Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 91 (2016) 182 – 189

Energy Procedia

SHC 2015, International Conference on Solar Heating and Cooling for Buildings and Industry

Practical test on a closed sorption thermochemical storage system with solar thermal energy

Asnakech Lass-Seyoum[a,*], Dmitry Borozdenko[a], Thomas Friedrich[a], Timo Langhof[b], Simone Mack[b]

[a]ZeoSys GmbH, Falkenberger Straße 40, 13088 Berlin, Germany
[b]Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, Nobelstraße 12, 70569 Stuttgart, Germany

Abstract

This paper presents the actual status of the experiments done with a large scale adsorption thermochemical storage system of a 750 liter volume in combination with solar thermal heat pipes as well as recent results of cyclic tests done on the used storage material. An output temperature of maximum 120 °C was realized to charge the storage system at a maximum of 4 kW thermal capacities. Through the succeeding discharging process, adequate thermal energy with temperatures above 60 °C could be released for providing hot water and space heating of an energy-autarkic house.

Peer-review by the scientific conference committee of SHC 2015 under responsibility of PSE AG

Keywords: adsorption, heat pipes, thermal capacity, energy density

1. Introduction

Solar energy is particularly well suitable for providing low-temperature thermal energy for domestic hot water supply and space heating purposes. As 80 % of the solar energy is incurred in the summer time, when there is hardly any heating demand, storing this energy for later utilization is getting considerable attentions [1-5]. Thus, an effective and environmentally favorable storage system should be considered as one of the key components for the further development of a solar technology.

* Corresponding author. Asnakech Lass-Seyoum Tel.: +49-30-92 70 10 17; fax: +49-30-92 68 132
E-mail address: lass-seyoum@zeosys.de

Peer-review by the scientific conference committee of SHC 2015 under responsibility of PSE AG
doi:10.1016/j.egypro.2016.06.200

Due to the permanent thermal losses and thus requiring volume-consuming and highly cost intensive thermal insulation measures, sensible or latent storage methods are not so effective for seasonal storage of relatively low temperature levels thermal energy. Thermochemical storage system (TCS) on the other hand allows to store substantially more thermal energy, by virtue of the possibly attainable four to six times higher storage density, for the same volume with barely any losses independent of the length of the storage period. It is therefore to be expected in the future that in solar assisted hot water supply and space heating systems such a technology to be an integral part of solar systems.

Regarding thermochemical storage system various research activities, in particular on the development and characterization of storage materials for low and high temperature levels in a laboratory scale, as well as theoretical works were performed [6-13]. On the other hand only few practical tests on a larger scale are known yet [14-16]. The studies reported here focus on the present status of the demonstration activities performed on a closed sorption heat storage system of 750 liter storage volume using solar thermal energy. These studies are intended to further assess the expected system performance based on thermodynamic and process engineering parameters such as energy density, thermal heat power, efficiency, cyclic stability as well as thermal energy / mass transfer in order to optimize the system for a real application.

Nomenclature

T_D	Charging temperature [°C]
T_V	Evaporation temperature [°C]
T_C	Condensation temperature [°C]
E/C	Evaporator/Condenser
ΔTI_i	Temperature difference between heat carrier fluid-bulk material at i position [°C]
MV	Main valve [0/1 = on/off]

2. Methodology

The first phase of the work, building the storage unit and its integration in the existing heating and cooling system of an energy-autarkic house associated with solar thermal heat pipes, has been already reported elsewhere [17, 18]. Based on the results obtained from those functional tests performed during the first phase using zeolite as a storage material, further system modifications in particular on process and energy management (Fig. 1) as well as several dynamical performance tests have been carried out. Thereby the maximum charging temperature (T_D) attained varied in the range between 100 and 120 °C depending on the intensity of the average solar radiation (60,000 to 80,000 lx) at the demo site. The maximum installed solar thermal capacity is 4 kW. The charging process has been carried out until a temperature difference between the solar and the storage cycle has fallen to 2 K.

Table 1. Summary of process parameters for charging and discharging cycles

Parameter	Max. value
Discharging temperature [°C]	120
Evaporation temperature [°C]	25 - 30
Condensation temperature [°C]	10 - 15
Heat carrier medium flow rate [m³/h]	2.5
Cooling cycle flow rate [m³/h]	1.8