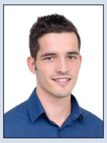

Fabio Lichtensteiger

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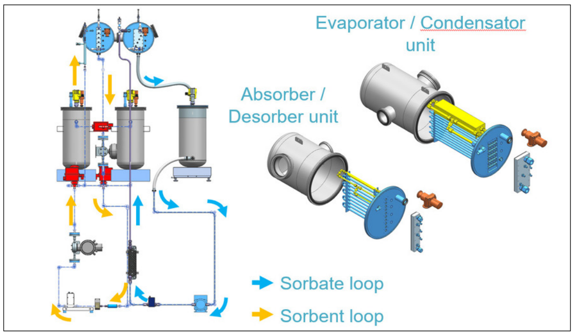
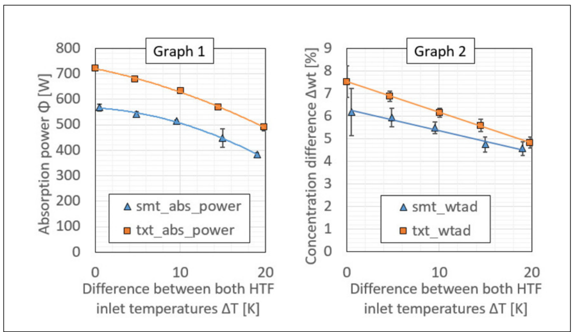
Subject Area	Energy and Environment

Seasonal thermochemical heat storage in liquid sorbents

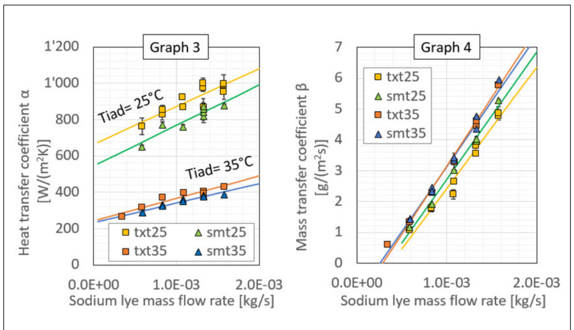
Measurement to determine the heat (α) and mass (β) transfer coefficients



Graph 1: Front CAD view of the experimental setup (left) and exploded view of the heat and mass exchanger units (right)
Xavier Daguenet (SPF)



Absorption power comparison (Graph 1) and the resulting concentration difference (Graph 2) for both tube shapes
Own presentment



Heat (alpha) and mass (beta) transfer coefficients at different sorbent mass flow rates
Own presentment

Introduction:

More than 1/3 of Switzerland's energy demand is currently used for heating applications. Nowadays, 64 % of this heat is still produced by non-renewable sources like gas or oil, which could be replaced by solar energy applications (BFE, 2018). However, the contrast between availability of solar energy produced heat in summer and heat demand in winter can only be remedied by seasonal thermal storage. A promising technology is the seasonal thermochemical energy storage with aqueous sorbents. The use of sodium lye ($NaOH$-H_2O) as sorbent and water (vapour) as sorbate theoretically achieves a higher volumetric energy density compared to conventional hot water storage tanks.

Objective:

In this thesis, different experiments were conducted to investigate the heat and mass transfer on the tube bundle heat exchanger (HX) used for the absorption and desorption process. Two types of heat exchangers were investigated; one with a smooth tube surface and another with textured tube surface structure to increase the HX area and surface wetting by the sorbent. Also desorption experiments were conducted but the absorption experiments were privileged. The heat exchangers were designed according to the falling film principle to achieve a large contact area between vapour and the liquid sorbate fluid. The heat (alpha) and mass (beta) transfer coefficients were calculated from the gained data in the experiments and the analysis done by the approach with dimensionless numbers i.e. Nusselt (Nu) and Sherwood (Sh).

Result:

A comparison of the HX showed a 20 % higher absorption power for the textured tube shape (Graph 1). The better wetting and the longer contact time of the sodium lye with the water vapour results in a higher concentration decrease, which leads to the higher absorption power measured and thus overall to a better compactness of the thermochemical storage (Graph 2). Apparently, the main influencing parameter on the absorption power is the high viscosity of the $NaOH$-H_2O solution at low temperature and high concentration, which prevent the smooth HX to be completely wetted as well as to reach an appropriate residence time of the sorbent in the heat and mass exchanger. The heat and mass transfer is strongly influenced by the fluid properties and changed with increasing heat transfer fluid temperature (HTF). The heat transfer coefficient obtained were in the range of alpha = 650-1'000 W/(m^2K) at low HTF temperature and beta = 250-400 W/(m^2K) at high HTF temperature (Graph 3). The mass transfer rate ranged from alpha = 1 to 6 g/(m^2s) and was almost independent of the tube surface structure (Graph 4). Comparison with literature values showed a good correlation for alpha whereas the mass transfer coefficients beta were smaller in these experiments. The performance of the developed numerical model could be increased by establishing new correlations with the dimensionless numbers. This possibly allows to model a heat and mass exchanger with a higher power, which can be used for system simulations of a seasonal thermal storage in a single family house.

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