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Limitations imposed on energy density of sorption materials in seasonal thermal storage systems

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Abstract

Extensive work is undertaken in search of new materials suitable for thermal sorption storage. High energy capacity is the all sought after goal. In most cases this translates to a high maximum water vapor uptake. While this is notably important, in the system development and operation additional factors become strong contributors to the success or failure of a seasonal thermal storage system. Included are, the required system charging temperature. In domestic applications temperatures below 100 °C are most fitting to the existing building solar collector infrastructure. Further charging limitations can result from possible material characteristics such as crystallization. Just as critical as charging is discharging. It is precisely at this point where much can be gained or lost. In discharging the temperature difference between the minimum absorber temperature and the minimum evaporator temperature is critical. A low temperature difference between these two temperatures permits low resulting sorbent concentrations and thus a high accessible capacity. In a system application, these temperature levels are not freely chosen. These considerations lead to highly varying operation results in both output temperature and concentration. In this paper insight is given in respect to a sorption demonstrator plant based on sodium hydroxide as sorbent and water as sorbate.

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1. Introduction

Energy density is a key criterion for the viability of sorption storage compared to solely sensible bases heat storage. Nevertheless precisely this parameter is heavily depending on operating conditions, making simple comparison virtually impossible. Major parameters are the temperatures in charging, discharging, condensation and evaporation. Naturally system engineering factors are also highly influential, but will not be further focused on in this paper. The liberty in operating parameters in material research can be the source of discrepancy between the ideal storage capacities indicated by material researchers and that resulting in system applications. It follows that the comparison of heat storage materials becomes very difficult. The actual operation of a sorption system under real conditions often leads too much lower energy densities than initially propagated. In order to prevent misleading indications in the theoretical capacity, a careful study of the sorbent vapor pressure vs. temperature diagram of a given sorbent is important, taking into account the application dependent system parameters. Indicated expected energy densities must be accompanied by assumed operation parameters. For the application of domestic seasonal solar thermal storage in Switzerland, the following operational parameters are suggested:

- Solar collector temperature: max. 95 °C.
- Heat sink temperature: max. 35 °C.
  This temperature depends on the type of heat sink; atmosphere, ground, water, etc.
- Discharging source temperature: min. 5 °C.
- Space heating return temperature: 26 °C,
  Corresponding to floor heating.
- Domestic cold water: 10°C
- Sorbent storage temperature: min. 10 °C. The sorbent material is stored in the facility of the house, possibly in the basement.

It remains to be clarified to what extend these parameters are applicable to other countries and regions with possible seasonal storage applications.

Nomenclature

T	Temperature
ω	Concentration

Indices

A	Absorber
C	Condenser
D	Desorber
E	Evaporator
h	High (ω_{seh}: solution with high sorbent concentration)
in	In
l	Low (ω_{sel}: solution with low sorbent concentration)
out	Out