HSLU Hochschule Luzern

Technik & Architektur
Master of Science in Engineering
Competence Center Thermal Energy Storage

Master-Thesis Energy & Environment

Experimental investigation of effects on supercooling and segregation of the PCM used in the SeasonCell concept

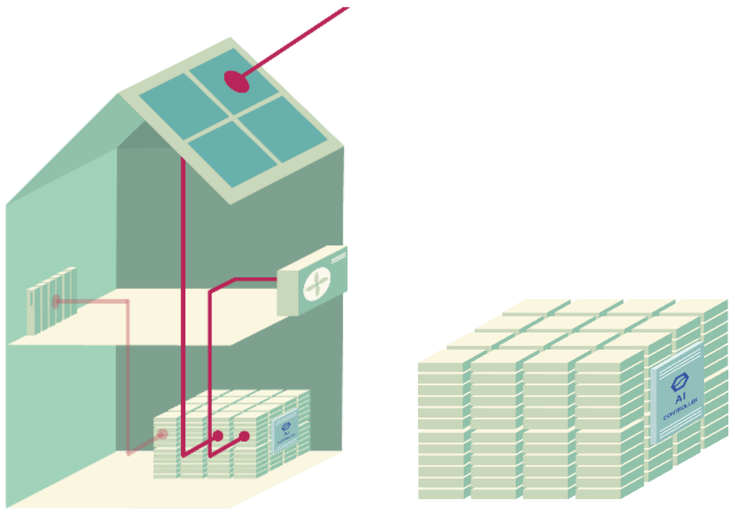

Fig1: SeasonCell storage concept

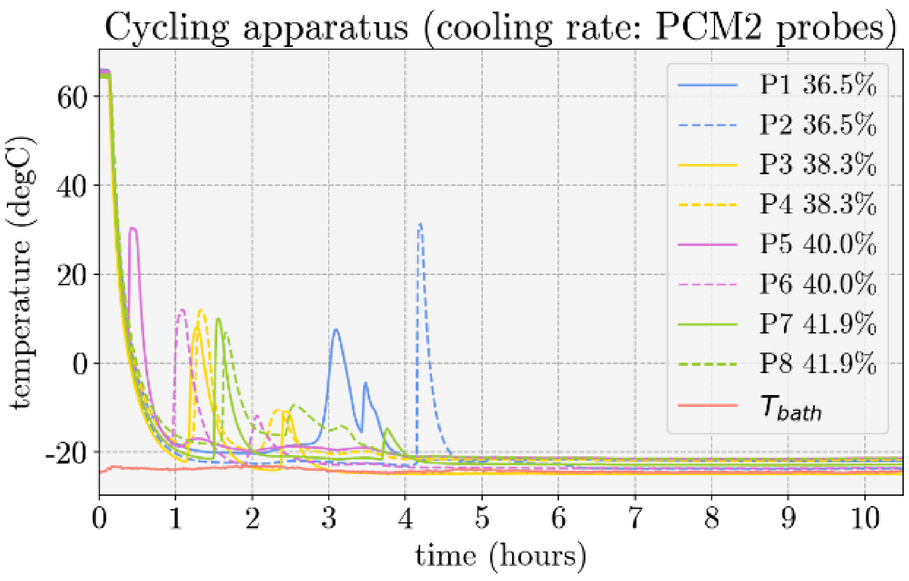

Fig2: Degree of supercooling of PCM2

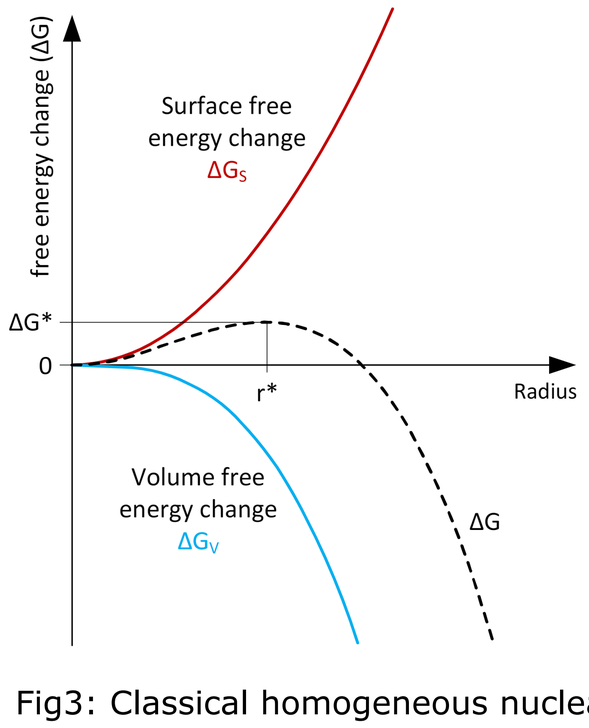

Fig3: Classical homogeneous nucleation theory

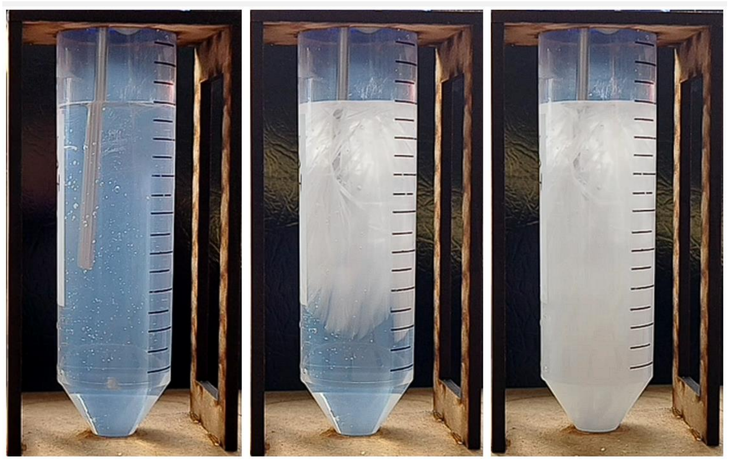

Fig4: Crystal growth of PCM1

Introduction

SeasonCell is developing a seasonal thermal energy storage for the building sector (see Fig1). Surplus heat is stored in multiple cells with phase change materials and is brought in supercooled state into the winter. There it is activated by triggered nucleation where the heat from the phase change is released again. This phenomenon is known for more than 100 years in the form of reusable handwarmers. The design relies on aqueous salt mixtures with stable supercooling properties. The use of a suitable material in terms of thermal, physical and chemical properties is key for a successful storage system. For this the goal is to observe three potential phase change materials (PCM's) on the thermal and physical behavior and influences on the supercooling and the segregation.

Procedure

In order to fully understand the phenomenon of phase change materials and their behavior, the fundamentals of crystallization are first studied. The thermal properties of the three potential PCM's are measured to form a database. Experiments regarding the influence on supercooling and segregation as well as crystal growth are done specifically for the three PCM's. In the end the three PCM's will be rated according to their usability in the SeasonCell storage concept.

Results

In this thesis, the fundamentals of the nucleation theory (see Fig3) and the crystal growth are extensively studied to fully understand the behavior of the crystallization and to understand the influences on the supercooling in a theoretical manner. The thermal properties of the three PCM's are conducted in the analytic laboratory. All the experiments and determination of the thermal properties are made with different water contents of the materials to observe an influence there. However, the goal is always to achieve a specific hydrate formation of the crystals.

Different experiments regarding the influences on supercooling, segregation and crystal growth were made. Influences on supercooling are for example the cooling rate, thermal history, volume size and surface roughness. The segregation of the PCM's can potentially be reduced by the addition of extra water, thickener agents or with the use of eutectic mixtures. The experiments showed great possibility of PCM1 and PCM2 with stable supercooling for more than 85 days at room temperature, supercooling degrees up to 80K (see Fig2) and stable supercooling for +10h at temperatures far lower than room temperature. PCM1 showed the highest linear crystal growth velocities out of the three PCM's (see Fig4), with the velocity influenced by the degree of supercooling.

SEASON CELL

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