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Modelling and experimenting thermal energy storage through the use of PCM in low thermal inertia office

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***Abstract*—Within the scope of this thesis, thirty DuPont Energain thermal mass boards were tested inside a shipping container located in Oeiras, Portugal. These phase change material (PCM) boards have a 21.7 °C melting point and they were experimented during August (Summer) as internal mass due to a structure specifically designed for this project. Results showed that these latent heat storage systems induced an indoor peak temperatures shift of three hours and a slight indoor temperatures reduction. An EnergyPlus model was validated using measured data and several parametric studies were made using this model. In this case, it was found that the best solution for this low thermal inertia enclosure was incorporating forty eight panels with 10 mm of thickness and a melting point of 20 °C. Although these panels have a payback period of thirty two years, in the future it can fall into a more acceptable value of five years.**

***Keywords*—phase change material, thermal inertia, thermal energy storage systems, buildings applications**

I. Introduction

Is the world spinning too fast? Large newspapers headers have been concerning world population but has it been enough to spark new habits on energy consumption? Some new studies on this matter say the opposite. Recent forecasts affirm that by 2050, energy consumption would have risen around 80% in respect to the value registered in 2010 of which more than 35% is due to space heating and cooling [1].

In this sense, an effort to discover reliable pas- sive cooling/heating strategies that could take over the ones that use conventional sources of energy have been done. Thermal energy storage (TES) systems are among those and are divided into three main groups: (a) sensible heat storage, (b) latent heat storage and (c) thermochemical heat storage. TES systems are mainly latent heat storage systems since this type of thermal energy predominates over sensible and, thermochemical is at an early stage. In latent heat storage, the amount of heat stored, Q, depends on the mass of the material, m, the frac- tion of melted material, am, and the latent heat of fusion per unit of mass, Δh_m (Eq. 1) [2].

$$Q \cong ma_m + \Delta h_m \tag{1}$$

Latent heat storage systems are usually sub- stances that absorb and release latent heat when a phase change occurs and, for this reason, they are called phase change materials (PCM).

In order to be effective latent heat thermal energy storage (LHTES) systems, PCM should satisfy several features. In terms of thermophysical properties, these materials must have high latent heat of fusion per unit of mass or volume, high thermal conductivity, no segregation, small volume change, high specific heat capacity, high volumetric mass density and a congruent melting. In terms of kinetic properties, although they should not suffer from supercooling, a high nucleation rate, a high rate of crystallization and a long term thermal stability are desirable. Moreover, chemically speaking, PCM should have complete reversible melt/freeze cycles, compatibility with constructions materials, no toxicity, no flammability and no corrosiveness. Lastly, these materials should be abundant, cost effective, recyclable and should not have an environ- mental impact's production [3, 4].

Furthermore, PCM can be classified according to their nature or phase change. The first classification split up PCM into eutectic, inorganic and organic (paraffin and non-paraffin), whereas the second separate them into solid-liquid, solid-solid, gas-solid and gas-liquid. Among those, the most widely studied and commonly applied in building's cooling and heating strategies are organic paraffin and solid liquid PCM [4, 5].

PCM can be integrated into buildings envelopes employing three main techniques such us incorpora- tion

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