FRAUNHOFER INSTITUTE FOR INTERFACIAL ENGINEERING AND BIOTECHNOLOGY IGB

1 *Zeolite packed bed in an experimental reactor.*

SORPTION HEAT STORAGE FOR RENEWABLE / WASTE HEAT EFFICIENT USE

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Nobelstrasse 12
70569 Stuttgart | Germany

Contact

Dr.-Ing. Antoine Dalibard
Phone +49 711 970-4130
antoine.dalibard@igb.fraunhofer.de

Dipl.-Ing. Siegfried Egner
Phone +49 711 970-3643
siegfried.egner@igb.fraunhofer.de

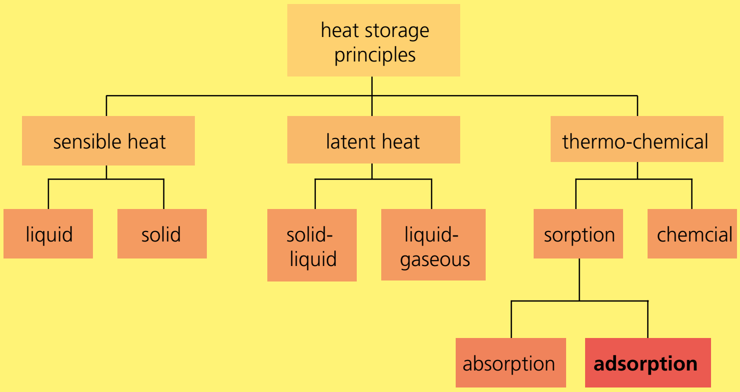
www.igb.fraunhofer.de

In order to meet the global climate protection targets, attention is now being focused on increasing the efficiency of utilization of fossil and regenerative energy. In 2016 industrial processes were responsible for almost 26% of European primary energy consumptions (3200 TWh/y) resulting in a multitude of waste heat streams at different temperature levels (370 TWh/y) which are currently mostly unused.[1] Furthermore, the direct use of renewables for heat has to be increased by 32% between 2014 and 2025 in order to meet the 2 °C global temperature scenario target.[2] In this regard, sorption heat storage systems offer the possibility to increase the use of renewable and waste heat by balancing the mismatch in time and space between supply and demand. In addition, sorptive heat storage can be operated as heat transformer in order to increase the temperature of the storage and therefore enable higher value and wider range use of the recovered low temperature heat. Thus, for example, waste heat from industrial plants can be stored and used for steam production inside or outside the industrial plant.

[1] Panayiotou et al. (2017). Preliminary assessment of waste heat potential in major European industries. Energy Procedia 123 (2017) 335-345.
[2] International Energy Agency (2017). Report Tracking Clean Energy Progress 2017. Informing Energy Sector Transformations.

Sorption heat storage – an alternative with a great potential

Heat storage units that are manufactured industrially at the moment and that are available on the market, store heat on the basis of water. This restricts the storage density and the temperature is limited to a maximum of 100 °C. A further disadvantage is that only sensible heat is stored. As a result, losses occur over the storage period due to the temperature gradients to the



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ambient environment. Sorption heat storage is a promising alternative. It provides clear advantages as regards storage densities, minimization of heat losses and available temperature levels. With sorption heat storage, energy is stored in the form of a chemical-physical potential. Compared with the currently available hot water storages three to six times higher storage densities can be achieved, thus enabling considerable more compact systems. Also, the working temperatures for charging and discharging are more flexible and can be adjusted depending on the thermodynamic parameters used (e.g. 100–300 °C if zeolites are used). The stored heat can be upgraded (temperature increase) if the system is operated as heat transformer. Since the energy is not stored as sensible heat, almost no thermal losses occur over the storage period. This enables both short-term (days to weeks) and also long-term storage (several months). In addition, we are also investigating cooling with sorption storage units. When the hygroscopic storage material binds water vapor in its pores (and heat is released in the process), heat is removed from the water tank by means of vaporization, resulting in a cooling effect.

Process and product development

In order to achieve a cost-effective solution, an integrated approach was adopted consisting of cost-conscious material, component and process developments and production-optimized construction. A demonstration of the modular heat storage system developed along these lines was conducted over several months under real conditions in an apartment house with more than 70 residential units; the aim was to increase the energy efficiency of a combined heat and power (CHP) plant. For this purpose excess heat from a mini-CHP unit with an power of 20 $kW_{electric}$ and 40 $kW_{thermal}$ was stored in order to make the thermal energy available when required for heating the building and thus to reduce the primary energy consumption. In addition, a newly patented process in which the refrigerant is circulated actively allow to increase the heat and mass transfer inside the reactor and therefore increase the system specific power without using expensive adsorption materials. With this new approach the thermal power during charging and discharging can be controlled more effectively according to the user's needs.

Application areas

For potential end users the new heat storage technology provides economic and process engineering advantages that result from an increase in the energy efficiency and savings in energy costs. Especially in industrial and/or building applications this opens up the possibility of storing heat more flexibly and more efficiently so that it can be reused at different times and places as required. As the adsorption process simultaneously provides heating and cooling, the technology can be utilized also for cooling purposes.

Range of services

- Market and technology analyses
- Feasibility studies and preliminary investigations on the laboratory and pilot plant scale as well as test operation on site
- Scientific evaluation, consultancy and studies in the field of energy management, heat and mass transfer, sorption processes
- Numerical modeling and simulation of processes, fluid flow, and heat and mass transfer processes
- Development of systems applied in accordance with the customer's individual requirements
- Engineering including control and automation

Equipment

- Laboratory facilities for characterizing and investigating adsorbents and electrolytes/absorption media
- Design and simulation software: SolidWorks, COMSOL MultiPhysics®, Design-Expert
- Laboratory facilities for examining solid heat exchangers for adsorbents and investigating sorption heat storage processes including heat transformation
- Measurement methods for measuring the thermal conductivity of bulk goods under vacuum

2 *Possibilities for thermal energy storage.*

3 *Pilot storage unit with a volume of 750 liters in a transportable container.*