Analysis and Design Optimization of Latent Heat Thermal Energy Storage System based on Phase Change Material Climate Module

Hafiz Muhammad Adeel Hassan, hah@iti.sdu.dk
Supervisor: Ivar Lund
Co-supervisor: Christian T. Veje
Department of Mechanical Engineering
Institute of Technology and Innovation

SDU
UNIVERSITY OF SOUTHERN DENMARK

Background

Latent heat energy storage technology based on Phase Change Materials (PCM) has attracted the scientists in past few years because of its advantage of high thermal energy storage capacity and small temperature variation for the whole process. A PCM based thermal energy storage system can be integrated with a ventilation system to improve its energy efficiency. The PCM storage system undergoes two kinds of processes; one is melting or charging of the PCM which occurs when the PCM absorbs heat and reaches its melting point. The second process is called solidification or discharging of the PCM which occurs when the PCM releases heat as seen in fig. 1 [1].

While using PCM storage in a ventilation system, the storage stores the coldness from outside (i.e. cold air passes through the system and it solidifies by rejecting its already stored heat to the air) and supplies this coldness inside the building for indoor cooling during the day time (i.e. the hot air from inside the building passes through the PCM storage and looses its heat to the storage, becomes cold, and the PCM gets melted as seen in fig. 2 [1] [2].

The climate module is an energy storage system consisting of a stack of PCM encapsulated plates which would be integrated with ventilation system to improve the indoor comfort conditions.

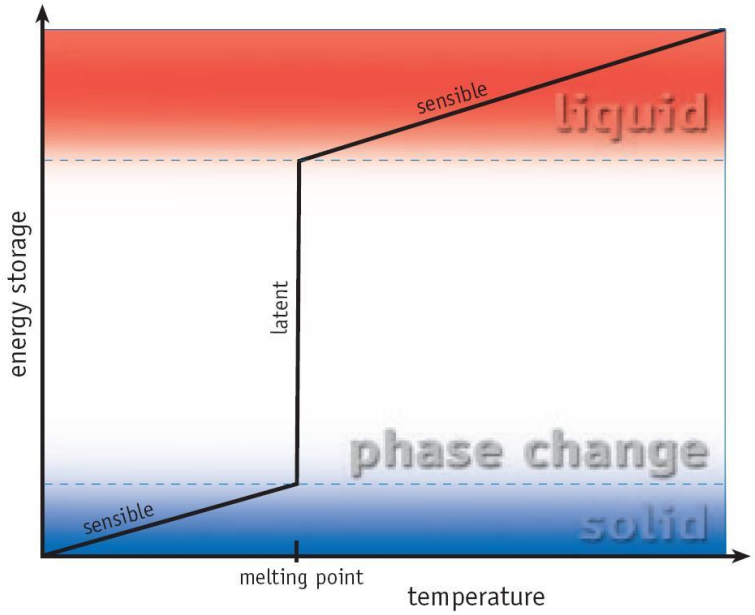

Fig. 1. Principle of Phase Change Materials [3]

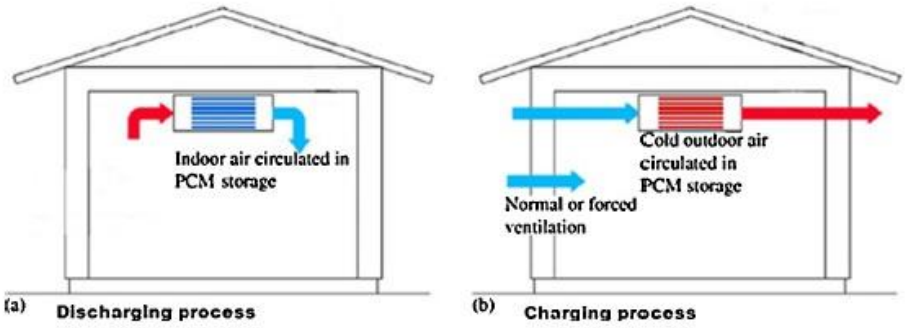

Fig. 2. Principle of free cooling system operation with PCM storage [4]

Objectives

The overall objective of the research is to investigate the process of heat transfer between air flow and PCM storage, with special focus on energy efficiency of the heat exchange process between air flow and the climate module for ventilation system application and come up with an optimized solution for the heat transfer process.

Methodology

The methodology includes literature study of state of the art on the PCMs. Developing numerical models and carry out simulations in ANSYS Fluent software to investigate the air flow distribution in PCM storage-based heat exchanger, design of air inlet manifold and effect of flow maldistribution. Experimental work will also be carried out in cooperation with industrial partners to observe the heat transfer phenomenon in real designs. Optimization will be applied to get better heat transfer and lesser pressure drops during the flow.

References

[1] X. Chen, Q. Zhang, Z. J. Zhai, X. Ma, "Potential of ventilation systems with thermal energy storage using PCMs applied to air conditioned buildings," *Renewable Energy,* 2019.

[2] Lina Yang, Y. Li, "Cooling load reduction by using thermal mass and night ventilation," *Energy and Buildings,* 2008.

[3] "Climatetechwiki," [Online]. Available: https://www.climatetechwiki.org/technology/jiqweb-pcm-0.

[4] S. Kamali, "Review of free cooling system using phase change material for building," *Energy and Buildings,* 2014.