

Thermochemical Energy Storage - Adsorption

Storage Principles

Adsorption heat storage belongs to the wider class of thermochemical heat storage. The principle on which this technology is based is the interaction between a liquid sorbate, usually water, and a solid sorbent (e.g. zeolites, silica gels, activated carbons). This interaction occurs between the sorbate molecules and the available surface of the solid, as represented in Figure 1.

Moreover, adsorption heat storages can be considered an indirect TES process. Indeed, in this case, heat is employed to drive a desorption process, which means that energy is stored in the form of adsorption potential energy. Actually, heat is stored without any loss until the refrigerant fluid (adsorbate) is kept separated from the adsorbent.

Generally, there are two system configurations for adsorption TES: closed and open cycle. Figure 2 and Figure 3 illustrate the working principles of the two configurations.

Adsorption TES is considered quite a promising technology both for seasonal and daily storage applications, nevertheless, its commercial diffusion is still not completely developed, mainly for its cost as well as lack of technical knowledge at system level. This means that there is still need for development and research, in order to make the technology commercially competitive. The research activities in the field is currently carried out at materials, components and system level.

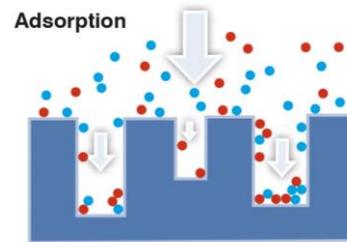


Fig. 1. Adsorption of refrigerant over the external surface of an adsorbent solid material (Klingenburg GmbH).

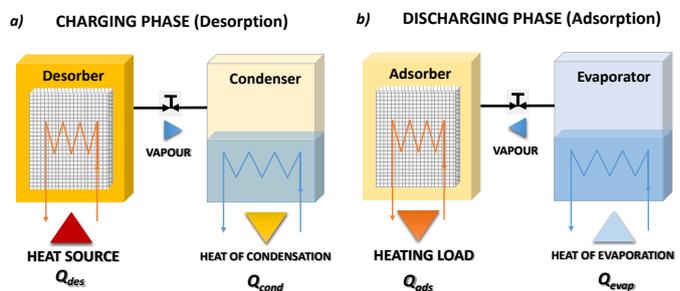


Fig. 2. Closed adsorption heat storage cycle: a) charging phase; b) discharging phase.

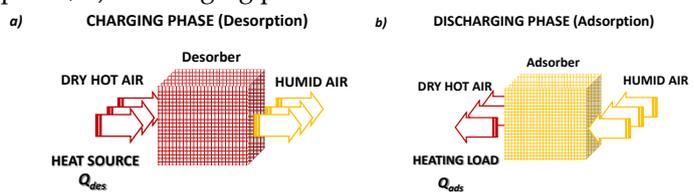


Fig. 3. Open adsorption heat storage cycle: a) charging phase; b) discharging phase.

Technical Characteristics

Typical Power (kW): 1-1000
 Feasible size (MWh): depends on the application
 Energy density (kWh/m³): 100 – 200
 Response time (min.): < 1
 Technical lifetime (y): 10-50
 Temperature range (°C): 60 - 150

Maturity

- Technology readiness level: 1 - 3

Challenges in development

- The research activities in the field are currently carried out at materials, components and system level.
- Scaling from prototypes to real.

Potential of technology

- Switchable and controllable store and release of thermal energy
- Environmental-friendly

Potential barriers

- Low technology readiness level for all types of technology
- System complexity
- System Engineering

Common Applications

- Solar thermal power plants
- Industrial process heat (heat transformation)
- Solar Cooling
- Automotive thermal management
- Seasonal storage and peak-shifting
- Industrial waste heat recovery
- Buffer storage in district heating
- Domestic heating, cooling and hot water (Figure 4)

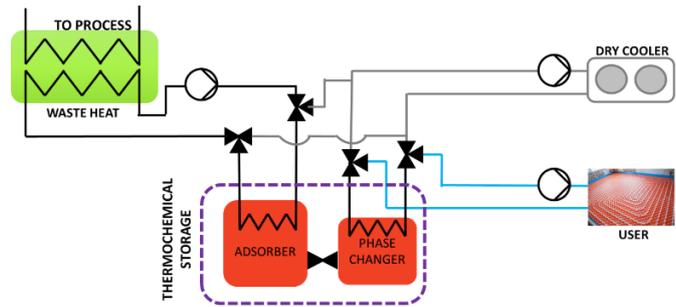


Fig. 4. Example of process diagram for the thermochemical storage

Example Applications

1. Mobile TES for Industrial application

An example of adsorption TES, is a large scale system for industrial heat recovery, storage and transportation, based on an open adsorption cycle. Figure 5 summarizes the concept, developed at ZAE Bayern laboratories [1]. It consists in recovering heat from an industrial site, by flowing hot air through a zeolite 13X bed. Once the adsorbent material is regenerated, the reactor full of dried zeolite (charged TES) is transported to the site where it is discharged, by flowing humid air through the zeolite bed, thus releasing heat to drive another industrial process.

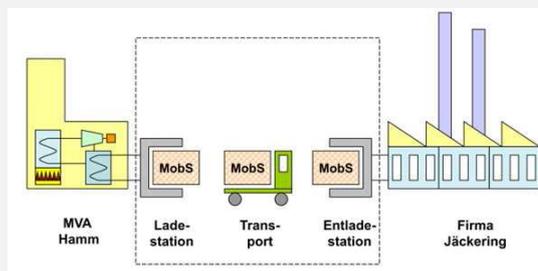


Fig. 5. Mobile adsorption TES for industrial applications.

2. Waste heat sorption storage for space cooling (Prototype)

The thermochemical storage prototype developed at ITAE is intended for cold storage starting from waste heat recovery in industrial processes at low temperature ($T < 100^{\circ}\text{C}$). Equipment cooling or space cooling are two examples of the possible applications of the storage. However, the storage is still at lab-scale and therefore there is not a specific application already set [2].

The prototype, shown in Fig. 6, consists of two vacuum chambers, representing the adsorber and the phase changer (working alternatively as condenser and evaporator). Both chambers are realised in AISI316, to avoid corrosion problems; the chamber of the adsorber has a removable cover, in order to change the heat exchangers to be tested, whereas the chamber of the phase changer is entirely welded. Inside the phase changer, 4 commercial fin-and-tube heat exchangers with copper fins and stainless steel tube have been placed.



Fig.6. Thermochemical storage installed in the lab

References

1. A. Krönauer et al., 2015.
2. V. Palomba et al., 2017.



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