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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
AUBURN UNIVERSITY

D7.2 - Report on Staff Exchanges

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SEVENTH FRAMEWORK PROGRAMME
MARIE CURIE ACTIONS

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1 Objectives

UniSA has been conducting research into PCM thermal storage systems for nearly two decades. The purpose of this exchange was to meet the researchers of UDL and enhance collaboration between UniSA and UDL.

Through the previous visit of A/Prof. Segarra and Prof. Fernandez from UB to UniSA, we have established a collaboration on high temperature PCM corrosion testing. The second objective of the secondment was to cement collaboration between UniSA and UB.

2 Introduction

Latent heat storage using phase change materials (PCMs) offers a highly effective method to store thermal energy generated from renewable energy resources, such as solar and wind. UniSA is developing a cost effective high temperature PCM thermal storage system for concentrated solar power (CSP) application. However, most of the salt PCMs have low thermal conductivity, which limits the heat transfer particularly during discharge. The technologies allow for the heat transfer improvement include increasing the heat transfer area by encapsulation, adding high conductive materials, adding heat pipes, using mobile systems and cascaded systems. Both UniSA and UDL are interested in using nano/micro particles as additives in the PCM to increase its thermal conductivity. Recently, graphite has been studied extensively as a heat transfer enhancer due to its high thermal conductivity [1,2]. For high temperature application, it is proved that the thermal conductivity of Solar Salt is increased by a factor of 10 with 20% of graphite [3]. Nano-particles has been used to enhance the specific heat capacity, thermal conductivity and density of the base fluid. If they can be successfully composed into the PCM, the heat transfer area required will be reduced and hence the cost of the storage unit will be reduced.

Compatibility of containment materials with molten salt PCM is a significant technical challenge in developing a cost-effective storage system. Most operational plants use Solar Salt for storage, which is relatively compatible with common stainless steel grades such as 304, 316 and 347 at high temperatures. PCM candidates considered for CSP applications contain carbonates, sulphates, chlorides, hydroxides, their eutectics or mixtures. Corrosion in molten salts is a very complex issue, encompassing many aspects of chemistry, metallurgy and thermodynamics. As yet, the mechanisms of corrosion in various salts are not fully resolved and the effects of different alloying elements are ambiguous. Additionally, how containment materials will be affected by the thermal cycling and mechanical loading required for a PCM system is almost totally uninvestigated and will be critical for providing safe and cost effective solutions for thermal storage. UniSA and UB have established a collaboration on high temperature PCM corrosion testing through the previous visits of A/Prof. Segarra and Prof. Fernandez.

3 Description of work

The problem with the added particles in the liquid PCM is the settling due to the density difference. UniSA has constructed a coil-in-tank test rig with agitation, which will move the liquid portion of the PCM and continuously mix the particles with PCM. The nano/micro particles with agitation for high temperature PCMs will be investigated at UniSA. Testing of nano/micro particles with low temperature PCMs will be carried out at UDL.

There are a number of different methods for determining corrosion rates. By far the most common one is the gravimetric analysis i.e. mass loss. By comparing the initial and final weights of a sample, and the time over which it was tested, a rate of mass loss can be determined. A test rig was set up at UB to evaluate the weight loss of the metal samples after the corrosion test. The corrosion test was carried out at UniSA and the corrosion rate will be evaluated using the test rig built at UB.

4 Materials and Methodology

The concept of adding nano/micro particles into PCMs with agitation requires further investigation to warrant its application in large-scale. The laboratory-scale tests will be conducted at UDL and UniSA. A research plan was developed to achieve this objective.

Eutectic PCMs based on nitrates, carbonates and chlorides are the most prospective PCMs in term of their high latent heat of fusion and the low cost. Currently UniSA works more on the carbonate PCMs. How the containment materials will be corroded by the PCM is very critical in order to provide safe and cost effective storage system. The isothermal corrosion test has been conducted at UniSA and the corrosion rate will be determined at UB. In the future, the thermal cycling test will be carried out and the cycling effect on corrosion behaviour will be studied.

5 Results

The investigation of nano/micro particles and agitation in PCMs will involve the following tests and it will be conducted at UDL and UniSA over the next few years. A small test rig will be designed and constructed at UDL, which will be used to measure the effective thermal conductivity of the PCM with/without additives. A PCM with a melting point of around 50 ◦C will be used to verify the test rig. UniSA has constructed a coil-in-tank test rig with agitation and a high temperature PCM with a melting point of 306 ◦C will be used. The rig will be tested with/without agitation and with/without additives to demonstrate the improvement of heat transfer when involving PCM movement and additives.

The corrosion effects of molten salt PCMs on common containment materials (e.g. SS304 and SS316) will be studied at UB and UniSA over the next few years. The PCMs under investigation will include carbonates, chlorides and/or metal alloys. Both isothermal and cycling tests will be conducted and the corrosion rate evaluation will be carried out at UB and UniSA. The scanning electron microscope with X-ray diffraction technique will be used to examine the corrosion type and mechanisms and it will be carried out at UB.

6 Outcomes or future work

Overall the objectives of the research exchange has been achieved and a deeper research relationship has been established. A joint conference paper is planned to be presented in 2016. The work described in previous sections will be continued in the next few years.

7 References

[1] Zhang P, Song L, Lu H, Wang J, Hu Y. The influence of expanded graphite on thermal properties for paraffin/high density polyethylene/chlorinated paraffin/antimony trioxide as a flame retardant phase change material. Energy Conversion and Management 2010;51:2733–7.

[2] Lopez J, Caceres G, Palomo Del Barrio E, Jomaa W. Confined melting in deformable porous media: a first attempt to explain the graphite/salt composites behaviour. International Journal of Heat and Mass Transfer 2010;53:1195–207.

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8 Assessment

Through this research exchange, I have the opportunity to meet the researchers from UDL and UB and established the research collaboration with them. The collaboration projects will expand the research capabilities in all three institutes in the field of PCM thermal energy storage. As a result, our collaboration will help in acquiring further research funding.