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Seasonal solar thermal energy absorption storage with aqueous sodium hydroxide sorbent and water sorbate

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Abstract

Solar thermal energy storage for heating and cooling application is one of the priorities in the renewable energy future. In the EU project COMTES three research groups with different technological approaches aim to reduce the required storage volume assigned for seasonal thermal storage. In our absorption-desorption energy storage concept with aqueous sodium hydroxide (NaOH-H_2O) and water, the energy provided by the solar collector field during the charging process in summer is used to evaporate a part of the water contained in the aqueous sodium hydroxide. The latent heat of water condensation is released to the ground by means of a bore hole. The liquid water as well as the concentrated sodium solution are stored in tanks separately at room temperature. For this reason and as long as the tanks are vacuum tighten this storage period can last without thermal losses. During discharging the ground heat is used to evaporate the water at low temperature (owing to the working under reduced pressure) and the absorption of the vapour in the concentrated NaOH-H_2O solution releases heat (heat of evaporation plus heat of dilution) at a temperature level sufficiently high to satisfy the building's heating requirements. Because the processes of desorption and absorption are seasonal shifted, this two process steps can be performed in the same apparatus. Thus, an absorption-desorption and an evaporation-condensation units are designed and placed in two separate vacuum chambers connected by a vapour feed through tube. The heat and mass transfer units in this thermochemical seasonal storage demonstrator are based on falling film tube bundle heat and mass exchangers. Thus, the key component of the storage system consists of tube bundle falling film absorber-desorber (A/D) and evaporator-condenser (E/C) units, figure 1a. These apparatus stand for the power unit of the system where sodium lye tanks and water tanks form the system capacity part. Additional hot water tanks charged by solar thermal energy act as sensible energy storage tanks. The size of the tube bundle absorber-desorber and evaporator-condenser of about 8 kW power is designed to fulfil the need of a well heat insulated single family house. Therefor a tube matrix arrangement of 4x18 hairpin bended tubes for the A/D and one of 12x16 hairpin bended tubes for the E/C was welded in a 400mm diameter vacuum flange, the tube bundle flange in figure 1a. Above these tube bundles a nozzle manifold is installed to equally distribute the liquids over the tube matrix. The first non-isothermal experiments campaign showed that the exchanged power in the discharging process was lower than expected and only a small decrease of the sodium hydroxide concentration was reached at the outlet of the absorber unit. The explanation of these results is a too low exposure time of the sodium lye to the water vapour and thus a lower mass transfer than needed. Therefore, instead of emulating yearly operating of a building, measurements in steady state conditions were made in order to characterize the heat and mass exchangers. A comparison of the experimental results with those obtained from the numerical modelling showed the weak points of the heat and mass exchangers in the absorption process. Contrary to this, figure 1b shows a comparison of the measured and the calculated power of the absorber-desorber tube bundle in the charging process were a much better agreement can be seen.

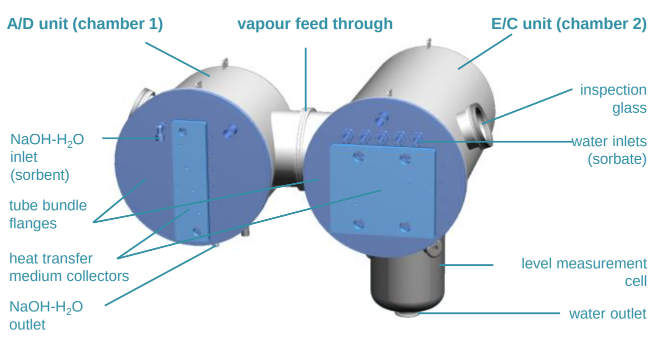

Fig. 1a: Power unit – absorber-desorber (A/D) on the left and evaporator-condenser (E/C) on the right. The tube bundle flanges are carrying all the feed throug for vacuum, heat transfer fluid and sensors.

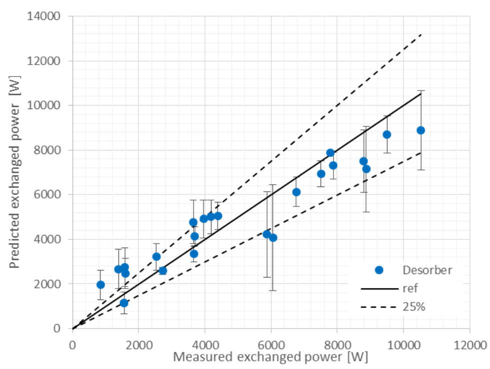

Fig. 1b: Desorption - charging process step. Comparision of the measured and calculated desorption power in the desorption units.

The measurements showed a good functioning of the desorption process i.e. charging, but the discharging process is fare from the expected power and temperature lift for application. In the presentation the development process, the set-up and measurement result will be shown and an outlook for further work is given.