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Research paper

An Integrated Approach to Assess the Impact of PCM [Phase Change Material] to Reduce the Energy Consumption in Buildings-a Review

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Abstract

The achievable joining of Phase Change Material [PCM] in building materials has pulled in a lot of examination intrigue overall due to the need on a dangerous atmospheric deviation and further more the capacity of PCMs to reduce vitality utilization in structures owing to their warm vitality stockpiling capacities. As a substance with high warmth of combination, PCM is equipped for putting away and discharging enormous measures of vitality inside the assortment of inert warmt in liquefying and hardening forms at the specific change temperature. For as long as 25 years,critical examination has been attempted on potential utilization of PCMs in concrete. Latent Heat Storage [LHS] aimed a PCM is unbelievably alluring because of its high vitality stockpiling thickness and its isothermal conduct all through the stage change process. Expanding the warm stockpiling ability of a building will upgrade the human solace by diminishing the recurrence of inside air temperature swings all together that the inside air temperature is nearer to the pre defined temperature for a broadened measure of time.

Keywords: *Phase Change Material [PCM]; Latent Heat Storage; thermal roofing; temperature;*

1. Introduction

The present research will center around concentrate the impact of PCMs, thickness of the piece, introduction of room and volume of room on indoor temperatures.The similar investigation on the warm execution of a PCM as stage change material will be done tentatively and hypothetically. For this reason,roof top structures will be worked to complete exploratory investigations.

The roof top structures will be demonstrated and the outcome yielded from the reproduction studies will be dissected and thought about.

2. Classification of PCMs:

The classifications of PCMs are based on its phase change state [1]. The PCMs are divided into three categories as shown in FIG-1

- Organic PCMs [Paraffin's and Non- Paraffin's].
- Inorganic PCMs [Hydrated Salts].
- Eutectics.

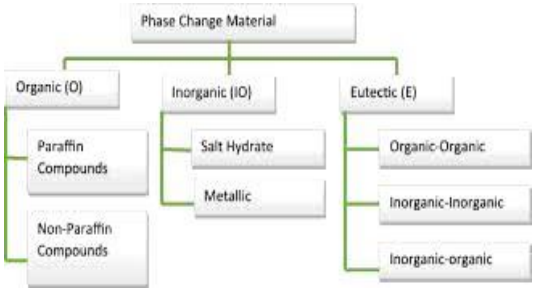

Fig. 1: classifications of PCMs

3. Criteria of Selection of PCMs

The criteria of selection of PCMs mainly depends upon

- Latent heat of fusion
- Thermal conductivity
- Recyclability and chemical stability
- Melting/ Transition temperature
- Non-Flammability

The merits and demerits of selection criteria of PCMs is given in the following Table-1 is according to N.SOARES and JJ COSTA [2]

Table 1: Selection criteria of PCMs

S.NO	*Type of PCMs*	*Merits*	*Demerits*
1	Organic PCMs[Paraffin's and Non-	➢ Availability in large temperature range	➢ Low thermal conductivity

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	Paraffin's]	➢ High latent heat of fusion ➢ Freeze with little or super cooling	around [0.2 W/mK] ➢ Occupies relatively large volume ➢ Highly flammable
2	Inorganic PCMs	➢ High thermal conductivity ➢ Low volume ➢ High heat of fusion ➢ Availability in low cost	➢ Corrosion ➢ Poor nucleating properties and super cooling problem
3	Eutectics	➢ Sharp melting point ➢ Higher volumetric thermal storage densities	➢ Bad odour ➢ Lack of availability in low cost

4. PCMs - Thermal Stability

The Thermal stability of PCMs depends on thermal properties of PCMs after testing for high number of thermal cycles. [1]. There should not be many changes in thermal properties of PCMs. The thermal properties include

A. Chemical properties
B. Kinetic properties
C. Thermo dynamic properties
D. Economic properties

A. Chemical Properties

- Non corrosiveness
- Non flammable
- Non toxic
- Chemical stability

B.Kinetic Properties

- Higher rate of precious stone development to meet requests of warmth recuperation from the capacity.
- Higher nucleation rate to maintain a strategic distance from super cooling.

C. Thermodynamic Properties

- Dissolving temperature is in wanted range.
- High thermal conductivity.
- High specific heat.
- High latent heat of fusion per unit volume.

D. Economic Properties

- Massive scale convenience.
- Low price.

Thermal cycling tests are led to inspect the warm strength of PCMs in inactive warmth stockpiling frame work for organics, salt hydrates and salt hydrate blends by numerous researchers [3-7].

In the wake of experiencing thermal cycling tests, a portion of the PCMs are distinguished to have great thermo-physical and compound solidness.

Tyagi and Buddi [8] led warm cycling test for Cacl26H2O and discovered minor changes in latent heat of fusion and melting temperature, only about 4% average variation and 1-1.50C respectively during 1000 warm cycles.

5. Thermo Physical Properties of PCMs Used In Building Envelope

TABLE 2: Some of the Thermo Physical Properties of PCMS Used in Buildings [9-11]

S.NO	*TYPE*	*NAME OF THE PCMs*	*THERMAL CONDUCTIVITY(W/m^0C)*	*HEAT OF FUSION (KJ/Kg)*	*TRANSITION POINT (^0C)*
1	Organic	Butyl stearate	0.21	123-200	18-23
2	Organic	Paraffin C_{18}	0.148(Liquid) 0.15(solid)	244-243.5	27.5-22.5
3	Fatty acid mixture	Capric-Lauric 45/55	---	143	21
4	Inorganic	$Cacl_26H_2O$	0.54-1.088	192	24-29
5	Inorganic (salt hydrate)	Climsel C_{24}	1.48	108	24
6	Inorganic (salt hydrate)	Mn $(NO_3)6H_2O$	---	125.9	25.5

6. Mechanism Of Heat Storage In PCMs Used In Buildings

The most promising use of PCMs used in buildings is incorporation of PCM bedded material in building roof or wall. The reason behind the incorporation of PCM in building roof is that most of the time the roof will be exposed to sun's heat or solar energy.

By utilizing PCMs in building increments indoor warm solace and further more chopping down building vitality utilization.

As the air temperature rises, the concoction bonds in PCM will separation and changes from strong to fluid. The response in endothermic and utilized PCM will ingest warm from within the room. In this way decreasing the temperature of inside room and the other way around and in this way delivering human solace.

The main purpose behind chosing inorganic PCM is that they are not combustile and will have higher warm conductivity [12].



Fig. 2: Model of encapsulation of PCM in building roof

7. PCM Encapsulation- Results With Different Roof Structures

The numerical arrangements and scientific plan for PCM incorporated roof top frame work is appeared in this segment. For the roof structures, the PCM will be put in center of the thickness of solid section (base roof top) and rooftop top piece.

Aimed daylight hours the PCM changes from strong to fluid state and assimilates inert warmth (latent heat (KJ/Kg)). Aimed night hours the PCM changes from fluid to strong by dismissing its warmth to the environment air inside the room. This strategy non-stop consistentently regular. A.Passupathi [13] led the trail examination of PCM in building roof in Madras city.

The radiation warm transition accessible month to month is gathered from handbook by Tiwari [14] for each one hour in Madras and used forcomputation. For outside breeze speeds, the connective warmth exchange coefficient 'h' is computed by utilizing the recipe.

8. Mathematical Formulation

The mathematical formulation for PCM based thermal analysis, the following Assumptions are considered: [13]
I) PCM is homogenous and isotropic
ii) Convection impact in liquid metal is ignored
iii) Thermal conductivity of the roof top chunk and cement are thought to be steady.
iv) The warmth conduction in composite chunk is one dimensional and the end impacts are dismissed.

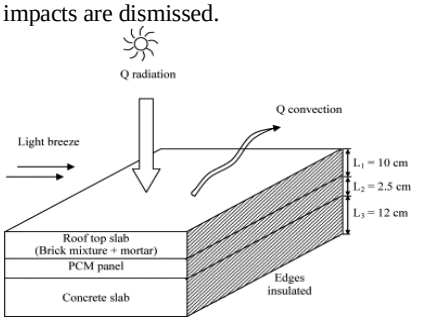

Fig. 3: PCM based thermal analysis

Some of the governing equations and boundary conditions are as below:
Governing equation

$$K_m \frac{\partial^2 T_m}{\partial x^2} = \rho_m C_{P_m} \frac{\partial T_m}{\partial t} [0 < x < l]; m = 1,2,3, \ldots.$$

Where m=1 for roof top slab,
m=2 for PCM panel
m=3 for bottom concrete slab
The external boundary layer at x=0 where the floor is exposed to solar radiation the boundary condition equation is

$$K_1 \left\{ \frac{\partial T_1}{\partial x} \middle| x = 0 \right\} = q_{rad} + h_0 (T_\infty - T_{x=0})$$

The radiation effect considered during sunshine hours.
For the bottom layer concrete slab at x=L, the boundary equation is

$$+K_3 \left\{ \frac{\partial T_3}{\partial x} \middle| x = L \right\} = h_i (T_{x=L} - T_{Room})$$

9. Technical Specifications Of PCM Used

Table 3: The technical specifications of PCM used by A.Pasupathy and R.Velraj for their experiments [13, 15]

S.NO	DESCRIPTION	VALUE
1	Density Kg/m3	1640
2	Latent heat KJ/Kg	188
3	Phase change temperature	26-28
4	Appearance	Grey
5	Thermal conductivity Solid Liquid	 1.09(0-270C) 0.54(28-600C)
6	Specific heat J/Kg0K	125000(26.50-280C)

The exploratory set up comprises of two indistinguishable test rooms built for concentrate the impact of PCM consolidated in top of building. One room is built having PCM board and another room without PCM board.

By doing as such it is noticed that the solace inside the working with PCM is considerable than by room without PCM.

10. Conclusion

From the above data collected, the use of PCMs in buildings is increasing the human comfort by decreasing the temperature inside the room or buildings.
Many researchers conducted experiments in China, Chennai, Pullivendula by using different PCMs for reducing the temperature of buildings.
There are the many varieties of PCMs that are used under different climatic conditions. Most of them being Inorganic PCMs.
By the above data collected, we are going to conduct experiments at Anantapur for PCMs in buildings and compare the results with other PCMs.

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