Annex 17

Advanced thermal energy storage through phase change materials and chemical reactions - feasibility studies and demonstration projects

Title of the project **Thermal energy storage with phase change. Experimental procedure**

Keywords (max 3 words) **Experimental, free-cooling, paraffin**

Contact person: Name: **Belén Zalba**
Address: **University of Zaragoza**
Phone : **+34976762566** Fax : **+34976762616** e-mail : **bzalba@unizar.es**

Institutions involved / Industry collaboration: **Trox, Basf, Cepsa-Petresa, Repsol, Rubitherm**

Type of project:
(mark the appropriate)
Demonstration project
x feasibility study
x experimental work
simulation study
other (specify):

Purpose (max 100 words)

The objective of the work was to design and construct an experimental installation to study PCMs with a melting temperature between 20-25°C. This installation could lead to a feasibility study of a free-cooling installation to store outdoors cold during night and release it indoors during day. This concept is feasible in climates where the temperature difference between day and night in summer is over 15°C. This was demonstrated studying the main influence factors by a Design of Experiments, and concluded with the development of an empirical model and the design of a real free-cooling system.

Budget (including: governmental grant / industry collaboration / manwork / rental of room and utilities)

49.000 euros

Summary (max 250 words, you may include pictures)

The experimental setup used is a closed air circuit, with fans to move the air, a heating and cooling device to set the air at the right temperature and a thermal energy storage. Several PCMs have been tested during the presented work, but finally only two were selected. One was a molecular alloy with 34% C16 and 66% C18, with a melting temperature of 19,5-22,2°C, and the other one was RT25 from Rubitherm, with a melting temperature of 20-24°C. The thermophysical properties of the materials were studied with different methods: adiabatic calorimeter, energy balance, DSC, andT-history method.

Using the technique of design of experiments, three different responses where analyzed: ratio energy/volume, load/unload rate, and cost of the installation. Of the three responses two were fixed, ratio energy/volume and cost of the

installation, and the load/unload rate was measured. The factors considered in the design of experiments were: PCM, thickness of the encapsulates, temperature of the air, and air flow. The experiments to be done were, following a DOE 23, 8 of the process of solidification and 8 of the process of melting.

From the results the following conclusions can be considered:

- **The tendency of the curves were as expected: the process was faster when the thickness of the encapsulates was lower, the temperature difference between air and melting temperature of the PCM was higher, and the air flow was higher.**
- **The heat transfer curves showed two steps in the process: a first step with low conductivity resistance (and therefore the air convection being the dominating heat transfer phenomena), and a second step with a higher thermal resistance.**
- **Although the encapsulates with smaller thickness gave a faster melting and solidification process, it can be seen that thickness optimization is possible.**

A statistical analysis was conducted to determine effects and significant interactions of the variables studied. Once the significant factors and interactions were known, an empirical model with multiple regression analysis was elaborated. Taking into consideration the effects and interactions with influence in the results, and the data of the experiments, an empirical model was developed.

With the results from the results, a real installation was designed. The storage device was designed with a capacity of 3.000 W, with an inlet temperature during night of 16°C for 4 hours, and an inlet temperature during day of 30°C.

Economical evaluation

An economic analysis of the system was carried out. All the materials were considered to be part of a serial production.

A viability analysis of the system was performed comparing the storage system with a conventional refrigeration system with similar power. The chosen system is a conventional split equipment. The comparison between the two systems says that the storage system needs an additional inversion of 9%, has a pay-off period of 3 to 4 years, and an electric power 9,4 times lower than the conventional one.