PCMS AS A TOOL FOR INCREASING THERMAL INERTIA IN BUILDINGS

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1 INTRODUCTION

It is well known, that energy consumed by the HVAC systems in buildings represents an important part of the global energy consumed in Europe (Directive 2010/31/EU). Latent heat storage has been widely studied (Cabeza et al. 2011, Zhou et al. 2012) for its potential in many applications for building energy management (Lim et al. 2014). Passive implementation of phase change materials (PCM) in buildings has demonstrated significant energy reduction of HVAC systems, but with some limitations (Castell et al. 2010). For this reason, active implementation of PCM in buildings has high potential. In this paper two innovative active systems are presented, consisting of thermal energy storage units embedded inside the two different parts of building components. A double skin facade and an internal slab were filled with PCM in order to act as a storage unit and a heating and cooling supply.

2 EXPERIMENTAL SET-UP

In the experimental set-up located in Puigverd de Lleida (Spain) several house-like cubicles were built to study different constructive systems and materials. Three of these cubicles are used to test the PCM active systems; one of them has a double skin facade with PCM, another one has an active slab as internal separation with PCM, and the third one has conventional constructive system acting as a reference. Both technologies presented in this paper are designed to cover the cooling and heating demand of a building. A structural component of the building is used as a storage unit with an active charge and discharge process for covering the energy demand of the building. The novelty of the system is the inclusion of phase change materials (PCM) inside the storage unit in order to increase the heat storage capacity.

3 OPERATING PRINCIPLE

3.1 Double skin facade with PCM

The ventilated facade acts as a solar collector during daytime in winter season (Figure 1, left). Once the PCM is melted and the solar energy is needed by the heating demand, the heat discharge period starts. The openings drive the air flowing from indoor to the facade cavity, where it is heated up by the PCM panels and sent it back into the cubicle. On the summer mode (Figure 1, right) the PCM is solidified by the outside air which is pumped into the channel during night time. The air is cooled down by the PCM and is pumped to the inner environment providing cooling supply. The air flow from outdoors to outdoors prevents the overheating effect in the air channel when there is no more cooling supply available. Moreover, night ventilation mode could be also performed to achieve a free cooling effect.

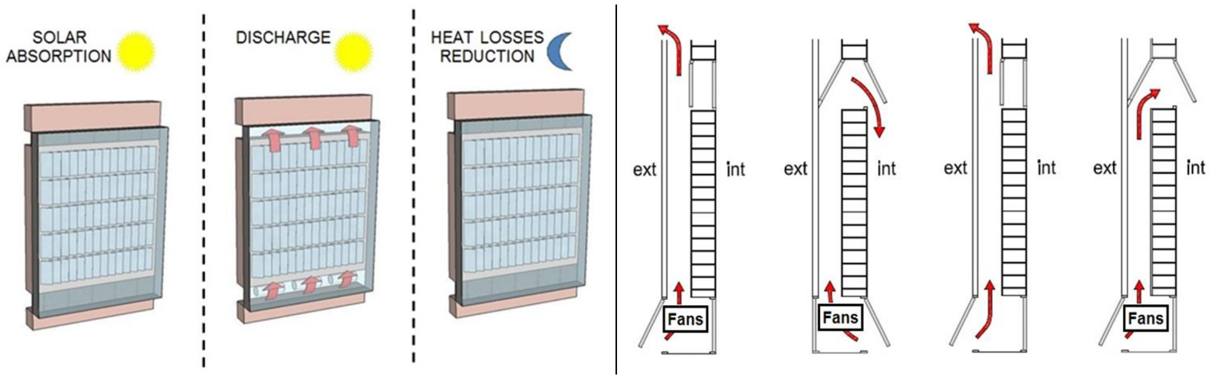

Figure 1: Operating principle double skin facade; left winter, right summer.

3.2 Active slab with PCM

In winter season, the active slab (Figure 2a) is charged during daytime through the injection of hot air from the solar air collector. The thermal energy is stored inside the slab until a heating demand is needed. The air of the internal ambient is pumped through the hollows of the slab and the heat exchange with the PCM provides the heat needed to cover the demand totally or partially. On the other hand, operational mode during the summer period (Figure 2b) outside cool temperature at night is used to cool down the concrete slab and to solidify the PCM by the circulation of outdoors air through the hollows. During daytime, the inner air of the cubicle is pumped through the slab getting a cooling supply and covering part or the whole cooling load. The operational schedule of both winter and summer periods are driven by a control system.

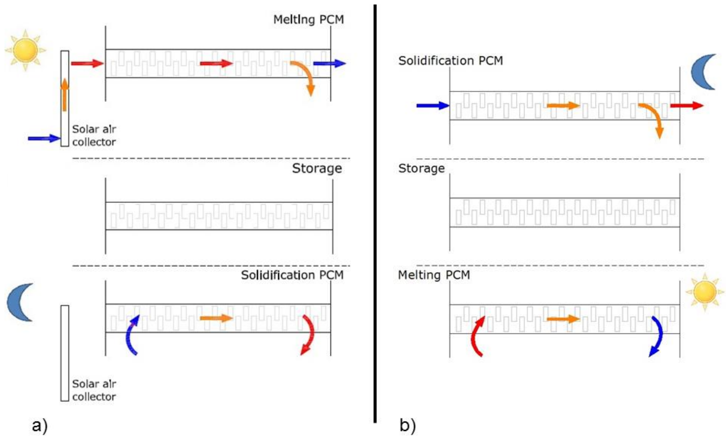

Figure 2: Operating principle active slab (a) winter and (b) summer.

4 RESULTS AND CONCLUSIONS

The use of the ventilated facade with PCM reduces the electrical energy consumption of the installed HVAC systems even without using mechanical ventilation in the air cavity (De Gracia et al 2013). The active slab system registered also significant energy savings that highlight its potential.

During the summer tests, the high potential of the night free cooling effect was demonstrated in both systems for reducing the cooling loads. In both cases, double skin facade (De Gracia et al 2013) and active slab, the use of fans must be optimized to reduce the overall electrical energy consumption. The cold storage capacity of the systems is very sensitive to the outer night temperature, being limited under severe summer conditions. In the case of the double skin facade the system prevents successfully the overheating effect that could be found in the air channel.

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