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Phase change materials for thermal storage

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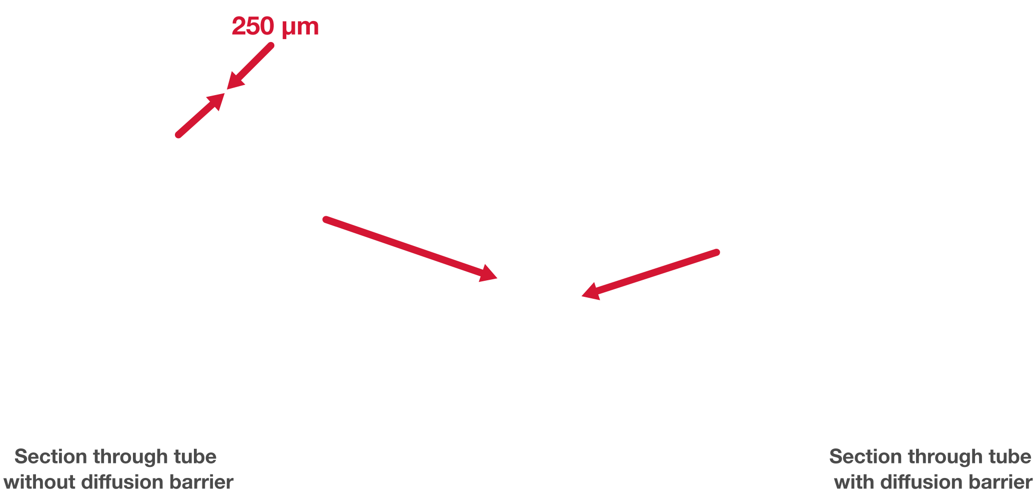

The picture in the middle shows the latent thermal storage system partially filled with the steel pipes. When fully filled, there are 296 steel pipes filled with an aluminium-copper-silicon alloy in the storage tank. On the left, you can see a section through a pipe without a diffusion barrier. After about 100 hours at high temperatures, a 250 µm thick intermetallic intermediate layer has formed. On the right, a section through a pipe with a diffusion barrier can be seen; despite high temperatures, no intermetallic intermediate layer has formed. *Source: Sophia Haussener (left and right), Viola Becattini (centre)*

A latent heat storage system uses an encapsulated phase change material as a storage material. The phase change material absorbs heat during charging through the melting process and releases it again during discharging through the solidification process. A peculiarity of the phase change is that the temperature corresponds to the melting temperature of the material until the entire material has melted or solidified. This makes it possible to stabilise the outflow temperature close to the melting temperature of the phase change material.

If the thermal storage system comprises both a sensible and a latent part, the heat is first stored in the latent part and then in the sensible part during charging. During discharging, heat is first released in the sensible part and then in the latent part.

For the tests with the pilot plant in Biasca, the phase change material had to have a melting temperature of about 500°C to 550°C. Metallic materials are particularly interesting because they have high thermal conductivity and therefore enable faster charging and discharging of the storage system. For the tests, an alloy of aluminium, copper and silicon with a melting temperature of 525°C was selected.

As the phase change material melts, it must be stored in an enclosure, for example in a steel pipe. The latent heat system can then be filled with several steel pipes. At high temperatures, the encapsulation and the phase change material are particularly reactive, resulting in the formation of an intermetallic layer between the encapsulation and the phase change material. The slow growth of this layer reduces the storage capacity. In addition, the encapsulation is attacked, which can endanger the mechanical stability of the encapsulation and the latent storage system.

The formation of the intermetallic intermediate layer can be prevented using a thin ceramic protective layer – the so-called diffusion barrier.[1] This extends the service life of the steel pipes and the thermal storage system.

Notes and References

1 S. R. Binder and S. Haussener, “Design guidelines for Al-12 %Si latent heat storage encapsulations to optimize performance and mitigate degradation”, Applied Surface Science, 143684, 2019