Mechanical Engineering Thesis Defense

The Optimized Use of Phase Change Materials in Buildings

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abstract

In recent years, 40% of the total world energy consumption and greenhouse gas emissions is because of buildings. Out of that 60% of building energy consumption is due to HVAC systems. Under current trends these values will increase in coming years. So, it is important to identify passive cooling or heating technologies to meet this need. The concept of thermal energy storage (TES), as noted by many authors, is a promising way to rectify indoor temperature fluctuations. Due to its high energy density and the use of latent energy, Phase Change Materials (PCMs) are an efficient choice to use as TES. A question that has not satisfactorily been addressed, however, is the optimum location of PCM. In other words, given a constant PCM mass, where is the best location for it in a building? This thesis addresses this question by positioning PCM to obtain maximum energy savings and peak time delay. This study is divided into three parts. The first part is to understand thermal behavior of building surfaces, using EnergyPlus software. For analysis, a commercial prototype building model for a small office in Phoenix, provided by the U.S. Department oF Energy, is applied and the weather location file for Phoenix, Arizona is also used. The second part is to justify the best location, which is obtained from EnergyPlus, using a transient grey box building model. For that we have developed a Resistance-Capacitance (RC) network and studied the thermal profile of a building in Phoenix. The final part is to find the best location for PCMs in buildings using EnergyPlus software. In this part, the mass of PCM used in each location remains unchanged. This part also includes the impact of the mass of PCM on the optimized location and how the peak shift varies. From the analysis, it is observed that the ceiling is the best location to install PCM for yielding the maximum reduction in HVAC energy consumption for a hot, arid climate like Phoenix.

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