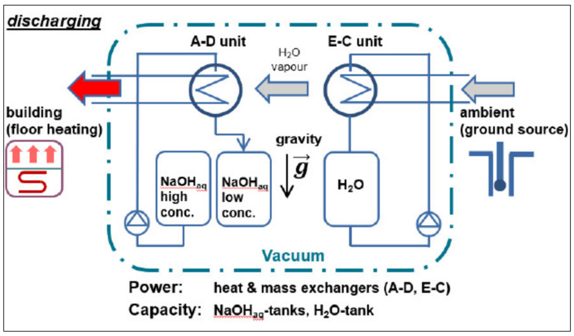
Graduate Candidate	Loris Laib
Examiner	Prof. Dr. Andreas Häberle
Co-Examiner	Dr. Elimar Frank, Frank Energy GmbH, Rapperswil SG, SG
Subject Area	Energy and Environment

Investigation of heat storage in liquid sorbents

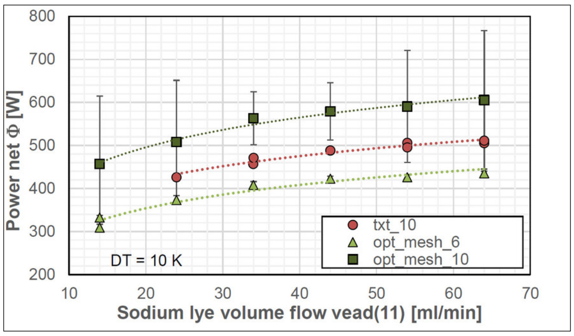
Determination of heat and mass transfer for different configuration of heat and mass exchangers



Desorption process (storage charging)
(Daguenet-Frick et al., 2018)



Absorption process (storage discharging)
(Daguenet-Frick et al., 2018)



Absorption power output with the textured ten-tube, optimized mesh six-tube and extrapolated ten-tube HMX
Own presentment

Definition of Task: The SPF institute for Solar Technology has built a 1 kW laboratory test facility, aimed to investigate compact thermo-chemical heat storage. Aqueous sodium hydroxide, which belongs to the thermo-chemical storage materials, is used as sorbent and water vapour as sorbate in this test rig. Many measurement campaigns have been carried out using this facility to characterise different heat and mass exchanger (HMX) versions. Focus was put on the absorption and desorption unit as one of the key components of such a storage type. The goal of this master thesis is to test various HMX designs and to assess their performances. For this purpose notably the heat and mass transfer coefficients are evaluated and compared.

Approach: During the project, four types of heat exchangers were investigated. One with textured tubes and additional surfactant, one with smooth tubes and as the second version, two HMX of mesh covered tubes. Due to practical reasons, the textured one is constituted of ten and the other three HMX only six tube rows. As this thesis is a continuation of previous work (Lichtensteiger, 2019), results from there are also taken into account. So the achieved results are compared with a smooth and textured ten-tube HMX characterised in the previous work. The falling film principle for absorption of sorbate vapour in the sodium hydroxide is used: manifold above the tubes distributes the sodium hydroxide on the tubes, in which water as a heat transfer fluid (HTF) flows. The lye drops from tube to tube and is absorbing water vapour and exchanging heat with the tube surface and the HTF in the tubes. The process runs at sub-atmospheric pressure conditions and thus the container has to be vacuum tight. So not only clean and accurate work is required but enough time for modifications and commissioning must also be scheduled. Due to some setbacks during cleaning and degassing of the facility, the project schedule had to be updated several times.

Result: With the second optimised version of the mesh HMX, the power and the concentration difference could be enhanced by about 20 % in comparison to the other HMX. With a mesh ten-tube HMX heat generation up to 600 W is achievable at a temperature difference between the heat transfer fluid inlet of the A/D and E/C unit of 10 K. In these conditions, a mesh ten-tube HMX would reach nearly 13 wt.% concentration difference. Heat transfer coefficients between 600 - 1'100 W/(m2.K) at a temperature difference of 10 K and 200 - 400 W/(m2.K) at 20 K were attained. The mass transfer coefficients of the different absorbers are closer together and have a range of 0.3 – 10 g/(m2.s). Compared to literature values for LiBr-H2O, similar heat transfer coefficients were achieved whereas, in the investigations conducted of this thesis, the mass transfer coefficients were smaller. To achieve the planned power of 1 kW, a further optimized mesh ten-tube absorber, with heat recovery and thermal insulation of the A/D unit, should be implemented. With these considerations, an overall efficiency over 90 % is achievable.