Experimental Analysis of Transition of Thermal Energy for Different PCM's in Concrete Wall

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Abstract- *Phase change material (PCM) is a substance which is capable of storing and releasing of energy in the form of latent heat of fusion during freezing and melting. It has been used as PCM material because of its property of active temperature compensation mechanism. Also it does not change its temperature while changing its phase. The benefits of storage of energy during melting process have been used for application. As temperature rises wax melts and PCM absorbs heat. This heat energy is used for cooling in building constructions. In this paper, it has been considered paraffin wax and bee wax as phase change materials. It has been compared with both waxes using graphical representation method. PCM was integrated in hollow concrete block. The reason behind using concrete block is because of its special properties like high specific heat capacity and its thermal conductivity. The main purpose of this paper is to determine that how much temperature can be reduced by using PCM material in concrete wall.*

Keywords- - Hollow concrete block, Phase Change Material, Thermal energy storage.

I. INTRODUCTION

Reduction of temperature in building construction by using PCM's (Paraffin wax and Bee wax) and comparing efficiencies of above PCM's by graphical method considering temperature parameter.PCM is used for the purpose of energy conservation. Here the thermal energy stored in PCM is used while melting for cooling purpose. Hollow concrete block is used incorporated with PCM as a wall material. The main purpose of this study is to utilize the stored latent heat of energy during melting (Phase Change) process for maintaining indoor environment. All the conclusions are made by taking temperatures of respective concrete block in particular interval of time by temperature sensor and plotted temperature difference variation Vs time graph.

II. TRANSITION OF THERMAL ENERGY ANALYSIS

Few years ago performance analysis using one concreted cement PCM system has been done. Theoretical research has been carried out on PCM concreted cement system. From last 40 years most studies have found that thermal mass component is a thermal energy performance parameter in building constructions. Use of concrete wall with PCM material is beneficial to store energy during day and releases it in night time and hence reduces cooling and heating load (Kissock et al.1998; Tomlison et al. 1992).

Any object in the environment tries to achieve thermal equilibrium. As the objects are at different temperatures than its surrounding, heat flows from higher temperature object to lower temperature object. The process is nothing but heat transfer process which is fully described in second law of thermodynamics. It is transition of thermal energy. Thermal energy transition is done by mainly three ways conduction, convection and radiation. When there is temperature difference there must be a energy transition. Conduction takes place by flow of valence electrons in conducting medium. Fluid motion is responsible for convection heat transfer. Basically there are two ways i.e. natural convection and forced convection. When fluid motion is natural then it is natural convection. As fluid motion is achieved by external sources then it is forced convection. Radiation is the energy transition phenomenon which is achieved by electromagnetic waves. In actual system energy transition is calculated as the combination of all operating modes. (Liang et al. and Saihi et al. 2009).

III. SELECTION CRITERIA

Various factors are to be considered and properties material should possess while selecting the Phase Change Materials (PCMs) as follows:

A. Chemical Properties:

1. Material stores or releases large amount of heat energy in the form of latent heat i.e. high latent heat capacity.
2. Release and absorption of heat at constant temperature for long duration of time.
3. Number of cycles of the process i.e. the release and absorption process is repeatable.

B. Environmental Properties:

1. Reduced co_2 emission can be achieved.
2. Environment friendly and natural process.

C. Economic Properties:

1. Payback period is less so economically feasible.
2. Low cost of material
3. Easy and large scale availability.

IV. EXPERIMENTAL SETUP

Materials and apparatus utilized in the experimental analysis

A. Concrete block:

Concrete block is a simple concrete brick which is used in the building construction. It is made by the mixture of cement, fine sand, concrete and water. This kind of concrete block is also well-known as a hollow cavity concrete blocks or simply hollow bricks in market. These types of bricks are used now days in construction of building walls than conventional bricks. We can found various kinds of hollow bricks in dimensions and in number of cavities present. We used such concrete brick as the building wall material. The size of the concrete block is given below-Block size 38cmX19cmX19cm.

Different properties of hollow concrete bock are as follows:

1. Mass (kg)) -15,7
2. Density (kg/m3)- 1200
3. Masonry mass (kg/m3) -212
4. Full share (%) -53
5. Pressure strength (N/mm2)- 9,54
6. Water permeability (%)- 3
7. Frost resistance (F) -50
8. Air/sound isolation index (Db)- 21/53
9. Thermal resistance, R (m2xK/W)- 0,35
10. Fire resistance (min) -REI 240

Fig 1: Hollow Concrete block

Different phase change materials have been poured in the concrete block as shown in below:

B. Paraffin wax:

1. Molten wax should be clear colourless, odourless and free from extraneous matter.
2. Melting point – 58°C-60° C
3. Sulphated ash – 0.05%

Fig 2: concrete block with paraffin wax

C. Bee wax:

1. Molten wax should be yellowish white soft wax
2. Total volatile matter at 105˚C is maximum 1.0 %
3. Melting point :62˚C-65˚C

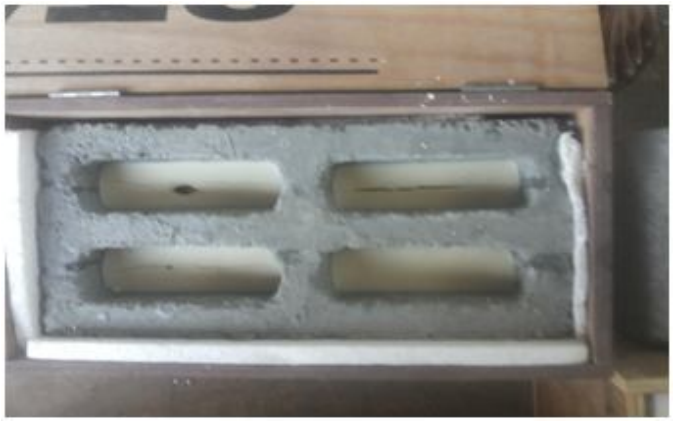

Fig 3: Concrete block with bee wax

D. Digital temperature sensor:

Temperature readings have been taken by digital temperature sensor.Specifications:

1. Temperature Range : -50˚C to 300˚C
2. Resolution : ±0.1˚C/˚F
3. Power Supply : 1.5 V

Fig 4: Digital temperature sensor

V. EXPERIMENTAL ANALYSIS

Following temperature readings have been taken for hollow concrete block without PCM.

Table1: For hollow concrete block

Sr. No	Time	Surface Temperature (T_1)˚C	Inside Temperature (T_2)˚C	Temperature Difference (T_1-T_2)˚C
1	11:00 AM	33	31.8	1.2
2	12:00 PM	33.4	32.0	1.4
3	01:00 PM	33.7	32.7	1.0
4	02:00 PM	32.7	31.0	1.7
5	03:00 PM	33.4	32.0	1.4
6	04:00 PM	34.0	33.3	0.7

Following temperature readings have been taken for hollow concrete block with bee wax as PCM material

Table 3: For Bee wax

Sr. No	Time	Surface temperature (T_1)˚C	Inside temperature (T_2)˚C	Temperature difference (T_1-T_2)˚C
1	11:00 AM	33.4	28.7	4.7
2	12:00 PM	33.9	29.6	4.3
3	01:00 PM	34.8	30.0	4.8
4	02:00 PM	34.2	30.2	4.0
5	03:00 PM	32.7	28.2	4.5
6	04:00 PM	33.4	29.6	3.8

Following observations have been taken for hollow concrete block with paraffin wax as PCM material.

Table 2: For paraffin wax

Sr. No	Time	Surface temperature (T_1)˚C	Inside temperature (T_2)˚C	Temperature difference (T_1-T_2)˚C
1	11:00 AM	32	26.3	5.7
2	12:00 PM	32.5	27.3	5.2
3	01:00 PM	33.2	28.1	5.1
4	02:00 PM	32.8	27.6	5.2
5	03:00 PM	31.7	26.3	5.4
6	04:00 PM	32.1	27.2	4.9

VI. RESULT AND DISCUSSION

Following graph has been plotted as temperature difference variation Vs time from the observations taken from experimental analysis.

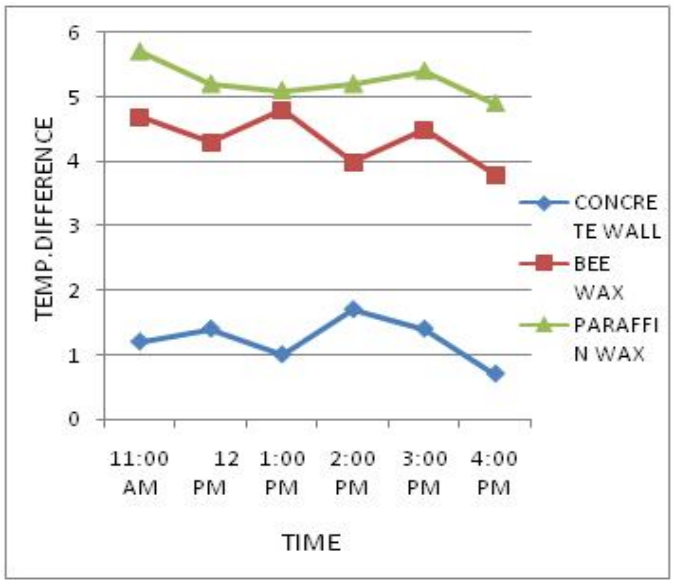

Fig 5: Temperature Vs time graph

- As per the readings general observation is, inside hollow concrete wall temperature ranges between 33.32˚C to 31.7˚C. For paraffin wax it is between 28.1˚C to 26.3˚C and for Concrete wall with bee wax is between 30.2˚C to 28.2˚C.
- Temperature difference during time 1pm to 3pm is larger than the temperature difference of 3pm to 5pm. Mostly temperature difference achieved at 4pm is least. From the experimental analysis observation has been made such as the average temperature difference for hollow concrete block, paraffin wax and bee wax are 1.20˚C, 5.25˚C, 4.35˚C respectively.

VII. CONCLUSION

PCM materials have special property which absorbs and releases the energy during heating and cooling process. It induces the indoor comfort in building and leads to increase the life of concrete construction. Experimental analysis of heat storage capacity for cooling is observed. Conclusions made by experimental analysis are as follows:

- Two PCM materials have been compared with hollow concrete block construction for thermal storage capacity.
- Graphs have been plotted comparing paraffin wax and bee wax with concrete block considering temperature and time parameters.
- From the readings taken it has been concluded that reduction in temperature is observed more in paraffin wax than bee wax in comparison with hollow concrete block.

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