COLD THERMAL STORAGE SYSTEM: LOADING AND UNLOADING STUDY ASSISTED BY A COOLING PROTOTYPE

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INTRODUCTION

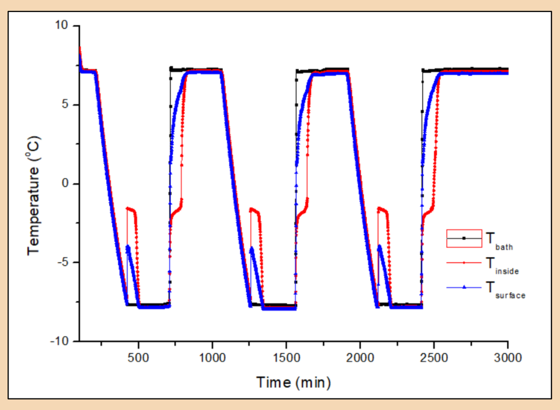
In this work, the use of a phase change material (PCM) for cold thermal storage is studied through two types of experiments: the phase change kinetics study in the laboratory, and using a storage tank with PCMs connected to a cooling machine prototype for refrigeration. In the former case, a single nodule is placed in a thermostated bath, and freezing and melting cycles are repeated, monitoring the temperature in several locations of the nodule. On the other hand, the latter experiments aim to simulate and optimize the loading and unloading strategies of the thermal storage system based on PCMs to be integrated in the refrigeration system of the research center for Solar energy in the University of Almeria (CIESOL), an institutional building with approximately 70 workers.

The photograph shows the cooling prototype together with the thermal storage tank. The control program records around 50 variables per minute, including temperature, pressure and flow rates in several positions, allowing to carry out the energy balance within the storage tank. Tests of energy loading and unloading in the PCM tank were carried out, varying the flow rate of the heat transfer fluid (HTF) and temperature in the charging case, while for unloading the effect of a thermal load offered by a resistance simulating the building's cold demand is also studied. The effects of modifying the position and configuration of the PCM nodules inside the tank are also studied, in order to optimize the geometrical configuration and operating conditions. The results were analyzed using Thermodynamics of open systems in order to quantify the heat stored or recovered, thus obtaining the efficiency of the system.

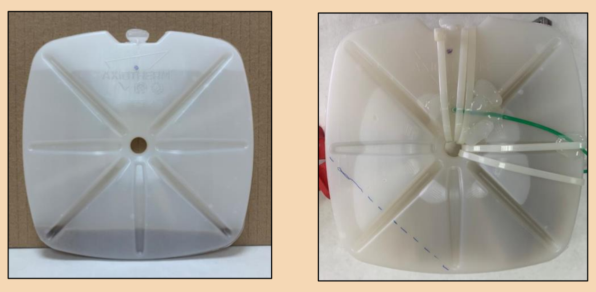
MATERIALS AND METHODS

Thermostatted bath for a single nodule

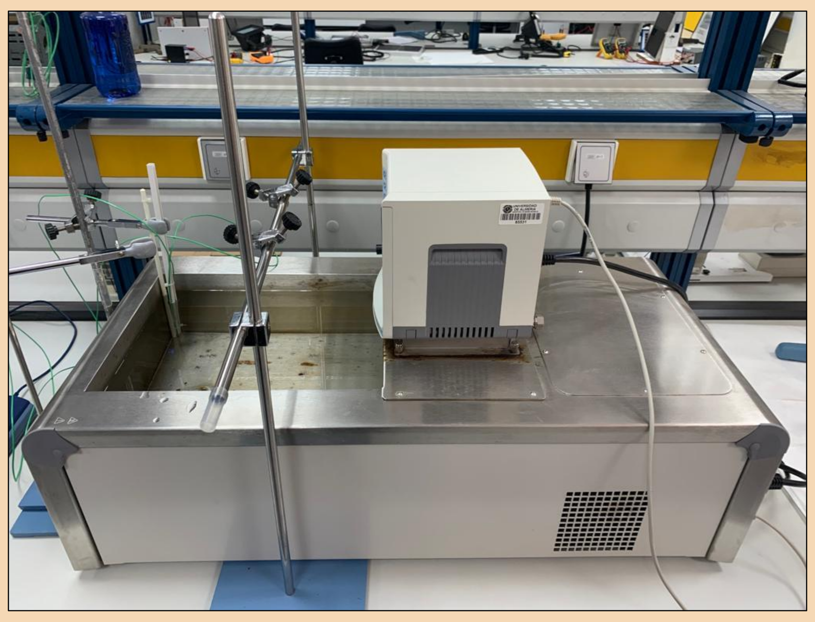
Phase change kinetics [7, -8 ºC]



heatSel capsule before and after preparation



Experimental setup



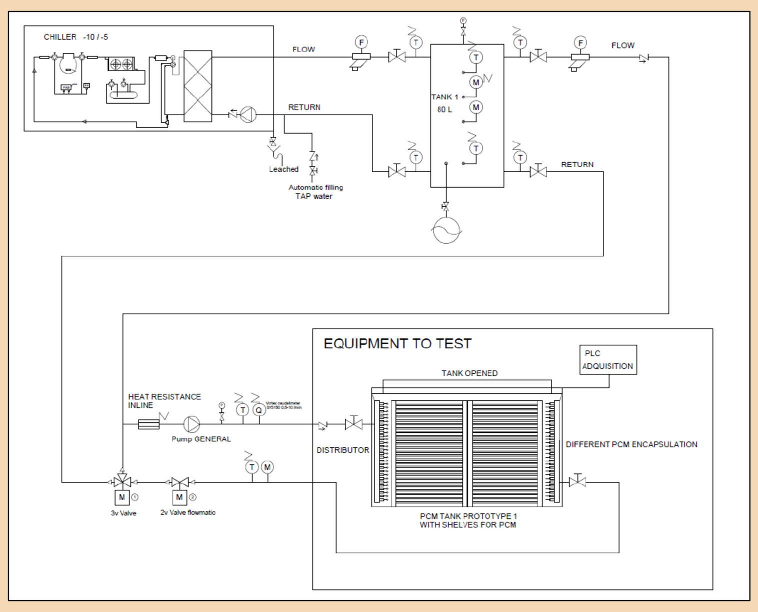
Cooling prototype of the cold storage tank

Chiller

Buffer tank

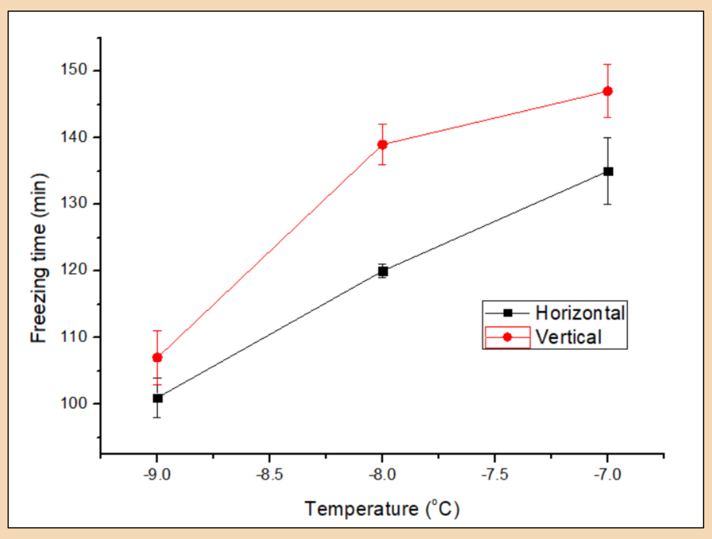
PCM storage tank

Scheme of the cold prototype

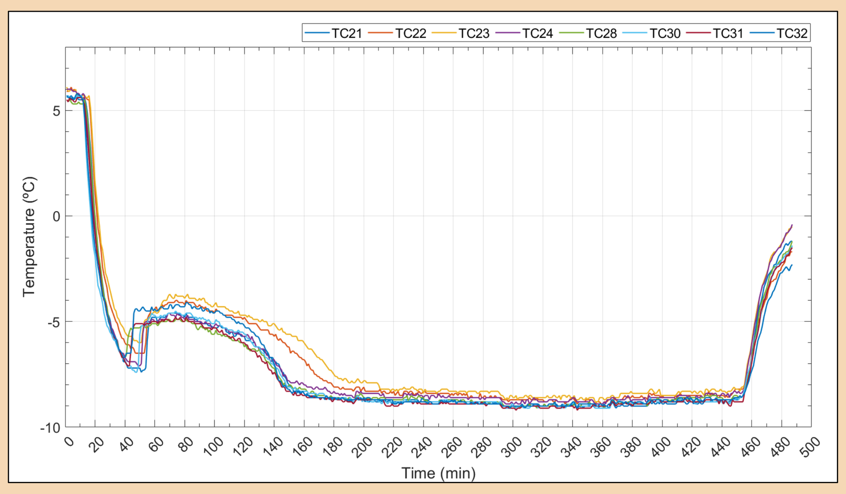


RESULTS

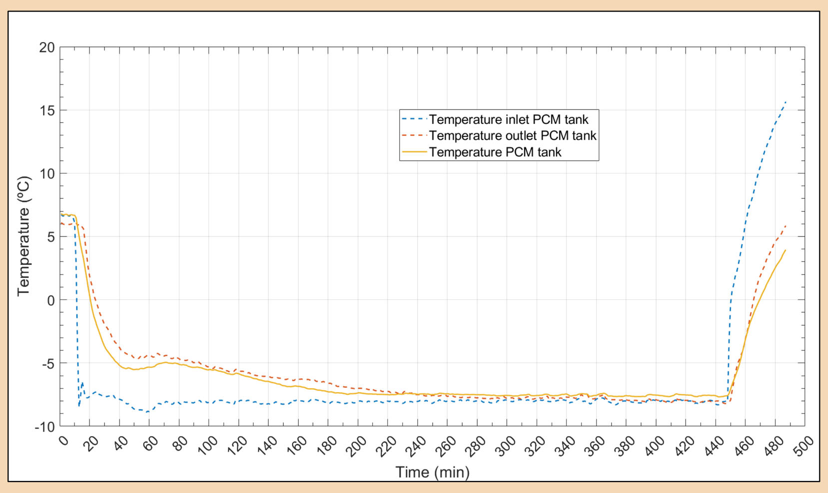
Evolution of freezing time as a function of temperature for heatSel



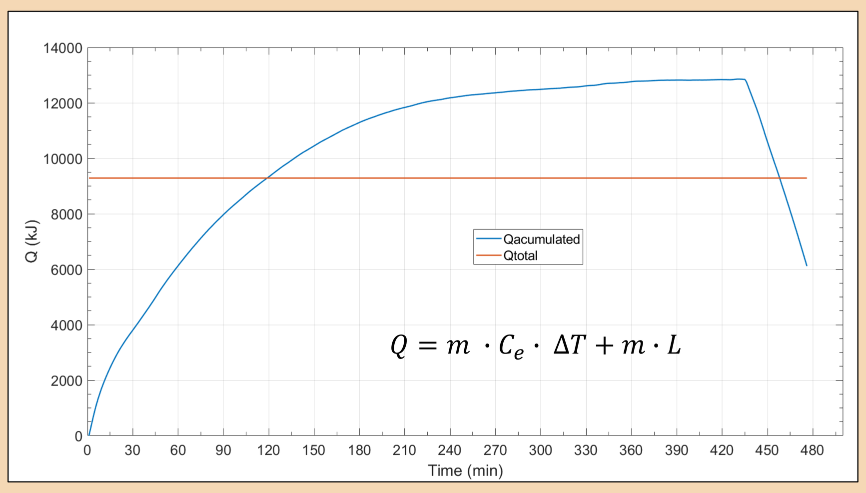
Evolution of the temperature in the surface of the PCMs



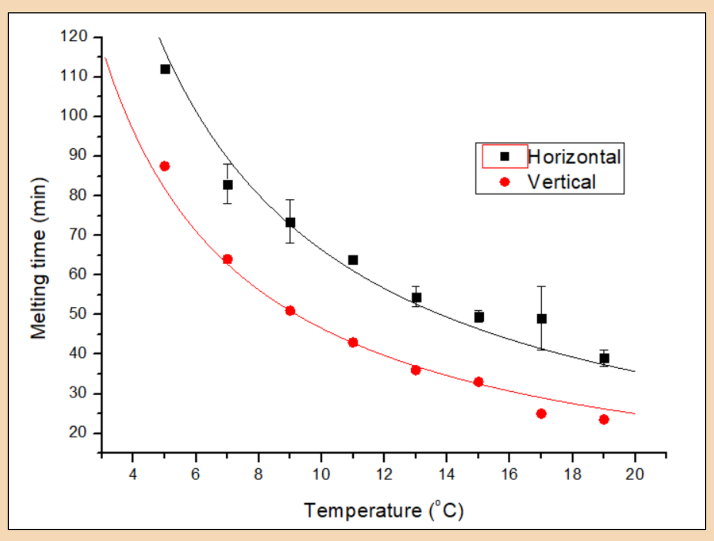
Evolution of the inlet, outlet and tank temperatures



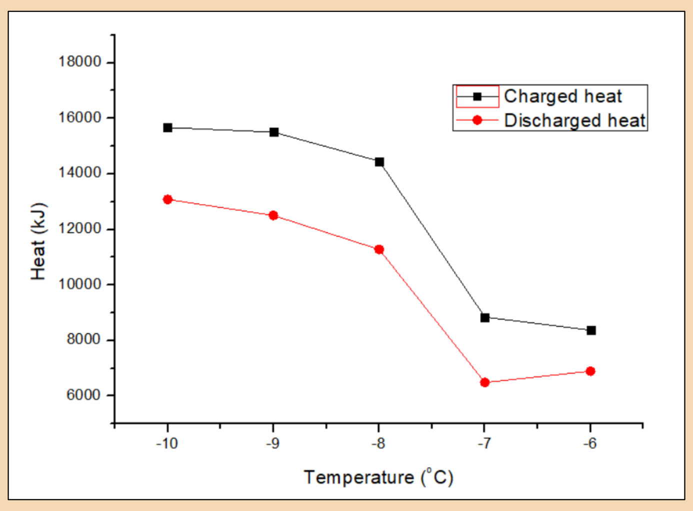
Evolution of the heat stored during loading and unloading (blue line) and maximum theoretical heat (red line).



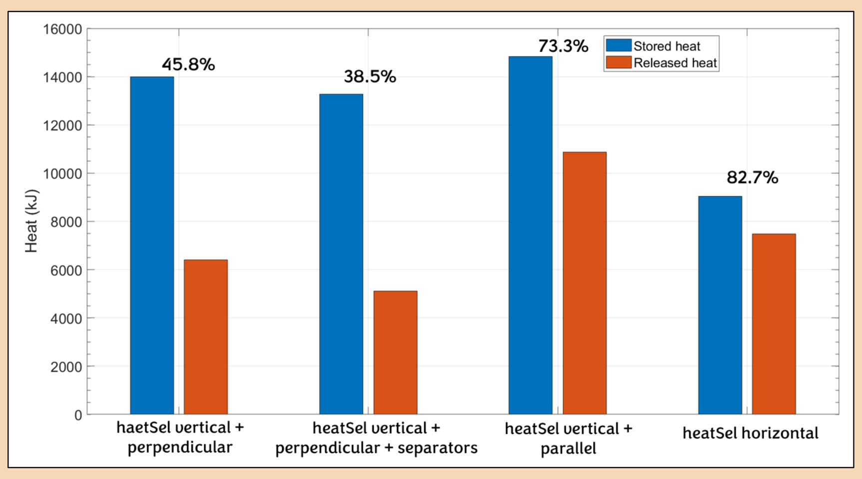
Evolution of melting time as a function of temperature for heatSel



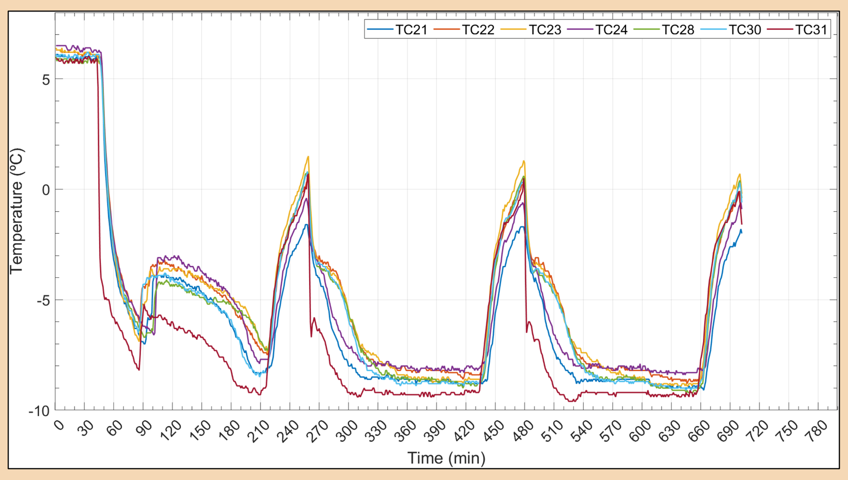
Evolution of the heat stored during loading and unloading as a function of the temperature



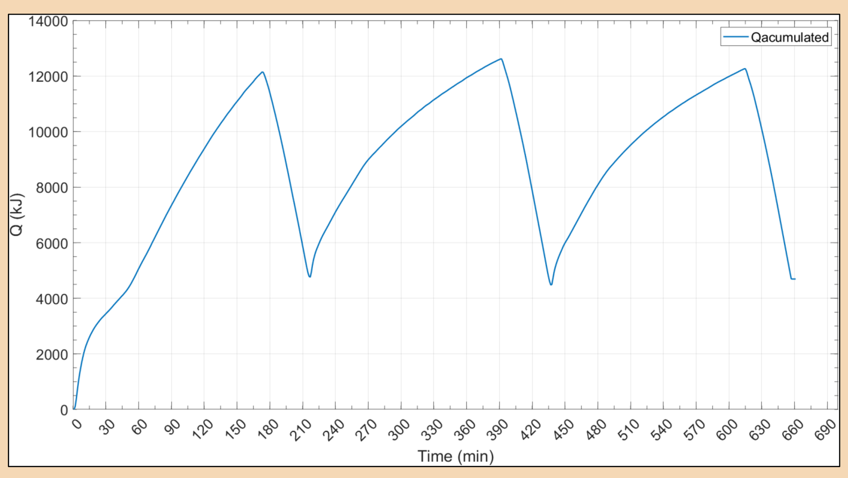
Comparative graph of the different heatSel configurations tested



Evolution of the temperature in the surface of the PCMs during continuous loading and unloading



Evolution of the acumulated heat in the PCM tank during continuous loading and unloading



CONCLUSIONS

1. In basic studies, the temperature of the bath has been varied during freezing and melting, showing that above -7 ºC the nodule does not freeze.
2. In the PCM tank, we can operate at a maximum of -8 ºC, above this temperature not all moritorized PCMs freeze.
3. Different configurations of the heatSel have been studied, the optimal being parallel and vertical to the flow, obtaining up to 73% heat recovery after discharge.

ACKNOWLEDGEMENT

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