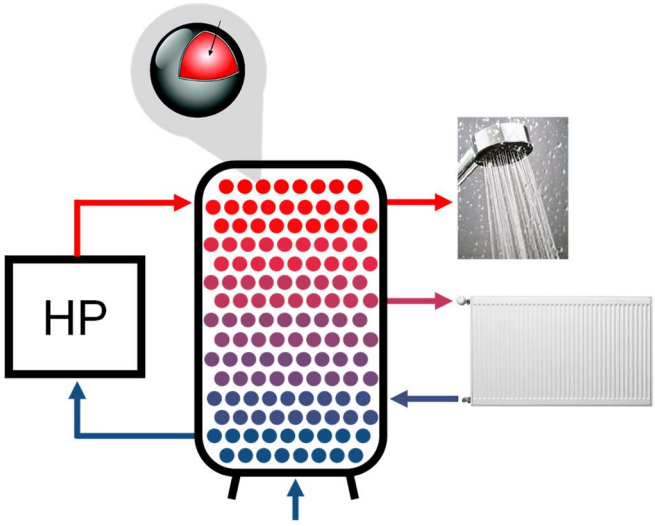
Master Thesis July 2023

Improving heat pump performance by stratified PCM storage

Background:



Residential heat pumps are usually combined with thermal energy storage. Thermal storage decouples demand and supply and enables the heat pump to work at an efficient operation point constantly. Standard storage devices are water tanks in which the water is stratified from cold at the bottom to hot at the top. The stratification ensures the efficient operation of the heat pump and is realized by differences in density. However, these storage tanks require large volumes due to the low volumetric energy densities. Furthermore, keeping the stratification is difficult due to heat conduction and mixing through water extraction and injection flows.

Phase change materials (PCM) can significantly increase the volumetric energy density and improve stratification. Polymers are promising candidates for use as a PCM since melting temperatures are higher and can be tailored by the polymer grade. For instance, semicrystalline cross-linked high-density polyethylene (cHDPE) could enable temperature stratification and thus improve the performance of the entire heating system.

Your thesis:

This work investigates the potential of polyethylene spheres with different cross-link densities in thermal storage tanks of residential heat pump heating systems. The work is simulation-based and includes the following work packages:

- Transient modeling of a stratified water storage tank
- Transient modeling of a storage tank equipped with polyethylene spheres
- Combining a quasi-steady-state heat pump model with the storage models
- Optimization of polyethylene's melting temperature as a function of position in the tank and in dependence of cross-linking
- Comparison of both storage systems by simulating typical demand profiles

About you:

- Student of mechanical engineering (e.g., energy flows & processes), chemical engineering, chemistry, physics, or a comparable subject
- Good understanding of thermodynamics and heat transfer
- Experience with coding (preferably Python or Matlab)
- Independent and goal-oriented working style

Working at EPSE:

In this project, you will gain insights into the thermodynamics of heat pumps, thermal storage, and phase-change materials. You will improve your coding skills by working with state-of-the-art optimization tools. Furthermore, you will get to be a part of a young and motivated team of researchers and students.

This work is joined project of the Energy and Process Systems Engineering Lab at ETH Zürich and the Chair of Thermodynamics at TU Clausthal (Germany). The place of work is primarily Zürich.

If you are interested, please contact Dr. Dennis Roskosch (ETH Zürich, droskosch@ethz.ch) or Prof. Dr. Dr. Michael Fischschweiger (TU Clausthal, Michael.fischlschweiger@tu-clausthal.de).

Begin of project: flexible
More information: www.epse.ethz.ch, https://www.ievb.tu-clausthal.de/