Technology: Low-Temperature Latent Heat Storage

GENERAL DESCRIPTION

Mode of energy intake and output

Heat-to-heat

Summary of the storage process

Latent heat storages utilise the absorption and release of heat at a constant temperature level during a phase change, usually from solid to liquid and vice versa. Compared to sensible storages, the energy density of latent heat storage materials (PCM = phase change material) is significantly higher in a narrow temperature range around the phase change (Fig. 1). The almost isothermal behaviour of the PCM during the phase change also allows for the passive smoothing of temperature fluctuations and reduction of temperature peaks.

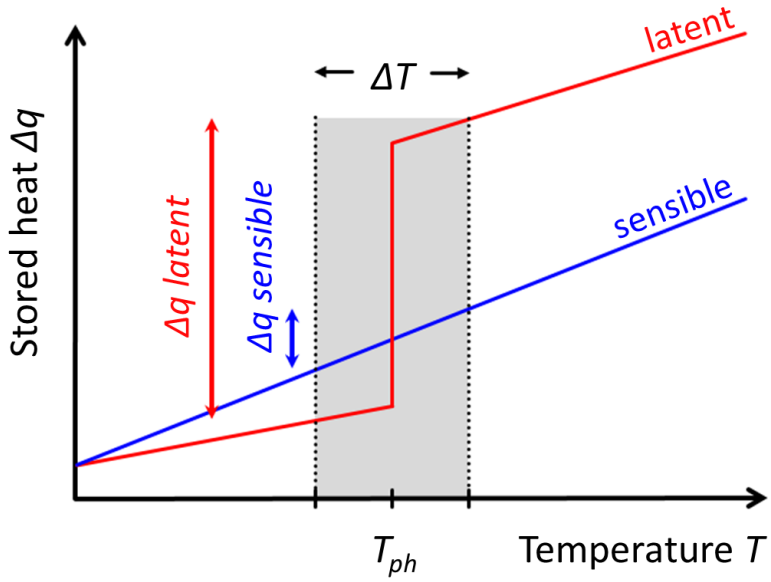

Figure 1: Stored heat as a function of temperature for sensible and latent heat storage (source: ZAE Bayern)

Focus on provision of power or energy

High-performance storages serve to provide high power outputs, high-energy storages to provide large amounts of energy. High outputs require the development of highly performant heat exchangers or the addition of heat-conducting structures, such as cellular metals, to the storage volume in order to increase the typically low thermal conductivity of PCMs (Fig. 2).

Suitable fields of application

Waste heat utilisation (power generation and industrial processes, automotive, biomass conversion plants, etc.; see Fig. 3), cooling applications (central storages, see Fig. 4, pumpable phase change slurries), homogenisation of cyclic temperature fluctuations, buffer storages in district heating networks.

State of development/commercial availability

R & D, first demonstration projects, high performance storage TRL 4-5, high-energy storage TRL 5-7, micro storage for food and pharmaceutical cooling TRL 9.

Figure 2: High-performance latent heat storage unit (without housing) with aluminium fibre structure for increased heat conduction. Laboratory model: structural volume 10 l, continuous output 2 kW, peak output 10 kW

Figure 3 : Waste heat utilisation with a mobile latent heat storage used by the waste management company of the Neckar-Odenwald district

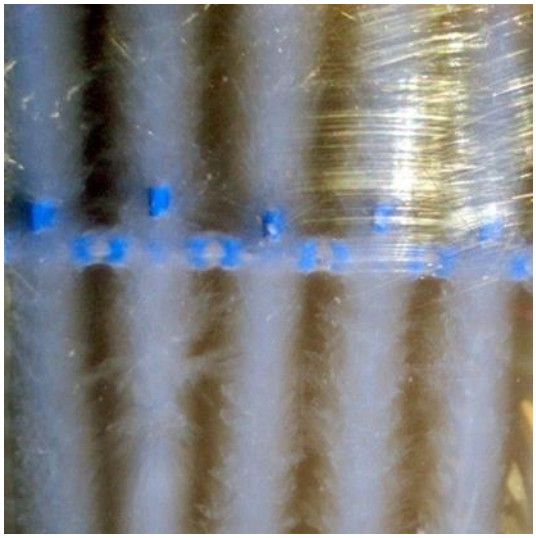

Figure 4: Latent heat storage for recooling of an absorption chiller used in solar air conditioning (left, source: ZAE Bayern), PCM crystallising on heat exchanger during discharge of storage (right, source: ZAE Bayern)

TECHNICAL SPECIFICATIONS

Specific energy storage density	kWh/m³ 80-110	kWh/t 40-110
Specific power density	kW/m³ 10-20	kW/t 5-15
Typical/feasible storage size	MWh_{out} 0.1-2.5	MW_{out} 0.01-0.22
Storage efficiency	80-98 %	
Storage duration	Hours-weeks	
Response time	Minutes	
Service life (maximum)	Cycles 3,500-10,000	Years n. a.
Loss per time in %	Max. 15 %, depending on operating conditions	

Notes on these specifications

The specific performance of latent heat storages may be significantly increased through appropriate measures. Current research indicates that 250-450 kW/m³ (or 160-250 kW/t) may be achieved. Such high-performance storage units would tend to be used for minute to day storage.

ECONOMIC SPECIFICATIONS

Investment cost per kW

200-400 €

Investment cost per kWh

20-100 €

Operating and maintenance cost (based on investment/kW and kWh)

2,500 €/a

Notes on these specifications

The cost given for a high-energy storage system includes the charging and discharging stations as well as the mobile latent heat storage unit excluding transport facilities.

For further information, see

ZAE Bayern, https://en.zae-bayern.de/
Fraunhofer UMSICHT, https://www.umsicht.fraunhofer.de/en.html
Fraunhofer IFAM, https://www.ifam.fraunhofer.de/en.html
Fraunhofer ISE, https://www.ise.fraunhofer.de/en.html