# Research on Thermal Properties in a Phase Change Wallboard Room Based on Air Conditioning Cold Storage[1]

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**Abstract:** After comparing the thermal performance parameters of an ordinary wall room to a phase change wall (PCW) room, we learn that phase change wallboard affects the fluctuation of temperature in air-conditioning room in the summer. We built a PCW room and an ordinary wall room, which are cooled by an air-conditioner. We used differential scanning calorimetry (DSC) to test the temperature field and heat flow fluctuation in these rooms. Through analyzing the data tested, we found that the mean temperature of PCW is lower than that of ordinary wall room by 1 to 2℃, and PCW can lower the heat flow by 4.6W/m$^2$. Combining phase change material with the building envelope can lower the indoor temperature, make the room thermally comfortable, and cut down the turn-on-and-off frequency of the air-conditioner and the primary investment and operating costs. It alleviates the urgent need for electricity.

**Key words:** phase change wall; indoor air temperature; cool storage

## 0. INTRODUCTION

As our living levels rising, we want to have more comfortable living condition. The more air-conditioners, the more electricity will be consumed. So our energy consumes more quickly than our estimate. But the application of phase change material (PCM) in building envelope can not only improve our residential indoor thermal environment, but also rationally use electric power.

PCW is one kind of building envelope. It's researched by American researchers since mid of 1980s [1]. It is a sort of walls, whose building materials include PCMs. These walls can store energy in the wallboard during the valley period，and release the stored energy during the peak period. So it can improve the energy efficiency of buildings.

Researchers do many experiments at phase change wall domain. J.Kelly Kissock, a researcher in American Dayton University, used stearic acid as PCM. Through the immerging method, they got phase change wallboard. They built a phase change wall experiment room and an ordinary wall room as compared. Their researches implied that those phase change wallboards can smaller the range of temperature fluctuation. They proved that phase change wallboard can make residential environment more comfortable, and cut down loads during the peak period[2][3]. The building research centre of Concordia University in Canada, combined 49% of butyl stearic acid with 48% of butyl palmitic acid to get a phase change material, and mixed it with lime-and-cement mortar, then dealt it followed the technological requirements to produce a phase change wallboard. They also tested the melting point, coagulating point, and thermal conductivity etc in their experiments. The conclusion: the storage capability of phase change wallboard produced in this way is higher than ordinary wallboards by 10 times [4] [5]. Khudhair's team used paraffin and gypsum board to make phase change wallboard which contains 24% of PCM. Their experiments implied that paraffin do not move when phase is changing and its capability

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of storing energy is not degenerated conspicuously [6]. We tested the thermal performance parameters in ordinary wall room and PCW room in summer. According to some relative theory and researches [7][8], this paper analyzes the phase change wall's impacts on improving indoor thermal environment and cutting down the building energy consumption.

## 1. BUILD THE EXPERIMENT ROOM

### 1.1 Experimental Place

The experimental place is Shenyang, in the northeast of China, latitude 41.8°N, longitude 123.4°E, where the four seasons are clearly distinctive and belong to the continental monsoon climate in the northern temperate zone. The mean temperature of July and August is the highest in a year. So the experiment was done in this period. The experimental room was built in the Residential Environment and Energy Efficiency Laboratory of Shenyang Jianzhu University. Room's dimensions are 4.3m×3m×2.8m. The south wall was external wall, which can be shined after 10 A.M. There was a window 1.5m×1.5m, on the south wall. The top face of the room was a ceiling. The door was in the north wall, sizes 1m×2m. The elevation of indoor floor was ±0.000m. The thick of external wall and bearing wall was 370mm. The thick of internal unhearing brick wall was 240mm. The ceiling contained an acoustic and thermal insulation layer and a 150mm glass wool layer. The door was an ordinary wooden door filled a layer. Its windows had double glass layers in a white frame. The glass was normal transparent glass. The phase change wallboard was made by the method of immerging directly. The PCM was a mixture of fatty acids. The basic material of wall was a gypsum board. The PCW's phase change temperature was from 18 to 24 [9]. When the PCW room's temperature was higher than the PCW's phase change temperature, PCW would become a construction of storing energy, absorbing the surplus heat. When the PCW room's temperature was lower than the phase change temperature, it would release the stored energy. This process can also be called cool storage. So we can use it to lower the indoor temperature in summer.

The equipments used in this experiment are a thermocouple calorimeter plate-type calorimeter, a differential scanning calorimetry (DSC), air-conditioners and Luban detective software. The thermocouple was PT 1000 platinum-copper thermocouple, whose attainable precision was 0.5 . We standardized the thermocouple in a constant temperature water bath or oil bath. Before the experiment, we put the thermocouple in an ice water and a boiling water separately to standardize the thermocouple. Plate-type calorimeter, produced by Beijing Shiji Building Material Limited Corporation, put out electricity signal. Its unit was mV. Multiplying a coefficient to the detected number, we can transit it into thermal flux. The coefficient, 11.63W/$m^2$ • mV, was set by the manufacturer. The DSC, made by Hongkong Changhui Automation System Limited Corporation, was made up of differential scanning meter and four input signal wiring cases. Every signal wiring case has 16 wiring terminals. The NO.1 wiring case's first four wiring terminals are wired to calorimeter, and the other 60 wiring terminals are wired to temperature sensor—thermocouple. SWP-LCD-SSR-M artificial 64 wiring terminal DSC was artificial multi-functions secondary equipment. It was adapted to detect multi-input circuit; alert control and data far-distant transmit. Luban engineering control configuration software can be running in Chinese version's windows 9x/NT. It's a facing user's application configuration running platform. At this platform, user can use the facing object method to write computer programs for application. The core of this program was system variants. It's the configuration software's real-time data base. In configuration, we used the pact unit, such as the drivers of the equipment and system module etc, to generate system variable quantities. Then we used other modules and pact units to calculate, turn out, alert, analyze etc.

## 2. TEST AND ANALYZE

### 2.1 Test Parameters

We built a PCW room and an ordinary wall room, and used air-conditioner to cool the rooms. The PCW can store cool in its walls. We compared the indoor thermal performance of the two rooms. The

working frequency of PCW room was 24 hours. At night, the valley period, we used air-conditioner to store cool to walls. At daytime, the wall would release the stored cool to resist indoor temperature to go up. We tested the indoor temperature, thermal flow through the face of wall, temperature difference and the change of temperature difference which is between wall inner face and indoor air. Then we analyzed the effect of PCW on decreasing the cost of equipments and cutting down the loads during the peak period.

2.2 Make the Experimental Plan

The test plan: kept air-conditioner running 5 hours to store cool in the walls at night, and kept it off at daytime to detect indoor thermal performance parameter, then got the results of using PCM.

2.3 Analyze Tested Data

Figure1. shows the curve of outdoor air temperature fluctuation during testing time. From the figure, it's easy to learn that the minimum of outdoor temperature was 20.9℃, while the maximum was 36.5℃. The lowest point of the outdoor temperature turned up at 5:00 A.M, while the highest point turned up at 14:00 P.M. From 10:00 A.M to 14:00 P.M the temperature went up quickly.

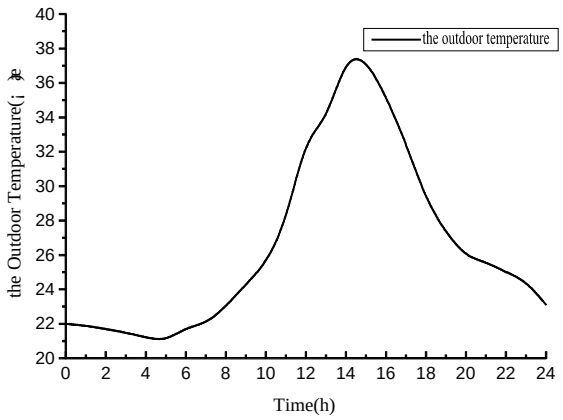


**Fig. 1 the Outdoor air temperature**

(1) The compare of the two rooms' temperature-changes

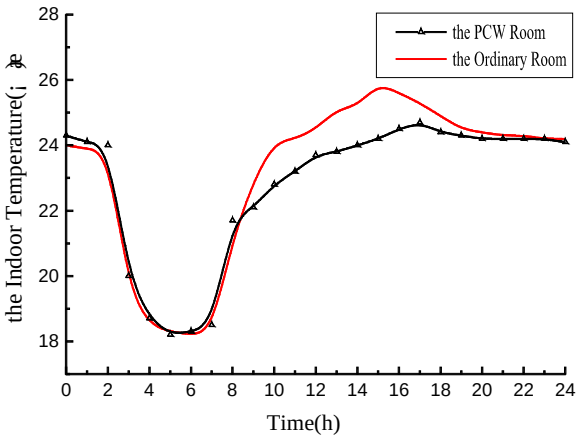


**Fig. 2 the Temperature changes of PCW room and ordinary wall room**

Form figure2, it's easy to learn that the indoor temperature's fluctuation in PCW room was smaller than that in the ordinary room. In the test period, the indoor temperature's highest point in PCW room was later to reach than that in the ordinary room by two hours, while the highest indoor temperature in the PCW was smaller than that in the ordinary room by 2℃. It proved that the stored cool in the PCW was released to make the temperature go up slowly at day time and to smaller the range of temperature fluctuation.

(2) the compare of temperature differences between indoor air and inner face of walls

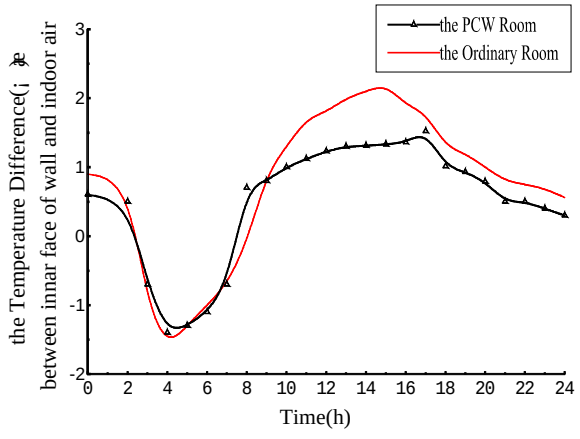


**Fig. 3 the Temperature difference between the indoor air and the inner face of east wall**

From figure3, it's easy to learn that the temperature difference between the inner face of east wall and indoor air in the PCW room was smaller than that in the ordinary wall room, and the moment of biggest temperature difference turned out was

delayed. In the ordinary wall room, the temperature difference between indoor air and inner face of east wall was from -1.5℃ to 2.3℃, and the moment of the biggest value turned out was the right moment of the highest indoor temperature turned out. After that moment, the outdoor temperature went down from the highest point, while the inner face temperature of wall went up slowly. The temperature difference between indoor air and inner face of wall reached the highest point when indoor air temperature got the highest point, then it went down accumulatively.

In the PCW room, the temperature difference between indoor air and inner face of east wall was from -1.4℃ to 1.3℃. It's easy to know that there are differences between the two rooms' temperature difference curves. The trend of the temperature difference was smooth. The biggest temperature difference between these two rooms was 1.1℃.

(3) The compare about the changes of heat flow

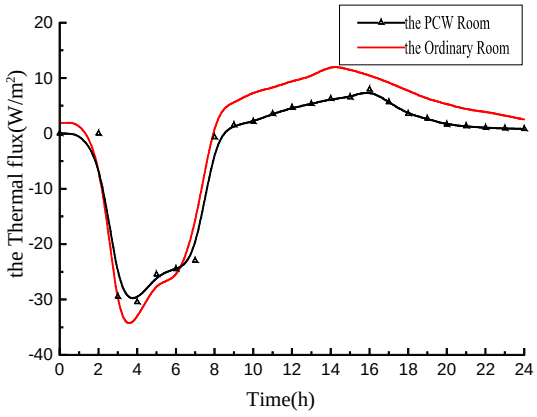


**Fig. 4 the Thermal flux of the east wall in the PCW room and the ordinary wall room**

Figure 4 shows the curves of heat flow through the east wall of both rooms. The air-conditioners were running continuously at night. So we can learn that the PCW's thermal flow was approximately equal to the ordinary walls', when they stored cool. The east wall's thermal flow in the ordinary room changes form 2.5 W/m$^2$ to 11.5 W/m$^2$ at daytime. The maximum was 11.5 W/m$^2$. The east wall's thermal flux in PCW room changes form 0.8 W/m$^2$ to 6.9 W/m$^2$ at daytime. The maximum was 6.9 W/m$^2$. In similar conditions, the thermal current of PCW room was smaller than that of ordinary room. The conduction heat value between PCW and outdoor was lower than that between ordinary walls and outdoor, so PCW has the ability of insulating heat. The thermal flow's maximum was delayed too.

## 3. CONCLUSION

(1)The indoor air temperature's fluctuation in PCW room was smaller than that in ordinary room, and the indoor air temperature's maximum in PCW room was lower than that in ordinary room by 2℃.

(2) PCW room's temperature difference between inner face of wall and indoor air, was lower than the ordinary room's. Its maximum turn out time was delayed.

(3) PCW room's thermal flow was lower than the ordinary wall room's, and the moment when the maximum turned out was delayed. The max difference between the two rooms was 4.6 W/m$^2$.

(4) Building envelope which contains phase change wallboard can improve the indoor thermal environment, and decrease energy consumption in buildings. Phase change wallboard can make impressive effect on energy efficiency of buildings.

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