Analysis and modelling of applications of phase change materials in HVAC systems

Ph.D. Student – Viktor Bue Ljungdahl
Principal supervisor – Christian T. Veje
Co-supervisor – Muhyiddine Jradi

Background

The continued emission of greenhouse gasses in addition to major pressure from policy makers to reduce the emissions means that energy solutions that either decrease the dependency of fossil energy sources or increases the efficiency of energy systems are needed.
In the last two decades, the implementation of Latent Heat Storage(LHS) is found to have large potential in increasing the energy efficiency of Heating Ventilation and Air Conditioning(HVAC) systems.

Increasing energy efficiency of ventilation systems through efficient latent Phase Change Material(PCM) storages provides better utilization of these systems. Despite of the large potential, the field of active applications of PCM in ventilation units is still not mature due to the main challenges in implementation and operation. Modelling and simulation of such systems are needed in order to show the applicability, behaviour and benefit of the technology. In addition, the nonlinear response of such system, due to the use of PCMs, may require new methods for control in order to utilize the full potential of the concepts.

In spite of the large block of research to improve the efficiency of the cooling sector, vapor compression systems are still dominating the cooling and refrigeration industry. Research in this field is mainly concerned with increasing efficiencies of specific system components and introducing innovations for specific units. Work have been done on improving the efficiencies of such systems, by for instance the inclusion of Fin and Tube (F&T) enhanced heat exchange in HVAC systems (Jagirdar and Lee, 2018).

The Next Generation Ventilation(NeGeV) project at SDU is closely related to this project and further work of the NeGeV project will help support the Ph.D.

NeGeV
Next Generation Ventilation

Contact:
e-mail: vikl@mmmi.sdu.dk
office: Ø14-611-2

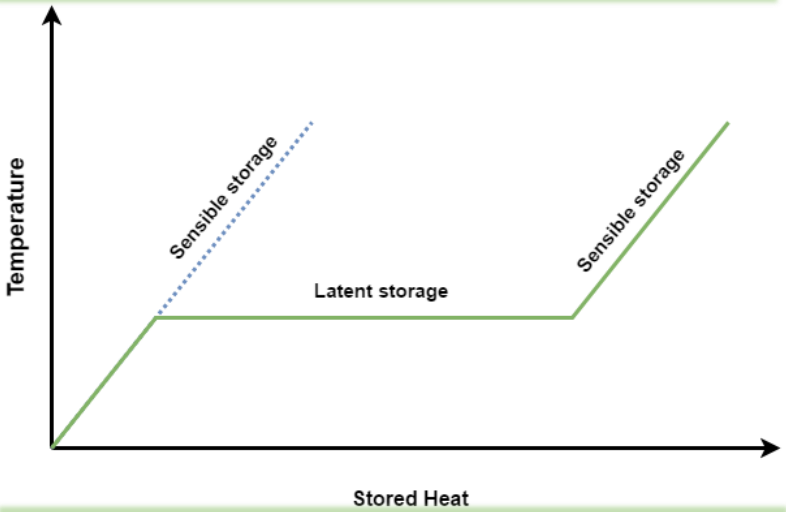
Goals and Objectives

The main objective is the design, dynamic performance modelling and evaluation of an innovative PCM-based unit in active cooling and heating applications.

Latent Heat Storage(LHS)

LHS utilize that additional energy can be stored in the phase change of materials. This means that a higher energy content is available within the same temperature difference.

This application is very dependent on the type of material chosen, since a very specific phase change temperature is usually required for a specific application. These materials are called Phase Change Materials(PCM) are usually tailored to the application.



Hypothesis

The inclusion of latent PCM storages for cooling in ventilation systems will increase the efficiency, improve the environmental impact and increase the cost effectiveness of ventilation systems.
Using a PCM-based LHS for heating applications in space heating will increase the efficiency and the cost effectiveness of heating systems.

Methodology

The design and analysis of the PCM unit and modelling the heat transfer, mass and energy balances within the system.

Dynamic behaviour of the system will be analysed through ordinary differential equations.
The relevant governing equations will be implemented in modelling softwares; MATLAB, EES and Modelica.

Optimization will be applied, and the system will be investigated through the use of programming in e.g., Python.