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# OPTIMUM HEIGHT OF PCM USED FOR COOLING OF BUILDINGS

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***Abstract*— It is observed that, demand of electricity for cooling of buildings goes on increasing day by day. As a result, more emissions of harmful gases in the environment due to continuous use of electricity. Hence, there is a need of an alternate energy sources for cooling of buildings. Use of Phase Change Material (PCM) is a on the good alternative. PCM is a good thermal storage material, that property makes it important. By keeping PCM on the top of the floor of the building it will absorb heat during day time and release heat during night time. To measure the PCM height that would use on the top of the building, we did an experiment with PCM inclosing in a transparent brick model. During experiment thermal behavior of PCM as well as melting and solidification phenomena of PCM is noted down. As the PCM is placed inside a transparent brick model, pictures of melting and solidification process are taken at different time interval. This experiment give the optimize use of PCM for the cooling of building.**

***Keywords*— PCM, Optimum PCM height, Cooling of Buildings.**

## I. INTRODUCTION

As a result of the ever-increasing amount of electricity that is being used by air conditioners to cool buildings, there is currently a lot of research being done in order to find ways to save electricity. During the hot summer months, there is also the possibility of using PCM to assist in the cooling of a structure, which is an alternate method. The phase change material (PCM) is a thermal storage device that has a high latent heat value. Yasiri et.al [1] do research to investigate the significance of PCMs in buildings. The key discoveries of PCM thermal performance have been presented, along with numerous research hiatuses for future investigations. This has been done while taking into account the reduction in cooling/heating load, the savings in energy, and the thermal comfort that has been attained. Alquaid et.al [2] conducted research using PCM using numerical and analytical methods, and they came to the conclusion that storing solar energy as latent melting energy in PCM can result in continuous ventilation in the room. This is also a possibility when considering very low solar fluxes. In addition, the utilization of PCM within the wall allows for a sizeable reduction in the wall's thickness. The findings also show that increasing the number of air conditioning cycles by utilizing PCM with a higher thermal conductivity results in an increased total number of cycles. The greatest number of people put their air conditioners on during the times of day with the highest levels of solar radiation. In hot, arid locations where there is a significant demand for cooling for the most of the year. Research was carried out by Zeinelabdein et.al. [3] to determine whether or not it is possible to achieve free cooling by utilizing phase change material (FCPCM) technology. It has been decided to develop a PCM storage system that would consist of many PCM panels. According to the findings, the system that was proposed has the potential to significantly cut the amount of cooling that is required, and the temperature of the air that is supplied by the system has the potential to be maintained well within the summer comfort zone of 25.5 to 30 °C for up to 14.5 hours during the discharging time in the climate that was studied. A numerical analysis for building cooling utilizing PCM was carried out by Kumar et.al. [4]. They discovered that PCM helps lowering building temperatures, although aluminium is added as a thermal conductivity enhancer during recycling when PCM is melted. PCM used is Glauber Salt. Kumar et al. [5] discovered that 4.3 cm of PCM height and 0.0025 to 0.006 percent of thermal conductivity enhancer added during solidification are ideal for the cooling of buildings. Building temperature is found to be 31.5°C. They used Glauber Salt as PCM in their numerical analysis.

During this particular experiment, PCM has been enclosed inside of a plexiglass brick model and place a copper heat exchanger on the top surface of the model. PCM will turn into a liquid when it is passed over by a hot fluid, but it will turn into a solid when it is passed over by a cold fluid. During this phase of the phenomena, the temperature inside the PCM is measured, and photographs of the process of melting and solidifying are taken. The findings indicate that PCM is used most effectively in the process of cooling buildings.

## II. EXPERIMENTAL SET UP

The arrangement of the experimental work as it currently stands is shown in Figure 1. The experiment makes use of a number of different components, including the thermocouple device, the constant temperature bath (CTB), the brick model with PCM, the copper plate heat exchanger, and the scale.

In the experimental setup CTB is attached with heat exchanger, heat exchanger is placed above the brick model.

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Thermocouples are placed inside a brick model and device is placed beside the brick model.

The location of each thermocouple within the brick model is illustrated in Figure 2. A total of seven thermocouples were utilised for the experiment. The temperature of the copper plate that is positioned above the brick model is determined with the help of one thermocouple (S), which is attached to the top of the structure. A thermocouple, denoted by the letter A, is positioned in the uppermost part of the brick model. The thermocouples (B, C) are positioned 1.5 centimetres below the surface of the top. Similarly, Thermocouples (D, E) are positioned three centimetres below the surface of the top. At the very bottom, a thermocouple marked "F" is positioned.

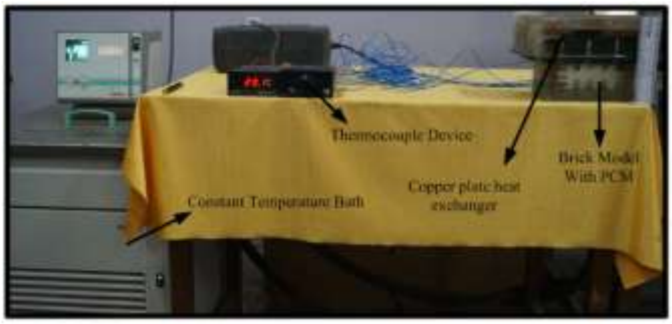


Fig. 1. Experimental set up of the equipments

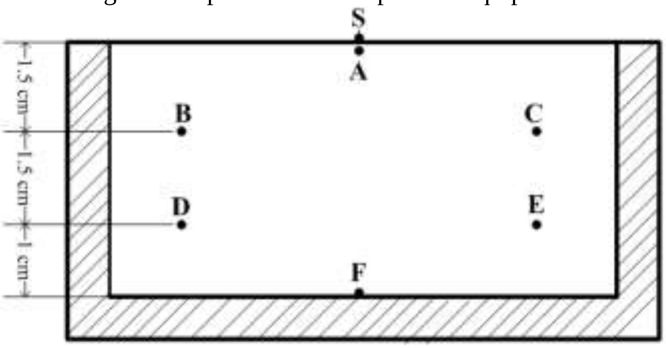


Fig. 2. Position of thermocouples inside a brick model

**Working Principle**

During the period of the experiment, CTB will supply both hot and cold fluid. A heat exchanger is used to transfer heat from one fluid to another. This heat is then transferred into the PCM brick, which causes the PCM contained within the brick model to melt. At each of the distinct locations, a thermocouple of type K is positioned in order to take readings of the temperature contained within the PCM bricks. Every single reading has been taken down. During the heating process, hot fluid is passed through the heat exchanger, which causes the PCM to start melting. After 15 hours of heating, cold fluid is passed through the heat exchanger, which causes the PCM to start solidifying. Throughout the course of this occurrence, images taken at varying time intervals are taken.

## III. RESULTS AND DISCUSSION

Several photographs are taken at different time intervals all the way through the process of heating the system. Figure 03 presents a collection of the images that were captured at the various time intervals. At this point, 2.2 centimeters of the PCM's height had been melted, which is depicted in Figure 3(a), which shows the portion of the PCM that melted after 7 hours. As time goes on, PCM goes through a melting process that is methodical and consistent. PCM with a height of 3.2 centimeters had melted after the heating had been operating for t = 15 hours.


(a) Picture at time t= 7 Hour


(b) Picture at time t= 10 Hour


(c) Picture at time t= 10 Hour

Fig. 3. (a),(b) and (c) are the pictures taken during melting process


(a) Picture at time t= 16:30 Hour


(b) Picture at time t= 16:50 Hour

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(c) Picture at time t= 24 Hour
Fig. 4. (a), (b) and (c) are the picturs taken during solidification process

The steps involved in the process of solidification are depicted in the images in figure 4. Within twenty minutes of the beginning of the cooling process, the PCM had melted down to a height of 0.1 centimetres, as shown in Figure 4 (a) and Figure 4 (b). The temperature drops precipitously as a direct consequence of this. Nine hours have been set aside for the cooling process

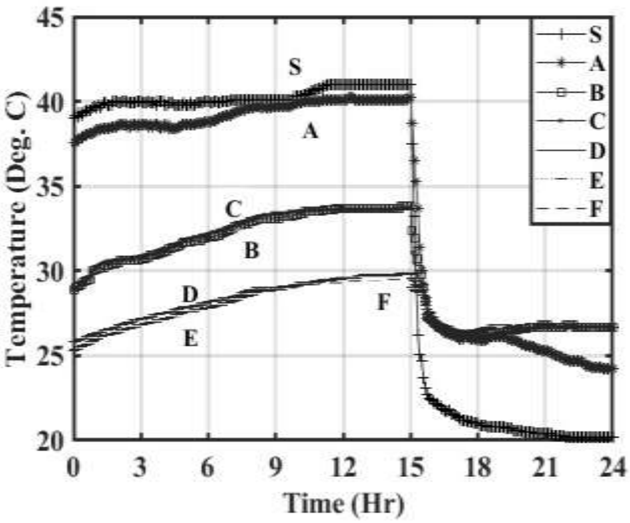


Fig. 5. Temperature variation inside a brick model

At the different locations thermocouples are placed and there readings are noted down. Figure 5 represent the temperature variation of the PCM during its solidification and melting process. In the graph S represents the temperature variation of the copper plate. From the graph it is clear that maximum temperature of the copper plate reaches to 41℃, although fluid temperature in the heat exchanger is 55℃. After 15 Hr. of heating CTB temperature set to 20℃ then copper plate temperature falls suddenly towards 20℃. In the graph A represents variation of temperature of top most layer of the PCM. As this layer is just below the copper plate so the variation of the temperature profile is almost similar to the graph S. Graph B and C follow the same pattern, as both the points in the PCM brick are on the same level. This graph give a good conclusion that at the 1.5 cm below the top surface of the brick, maximum temperature reaches is 33.8℃. Thermocouple D and E is placed 3 cm below the top surface and the variation of the temperature profile at the height is represented by the graph D and E in figure 05. This is concluded that at this height maximum temperature reaches after 15 Hr. of heating is 29.8℃. That is as the height of the PCM is increases maximum temperature at that point decreases. Thermocouple F is placed below the bottom of the brick model. At that point maximum temperature reaches is 29.6℃. That is as the height variation is 1 cm but the maximum temperature difference is only 0.2℃. So as from the temperature distribution graph the optimum height should be 3 cm.

Figure 5 also conclude that thermocouple placed at D, E and F position give an approximate same temperature profile.

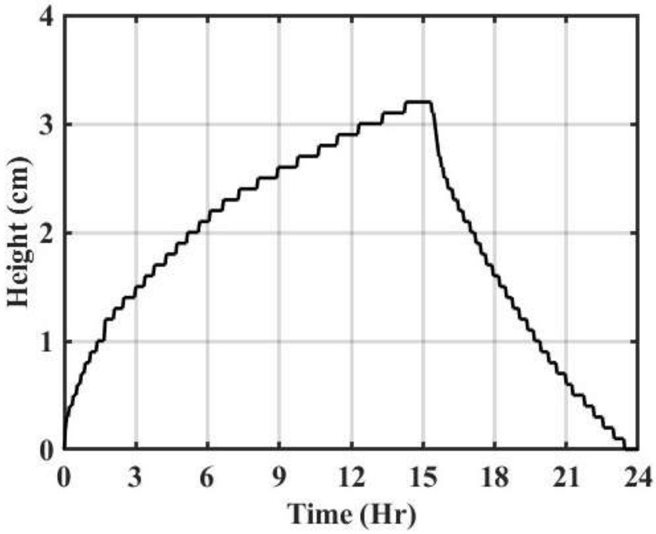


Fig. 6. PCM height variation with respect to the time

Figure 6 represents the height variation of the PCM with respect to time during the melting and solidification process. From the graph it is concluded that 3.2 cm height of PCM is melted in 15 hours of heating. And 3.2 cm height of PCM is solidifying in 9 hours of cooling. From the graph 05 it was concluded that optimum height of the PCM should be 3 cm. But 3 cm height of the PCM is melted within 13 hours of heating. From the both graph it is concluded that heating range between 13 to 15 hr., PCM optimum height lies between 3 to 3.2 cm. But in case of maximum hour of heating (15 hr) 3.2 cm height of PCM is a good enough for cooling of building.

## IV.CONCLUSIONS

PCM is a viable choice for cooling buildings since it acts as a heat storage device. The question of what height the PCM should take on the building top arises, and this experiment yields positive results. PCM is placed within a brick model and a heat exchanger is added to it. As the melting and solidification occur, photos are taken. Simultaneously, the temperature within the brick model is recorded. During the melting process, the top surface temperature was around 40°C. The greatest temperature reached at the bottom of the brick model throughout the heating process is 29.6°C at 4cm below. Maximum temperature is roughly 30°C below 3.2 cm from the top surface. As a result, the 3.2 cm height of PCM is the best height for mounting on the building's top. The bottom most temperature of the surface will be 30°C if the PCM is kept at a height of 3.2 cm on top. It was also discovered that after 9 hours of cooling, the 3.2 cm height of the PCM had solidified completely. That is, PCM recycling is conceivable.

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