ID: 5060

Numerical Investigation of Heat Exchanging and Heat Comfort in Building Room Embedded with Phase Change Material

Bousseliou Mahyeddine*, Bechiri Mohammed

Advanced design and modeling laboratory for mechanical and thermo-fluid systems, University of Larbi Ben M'hidi of Oum El Bouaghi, Algeria

*Corresponding author's email: mohyei.enset21@gmail.com

ABSTRACT

This paper presents a one-dimensional numerical investigation to study the heat exchanging and the thermal comfort conditions inside a building room during the heating season. three walls of the room are insulated, and the remained wall is constructed with brick that is embedded with phase change material (PCM). The mathematical model is based on pure conduction in brick and PCM, and on natural convection in the indoor air; the non-insulated wall is subjected to a constant temperature at the external surfaces. The enthalpy method is used to resolve energy equations in both solid and liquid phases of PCM. The natural convection inside the liquid phase of PCM storage unit is taken into account in via the dependence of the effective thermal conductivity on the liquid fraction. The model developed in this study is analyzed and compared with literature, and a good agreement is showed. Then, a parametric study for different geometrical and thermo-physical parameters of the building room is conducted.

Keywords: PCM, thermal comfort, brick, storage energy.

1 Introduction

The heat comfort in buildings means to obtain the right thermal environment to avoid certain daily inconveniences. In fact, an unwell regulated temperature disrupts the well-being of the occupants at a home. Thermal comfort means to adjust the environment between the in-home temperature and the external conditions to better control the energy consumption. That is good for the daily fees and good for the planet, in particular by limiting the greenhouse effect. In this paper, we address the one-dimensional analysis that aims to comprehensively understand the mechanisms of heat exchange and thermal comfort conditions inside the building room during the heating season. The focus of the study is on a room with three insulated walls and a fourth wall built of brick and embedded with a phase change material of the RT25 type, as shown in the corresponding figure Fig. 1.:

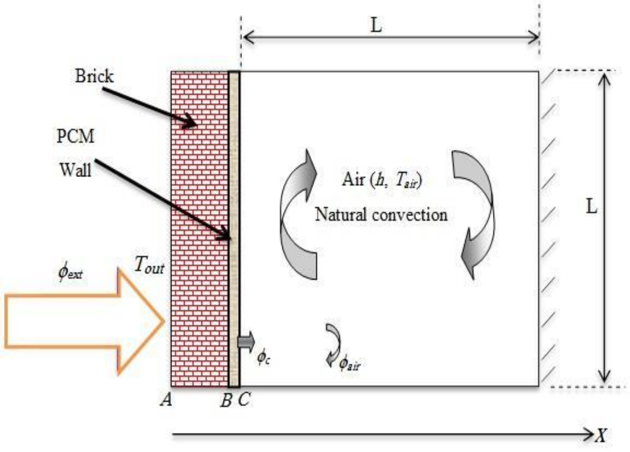

Figure1: Schematic of the considered geometry.

DOI: 10.21467/abstracts.170 ISBN: 978-81-970666-1-0 (eBook)

Table 1:*Thermo-physical properties of RT25, Clay Brick and Air [2], [3], [4]*

	T_{solide} (K)	$T_{Liquide}$ (K)	L (kj/kg)	Cp(kj/kg.K)	〉 (kg/m^3)	K(w/mK)	⌠(kg/m.s)
RT25	*300.15*	*302.15*	*230*	*2*	*770⊔ 880*	*0.2*	*0.026*
Clay Brick	-	-	-	*741000*	*664*	*207*	-
Air	-	-	-	*1.00144*	*1.22*	*0.026*	*1.789x10-5*

The mathematical model, formulated for unsteady one-dimensional coordinates is written on dimensional form as:

For the brick region:

$$\frac{\partial_{br}^{2T}(x,t)}{\partial x^2} = \frac{1}{\alpha_{br}} \frac{\partial T_{br}(x,t)}{\partial t}, t > 0, \quad 0 < x < X_B \qquad (1.1)$$

$$T_{br}(x,t) = T_{out}, \qquad t > 0, x = 0 \qquad (1.2)$$

$$k_{br} \frac{\partial T_{br}(x,t)}{\partial x} = k_{pcm} \frac{\partial T_{pcm}(x,t)}{\partial x}, t > 0, x = X_B \qquad (1.3)$$

For the PCM region:

$$k_{pcm} \frac{\partial^2 T_{pcm}(x,t)}{\partial x^2} = \rho_{pcm} \frac{\partial H(x,t)}{\partial t}, t > 0, X_B < x < X_C \qquad (1.4)$$

$$-\frac{k_{pcm}\left(\partial T_{pcm}(x,t)\right)}{\partial x} = h\left(T_{pcm} - T_{air}\right), t > 0, x = X_C \qquad (1.5)$$

For the air region, the energy balance can be expressed as:

$$\phi_C = \phi_{air} \Rightarrow hL\left(T_{pcm}(x = X_C) - T_{air}\right) = (\rho cp)_{air} L^2 \frac{\partial T_{air}(t)}{\partial t}, \qquad (1.6)$$

The enthalpy, *H*, is a function of temperature, *T*:

$$H(T) = \begin{cases} cp_{pcm}(T - T_m), & T < T_m \\ cp_{pcm}(T - T_m) + q & T > T_m \end{cases} \qquad (1.7)$$

and at the melting point of the PCM, the enthalpies of solid and liquid phases at the melting point are 0 and *q*, respectively.

From these equations (1.7), the temperature ´T´ is:

$$T = \begin{cases} T_m + H/cp_{pcm} & H < 0 \\ T_m & 0 \leq H \leq q \\ T_m + (H - q)/cp_{pcm} & H > q \end{cases}$$

In the following, we will adopt the numeric resolution with using the Finite Difference Method, each location and time are represented by *i* and *n*.

$$T(x,t) = T_i^n = T(i\Delta x, n\Delta t)$$

References

[1] Guobing Zhou , Yongping Yang a, Xin Wang , Jinming Cheng , Thermal characteristics of shape-stabilized phase change material wallboard with periodical outside temperature waves, Applied Energy 87 (2010) 2666–2672 .

[2] Said Hamdaoui , Abdelhadi Bouchikhi , Mohammed Azouggagh , Building hollow clay bricks embedding phase change material: Thermal behavior analysis under hot climate, Solar Energy 237 (2022) 122–134.

[3] Ubaid ur Rehman, Muhammad Ashiq, Muhammad Ahmad Rafi, Investigating Energy-Saving Strategies: A Numerical Studyof Translucent Insulation and Phase Change Materials in Windows, engineering Proceedings.

[4] M. Faghani , M.J. Hosseini , R. Bahrampoury, Numerical simulation of melting between two elliptical cylinders, Alexandria Engineering Journal.