APPLICATION FOR A DOCTORAL RESEARCH GRANT FROM ED SIE (USMB)

SUBJECT OF THESIS: Characterization of the thermodynamic behavior of PCMs with supercooling reflecting the kinetics of crystallization during the charge-discharge cycles of a heat storage

ABSTRACT : In the building sector, the most widespread heat storage is sensible storage for systems (heating and domestic hot water) as well as walls. Latent storage is of real interest compared to sensible storage when the temperature variation during charge/discharge cycles is limited, and when space becomes a crucial problem (renovation, cost of m^2). Even if the additional cost related to the use of phase change materials (PCM) can in this case be justified, PCMs are ultimately used very little. One of the reasons is certainly the lack of reliable behavior laws of available PCMs which often exhibit complex behavior (supercooling, non-eutectic mixtures, etc.) for realistic conditions of use (partial charge-discharge cycles). Moreover, the need to replace PCMs from the oil industry with PCMs with low environmental impact reinforces this problem.

The scientific objective is thus to develop and identify by inverse method laws of thermodynamic behavior better reflecting the kinetics of crystallization when the PCM presents supercooling. These behavior laws involve a certain number of thermo-physical parameters which must be identified using energy balance equations or by inverse methods for thermodynamic characterization. On the one hand, it will be a question of proposing a set of complete cooling curves h(T) (enthalpy-temperature) allowing to consider the heterogeneity of the temperatures within the PCM at the very beginning of the crystallization. The behavior of the MCP during cooling will thus be defined locally rather than globally with a single cooling law. On the other hand, it will be necessary to propose new more efficient behavior laws during partial charges and discharges in order to better represent the crystallization kinetics specific to each PCM. Within the framework of the ANR EUROPA project, we were able to observe that the "curve scale" approach usually considered is not satisfactory and avenues for improvement have been proposed. During the thesis, it is planned to carry out analyzes of images obtained by X-ray diffractometer in order to make the link between the evolution of the structural states and the thermodynamic states obtained with the new behavior laws.

This characterization work will make it possible to analyze the role of supercooling in the efficiency of storage with PCM for the production of solar hot water. It will be possible to determine to what extent it is possible to exploit supercooling (reduced storage losses in the absence of withdrawal over several days), as well as the influence of supercooling during daily discharges.

The thesis work will focus on four main parts:

1. Bibliography study: biosourced materials and supercooling (laws of behavior and kinetics of crystallization)
2. Experimental study of PCM behavior with a thermodynamic and structural approach for a better understanding of supercooling phenomena
3. Identification of the thermodynamic behavior laws from the experimental data obtained
4. Influence of supercooling on the performance of a heat storage

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LOOKING FOR CANDIDATE

− Significant skills in numerical modeling and heat transfer
− Ability to handle an experimental device allowing to solicit a cavity containing the PCM, to measure the temperatures and heat fluxes, and to identify the behavior laws
− Skills in materials and crystallization kinetics would be highly appreciated
− Ability to integrate and work in a team

LABORATORY : LOCIE UMR 5271 (https://www.univ-smb.fr/locie/)

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(Send a cover letter + CV)

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