Study on structural optimization of phase change hollow brick

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Abstract

China is a populous country, the demand for housing is huge, and most of them are high energy consuming buildings, which has brought a lot of construction load, resulting in a large number of energy losses. The phase change material in our country has just started, the development of phase change material is mainly based on the energy efficiency of the building, but after years of development, the types of phase change materials in China have covered most of the fields. The phase change material can achieve the effect of heat preservation through the latent heat of vaporization of phase change, and the phase change material can be effectively combined with the building material. The design of the ANSYS can be used to optimize the simulation of the phase change of the hollow brick simulation, as the phase change material is vulnerable to the impact of the external environment, so we can optimize the structure simulation.In this paper, the heat transfer performance of four kinds of common hollow brick structure is simulated and analyzed.

Keywords

Energy loss, Building energy saving, Phase change material, ANSYS simulation.

1. Introduction

China's second largest economy in the world, the total energy consumption is also ranked first in the world, of which the building energy consumption is also very large. According to incomplete statistics, China's energy-saving building area is only 230 million square meters, but China's built houses have more than 40 billion square meters of high-energy-consumption buildings. China's construction annual consumption of commodity energy totals 376 million tons of standard coal, accounting for the entire society. 27.6% of total consumption.

PCM (Phase Change Material), also known as phase change energy storage material, is a material that absorbs or releases a large amount of latent heat of phase change during the phase transition of a material. The most common phase change material in life is water. When the water is not more than 0 ℃, it will change from liquid to solid. The temperature will change during the phase change and a large amount of latent heat will be released. At the same time, the water will have liquid at not less than 100 ℃. It becomes a gas and absorbs a lot of heat at this time. The latent heat of phase change is generally large. For example, the latent heat of phase change of infinite hydrated salt and organic acid is between 100 and 300 KJ/kg, and the metal can reach 400 to 510KJ/kg. This shows that the phase change material has great advantages in energy storage.

The heat storage material is an economical and effective material that can realize energy saving of the building. By combining the phase change material and the wall reasonably and efficiently, the high storage performance of the phase change material can be fully utilized, and the thermal performance of the wall body can be improved, thereby achieving Adjusting the indoor ambient temperature and reducing the energy consumption of the building, and also reducing the energy consumption of the temperature control tools such as air conditioners, so the phase change insulation materials have important application prospects for building energy conservation. Phase change hollow bricks have various advantages such as economical, convenient transportation and excellent thermal insulation effect, and have attracted attention at home and abroad. The development of phase change materials in China has also started from building energy conservation. After years of development, its types have covered most of the fields, and production costs and process requirements have also declined. This has paved the way for the development of phase change hollow bricks. Therefore, the optimization of phase change hollow bricks has also been put on the agenda. In this paper, we mainly optimize the structure of phase change hollow bricks, because the selection of phase change materials is greatly affected by the ambient temperature, and the structural optimization can simulate the external environment, and the final conclusion is drawn.

2. Material selection

2.1 Selection of phase change materials

The main research direction of this design is the structural optimization of phase change hollow bricks. Therefore, for phase change materials, we can select a cost-effective phase change material suitable for the simulated environment, and the hollow brick structure optimization is also not affected by the external environment.

Sodium sulfate decahydrate is known as mirabilite, which is an important phase change material for cold storage air conditioners. Currently, it is widely used for sodium sulfate decahydrate.

TABLE Ⅰ Several physical parameters of sodium sulfate decahydrate

Character	Colorless transparent or colorless and transparent, crisp, brittle	melting point (℃)	32.35
Thermal conductivity ($W/(m\bullet K)$)	239.7	latent heat (kJ/kg)	251.2
Specific heat capacity ($kJ/(kg\bullet K)$)	1.93	density (kg/m^3)	1485

2.2 Selection of hollow brick materials

Cement can be divided into silicate cement, aluminate cement, sulphoaluminate cement, iron aluminate cement and fluoroaluminate cement according to its components.

Here we choose Portland cement as the hollow brick material for this simulation experiment. Portland cement is water made from Portland cement, 0~5% limestone or granulated blast furnace slag, and appropriate amount of gypsum. A hard gelling material called Portland cement.

3. Numeral Calculations

3.1 Calculation of the enthalpy value of phase change materials

When using ANSYS simulation software for simulation analysis, phase transformation problems such as solidification and melting are often encountered. Because of the nonlinear process in the phase change material analysis process, it is necessary to determine the latent heat in the process compared with the linear process. Pig.1 is shown. ANSYS can simulate nonlinear non-linear processes by customizing the enthalpy of materials at different temperatures. We can assume that the enthalpy of noctanoic acid at 20 ℃ is 0, and the enthalpy at other temperatures can be calculated using the following formula:

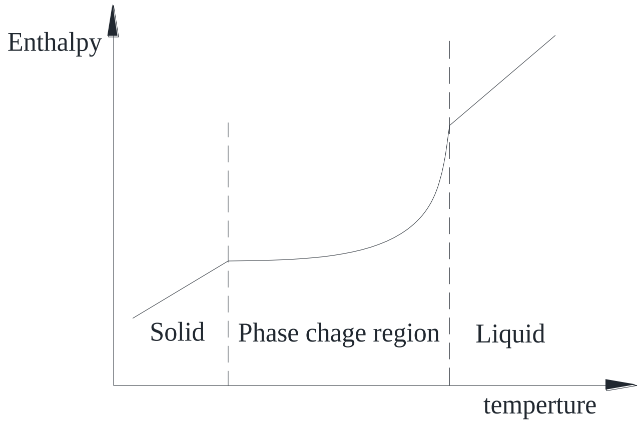

Fig. 1 The change of enthalpy of phase change material with temperature

The value of the solid state at the beginning of the phase change can be calculated by the formula:

$$H = p_1 C_1 \Delta T \tag{3.1}$$

where p_1 denote solid Material density, C_1 is Specific heat capacity in solid state.
For the phase change region we use the formula:

$$H = p_1[CT_1 + \frac{\Delta Q}{T_2 - T_1}(T - T_1)] \tag{3.2}$$

where T_1 is The temperature at which the material begins to phase change, T_2 denote temperature at the end of phase change, T denote room temperature, and ΔQ is Latent heat.
For the devaluation of the liquid we use the formula:

$$H = p_1[C_1 T_1 + \Delta Q] + p_2[C_2(T - T_2)] \tag{3.3}$$

where p_2 is Density in liquid state, C_2 denote Specific heat capacity in liquid state.

4. Simulation of ANSYS

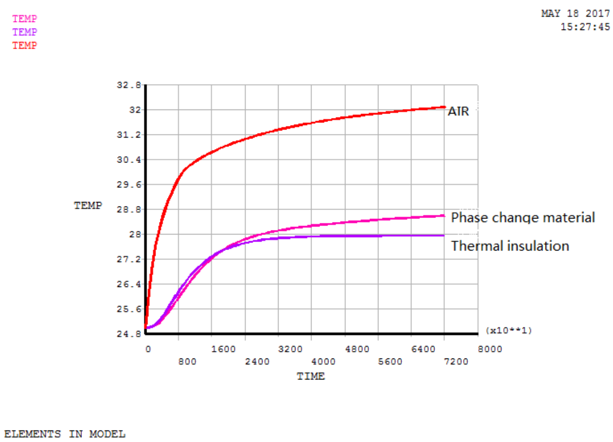

Fig. 2 Temperature profile of different fillings over time

It is the temperature curve of the interior side of the hollow brick containing three different materials. It can be seen that the temperature change of different hollow bricks has the shortest corresponding time and the highest temperature rise slope, indicating that the heat transfer is the fastest. Thermal insulation materials cause a relatively slow temperature rise due to their extremely low thermal conductivity.

Finally, for the phase change material, the phase change absorption phase change latent heat occurs due to the phase change material near the outdoor side, and the heat transfer becomes relatively slow. However, as time goes by, the phase change material will no longer absorb heat, causing the temperature to rise.

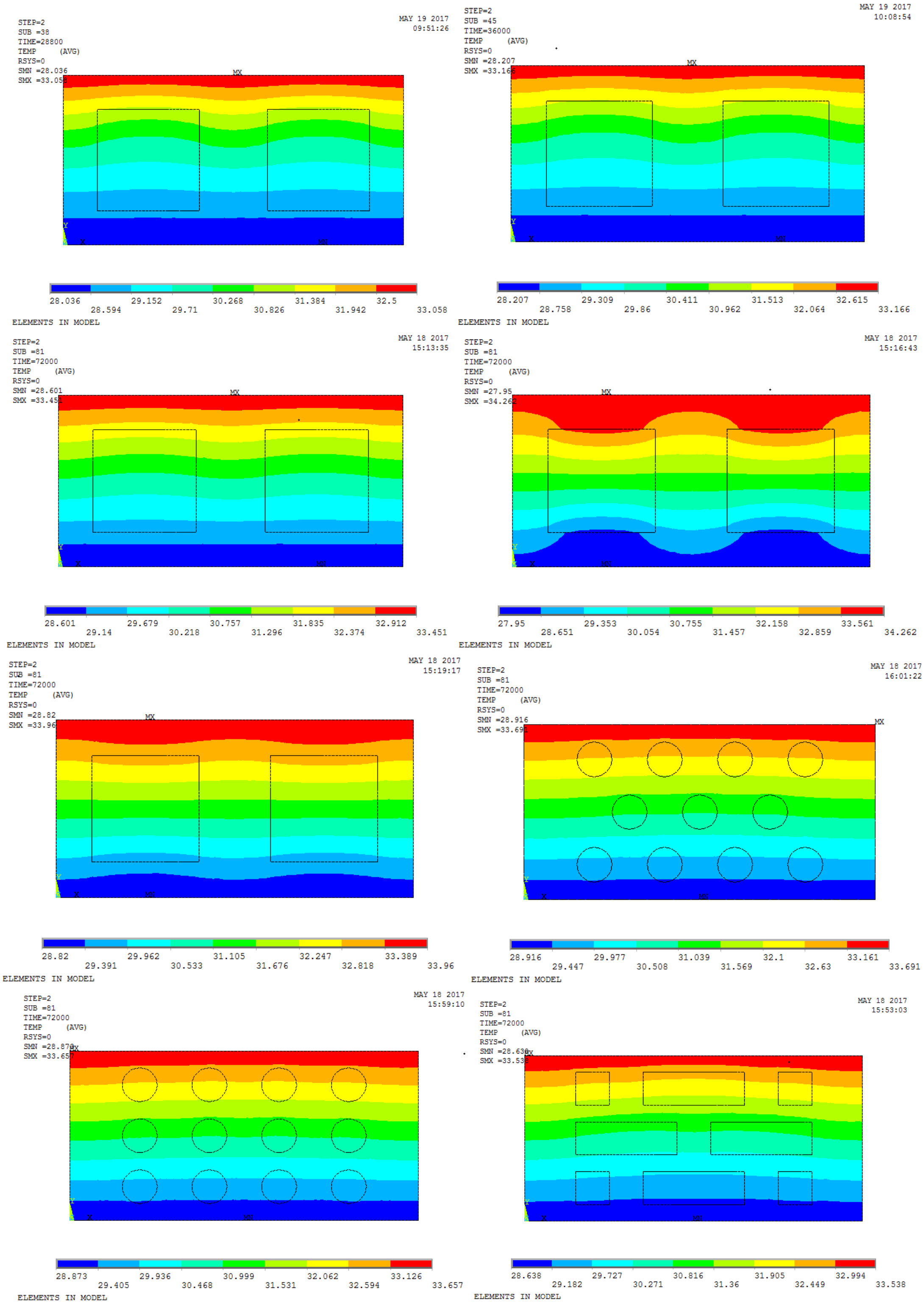

Fig. 2 Temperature change of hollow bricks with different structures over time

First, let's compare the temperature curves of the indoor side of the No. 2 and No. 3 hollow bricks. The hollow bricks of No. 2 and No. 3 are not much different as porous hollow bricks, but in the heat transfer, the order of the pipelines in the radiator can have a great influence on the heat exchange efficiency of the heat exchanger, so I want to study the hollow holes in the hollow bricks. Whether the order of the bits can have a greater impact on the insulation effect.

Through the comparison of the above two temperature profiles, we found that the temperature curves of No. 2 and No. 3 basically coincide. If you consider the economic cost, the second hollow brick is better than the third.

5. Conclusion

The main research object of this paper is the influence of the structure of phase change hollow brick on its heat transfer performance. At the same time, in order to compare the heat preservation performance of phase change material, hollow bricks of other two materials are added for comparison. Then, the temperature variation curves of the indoor side of four hollow bricks with different structures were analyzed.

1. By comparing with other hollow bricks of different materials, we know that although the phase change material has a large thermal conductivity, it will absorb a large amount of latent heat of phase change due to its phase transition process at the phase transition temperature. The rate of exhaustion is greatly reduced.

2. By analyzing the temperature cloud of three different filling materials, it is found that the smaller the thermal conductivity, the closer the isotherm is to it. Because the thermal conductivity is low and the heat transfer rate is low, the heat cannot be transferred in a large amount and then emanating, eventually bringing the isotherm closer to it.

3. Analysis of the temperature variation curve of the interior of four hollow bricks with different structures, we found that the main factors affecting the heat transfer performance of phase change hollow bricks are the number of phase change materials and the degree of dispersion of phase change materials. The more the number of phase change materials, the lower the heat transfer performance; the more dispersed the phase change material, the lower the heat transfer performance.

References

[1] Zhang Yuping. Phase change energy storage: theory and application [M]. Hefei: University of Science and Technology of China Press, 1996.11: 8.

[2] Xie Pengcheng, Yan Hua .Research Progress in Solid-Liquid Shaped Phase Change Materials[J].China Storage and Transportation,2012(11):120.

[3] Zhang Renyuan. Phase change materials and phase change energy storage technology [M]. Beijing: Science Press, 2009.1:109.

[4] Zhang Liang,Yu Hua.Research progress of phase change materials and their application in the field of architecture[J].Development and Application of Materials,2010(1):71-72.

[5] Mo Youbin,Liao Yanfang.Research Progress in Phase Change Materials for Construction[J]. Popular Science & Technology,2012(159):61-62.

[6] Sun Wubin, Yan Hong. Building Materials [M]. Beijing: Tsinghua University Press, 2004.8:36.

[7] Zhang Chaoyang. ANSYS Thermal Analysis Tutorial and Case Analysis [M]. Beijing: China Railway Publishing House, 2007.5:82.

[8] Yang Shiming, Tao Wenzhao. Fourth Edition of Heat Transfer Theory [M]. Beijing: Higher Education Press, 2006:211-218.

[9] Hua Zisen.Insulation performance analysis of porous brick and design of its automated code transportation system[D].Shandong: Shandong Jianzhu University, 2014.