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Simulation of a PCM based roof structure for thermal comfort in buildings using COMSOL software

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Abstract

Energy conservation in industrial, commercial and domestic application is one of the burning topics among the researchers around the globe. Thermal comfort and energy savings in buildings by the use of latent heat storage in a phase change material (PCM) is very attractive, because of its high energy storage density and its isothermal behavior during the phase change process. Several promising developments are taking place in the field of thermal storage using phase change materials (PCM) in buildings. It has been demonstrated that for the development of a latent heat storage system (LHTS) in a building fabric, the choice of the PCM plays an important role in addition to heat transfer mechanism in the PCM. Increasing the thermal storage capacity of a building can enhance human comfort by decreasing the frequency of internal air temperature swings, so that the indoor air temperature is closer to the desired temperature for a longer period of time. In this work, an attempt is made to study the thermal performance of an inorganic and organic type of PCM based building roof for thermal comfort in a building. The system has been analyzed by theoretical simulations using COMSOL software for PCM based roof and simple RCC roof to test its suitability for the summer months. The performance of both the roofs was compared. The PCM roof was able to maintain a constant temperature throughout the day

Keywords: PCM,COMSOL,RCC ROOF

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1. INTRODUCTION

Scientists all over the world are in search of new and renewable energy sources. One of the options is to develop energy storage devices, which are as important as developing new sources of energy. Thermal energy storage systems provide the potential to attain energy savings, which in turn reduce the environment impact related to non-renewable energy use. In fact, these systems provide a valuable solution for correcting the mismatch that is often found between the supply and demand of energy. Latent heat storage is a relatively new area of study although it previously received much attention during the energy crisis of late 1970's and early 1980's where it was extensively researched for use in solar heating systems. When the energy crisis subsided, much less emphasis was put on latent heat storage. Although research into latent heat storage for solar heating systems continues, recently it is increasingly being considered for waste heat recovery, load leveling for power generation, building energy conservation and air conditioning applications. As demand for air conditioning increased greatly during the last decade, large demands of electric power and limited reserves of fossil fuels have led to a surge in interest with regard to energy efficiency. Electrical energy consumption varies significantly during the day and night according to the demand by industrial, commercial and residential activities. In hot and cold climate countries, the major part of the load variation is due to air conditioning and domestic space heating, respectively. This variation leads to a differential pricing system for peak and off peak periods of energy use. Better power generation/distribution management and significant economic benefit can be achieved if some of the peak load could be shifted to the off peak load period. This can be achieved by thermal energy storage for heating and cooling in residential and commercial building establishments. There are several promising developments going on in the field of application of PCMs for heating and cooling of building.

2 MATERIALS AND METHODS: DESIGN IN COMSOL SOFTWARE PCM

Material	Density(KG/M3)	Thermal conductivity (W/MK)	Specific heat(J/KG-K)
Concrete	2300	1.279	1130
Roof top slab	1300	0.25	800
PCM (calcium chloride hexa hydrate)	1500	1.01	1440

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DIMENSIONS

Material	Length(meters)	Thickness(cm)
RCC	**2**	**12**
PCM (Calcium Chloride Hexa Hydrate)	**2**	**2.5**
Roof top slab	**2**	**10**

3. COMSOL SOFTWARE:

First a composite roof is modeled in COMSOL SOFTWARE by using the following steps:

1) Creating Three blocks with dimensions

2) Applying material property data

3) Meshing the model

4) Boundary conditions

5) Result

COMSOL Multiphysics

COMSOL Multi physics is a powerful interactive environment for modeling and solving all kinds of scientific and engineering problems based on partial differential equations (PDEs).

With this software you can easily extend conventional models for one type of physics into multi physics models that solve coupled physics phenomena – and do so simultaneously.

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PCM:

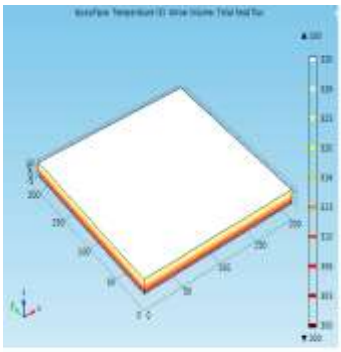
Phase Change Materials, commonly known as PCM are capable to store energy by changing from solid to liquid (melting) and releasing heat by changing from liquid to solid (freezing), as well to provide a large heat capacity over a limited temperature range. The increasing cost of energy supply for the purposes of heating and cooling reshapes the design criteria for developments by searching for new and more energy efficient ways of building, including the use of improved construction techniques and enhanced materials technology.

MODEL OF A PCM BUILDING ROOF:

Simulation Results:

RCC BLOCK

12am



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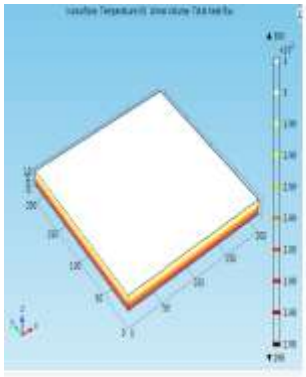

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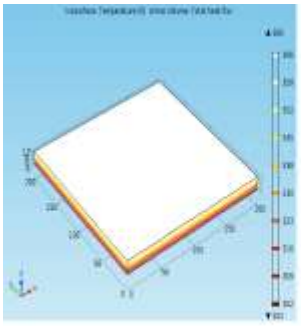
At 12:00 pm



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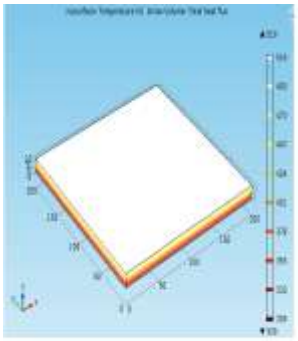
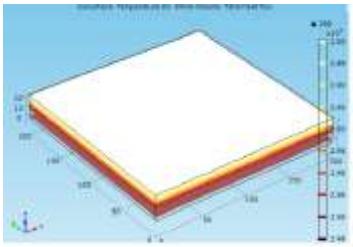
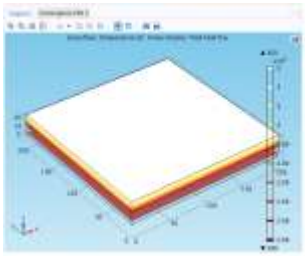


PCM1: CALCIUM CHLORIDE HEXA HYDRATE

At 12:00 am





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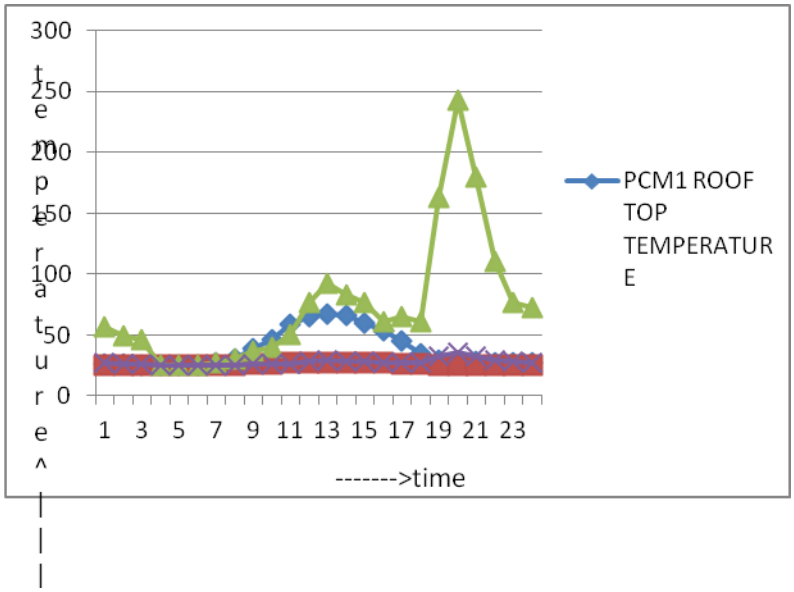
PCM1 VS RCC



CONCLUSION

The simulation study on the thermal performance of a phase change material based roof for energy conservation in building is analyzed and discussed. The two roofs that are modeled in COMSOL are analyzed to study the effect of having PCM panel on the roof for thermal comfort of a residential building. A comparison of PCM roof with the RCC is made and simulation runs are conducted for the average ambient conditions for three months of summer in a year and for the various other parameters of interest. The obtained results are promising to achieve energy conservation and thermal comfort in buildings.

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