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

A. Castro-Vizcaíno[1], M. S. Romero-Cano[1], J. L. Bosch-Saldaña[1], J. Alonso-Montesinos[1] M. J. Ariza[1], F.J. Batlles[1], A.M. Puertas[1], K. Babul[2], B. Gil[2,] S. Rosiek[2]

[1] Departamento de Química y Física, Universidad de Almería, E04120 Almería, Spain and Centro de Investigaciones de la Energía Solar (CIESOL), Universidad de Almería-CIEMAT, 04120 Almería, Spain
[2] Wrocław University of Science and Technology, Faculty of Mechanical and Power Engineering, Department of Thermodynamics and Renewable Energy Sources, Wybrzeże Wyspiańskiego 27, 50-370, Wrocław, Poland

acv167@ual.es

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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 carrying out the analysis of 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.

Figure 1 shows the cooling prototype together with the thermal storage tank. The control program records around 50 variables, 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.

Because the conditions of the building require operating temperatures below 0ºC, a commercial PCM with a freezing point of -3 ºC was purchased in capsules of different shapes and placed in a pilot tank of 60 liters, used as storage system. The results show that as the charging temperature decreases, the system is capable of storing and releasing a greater amount of heat, reaching a plateau at -8 ºC. By modifying the HTF flow rate, we observe that during charging the system works better for higher flows while for discharging we obtain better results with lower values. In the same way, during discharge the system is capable of absorbing more heat when a lower resistance thermal load is applied. Calculating the (negative) heat stored in the load, the heat released and performance for the different configurations, a maximum percentage of energy recovery of 78% has been obtained.

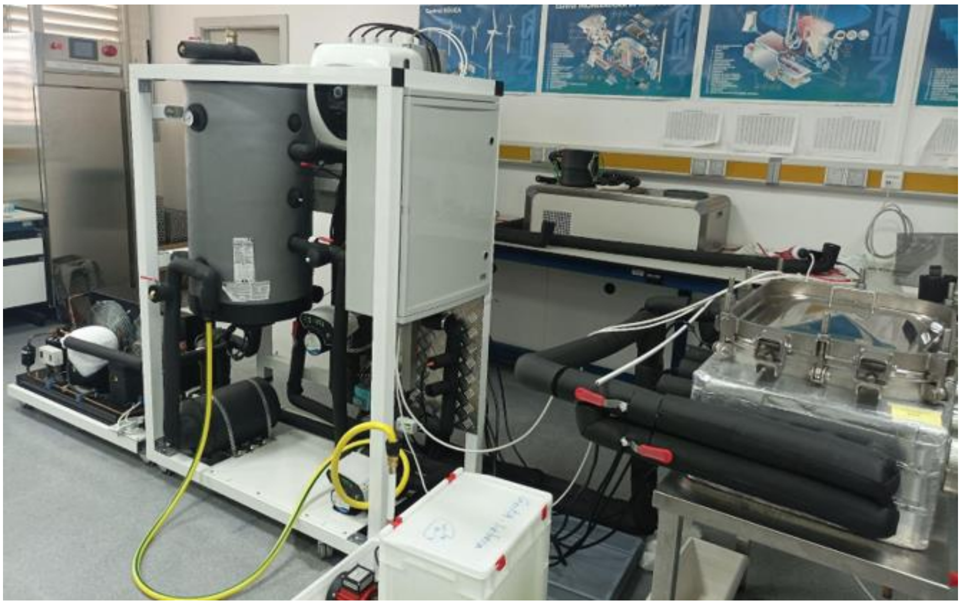

Figure 1. Photograph of the cold prototype and storage tank.

This study is complemented with modelling at different levels: i) a theoretical modelling of the freezing/melting process inside the nodules using the heat equation, ii) finite element simulations for the tank with the PCM capsules and flowing HTF, and iii) thermodynamic modelling of all the elements of the prototype (including HTF buffer, pumps, valves…). The comparisons of experimental results and models allow more reliable predictions for the thermal storage system to be installed in the CIESOL.