Adsorption Storage Systems

Thermal Energy Storage

1. Technical description

A. Physical principles

The physical process of sorption in general is characterised of the take-up and accumulation of one material by means of a second material. The aggregate state of the second material is solid or liquid. The accumulation of a material on a surface is called adsorption. In the case of the accumulation in the liquid phase the process is called absorption. Adsorption and absorption are exothermal processes. The release of the material is called desorption which is an endothermic process.

Adsorption storage systems use a combination of two different materials. One is the adsorbent as the solid material (e.g. zeolite) and the other one is the adsorbate as the gaseous material (e.g. water vapour).

Adsorption heat storage is nearly free of heat losses over a long period of time. After charging, the storage tank can cool down to ambient temperature, but the energy stored remains constant as long as the two materials (adsorbent, adsorbate) are kept separate.

B. Important components

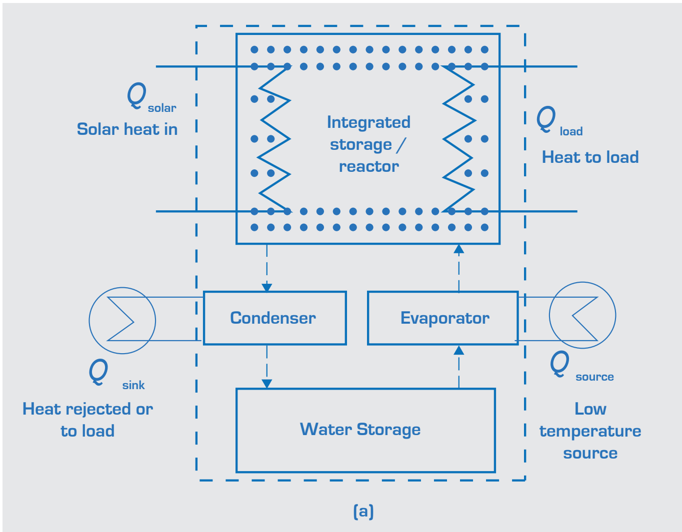
The main components of an adsorption storage unit are the adsorber storage reactor with an internal heat exchanger, an external heat exchanger, an evaporator and a condenser.

C. Key performance data

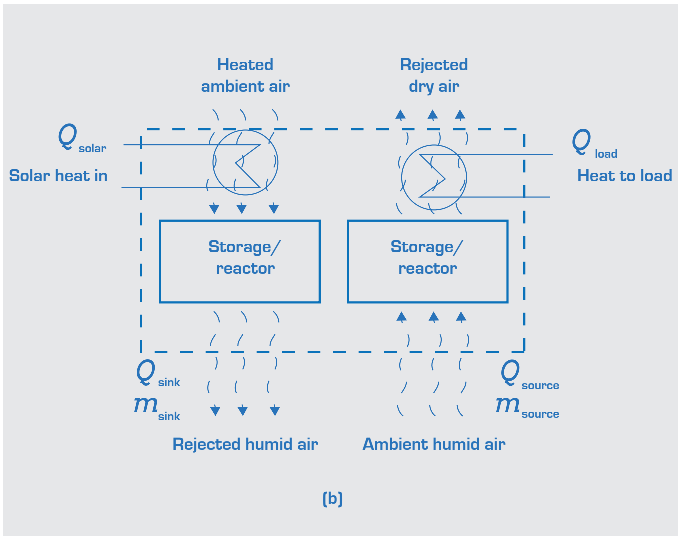
	Zeolite	Silica gel
Storage density	180 kWh/m3	220 kWh/m3

Thermo-chemical storage materials have the highest storage capacity of all thermal storage media. Solid silica gel has a storage capacity roughly up to 4-times that of water.

D. Design variants (non exhaustive)



Closed-cycle adsorption system



Open-cycle adsorption system

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Closed-cycle adsorption system

In a closed-cycle system heat exchangers are embedded within the adsorbent to transfer heat from the heat source to the load. These systems typically operate at low pressure. During charging, the storage reactor is heated to release water vapour, which is condensed and stored in a separate vessel. The heat from the condenser is either rejected to the surroundings or may be used to meet the load. To discharge the system, the stored water is transported to an evaporator where a low temperature source provides the energy for evaporation. The evaporated water passes through the storage reactor where it is re-adsorbed by the adsorbent thereby releasing its energy.

Open-cycle adsorption system

In an open-cycle system the heat exchangers are external to the integrated storage reactor. During charging, the heated air stream is circulated through the storage reactor to desorb water vapour. To discharge the system, moist ambient air is passed through the storage reactor. It exits the storage reactor as warm dry air which is passed through a load-side heat exchanger. There is no condenser or evaporator. The advantages of the open-cycle are that: there are fewer components, the system operates at atmospheric pressure, and the heat exchangers do not scale with the volume of the storage. The disadvantage is that a source of warm moist air is required during the heating season .

2. State of the art

Some basic technology components are state of the art and are commercially available. Thermal storage on the base of adsorption has been demonstrated on pilot and industrial scale.

3. Future developments

Research and development of new adsorbents that have optimised characteristics for adsorption storage units is required.

4. Relevance in Europe

Adsorption energy storage can help balance energy demand and supply on a daily and weekly basis. They can also reduce peak demand while increasing overall efficiency of energy systems. Furthermore, the conversion and storage of renewable energy in the form of thermal energy can also help increase the share of renewables in the energy mix. Adsorption energy storage is becoming particularly important also for cooling, air conditioning and in combination with heat pumps or CHP plants.

5. Applications

Adsorption energy storage systems for heating, cooling and air conditioning are designed for mobile and stationary applications in the energy range up to some MWh.

- Mobile heat storage using industrial waste heat
- Stationary heat storage in dishwashers
- Stationary heat storage in buildings with thermal solar collectors
- Stationary heat storage in a school combined with district heating
- Mobile cold storage of beer kegs and food containers
- Stationary CHP plant with heat storage for demand side management

6. Sources of information

- EASE members
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