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Numerical Investigation of Heat Exchange and Convective Heat Transfer in a Building Room with In-Wall Embedded PCM

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ABSTRACT

This paper presents a two-dimensional numerical investigation to study the heat exchanging and the convective heat transfer coefficient inside a building room during the heating cooling seasons. 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 the Boussinesq model for the 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 conservation of masse and momentum equations are resolved by using Ansys-Fleunt code. 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, Convective, Heat, The enthalpy method.

1 Introduction

The pursuit of energy efficiency and thermal comfort in building design has led researchers to explore innovative solutions, among which the integration of phase change materials (PCMs) stands out. PCMs have the remarkable ability to store and release thermal energy during phase transitions, offering significant potential for reducing energy consumption and enhancing indoor comfort. This paper presents a comprehensive numerical investigation aimed at understanding heat exchange and convective heat transfer inside a building room throughout both heating and cooling seasons. Specifically, the study focuses on a room configuration where three walls are insulated, while the remaining wall is constructed using brick embedded with PCM. The utilization of PCM in building materials allows for the absorption and release of thermal energy, thereby influencing the overall thermal dynamics of the enclosed space. The mathematical model employed in this investigation is founded upon principles of pure conduction within the brick and PCM, along with the Boussinesq model to describe natural convection within the indoor air. Additionally, the non-insulated wall is subjected to a constant temperature at its external surfaces, reflecting real-world conditions. To resolve the energy equations within both solid and liquid phases of the PCM, the enthalpy method is employed, while the conservation of mass and momentum equations are solved using the Ansys-Fluent.

Thermal properties

Initial temperature: $T_0 < T_m < T_{out}$. $T_{out} > T_{air}$.Tm = heat comfort temperature = 25 °C.

$T_0 = 20\ °C$, Tout = 40 °C.

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

	T_{solide} (K)	$T_{Liquide}$ (K)	L (kj/kg)	Cp(kj/kg.K)	〉 (kg/m^3)	K(w/mK)	⌠(kg/m.s)
RT25	*295.15*	*298.15*	*230*	*2*	*880*	*0.2*	*0.026*
Clay Brick	-	-	-	*741000*	*664*	*207*	-
Air	-	-	-	*1.00144*	*1.22*	*0.026*	*1.789x10-5*

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Geometry and Meshing

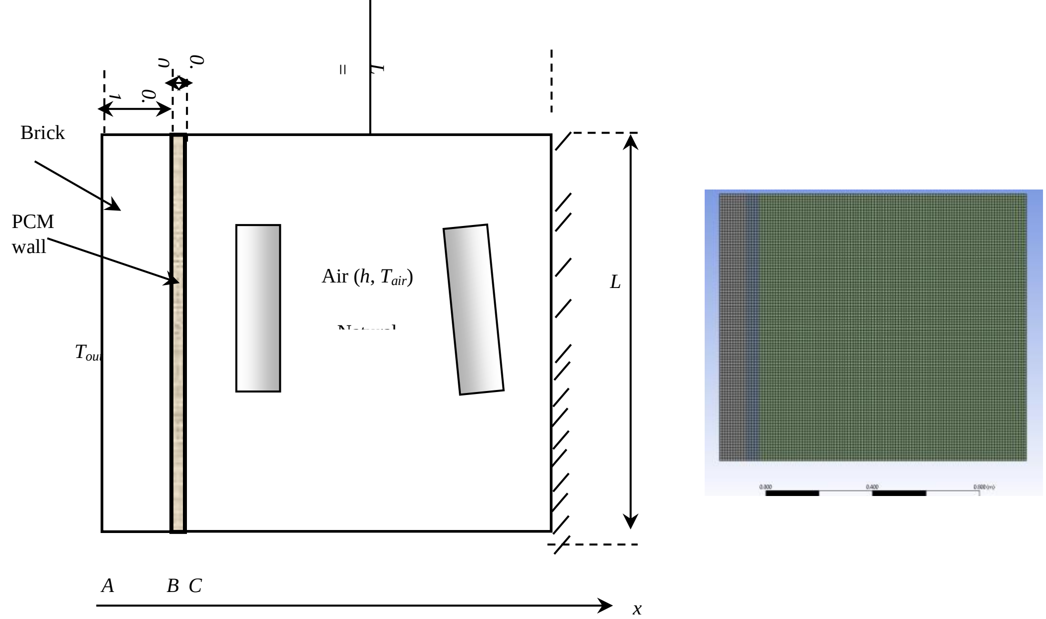

Figure1: Schematic of the considered geometry and used mesh.

2 Results:

Remark: This is the initial result for new

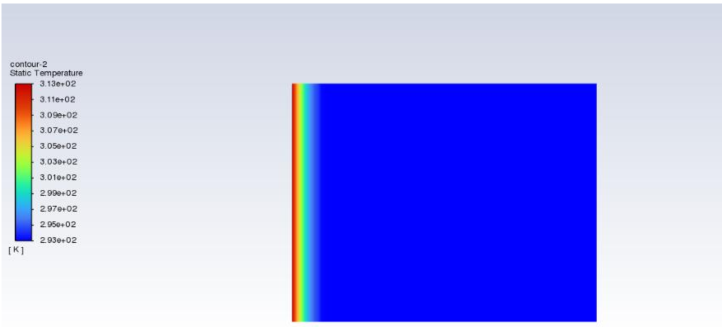

Figure2: Temperature Contour.

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