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INNOSTORAGE – USE OF INNOVATIVE THERMAL ENERGY STORAGE FOR MARKED ENERGY SAVINGS AND SIGNIFICANT LOWERING CO_2 EMISSIONS

Beneficiaries:

Partners:

D7.2 - Report on Staff Exchanges

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Contents

1 Objectives

The main research objective is to study the applicability of PCMs as a mean to keep cold storage units, which are heated by the ambient, at a lower temperature for longer periods than conventional insulation techniques. This will be studied experimentally, theoretically and numerically for different storage conditions. Agreement between the experimental and numerical results will make the numerical simulations valid for optimization of the PCM cold storage according to any given conditions. The project is related to Tasks 3.1, 3.3, 4.1, 4.2 and 4.4. A secondary goal is to discuss about further collaborations and share different ideas for research.

2 Introduction

Phase-change materials (PCMs) are advantageous for thermal energy storage (TES) due to their high energy density and relatively constant temperature during the phase-change process. These properties can be useful for different industrial applications related to TES.

One application is related to transportable cold storage containers which suffer from heating by the ambient. The use of various insulating materials and their performance at different conditions has been studied in the past, both experimentally and numerically [1-4]. This type of systems are characterized by an increasing temperature of the storage due to sensible heating by the ambient. A possible solution that will allow an almost constant temperature at the inner part of the container is replacing some of its insulation with a PCM. It has been shown in [5] that this solution can extend significantly the storage time of the products in the container. Also, containers for ice cream, which were enhanced by PCM, were studied both experimentally and numerically, finding them effective for at least 3 hours [6].

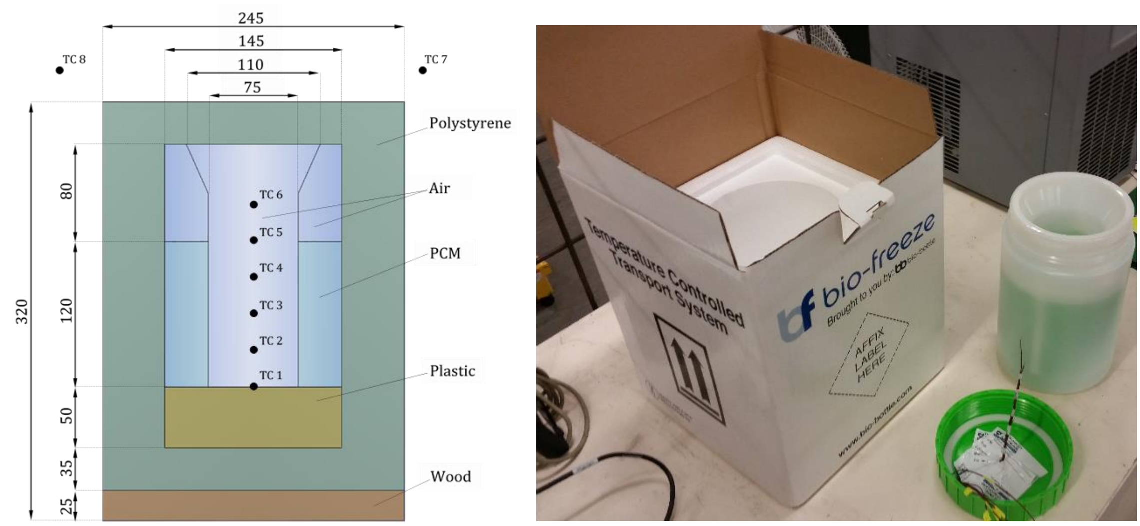
The current research will explore both experimentally and theoretically the use of PCM combined with conventional insulation as a possible solution for cold storage of transportable containers. The results will allow optimization of a container which will guarantee a low storage temperature for a maximal time.

3 Description of work

Two different packages with different PCM types and dimensions, supplied by the University of Auckland group, are tested experimentally. Temperature measurements in several locations and in various conditions are analysed. The results are validated by numerical models which are accompanied with theoretical analysis developed by the Ben-Gurion University group. The influence of different physical phenomena on the numerical results is tested in order to find the most essential ones for proper modelling. Various modelling techniques, analytical and numerical, are utilized to assess the package performance.

4 Materials and Methodology

Two different PCM packages are tested experimentally. The packages have dimensions of 32×25×25 cm and 50×50×50 cm with PCM melting temperatures of about -10 °C and -33 °C, respectively. Figure 1b shows the smaller package which includes a cylindrical container with a double plastic wall filled with an aqueous solution as PCM. Eight thermocouples monitor the air temperature distribution in the container and the ambient, as shown in Fig. 1a. In a typical experiment the container is held in a refrigerator at -18 °C or -70 °C for more than 36 hours until the PCM is completely solidified, then the container is sealed with a cover and inserted to the insulated package which is exposed to the ambient temperature.



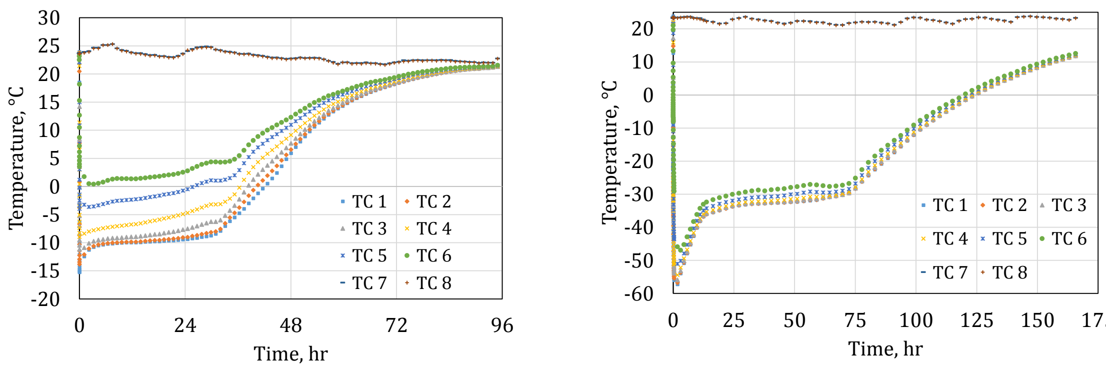
(a) (b)

Figure 1. The cold storage package: (a) schematics and thermocouple locations. (b) The insulated package, the container and the cover.

5 Results

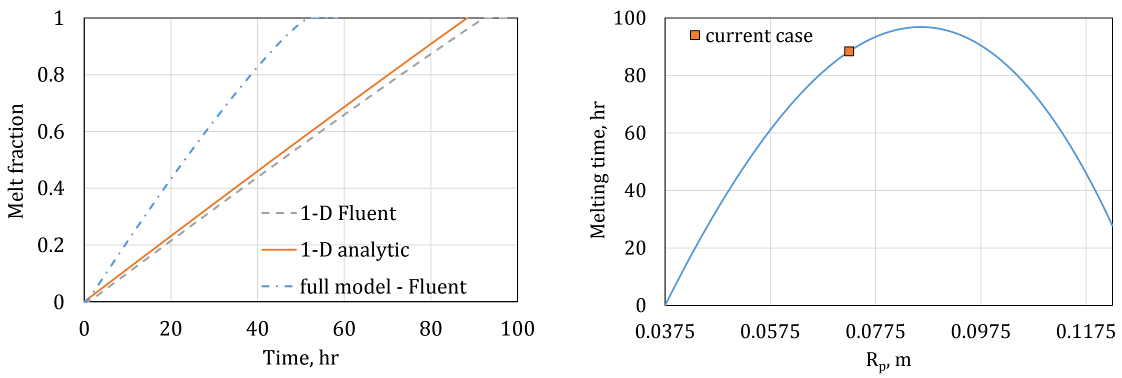
The results include experiments performed on the two packages and modelling with analytical approximations and CFD models. Figures 2a and 2b show the air temperature distribution along the height of the container together with the air ambient temperature for the smaller and bigger package, which were initially cooled to -18 °C and -70 °C, respectively. Both packages allow a long period of above 24 hours for storage below 0 °C.

The numerical results include three different models, Figure 3a compares the melt fraction predicted by the approximate analytical model and two other CFD models. Figure 3b shows the melting time as a function of the PCM thickness predicted by the analytical model for the smaller package. The results show that there is an optimal PCM thickness for the maximal melting time which will allow the longest storage period at a low temperature.



(a) (b)

Figure 2. Experimental temperature measurements for: (a) the smaller package. (b) The bigger package.



(a) (b)

Figure 3. Theoretical results: (a) the predicted melt fraction for the different models. (b) The melting time with variation of the PCM thickness.

6 Outcomes or future work

This is an ongoing research, hopefully there will be more experimental and numerical results that will be used for optimization of the packages under various conditions and reveal the different features associated with this type of cold storage. It is also has been found that there is an optimal PCM thickness which allows maximal storage time at a low temperature which can be predicted analytically. This work can be developed even further, with more elaborate modelling techniques that will show better agreement with the experimental results.

7 References

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8 Assessment

The secondment gave me an opportunity to exchange ideas and work with one of the world-leading groups in phase-change processes study. The collaboration enriched my world-view as a researcher and exposed me to different innovative ideas. I have learned much on different aspects in the field such as cold storage and insulating applications. Not only that new frontiers in PCM research were explored in this collaboration, but this secondment allowed me to expand my own horizons.