HSLU Lucerne University of Applied Sciences and Arts

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

Energy-Efficient Cold Water Recirculation System

Student: David, Müller

1. Introduction, Goals and Research Questions

Maintaining low cold-water temperatures in building systems is essential to prevent Legionella bacteria growth, which thrives above 20°C and poses significant health risks. Cold water can heat up due to proximity to hot water pipes, insufficient insulation, or ambient heat. This research explores energy-efficient solutions for maintaining low cold-water temperatures, focusing on Phase Change Material (PCM) storage. PCM storage uses thermal energy absorbed during phase changes to delay temperature increases without additional energy consumption. The primary goal is to analyse and experimentally test PCM storage for practical use in building water systems.

2. Method Overview and Materials

The experimental setup for this thesis was designed to simulate real-world conditions in building water systems and evaluate the effectiveness of PCM storage in maintaining cold-water temperatures below 20°C. The system operates by constantly circulating water through the PCM storage unit seen in Figure 1.

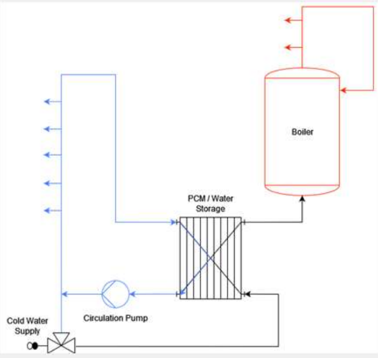

Figure 1: Diagram PCM in building

To cool the storage, cold water at 11-15°C from the water supplier enters the system, first passing through the PCM storage. In this process, the water absorbs heat from the storage medium, cooling the medium and slightly warming the water. This preheated water is then directed to the boiler. For experimental purposes, the heating of the building is simulated with an electric heater, and for cooling, tap water is flushed through the system. The following Figure 2 shows a photograph of the setup.

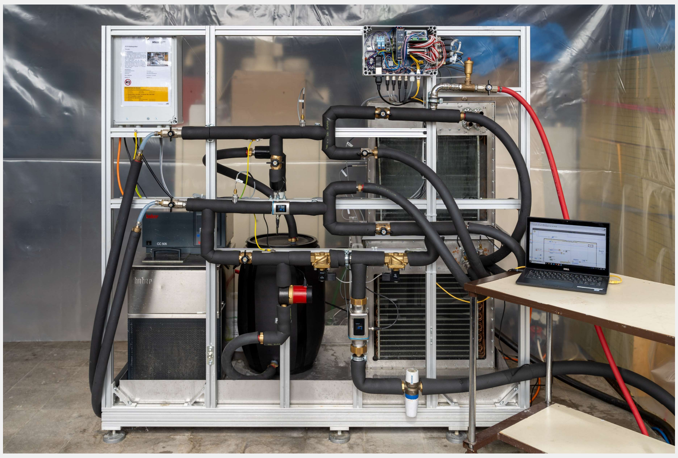
Figure 2: Photograph of the experimental setup

Industry Partner NUSSBAUM RN

3. Results and Discussion

The experiment involved constantly heating the water in the setup with 200W to simulate the heating of pipes in a building. This was conducted twice, once with PCM storage and once without. In both cases, water was constantly circulated, and the PCM storage was pre-cooled (frozen) to assess its effectiveness in delaying the temperature increase. The following graph on Figure 3 shows how temperature changes over time.

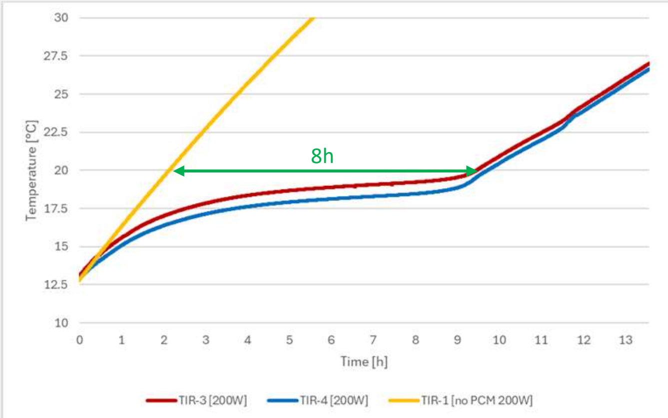

Figure 3: Diagram of the experimental setup

The results showed that PCM storage delayed the temperature increase by approximately 8 hours compared to the experiment without storage. This indicates that in a real-case scenario, a PCM storage system can keep temperatures below 20°C overnight when water is stagnating. Afterward, when people in the building start using water, the storage will be cooled again.

4. Conclusion and Recommendations

The experiments showed PCM storage as energy-efficient, delaying temperature rise by 8 hours and reducing heating costs by preheating the water. Performance depends on water usage, incoming water temperature, and consumption. While the results are promising, further research is necessary to optimize the PCM storage system under realistic conditions and for practical real-world applications.

References

Bundesamt für Gesundheit BAG. (2018). Bundesamt für Gesundheit BAG Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV Modul 0 Einleitung Legionellen und Legionellose BAG-/BLV-Empfehlungen.

Rhoads, W. J., Ji, P., Pruden, A., & Edwards, M. A. (2015). Water heater temperature set point and water use patterns influence Legionella pneumophila and associated microorganisms at the tap. Microbiome, 3.

Thomas, H., Benoit, S., & Reto, von E. (2016). Strategie für den Ersatz von Elektrowassererwärmern unter Einbezug des Gesamtwärmesystems im Gebäude. www.bfe.admin.ch

Supervisor: Ludger, Fischer
Expert: Kai, Lieball
Semester: Spring Semester, 2024