

Aqueous Sodium Hydroxide Seasonal Thermal Energy Storage: Reaction Zone Construction and Assessment



Scope of project

In the frame of the EUFP7 project «Combined development of compact thermal energy storage technologies – COMTES», the falling film absorption and desorption technology was identified as a promising technology for developing a seasonal thermal energy storage.

With the concept of separating

- the power – the reaction zone (absorption & desorption and evaporation & condensation) and
 - the capacity – storage of sorbent and sorbate in individual tanks,
- a power and capacity scaling can be done separately. The heat and mass exchanger modelling having been carried out [1], the results were used to size, design and manufacture the unit. Once done, the last year the heat and mass exchanger was commissioned and experimentally assessed [2, 3].

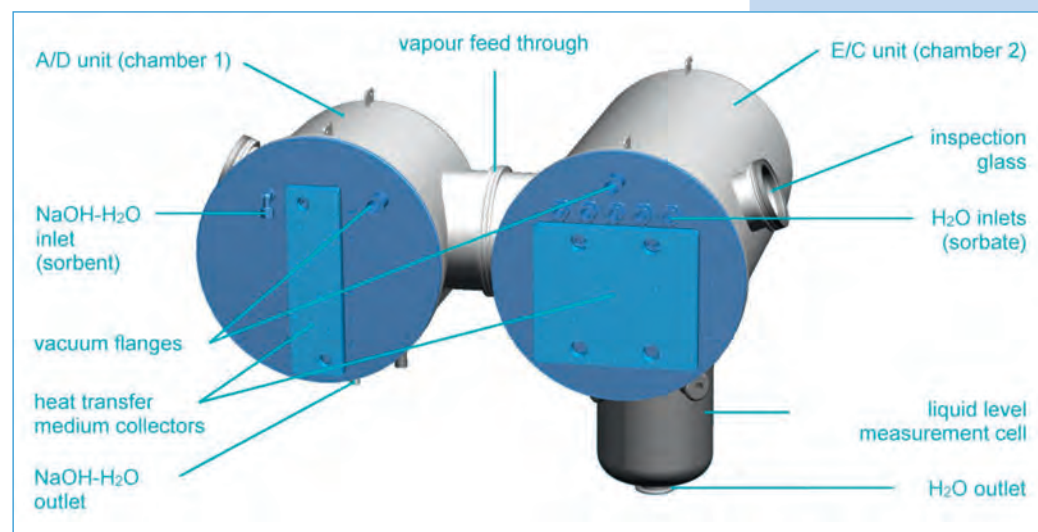
Status of project and main scientific results of workgroups

Heat and mass exchanger manufacturing

The components of the heat and mass exchanger are shown in Figure 1. Two challenging design concepts were used: modularity (each component is easily dismantlable) as well as a limited number of vacuum sealing gaskets for the vacuum envelope.

For processing and handling reasons as well as for fluid separation, both A/D (Absorber/Desorber) and the E/C (Evaporator/Condenser) units are placed in different containers (Figure 1). The vapour feed connects through both units, enabling the required exchange of vapour in both directions. Additionally it should only act as mass transfer unit and, therefore, should create a thermal infrared barrier. Thus, a nickel plated and bended metal sheet was implemented. It will predominantly form a radiation shield (radiative disconnection due to the high reflectivity of the nickel in the infrared).

The manifolds placed at the top of the tube bundle should



ensure a homogeneous fluid distribution above the tubes, taking advantage of the experimental results obtained with a preliminary test rig.

Particularly challenging was the nozzles manufacturing from 1.4404 stainless steel alloy. From the other possible designs, a version with nozzles directly machined in a stainless steel plate was selected. Using this solution, a high flexibility on the nozzle geometry is reached, enabling a good liquid distribution.

Experimental results obtained with the demonstrator

The first non-isothermal experiments campaign showed that the exchanged power during the discharging process (absorption) is quite lower than expected. Only a small concentration decrease from the initial 50 wt% sodium hydroxide solution is reached at the outlet of the absorber unit. Therefore, instead of emulating yearly operating of a building, measurements were run in steady state conditions in order to characterize the heat and mass exchangers and to

List of abbreviations

A/D	Absorber/Desorber
E/C	Evaporator/Condenser

Figure 1:

CAD drawing of the reaction zone with both A/D (left) and E/C unit (right).

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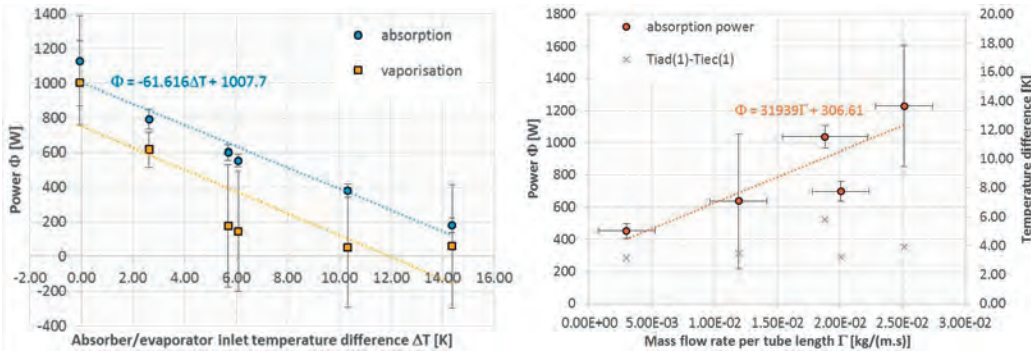


Figure 2:

Discharging process: development of the power (Φ) in function of the temperature difference (ΔT) between both absorber and evaporator chamber (left) and of the absorption power in function of the linear mass flux (Γ) arriving on the absorber (right).

compare the experimental results with those obtained from the numerical modelling. The aim was to find out the weak points of the heat and mass exchangers to further increase the exchanged power value for the absorption process.

The optical inspection has indicated that during the discharging process only a fraction (about 50 to 60%) 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 (Figure 2, left), it was also noticed that this power was depending on the

sodium hydroxide mass flux flowing over the absorber (Figure 2, right). An increase of the sodium lye mass flux leads to a better tube wetting, showing that this parameter is a limiting factor for the exchanged power on the absorber side.

During the charging process (sorbent desorption with an initial sodium hydroxide concentration of 30% wt.), it seems that the exchanged power only depends on the temperature difference between the desorber and the condenser (Figure 3, left). A higher temperature difference leads to a higher pressure difference between both units

and therefore an increased vapour transfer rate.

The wetting of both tube bundles surfaces as well as the exchanged power on both desorber and condenser are appropriate. For a temperature difference of 60 K (similar to the boundary conditions taken for the modelling), a power of 9.5 kW can be reached. Figure 3 (right) shows that the desorber modelling is relatively accurate in terms of power, especially around the nominal power value. In this point, the measured power differs from the predicted value with less than 25% of relative error.

Further work will be carried out at lab scale in order to improve the low heat transfer encountered during the absorption process. Thus, the wetting [4] between the viscous fluid (sodium hydroxide at ambient temperature and high concentration) and the heat and mass exchanger has to be increased. The use of surfactants [5] as well as surface texturing and coating are currently investigated. An increase of the heat and mass transfer interface area is also considered (use of metallic fibres for example).

References

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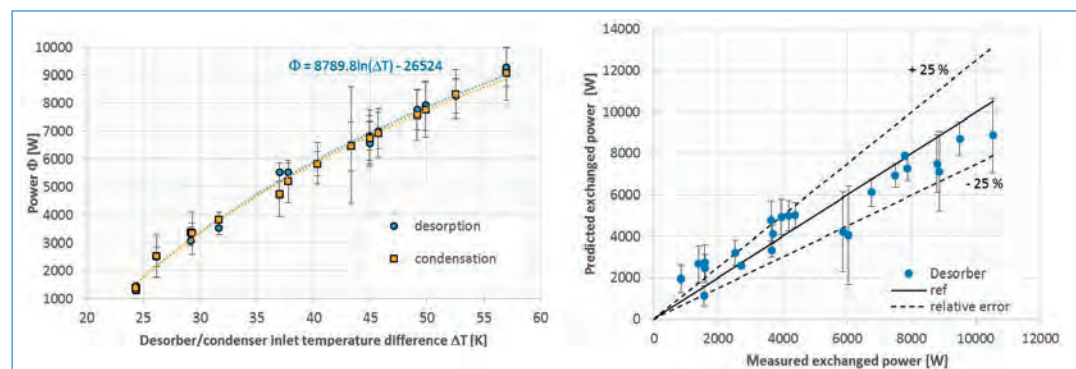


Figure 3:

Charging process: development of the power (Φ) in function of the temperature difference (ΔT) between both desorber and condenser chamber (left) and comparison of the measured exchanged power with the modelling results (right).