HSLU Lucerne University of Applied Sciences and Arts

Engineering and Architecture
B.Sc.. Energy and Environmental Systems Engineering
Bachelor-Thesis

Evaluation of a Seasonal Latent Heat Storage Prototype

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1. Background and Goals

The energy transition towards an energy system relying mainly on renewable energies requires the development of new storage technologies. The startup SeasonCell AG is developing a supercooled latent thermal energy storage system based on phase change material. Seasonal thermal energy storage can make a valuable contribution to the energy transition. During the past year, the SeasonCell team has done multiple research projects. Since this year they have a first prototype in real scale. Based on this first prototype an evaluation was made to access the thermal and physical limitations of such a system in a laboratory setup.

The goals were as follows:

- Defining parameters to be tested.
- Planning and executing the measurement procedures.
- Analysis of the measurement data and of shortcomings of the prototype.

2. Methodology & Experimental Setup

What was measured? → Key performance indicators:

Energy Efficiency: What percentage of charged energy, can get discharged? $\eta_s = \frac{Q_{discharge}}{Q_{charge}}$

Exergy Efficiency: What percentage of high-quality energy gets lost? $\psi = \frac{Ex_{discharge}}{Ex_{charge}}$

Heat Transfer: What heat flow is transferred within the system, based on the change in temperature? $k \cdot A = \frac{\dot{Q}_{charge}}{\Delta T_m}$

Nominal Heat Transfer Performance Coefficient: How is the heat transfer performing, compared to its volume? $NHTPC = \frac{k \cdot A}{V_{tot}}$

Compactness: How compact is the storage built, regarding the volume of phase change material. $\phi_{PCM} = \frac{V_{PCM}}{V_{tot}}$

Reliability: How reliable is the activation of the phase change material? $\text{Reliability} = \frac{N_{success}}{N_{total}}$

Pressure Drop: What pressure losses happen within the storage unit? $\Delta p = p_{in} - p_{out}$

How was it measured? → Experimental Setup

To measure the needed parameters, a test rig was built. Multiple temperature sensors in and around the prototype were installed. At the inlet and outlet of the heat transfer fluid, pressure sensors, temperature sensors and a volume flow meter were installed. A set of test scenarios were formulated and conducted accordingly.

Figure 1: Test bench.

3. Results and Discussion

Experimental performance

The system was evaluated based on the overall performance. The control unit was regularly updated during the experiment and achieved great improvements. It started of with strong fluctuations in the controlled parameters but reached steady controlling at the end of this thesis. A total of 15 tests were conducted. The activation was proven to be successful on some but not all occasions.

Numerical results

The average charging energy was successfully measured. But the results varied extremely from scenario to scenario. The heat loss of the prototype was exponentially increasing based on the inlet temperature. The pressure drop turned out to be difficult to give a clear answer, since the sensors were not accurate enough. The drop is however very small. The heat transfer is very dependent on the scenario, and if it is charging or discharging.

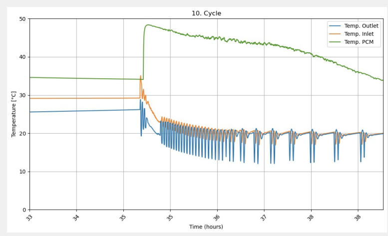

Figure 2 : Example of successful activation.

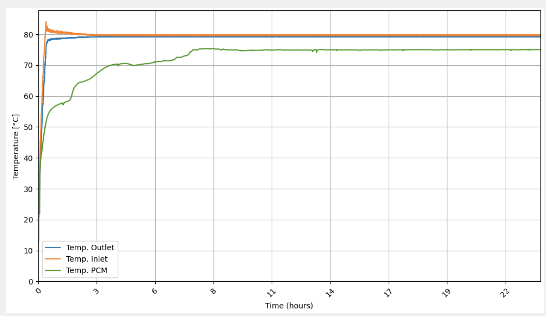

Figure 3: Example of a charging scenario.

Discussion

Compared to other results, most values were slightly below average. Especially the reliability and the heat transfer. The positive results are that the activation was proven to work, the supercooling state can be reached and that the concept in overall can be achieved.

4. Conclusion

Multiple challenges arose during the experiments, but the potential of latent heat storage was proven. The reliability of the supercooling still needs a lot of improvement, but with refined controls, this might work better in future. It is important to note that this thesis only marks the starting point of the experiments, and improvements are almost certain.

References

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