

Seasonal thermal energy storage with aqueous sodium hydroxide – experimental assessments of the heat and mass exchanger unit.

Summary

Closed sorption heat storage based on water vapor sorption in aqueous sodium hydroxide (NaOH-H₂O) solution theoretically allows to reach a significantly higher volumetric energy density compared to sensible thermal storage systems [1]. In the present work, the heat and mass exchangers of an absorption/desorption concept will be highlighted and investigated, focusing on the experimental assessment.

Tube bundle, falling film, absorption, desorption, sodium lye, seasonal thermal energy storage, experimental assessment.

1. Introduction

In this absorption/desorption storage concept with NaOH and water, the energy provided by the solar collectors during charging process in summer is used to vaporize under reduced pressure a portion of the water contained in the diluted NaOH solution (desorber). Then, the latent heat of condensation (condenser) is released to the ground by means of a bore hole and the liquid water as well as the generated concentrated solution are stored separately at room temperature. During discharging, the process is reversed: The ground heat is used to evaporate the water under reduced pressure (evaporator) and the absorption of the vapor in the concentrated NaOH solution releases heat (absorber) at a temperature level sufficiently high to satisfy the building's heating requirements in winter time [2]. Thus, this storage design concept is based upon the thermal driven heat pump principle.

The thermochemical seasonal storage demonstrator heat and mass exchange unit design is based on two falling film tube bundle exchangers working under reduced pressure and placed in two separate evacuated containers connected by a vapor feed through (see Fig. 1.).

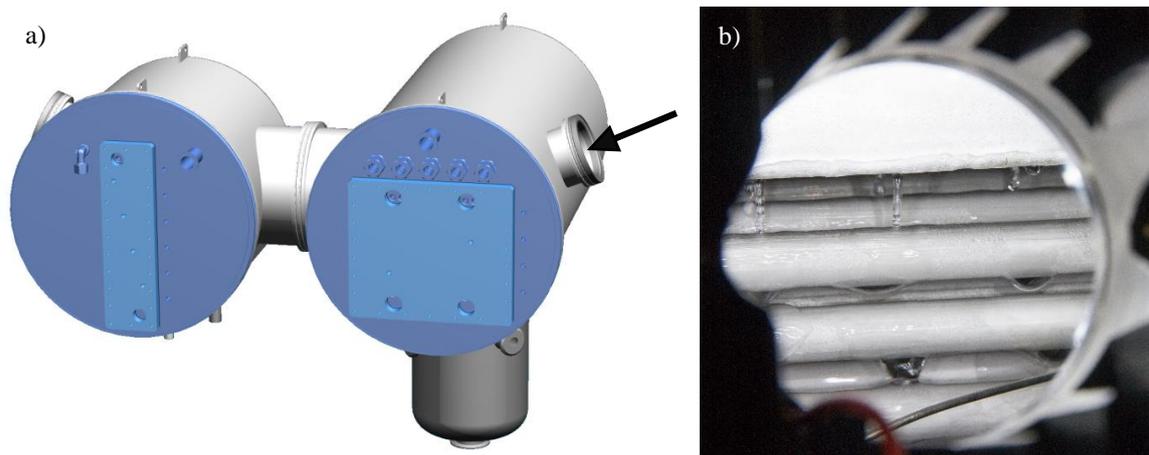


Fig. 1. a) - CAD drawing of the reaction zone with both A/D (left) and E/C unit (right); b) - Side view through the show glass (black arrow) of the falling film on the E/C tube bundle heat and mass exchanger.

Heat and mass exchangers are core components in this storage design: after having developed a numerical model for the tube bundle design [3], the units were manufactured and preliminary assessments were carried out (leakage tests, validation of the manifolds functioning and influence of the instrumentation on the fluid flow profile) [4]. The present study will focus on the heat and mass exchanger's experimental assessment.

2. Content

These heat and mass exchangers are implemented in a demonstrator facility (7 m long shipping container). The objective is to develop a mobile unit able to supply heat and domestic hot water to a typical low consumption single family house. Apart from the high temperature heat source (18 m² of solar thermal vacuum tubes collectors), the other heat sources and sinks are emulated (borehole and building).

After a commissioning phase, the first non-isothermal experiments campaign showed that the exchanged power during the charging process was quite lower than expected; only a small decrease of the sodium hydroxide solution concentration was reached at the outlet of the absorber unit.

Therefore, instead of emulating yearly operating of a building, it was decided to run measurements in steady state conditions in order to characterize the heat and mass exchangers, compare the results with those obtained from the numerical modeling and find out the weak points of the heat and mass exchangers so as to increase the exchanged power value for the absorption process.

The measurement points presented in Fig.2 are averaged values obtained on 30 minutes steady state experiments.

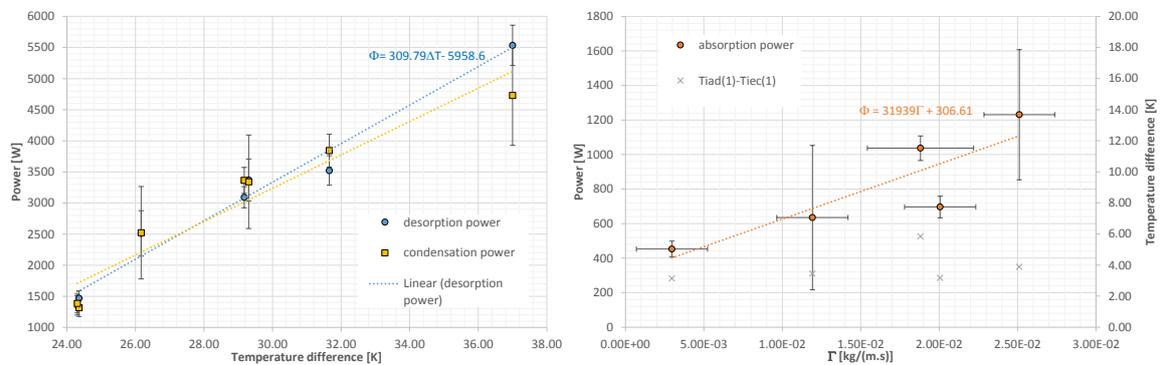


Fig. 2. Development of the power (Φ) in function of the temperature difference between both desorber and condenser chamber during charging process (left) and of the absorption power in function of the linear mass flux (Γ) arriving on the absorber (right).

During the charging process, it seems that the exchanged power only depends on the temperature difference between the desorber and the condenser (Fig. 2, left), a higher temperature difference leads to a higher pressure difference between both units and therefore an increased vapor transfer rate. The wetting of both tube bundles surfaces as well as the exchanged power are appropriate.

During the discharging process only a fraction of the absorber tube bundle surface is wetted. Besides the dependence of the exchanger power on the temperature difference between the evaporator and the absorber, it was also noticed that this power was depending on the sodium hydroxide mass flux flowing over the absorber (Fig. 2, right). An increased sodium lye mass flux leads to a better tube wetting. Therefore, the influence of this parameter on the exchanged power is shown for the absorber.

Acknowledgements

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References

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