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

Beneficiaries:

Universitat de Barcelona

Universitat de Lleida

Université de Lyon

Ben-Gurion University of the Negev

Partners:

The University of Auckland, New Zealand, Te Whare Wananga o Tamaki Makaurau

University of South Australia

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D7.2 - Report on Staff Exchanges

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Seventh Framework Programme

Marie Curie Actions

Contents

Objectives

The objective of this secondment is to experimentally investigate and demonstrate the improvement on the heat transfer of the dynamic melting concept in a cylindrical shell-and-tube heat exchanger using water as PCM and compare the results and statements with the numerical ones obtained in a previous study by Tay et al. [1].

Introduction

Latent heat thermal energy storage (LHTES) systems have been widely studied and the benefits on improving the thermal performance because of their high energy storage densities and almost isothermal operating characteristics have been demonstrated during the last few years [2]. However, the low thermal conductivity of the most extensively studied phase change materials (PCM) reduce the fully implementation of these systems at the industry.

Several research have been focused on the implementation of heat transfer enhancement techniques, such as adding high conductive extended surfaces and combining high conductive materials with the PCM, in order to overcome the low thermal conductivity problem [2]. Recent studies try to demonstrate the thermal performance enhancement by moving the PCM while undergoing phase change [1],[3]-[5], also referred as dynamic melting or heat flux. This technique consists on creating melted paths in the PCM around the heat transfer area during the charging process. Once they are created, the liquid PCM is recirculated using a pump, which can be used to control the PCM flow rate and therefore the heat transfer rate. The continuous movement and mixing of the PCM not only increases the overall heat transfer, reduces the charging process and increases the effectiveness of the system, but also avoids phase segregation and PCM degradation and increases the compact factor.

Description of work

An experimental set-up designed and built at the University of South Australia was used to perform the experimentation shown in the present report. The set-up consists on a shell-and-tube heat exchanger connected to two different heat transfer fluid (HTF) storage tanks depending on the charging/discharging processes. The tank is composed of two concentric tubes. The interior tube is made of stainless steel, has a length of 926 mm with an outer diameter is 25.4 mm The outer tube is made of clear polycarbonate, which allows an easy visual inspection of the tank and photographic record of the process, has a length of 926 mm, with inner and outer diameters of 94 mm and 100.6 mm. A single melted pathway is formed around the heat exchange tube allowing for melted PCM to be pumped out of recirculation outlet tubes at the bottom of the tank and returned through inlet tubes entering the top of the tank. Temperature measurements will be taken by resistance temperature detectors (RTDs) within the tank and by RTDs at the inlet and outlets and measurements recorded by the datalogger.

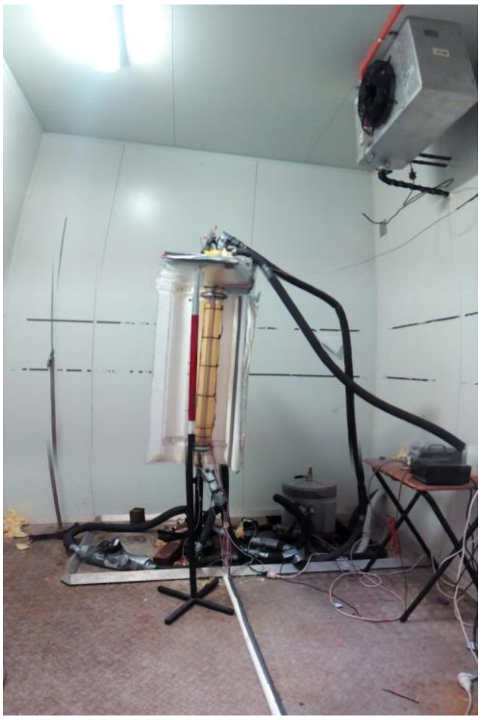

Fig. 1. Shell-and-tube heat exchanger used in the present experimentation.

Materials and Methodology

- <u>Materials</u>

Water was used as PCM and Dynalene HC-50 as HTF.

- <u>Methodology</u>

The experimentation consisted on different charging (melting) and discharging (freezing) at a temperature range between -5 ºC and 10 ºC. The HTF flow rate was set at a constant value of 1 L/min for all the experiments carried out and only the PCM flow rates to perform the static and dynamic melting were modified, setting them up at 0, 0.5, 1 and 2 L/min.

Results

Table 1 shows the most important results obtained during the present experimentation.

Table 1. Summary of the most important results obtained during the present experimentation

HTF flow rate	PCM flow rate	Variation Average effectiveness	Variation Phase change duration
Experimentation without dynamic melting			
1 L/min	0 L/min	-	-
Experimentation without dynamic melting			
1 L/min	0.5 L/min	-6.27 %	-110.66 %
1 L/min	1 L/min	29.31 %	-114.99 %
1 L/min	2 L/min	76.29 %	-323.89 %

The following conclusion can be obtained:

- The dynamic melting concept decreases the phase change duration in all cases, being the higher decrease in the case where the PCM flowrate was higher.
- An increase in the effectiveness can be obtained when the dynamic melting concept is implemented when the PCM flowrate is equal or higher than the HTF flowrate,
- The heat gains during the PCM recirculation can diminishes the heat transfer between the PCM and the HTF.

Outcomes or future work

It is expected that at least one paper will be published from the experimentation carried out during this research stay. Moreover, further research will be carried out implementing other enhancement techniques in this experimental set-up.

References

[1] Tay, NHS, Belusko M, Liu M, Bruno F. Investigation of the effect of dynamic melting in a tube-in-tank PCM system using a CFD model. Appl Energy. 2015; 137:738-47

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[4] Pointner H, Steinmann WD, Eck M. Introduction of the PCM flux concept for latent heat storage. Energy Procedia. 2014;57:643-652.

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Assessment

This secondment has been a great opportunity on working during three months with worldwide well-known researchers in the field of thermal energy storage. I could work on a different environment and with different working methods from the ones I was used to. Very enriching discussions allowed both University of Lleida and University of South Australia research groups to work on demonstrating the benefits of the dynamic melting concept in fields which are going to be presented during the year 2016.