SYSTEMS WITH PCM-FILLED RECTANGULAR CAVITIES FOR THE STORAGE OF SOLAR THERMAL ENERGY FOR BUILDINGS: THE CASE OF THE PCMS4BUILDINGS PROJECT

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Abstract *This paper provides an overview of the ongoing research project "PCMs4Buildings - Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings". The main goal of this project is to develop a holistic approach for the experimental and numerical evaluation of the thermal behaviour of new thermal energy storage (TES) systems with rectangular cavities filled with phase change materials (PCMs) for building applications. The project also intends to define full-scale prototypes to be numerically and experimentally optimized. "PCMs4Buildings" is a challenging project involving researchers from different scientific backgrounds, namely civil, mechanical and chemical engineering and two institutions: the Association for the Development of Industrial Aerodynamics (ADAI) and the University of Coimbra (UC). It also involves three research units, the Associate Laboratory of Energy, Transports and Aeronautics (LAETA), the Institute for Sustainability and Innovation in Structural Engineering (ISISE) and the Chemical Process Engineering and Forest Products Research Centre (CIEPQPF).*

1. FRAMEWORK

PCMs are materials that undergo melting/solidification at a nearly constant temperature. Therefore, they are very suitable for thermal management and TES applications (Figure 1). They also provide a large heat capacity over a limited temperature range (due to the latent heat involved in the solid-liquid phase change processes). Some PCMs have been identified in literature for integration in different TES systems and several ways of containment (in order to avoid liquid leakage) have been studied and optimized [1].

Commercial paraffin waxes to be used as PCMs in TES applications have typically low thermal conductivity which can be problematic regarding the efficiency of these elements. The incorporation of fins of high-conductivity material within rectangular macrocapsules containing PCMs has been one of the techniques used for containment and to improve the heat transfer through the PCM-bulk. These capsules can then be integrated in different TES systems such as PCM-enhanced concrete walls, PCM-bricks, PCM-shutters, PCM-window blinds, PCM-enhanced photovoltaic systems, PCM-enhanced solar panels, etc.

For these reasons, solid-liquid phase change in rectangular cavities is of great interest from the theoretical point of view and for the development of new TES systems.

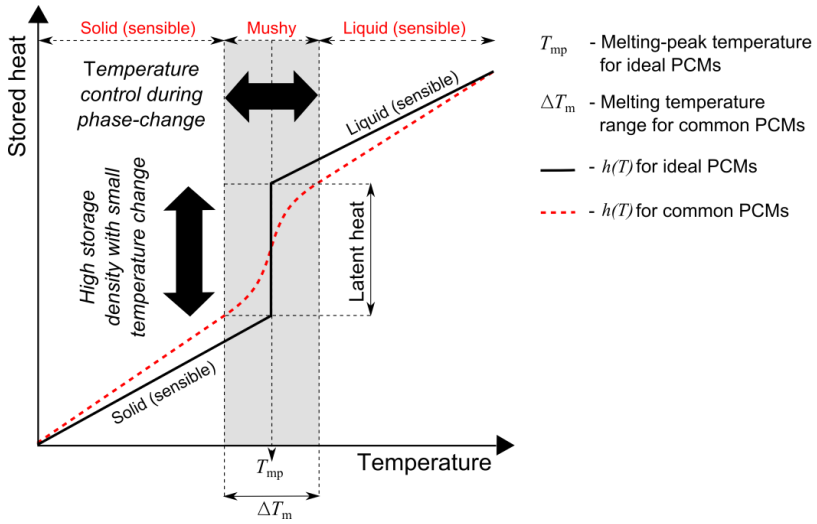

Figure 1. Potential fields of application of PCMs: (*i*) temperature control and (*ii*) storage and supply of heat with high storage density in a small quantity of material [2].

The specific goals of the 3-years project "PCMs4Buildings" [3] are: (*i*) to propose new TES systems for improving the energy performance of existing systems and/or to take advantage of solar thermal energy for reducing cooling and heating energy demand in buildings; (*ii*) to create an active multidisciplinary lab provided with the skills and equipments necessary to study new passive TES systems incorporating PCM-filled rectangular cavities for building applications; and (*iii*) to create a dynamic organization scheme to cover all the research steps necessary for the study of new TES systems, from the thermophysical characterization of the materials to the final experimental and numerical evaluation of the thermal performance of some prototypes. The problems to be studied lie in the mainstream areas of (*i*) the experimental and numerical characterization of the heat transfer through rectangular cavities filled with PCMs; (*ii*) the characterization of the thermophysical properties of PCMs; (*iii*) the CFD simulations considering solid-liquid phase-change processes; and, (*iv*) the experimental evaluation of the overall transient heat transfer through both small- and full-scale, non-homogeneous TES building structures. It is believed that the "PCMs4Buildings" project will give new and relevant contributions to the present knowledge in these research fields. Additionally, the team aims to be better positioned to participate in worldwide inter-laboratory studies and to join a network of research groups that today exchange not only samples to be characterized, but also researchers to potentiate the research carried out. The team will organize several national and international events to foster the dissemination of the results. These events are aimed to bring together researchers from different institutions, students and several companies in order to share experiences and to potentiate future research.

2. METHODOLOGY - MAIN TASKS

The research plan is composed by six main tasks (Figure 2): (*i*) thermophysical characterization of PCMs; (*ii*) numerical modelling and CFD evaluation; (*iii*) tests in the small-scale experimental setup; (*iv*) tests in the Guarded Hot Box apparatus; (*v*) definition of full-scale prototypes; (*vi*) technical seminars and workshop. Task 1 refers to the

evaluation of alternative methods for the thermophysical characterization of PCMs. Task 2 involves the numerical modelling of the heat transfer with solid-liquid phase change and the development of a CFD methodology for a detailed parametric analysis of the thermal behaviour of TES systems. Task 3 involves developing an experimental methodology to provide benchmarking data for numerical validation purposes, considering an existing setup designed to measure the transient heat transfer with phase-change through small-scale TES units. Task 4 involves adapting the existing Guarded Hot Box apparatus installed in the Civil Engineering Department of the University of Coimbra to evaluate the thermal performance of full-scale prototypes in a transient mode, and to provide experimental data for validating more complex CFD models. Task 5 involves the design of full-scale prototypes to be numerically and experimentally optimized. Task 6 involves organizing technical seminars and workshops to disclose the results achieved.

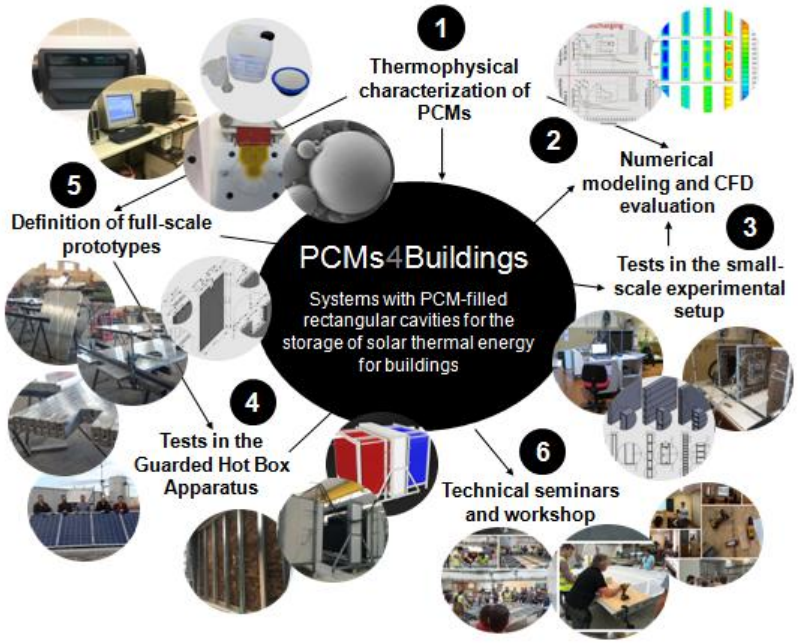

Figure 2. Dependencies and relationships among the main tasks of the project "PCMs4Buidings".

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