Recommissioning of a Laboratory Apparatus to Study the Storage of Heat in Liquid Sorbents

Determination of the parameters α (heat transfer) and β (mass transfer) for a ceramic foam heat and mass

Graduate

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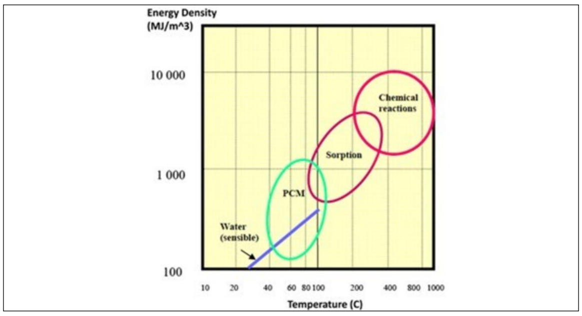
Introduction: With the Energy Strategy 2050, Switzerland has set itself the goal of replacing fossil fuels with renewable energy sources. This requires a far-reaching restructuring of the Swiss energy system, for which the devel-opment and use of heat storage systems is essential. Today, space heating and hot-water processing con-sume about one third of Switzerland's total final energy consumption. In particular, the heating demand aris-es mainly in the cold winter months. To fully potentiate solar energy as an energy source, the seasonal shift between energy production and energy demand must be adequately addressed.
Heat storage systems show great potential to overcome this seasonal shift in energy production and de-mand. Together with its research partners, the Institute for Solar Technology SPF has set itself the goal of developing a thermochemical heat storage system based on sorption technology.

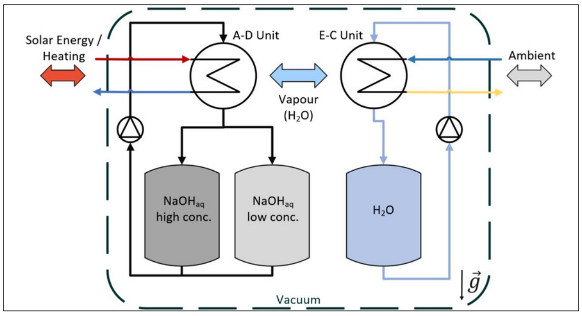
Approach / Technology: The storage discharge is based on the absorption of water vapour in aqueous sodium hydroxide solution (50 wt.% NaOH). This process releases heat that can be used for heating purposes in buildings. For storage charging, the reverse process (desorption) is used. For this purpose, water is evaporated from the sodium lye by supplying heat and the low concentrated solution of 30 wt.% NaOH is returned to its original state. The heat and mass transfer unit (HMX) of the absorber/desorber (A/D) forms the power unit and thus the core of such a system. A 1 kW experimental unit was developed to characterise different HMXs. The aim of this master thesis was to recommission the test plant and to characterise a new HMX with ceramic foam coating. The ceramic foams are expected to provide better heat and mass transfer due to a longer resi-dence time and a better formation of the fluid film.

Result: Recommissioning the system proved to be extremely time-consuming due to problems with a pump and a flow sensor, as well as mostly due to repeated leak detection and repair. After the first test runs, it was final-ly found that the leakage rate of the system was still too high or had become too high again. In order to be able to carry out measurements as part of this thesis, the system had to be constantly evacuated by the vacuum pump during the measurement campaigns.
In summary, the following conclusions can be drawn from the experiments. The absorber efficiency of the ceramic foam HMX at a temperature difference between the entry of the heat transfer fluid into the A/D and E/C unit of ∆T = 10 K and a NaOH volume flow of 54 ml/min was 330 W, about 20% lower than that of the best other HMX. The reasons for this are probably either the increased thermal resistance of 0.007 K/W due to the additional ceramic tube or the lower inlet concentration of about 1 wt% NaOH (due to water ingress at the leak). Once the leak has been repaired, the measurement campaign should be repeated and, if the re-sults are confirmed, adjustments made to the design of the ceramic foam. On the positive side, the perfor-mance, is less dependent on the flow rate which has a positive effect on the storage density. Under the mentioned operating conditions, a heat transfer coefficient of 1'100 W/(m2*K) and a mass transfer coeffi-cient of 9.5 g/(m2*s) were achieved. This gives the HMX an theoretical absorber power of 0.9 kW.

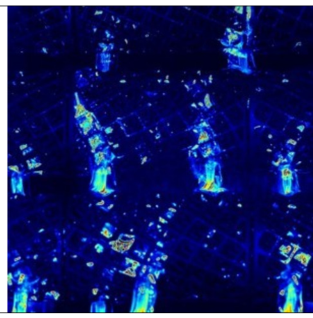
Energy densities of different thermal energy storage methods
N'Tsoukpoe et al., 2009



Schematic representation of the principle of a thermochemical heat storage based on sorption technology.
Own presentment



Coloured greyscale image of the ceramic foam HEX generated from 100 images
Own presentment



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