# HIGH TEMPERATURE THERMOCHEMICAL HEAT STORAGE: EXPERIMENTAL RESULTS OF A PILOT REACTOR BASED ON $CaO/Ca(OH)_2$

**Matthias Schmidt, Christian Roßkopf, Marc Linder, Antje Wörner**

German Aerospace Center – DLR e.V., Institute of Technical Thermodynamics, Linder Höhe, 51147 Köln, Germany, Phone: 49 (0) 2203 601 4091, Matthias.Schmidt@dlr.de

Efficient thermal energy storage systems for high temperatures at reasonable costs are essential for the economic success of concentrated solar power and can lower production cost through the recovery of waste heat in industrial processes. The thermochemical storage of heat using gas-solid reactions offers several advantages compared to conventional sensible and latent storage methods: Storage densities are higher, thermal losses are minimal and the power level can be decoupled from the capacity of the storage tank. Additionally, application of different reaction systems offers the possibility to adapt the storage temperatures to the respective process needs.

Due to the good availability at low cost and its favourable temperature range, previous work at DLR focused on the reversible dissociation reaction of calcium hydroxide:

$$CaO\ (s) + H_2O\ (g) \leftrightarrow\ Ca(OH)_2\ (s) +\ \Delta H_{reaction}$$

Complete reversibility and cycling stability of the system has already been demonstrated in laboratory scale [1]. Furthermore, the effective reaction kinetics [2], the high reaction enthalpy of 100 kJ/mol and the adjustable temperature range between 410°C and 520°C make the system a promising candidate e.g. for an application in concentrated solar power plants. Nevertheless, demonstration of thermochemically stored heat in a technically relevant scale is still missing. Additionally, the influence of physical bulk properties, especially their cycling stability, and their influence on the performance of the reaction bed are still unclear.

Therefore, a new multifunctional test bench capable to investigate various thermochemical reactors with a thermal power output of up to 10kW and a possible capacity of 100kWh was developed and brought into operation at DLR [3]. The test bench is able to supply process air serving as heat transfer fluid (HTF) as well as the gaseous reactant – water vapour – at respective pressures and temperatures (Fig.1). Simultaneously, a reaction bed has been designed, manufactured and integrated into the test bench (Fig.2). Thereby, two different reaction modes can in principle be realized depending on the bed thickness, the HTF temperature and flow rate, the reaction gas pressure and the porosity and permeability of the bed (Figures 3a and 3b).

The presentation will outline the possibilities of the test bench at DLR and present experimental results of the calcium hydroxide reaction bed. Parameters such as the reachable power level, storage capacity, charging and discharging temperatures will be determined as well as the influence of the bed permeability on the performance of the reaction bed.

Intended form of presentation: oral presentation

[1] Schaube F. et al., High Temperature Thermochemical Heat Storage for Concentrated Solar Power Using Gas-Solid Reactions, J. Sol. Energy Eng., 133(4)
[2] Schaube F, et.al., A thermodynamic and kinetic study of the de- and rehydration of $Ca(OH)_2$ at high $H_2O$ partial pressures for thermo-chemical heat storage, Thermochimica Acta, http://dx.doi.org/10.1016/j.tca.2012.03.003
[3] Linder M. et al., Thermochemical Heat Storage Based on $CaO/Ca(OH)_2$, IRES 2011, Berlin, Germany

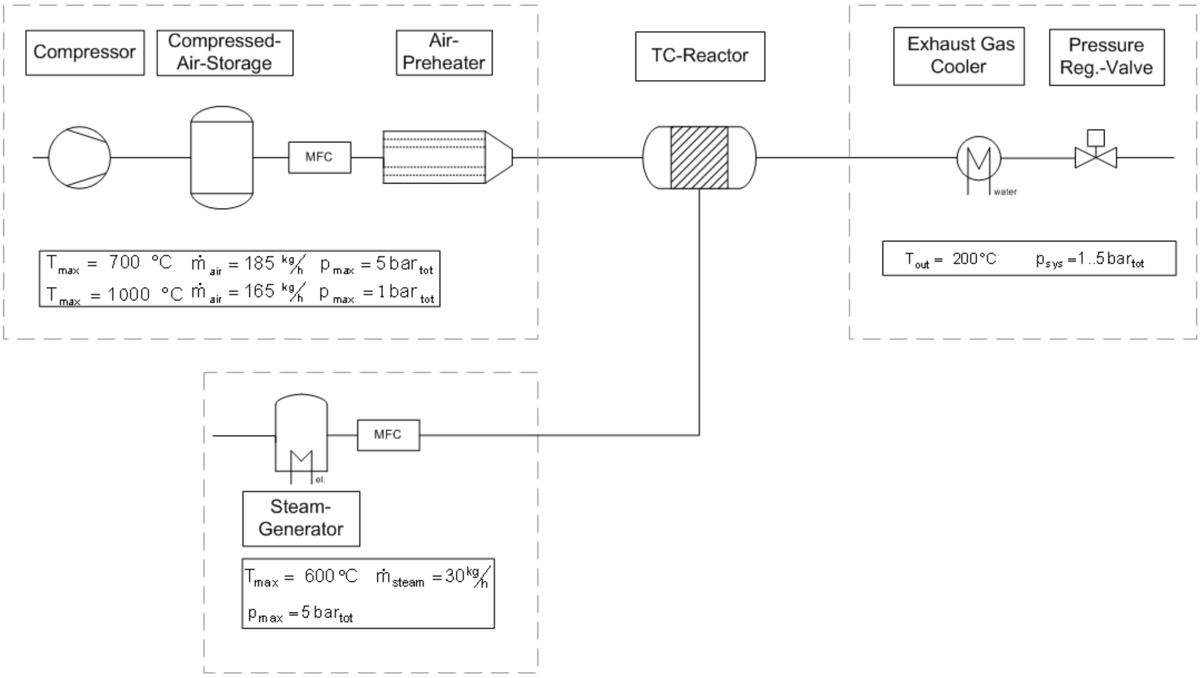


Fig.1: Multifunctional test bench for the investigation of high temperature thermochemical storage reactors. Air can be supplied at 700°C and 5 bar or up to 1000°C at 1 bar. Additionally water vapour can be supplied at 600°C and 5 bar.

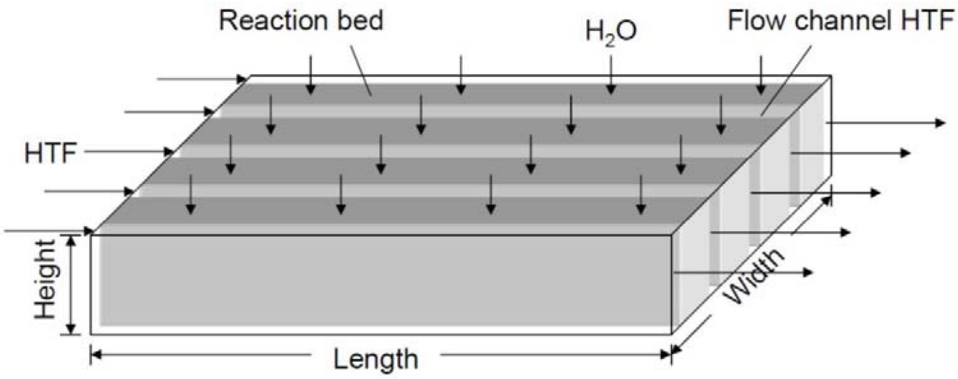


Fig.2: Indirect reation bed with HTF and reaction gas arranged in cross flow.

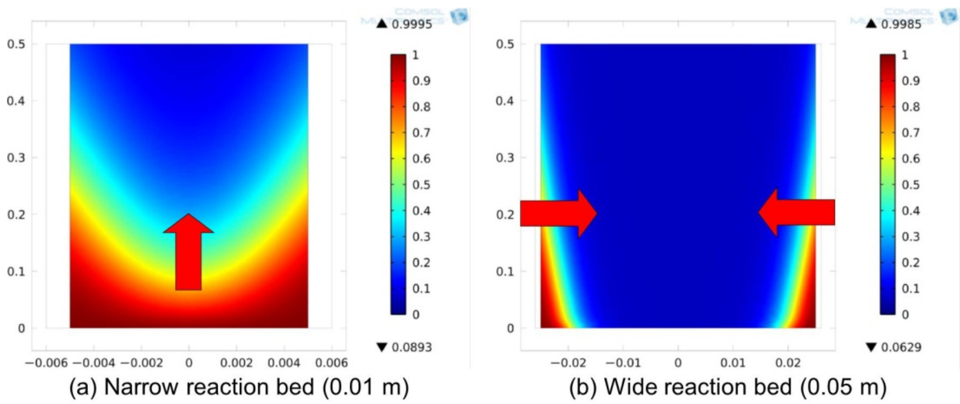


Fig.3: (a) Straight reaction front moving along the length of the bed resulting in constant power output. (b) Reaction front along the length of the bed resulting in a maximum but decreasing power output.