Low-Temperature Latent Heat Storage

Storage Principle

Latent Heat Thermal Energy Storage (LHTES) systems with phase change materials (PCMs) store large amounts of heat at a nearly constant temperature. Most commonly applied materials are solid/liquid PCMs where the phase transition is defined by melting and solidification.

PCMs with phase change between -40 to 100 °C are especially attractive for low temperature applications, where volume plays a critical role. Otherwise, water instead of PCM is preferable because of its lower specific costs and ease of use. Most of low temperature PCMs have a low heat conductivity which then makes heat transfer enhancement techniques, i.e. fins or additives like graphite, necessary.

Figures 1 and 2 give an overview of latent heat and energy density versus phase change temperature of PCMs reported in literature [1-5].

Most important parameters and their common values are given below:

Specific costs: 0.03 - 1 €/Wh
Heat conductivity: 0.15 – 0.7 W/mK
Energy density: 55 - 350 kJ/dm³

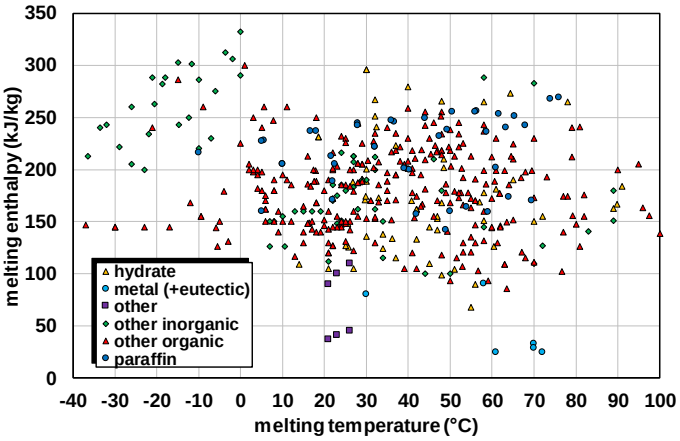

Fig. 1: Latent heat vs. phase change temperature of various low temperature PCMs (data [1-5]).

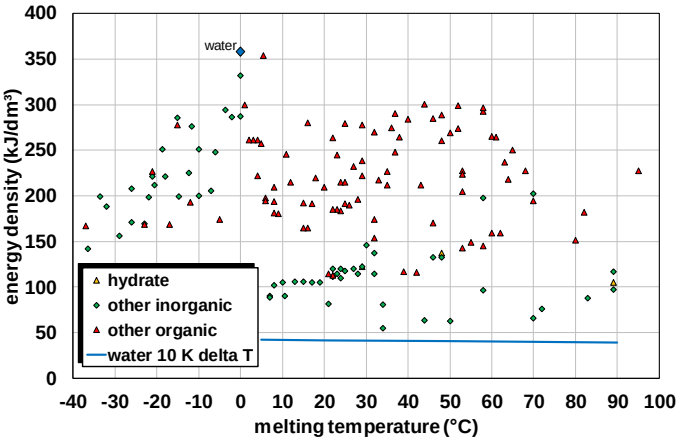

Fig. 2: Energy density vs. phase change temperature of various PCMs (data [1-5]).

Technical Characteristics

Typical Power (kW): -
Feasible size: application-dependent
Energy density (kWh/m³): 14 – 100
Response time: application-dependent
Technical lifetime (y): 10-50
Temperature range (°C): -40 - 100
Efficiency (%): -

Maturity

- Technology readiness level: 4 – 7

Challenges in development

- The research activities in the field are currently carried out at materials, components and system level.

Potential of technology

- Switchable and controllable store and release of thermal energy
- Environmental-friendly and widely available materials

Potential barriers

- High costs
- Low heat conductivity of PCM
- Toxicity, corrosivity, flammability

Common Applications

- Thermal load management and peak shaving in various applications, especially buildings
- High-performance electronics
- Automotive thermal management
- Textiles, fibers and fabrics
- Personal comfort

Example Applications

1. Thermal management for batteris

PCM was applied to a car battery module at AIT for optimal thermal management during quick charging of the batteries. Peak temperatures were reduced by 7.5 K. In that way charging times could be significantly accellerated. In figure 3, the temperature reference scenario is compared with various optimized scenarios employing PCMs. Further information can also be found in a work carried out at TU München [6].

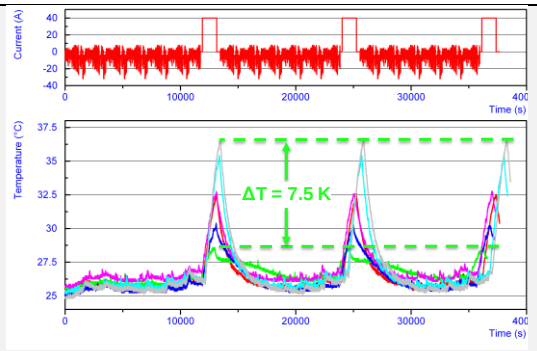

Figure 3: Peak shaving with low temperature PCMs during quick charging of batteries (source: AIT)

2. PCM in evaporators of heat pumps and air conditioning systems

The evaporator has an aditional PCM section filled with paraffin. In stop and go traffic the AC can still provide cool air with the compressor switched off. The PCM is recharged when the vehicle is moving again.[1]

This technique is also being investigated for domestic heat pumps.[2]

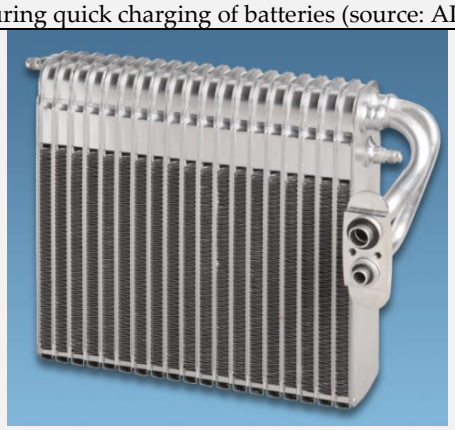

Figure 4: AC-Evaporator with PCM (source: Delphi Automotive PLC)

3. PCMs for personal comfort

PCMs are used in many fabrics, most of them for sports. As an example the Canadian wheelchair rugby team[3] uses PCM cooling vests. There is a whole lot of different products, including hats, caps and vests including products for pets.[4]

Figure 5: Cooling dog pad[4]

References

1. N. Sarier et al., 2012.
2. A. Sari et al., 2014.
3. W. Su et al., 2015.
4. A.M. Khudhair & M.M. Farid, 2004.
5. A. Sharma et al., 2009.
6. C. Huber, 2017.

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[1] Phase Change Material evaporator
[2] www.akg-group.com
[3] Wheelchair Rugby team
[4] www.techniche-intl.com