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# A COMPARITIVE STUDY OF ENERGY SAVINGS IN BUILDINGS USING TWO DIFFERENT PHASE CHANGE MATERIALS

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Phase change materials possess the property to absorb heat energy and convert their phase to semi solid form and by doing this,it absorbs more and more amount of heat.By this phenomenal change we are able to maintain the temperature of the system in a comfort range.These phase change materials are used in many systems.So a numerical study is done by using the phase change materials in building by incorporating it near the concrete layer. By doing this the thermal comfort of the building can be increased. Three different types of orientations are modelled with the PCM at different sections and the best orientation is studied. This is done for two different climatic conditions.



Keywords: Phase change Materials, Latent Heat Storage, Fluent

## 1. INTRODUCTION

Phase-change materials (PCMs) are substances with a high heat of fusion that, melting and solidifying at a certain temperature range, are capable of storing and releasing large amounts of energy. In PCMs, energy is absorbed or released when the material changes from solid to liquid and vice versa. Different types of PCMs have been tested as dynamic components in buildings during the last four decades. Most historical studies have found that PCMs may notably improve building energy performance. Experimental results that are reported for both laboratory-scale and full-size building elements were tested in the field. Some PCM-enhanced building materials, such as PCM-gypsum boards, PCM-impregnated concretes, or PCM-enhanced fiber insulations have already found their limited applications in different countries.

PCMs latent heat storage can be achieved through solid–solid, solid–liquid, solid–gas and liquid–gas phase change. However, the only phase change used for PCMs is the solid–liquid change. Liquid-gas phase changes are not practical for use as thermal storage due to the large volumes or high pressures required to store the materials when in their gas phase. Liquid–gas transitions do have a higher heat of transformation than solid–liquid transitions. Solid–solid phase changes are typically very slow and have a rather low heat of transformation.

Initially, the solid–liquid PCMs behave like sensible heat storage (SHS) materials; their temperature rises as they absorb heat. Unlike conventional SHS, however, when PCMs reach the temperature at which they change phase (their melting temperature) they absorb large amounts of heat at an almost constant temperature. The PCM continues to absorb heat without a significant rise in temperature until all the material is transformed to the liquid phase. When the ambient temperature around a liquid material falls, the PCM solidifies, releasing its stored latent heat. A large number of PCMs are available in any required temperature range from −5 up to 190°C. Within the human comfort range of 20° to 30°C, some PCMs are very effective. They store 5 to 14 times more heat per unit volume than conventional storage materials such as water, masonry or rock.

The most commonly used PCMs are salt hydrates, fatty acids and esters, and various paraffins (such as octadecane). Recently also ionic liquids were investigated as novel PCMs. As most of the organic solutions are water-free, they can be exposed to air, but all salt based PCM solutions must be encapsulated to prevent water evaporation or uptake. Both types offer certain advantages and disadvantages and if they are correctly applied some of the disadvantages become an advantage for certain applications.

The temperature range offered by the PCM technology provides a new horizon for the building services and refrigeration engineers regarding medium and high temperature energy storage applications. The scope of this thermal energy application is wide ranging of solar heating, hot water, heating rejection, i.e. cooling tower and dry cooler circuitry thermal energy storage applications.

## 2. LITERATURE REVIEW

**Edwin Rodriguez et.al** investigated the usage of PCM's in buildings and also discussed their various applications. They dealt about the way in which these PCM's can be used along with concrete. They gave out two ways in which the PCM can be incorporated such as active and passive manner. When the PCM are used as a single layer they are classified as component and if they are mixed with the construction material they are said to be integrated.

**A. Pasupathy et.al** investigated the usage of a dual layer of PCM in building roofs and from that the mathematical and numerical formulation are studied. Boundary condition for inner wall is fixed to be natural convection. For the mathematical formulation the end effects are neglected and the thermal conductivity of the concrete slab and the roof top slab are considered constant and not varying with respect to temperature. The composite wall is set to be one-dimensional. The governing equations along with the boundary conditions are discretized using semi-implicit control volume formulation. Due to the low thermal conductivity of the liquid PCM it is found that the roof top surface temperature is slightly higher than the non-PCM room.

**B.L. Gowreesunker et.al** validated the usage of PCM in clay boards with CFD. They carried out this study in a ventilated room and a non-ventilated room.CFD was used by them to predict the air flow and the temperature distribution in the indoor environments by numerically solving the NavierStokes set of partial differential equations for mass, energy and momentum. The performance of the PCM is based on the surrounding temperature and the time period till which the PCM boards exceed the melting temperature of the PCM.The working condition in CFD is set to be a transient one. Due to the temperature stratification in space only 80-90 % PCM are used. The melting and freezing characteristics of the PCM obtained from DSC analysis.

**V.V. Tyagi et.al** designedand studied about the thermal management system for cool storage. They designed a prototype room along with different working conditions in under comfort range. For the heating load of 1 kW they got the result that the indoor air temperature of the test room was maintained in the thermal comfort range with the help of TMS for a long time.

**K. Darkwa et.al** evaluated the thermal effectiveness of a PCM drywall. They were evaluated in a dry solar building. Thermal simulations for the room are taken by implicit finite-difference method. The outdoor temperature was assumed to be in Sinusoidal pattern. It was found that the laminated PCM wall boards showed better thermal performance than the randomly mixed type. The same thing was seen with the wall surface temperature also.

**Pascal Henry Biwole et.al** investigated the use of PCM's in solar photovoltaic and thermal panels. This investigation was mainly carried out to reduce the temperature to ambient conditions. The performances of the solar panels are studied with the help of models that are analyzed in CFD. The model is validated with the help of velocity field inside the PCM layer. The parametric study was performed on the temperature of the panel represented by a flat aluminum plate with the purpose of predicting the efficiency. Limitations to this investigation are the usage if aluminium in solar panels and the impact of sky temperature which was not included in the numerical model.

**Esam et.al** studied about thermal analysis of a building brick containing PCM**.** The objective of using the PCM is to utilize its high latent heat of fusion to reduce the heat gain by absorbing the heat in the bricks through the melting process before it reaches the indoor space. A two dimensional model was create and the thermal analysis were carried out with that model. Different geometrics were used and three types of PCM's are also used. The results showed that n-eicosane is the best PCM ant when it is placed at the center line of the brick the thermal performance is compared with the other geometry and the type of PCM.

**François Mathieu et.al** studied about the thermal shielding of external building walls with the help of a numerical model. In a thermal steady-state regime, a low thermal conductivity wall results in low heat gains and heat losses which are beneficial to reduce energy consumption. A finite-volume code has been developed in order to determine the temperature in a multilayer wall with PCM's. Full optimizations of the wall composition with genetic algorithm (GA) were performed. The GA had a possibility to combine different materials and PCM melting temperatures in the wall.

## 3. OBJECTIVE OF THE PAPER

To reduce the room temperature to the human comfortable range.By selecting the suitable PCM Material which is readily available in the market.

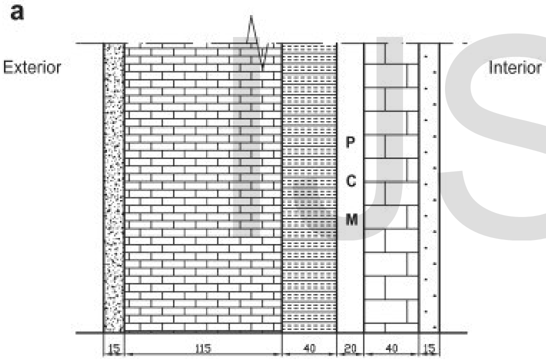
Increase the performance of PCM by further modification.

## 4. PROBLEM DEFINITION

As a demand for air conditioning increased greatly during the last decade, large demands of electric power have led to a surge of interest with efficient energy application. Thermal storage plays important role in building energy conservation, which is greatly assisted by the incorporation of latent heat storage in building products. PCM is one of the thermal energy storage devices. LHS in a phase change material (PCM) is very attractive because of its high storage density with small temperature swing. Increasing the thermal storage capacity of building can increase human comfort by decreasing the frequency of internal air temperature swings.

So, in order to give the thermal comfort to the buildings three different types of orientations are modelled which has the PCM at different orientations. These orientations are modelled in Gambit and are analysed in Fluent to get the temperature distribution between the exterior and interior by giving in the necessary boundary conditions. The three different orientations are given below,

a

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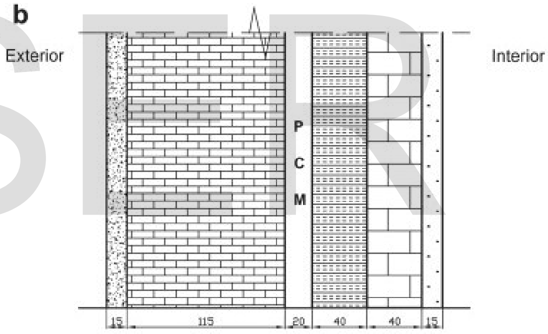


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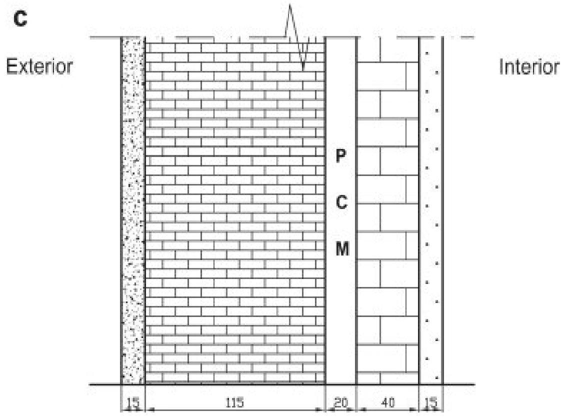


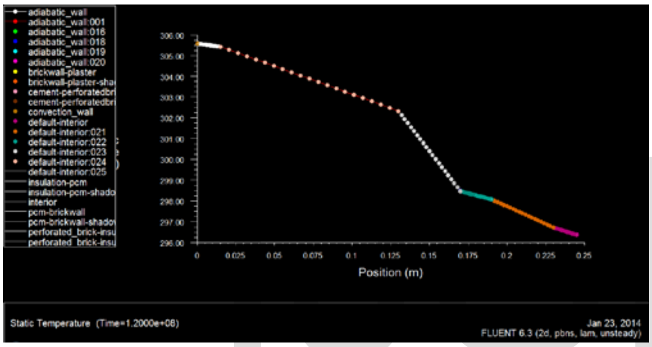
## 5. ANALYSIS & RESULTS

The models are modelled in Gambit in 2D condition since it has a small geometry and it is analysed in Fluent 6.3 using the unsteady state heat conduction and the results are got and the best orientation for the given climatic condition is finalised.For the summer condition the outer surface temperature is given to be 35$^0$C and the temperature distribution curves throught the geometry is got by using Fluent 6.3

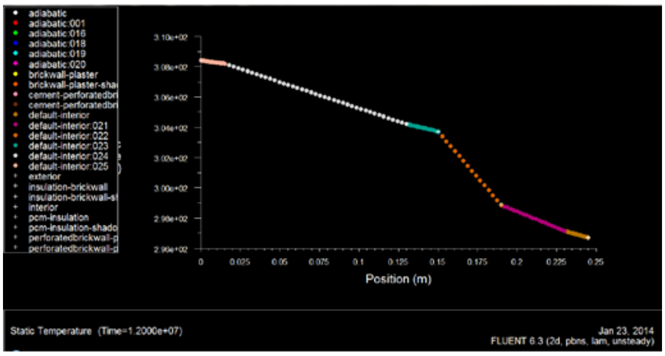
Two different PCM's are used during the course of this paper. They are N-Octadecane and a Eutectic mixture of Capric acid and Lauric acid. The results are shown below.

## 6. RESULTS USING N-OCTADECANE

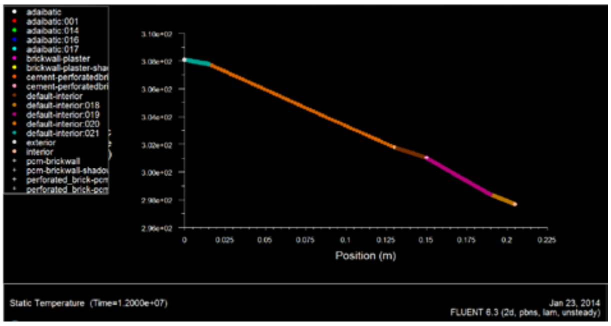
For the first orientation the PCM is placed right to the insulator the outlet condition is given to be 36$^0$C and temperature reduce to 30$^0$C near the PCM layer.The melting temperature of PCM is 28.2$^0$C and the temperature drop at the PCM layer is found to be around 6$^0$C and the graph is shown below,



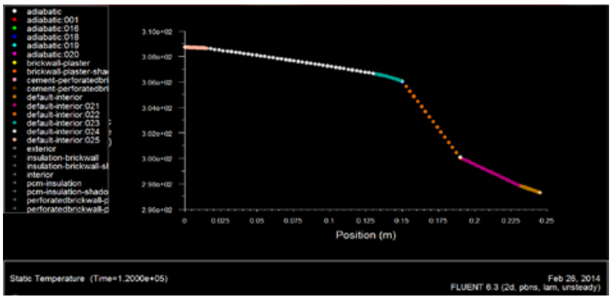

For the second orientation the PCM is placed left to the insulator.The output conditions are same as that of the first orientation and here the temperature drop in the PCM layer is found to be 5$^0$C.The graph is shown below,




For the third orientation the insulator is avoided and then it was analysed and the temperature drop in PCM layer is found to be around 1$^0$C which is having the least temperature drop.The graph is shown below,

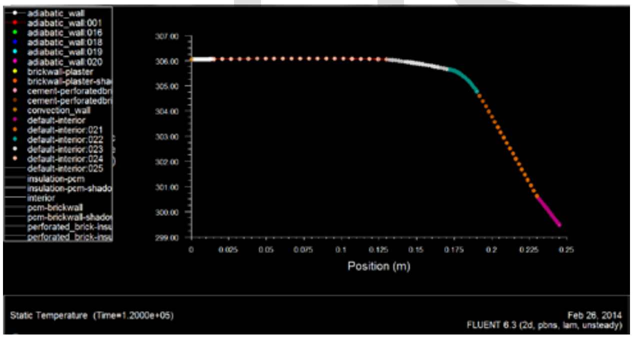



## 7. RESULTS USING PARAFFIN WAX

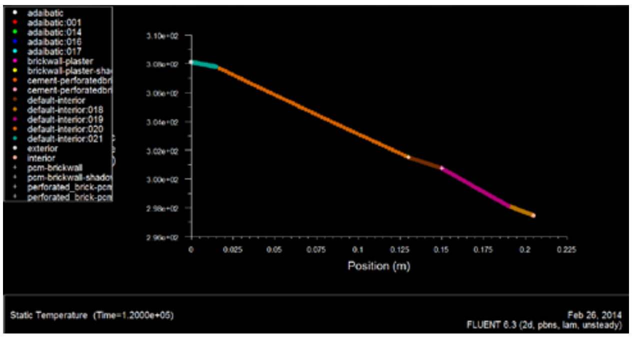



For the first orientation where the PCM is placed right to the insulator the temperature drop is found to be nearly $1^0$C which according to the efficiency is very low.So this orientation with this PCM cannot be used.






For the second orientation where the PCM is placed left to the insulator the temperature drop across the PCM is found to be $1.4^0$C which can be somehow give out the needed efficiency.



For the third orientation where there is no insulator the result is same as that of the previous case.So by comparing these two analytical values the results are given below

## 8. RESULTS & DISCUSSION

By doing the analysis in Fluent the various results are given.Based on the results the best orientation is selected to be the first orientation where the PCM is placed right to the insulator and also the second PCM which is Paraffin wax is giving out only a smaller temperature drop and so the best PCM among these two is N-Octadecane.In the further research work the PCM can be changed to get further more comfortness. One further variation is the dimension of the Brick wall can be reduced and the size of the insulator can be increased to give an increased efficiency.

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