Seasonal heat storage

Innosuisse - HexCer

Student

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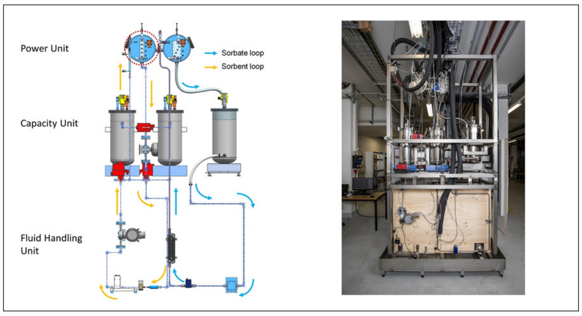
Introduction: One third of Switzerland's final energy consumption is being used for space heating supply. Thanks to more energy efficient buildings and warmer average temperatures, the demand decreased over the last 20 years. However, the share of electrical energy has risen, mainly because more and more heat pumps have been installed. This trend is continuing.
Due to the increased use of solar-powered systems, more energy is being generated in summer. However, the heating period, where demand is highest, is in wintertime. Therefore, technologies are needed to store the surplus heat for the next winter.
The SPF has developed a 1kW test facility, that theoretically stores captured heat energy without loss. It uses high and low concentrated sodium lye (NaOH) and water stored in three different tanks. When the high concentrated lye is diluted with water (absorption mode / discharging), absorption heat is released. When heat is added to the low concentrated lye (desorption mode / charging), the process can be reversed and water evaporates. As a result, the lye is highly concentrated again. To enable these processes to take place at the required temperature levels, the entire system is operated under vacuum.

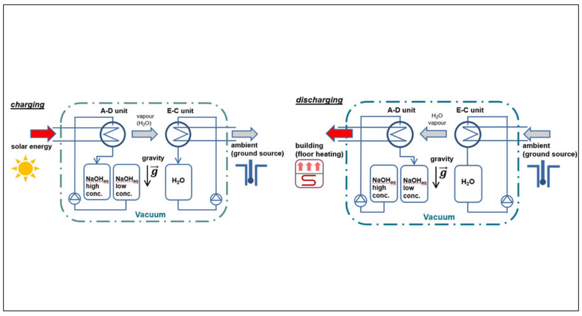
Problem: The system is still in development and the focus is on the A-D unit (red dashed circle), where contact between lye and water vapor is established. The mass transfer is based on the principle of a falling fluid film. The lye is being distributed on the heat exchanger and drips from one tube to the next. Both charging and discharging take place in the same heat and mass exchanger (HMX). Due to effects observed during desorption, a design of the exchanger area, that fits both processes, is difficult. Various designs for the HMX (metal tube bundles) had been tested. However, the results were not good enough. Therefore, a new approach has been developed, whereby the metal tubes of the HMX are covered with 3D printed carbon-ceramic structures. They should allow an ideal environment for both absorption and desorption mode.

Conclusion: As a continuation of earlier work, the 1kW lab-facility was to be put back into operation and measurement results reproduced. This did not happen because after a long period of standstill, some leaks have been discovered and the system needed repairs. Cause for the leaks were seals that could not handle the long-time exposure to these strong alkalic substances. The rig was dismantled, cleaned and rebuilt. Presence of highly concentrated lye, as well as delivery delays made this process time consuming.
In the meantime, three different ceramic geometries were tested. A particle image velocimetry camera with associated software helped to visualise the flow over the structure. If a sample passes the test, it will later be shrunk onto the exchanger pipes and tested under operating conditions. Since the measurement setup had some weaknesses, the first measurements turned out to be of limited use. As a result, the setup was improved. The fluid distribution is now closer to real conditions, but the measurements still show large uncertainties, which made an assessment difficult. In the end, the sample shown on the bottom achieved the best results and is the most suitable for further testing in an operating environment.

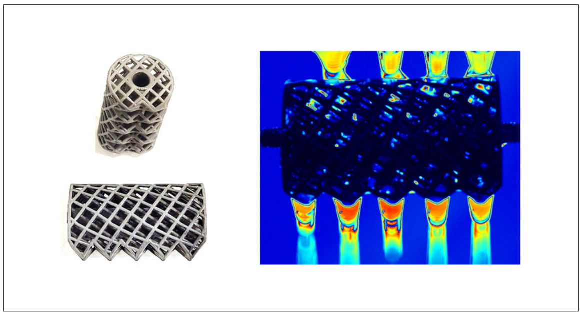
Test facility: schematic drawing and frontal view
Daguenet et al. 2018



Charging process: desorption of water vapor from NaOH
Discharging process: absorption of water vapor into NaOH
Daguenet et al. 2018



Carbon-ceramic structure for heat and mass exchanger
left: frontal and lateral view, right: PIV-Image with visible flow
Own presentment



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Subject Area
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