Technology: Thermochemical Heat Storage (Chemical Reaction)

GENERAL DESCRIPTION

Mode of energy intake and output

Heat-to-heat

Summary of the storage process

Thermochemical processes based on gas-solid reactions are fundamentally comparable to sorption processes. Upon supply of thermal energy, a chemical compound dissociates in an endothermic reaction, resulting in the release of the gaseous reaction component (the sorbate) from the solid or liquid (the sorbent). If sorbate and sorbent are later brought back together, the exothermic reverse reaction takes place, i.e. the reaction heat that was originally absorbed is now released. The chemically stored fraction of the thermal energy can therefore be stored loss-free over long periods. Losses, however, will still occur during charging and discharging. The essential difference to sorption processes lies in the chemical reaction – a new chemical compound is formed. This process takes place for a given reaction system and gas pressure at a constant temperature. Therefore, a thermochemical energy storage can be adapted to its respective application through the choice of sorbent and sorbate, as well as by influencing the pressure of the sorbate (by changing the evaporator temperature/pressure or by adding an additional compressor to achieve a higher sorbate pressure).

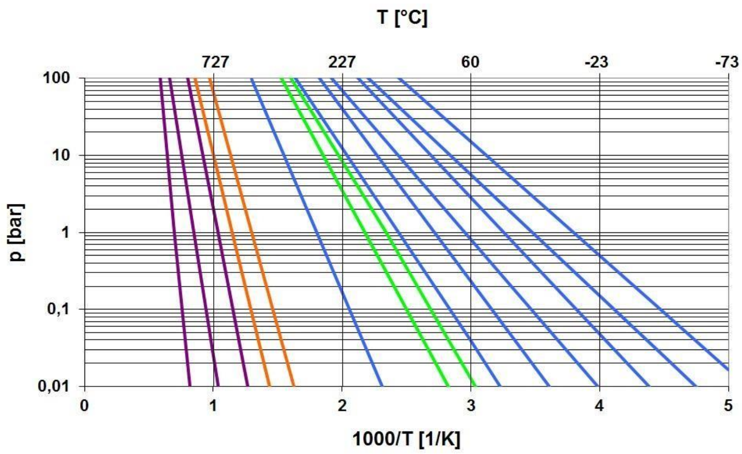


Figure 1: Selected gas-solid reaction systems for thermochemical storage with the reaction partners: oxygen with various metal oxides (purple), water vapour with salts or metal oxides (orange and green), and hydrogen with various metal hydrides (blue) (source: DLR)

Due to the reaction temperature's dependence on the sorbate pressure, variation of said pressure results in a change of the storage's temperature level. Thus, a special feature of thermochemical storage is the combination of a heat pump with a storage process. Thermochemical heat storage systems can discharge energy at a higher temperature than they were charged at, if vapour pressure is increased. This is possible for all thermochemical reaction systems, depending on the process conditions.

Focus on provision of power or energy

Provision of energy, upgrading of thermal energy

Suitable fields of application

Solar thermal power plants

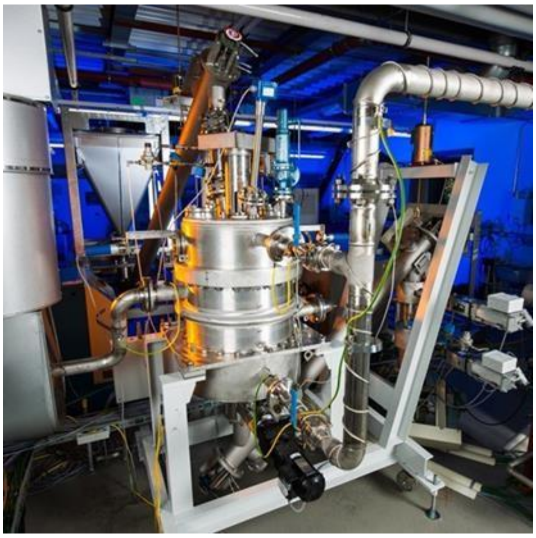
Technology-Readiness-Level (TRL)

3-4

State of development/commercial availability

Current research mainly focuses on:

- The development of adaptable and simplified reactor concepts (=mass and heat transfer).
- Integration concepts, especially for integration of the gaseous reaction partner
- Stabilisation of the reactive bed/structure, e.g. pelletisation, granulation, gas-permeable encapsulation etc.
- Selection and further development of storage materials regarding thermodynamics, kinetics, and cycle stability



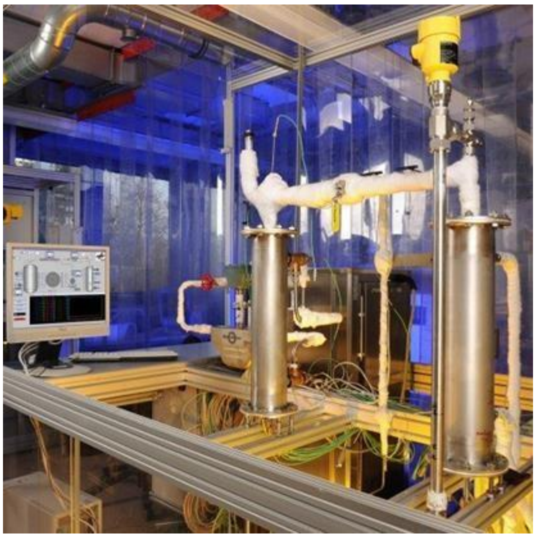


Figure 2: Experimental installation for thermochemical high-temperature storage (10 kW/100 kWh, left), testing rig for thermal upgrading of waste heat at temperatures > 140 °C (right, 1 kW) (source: DLR)

TECHNICAL SPECIFICATIONS

Specific energy storage density	kWh/m³ 100-400	kWh/t 100-400
Specific power density	kW/m³ Depends on reaction system	kW/t
Typical/feasible storage size	$MWh_{th\ out}$ Depends on reaction system	$MW_{th\ out}$
Storage efficiency	Depends on reaction system	
Storage duration	Hours-weeks, months if necessary	
Response time	Minutes	
Service life (maximum)	Cycles Depends on reaction system	Years
Loss per time in %	Depends on reaction system	

ECONOMIC SPECIFICATIONS

None yet, only R & D activity so far

For further information, see

German Aerospace Center (DLR), https://www.dlr.de/EN/