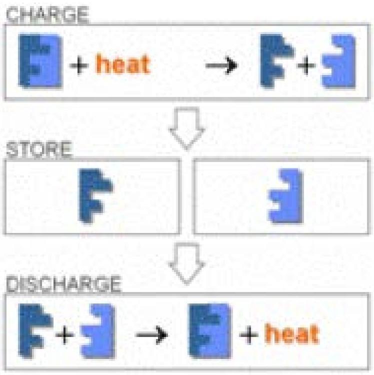
Testing and modelling of a 1 liter thermochemical heat battery for seasonal heat storage

Introduction

Solar energy is one of the most promising sources of energy, especially since tap water and space heating account for 64% of the total energy consumption in Dutch households. However, there is a mismatch between supply and demand. During summer, solar energy is abundant but the demand for heating is low, while in winter the demand is high but the supply is low. This mismatch between supply and demand could potentially be resolved by seasonal thermal energy storage. The principle of thermochemical heat storage is based on a reversible hydration / dehydration reaction of a thermochemical material (TCM) with water vapor. When a TCM is dehydrated, energy is stored and when the TCM is hydrated, energy is released again (see reaction equation below). The ability to store and release heat using a TCM allows one to create a "heat battery".



$$TCM \cdot xH_2O_{(s)} + heat \leftrightarrow TCM_{(s)} + xH_2O(g)$$

Problem definition

A 1 liter prototype heat storage reactor has just been manufactured. Extensive testing of the reactor setup is required to make sure it performs accordingly. Temperature behavior, the effect of mass flows, pressure drops and the production of water vapor in the setup should be completely understood after testing. For the initial tests, zeolite 13XBF is used as a heat storage material because of its inherent stability and infinite recyclability. The reactor test results are to be compared to an existing numerical model that simulates the reactor vessel, using Zeolite as heat storage material.
After the reactor tests with Zeolite are complete and the comparison to the model is done, the Zeolite is changed to the real storage material: a salt hydrate. Salt hydrates are suitable for long-term heat storage because of their inherently high energy density, however they tend to degrade after multiple charge and discharge cycles. A salt hydrate that performs well on reactor scale even after multiple charge and discharge cycles needs to be found and thoroughly tested. The numerical model should be adjusted accordingly and compared to reactor experiments with a salt hydrate as storage material.

Project description

The aim of this project is to extensively test a newly built heat storage setup, and to compare a numerical model with the experimental results. The focused tasks in this project are:

- Extensive testing of a newly built reactor setup using Zeolite as TCM.
- Modelling the reactor vessel in Comsol, using Zeolite as TCM and comparing this model with the experimental results.
- Changing Zeolite to a salt hydrate and perform reactor experiments to evaluate the reactor performance.
- Updating the numerical model for salt hydrates and comparing it to experimental results.

Required characteristics

- Hands-on attitude and interest in performing experiments and numerical simulations.
- Experience with Comsol modelling is a plus, but not mandatory.

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