NUMERICAL ANALYSIS OF HOUSE WITH TROMBE WALL

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Abstract - *The annual heating demand in the building industry could be considerably reduced by passive solar techniques which use the architectural devices such as Trombe wall. The flow fields and the temperature fields in the room with Trombe wall are simulated. The pre-processing will be done utilizing GAMBIT software while ANSYS FLUENT CFD code will be used as solver. The present study would be useful to increase the utilization of renewable energy in the building industry effectively. When a Trombe wall is used for summer cooling by considering constant heat flux $q = 210\ W/m^2$, air inlet temperatures are 308 K, 310 K and 312 K. The ventilation rate made by the buoyancy effect progresses with wall temperature, solar heat gain, wall height and thickness. To maximize the ventilation rate for summer cooling, the interior surface of storage wall should be insulated. This also prevents unwanted overheating of room air due to convection and radiation heat transfer from the wall. When a Trombe wall is used for winter heating by considering constant heat flux $q = 125\ W/m^2$, air inlet temperatures are 294 K, 296 K and 298 K. The efficiency of winter heating system can vary with the location of the outlet vent and the outlet vent position at bottom is better linked at top and centered. From the results of 2D analysis showed that the hot air entered the living space and it gives the heating effect in case of winter heating mode. The temperature of wall is directly proportional to the quantity of heat flux hits on the wall. Finally we can conclude from 2D results that former can be used for faster.*

***Key Words*: trombe wall, summer cooling, winter heating, Ansys fluent, Gambit etc.**

1. INTRODUCTION

The effect on the environment and the fast progress in the price are the main factors disturbed with the utilization of fossil energy which is a needed component of daily life. As an outcome the renewable sources of energy such as sun, wind, biomass, waves, rain, tides and geo thermal heat has increased lot of importance. Solar energy in specific has got wide spread usage as it can be used in almost all parts of the world comprising the remote and undersized regions. It can be used for space heating which can decrease the annual heating mandate to nearly about 25% in the building sector [1].

Hence the solar space warming plays a dangerous role in the nominal usage of the non-renewable energy sources.

The space heating can be done using both the active and passive solar methods. The active is one in which a mechanical device like a fan or a blower is used whereas in the later one it is not used. Therefore it is important to study the Passive solar techniques which are not only energy saving but also inexpensive.

1.1 Trombe Wall

Trombe wall initiative was first untested by Edward Morse an American engineer in the year 1881. It was more propagated by Felix Trombe and Jacque Michel a French Engineer and French architect separately. Hence it is called Trombe wall. In this kind of system, natural convection mode of heat transfer is developed to circulate the air in the room over a thin channel made by a window on one side and a wall on the other. The solar energy composed by the wall and the opening is distributed to the room through the flowing flow. Trombe wall system shown in fig.1.1

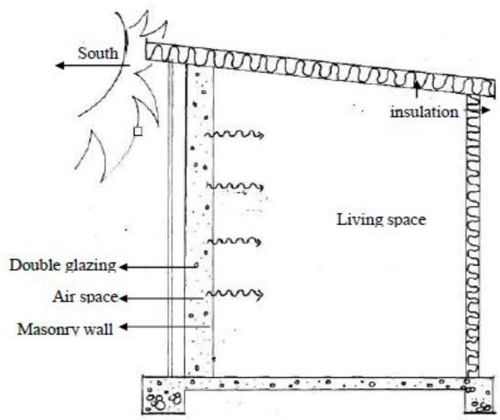


Fig.1.1: Trombe wall system

2. Numerical Method & Solution Procedure

Assumptions

In order to facilitate the formulation of the problem and solution the following assumptions are made. A two dimensional model is considered for the analysis. The analysis is carried out considering steady state and air as working fluid. There is no heat transfer after the roof and the wall either to the living space or to the air space i.e. floor and the roof are totally insulated. The influence of radiation mode of heat transfer is considered negligible. The heat transfer inside system only because of natural convection.

2.1 Creation of Geometry and Generation of Mesh Utilizing GAMBIT

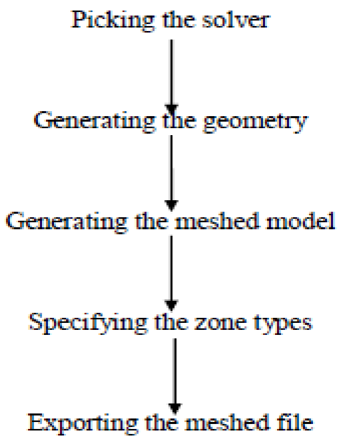


Fig.2.1: Steps used in Gambit to create a model

The basic steps are used to create a model in Gambit software and its model in fig.2.1.

2.2 Analysis Utilizing FLUENT 5/6

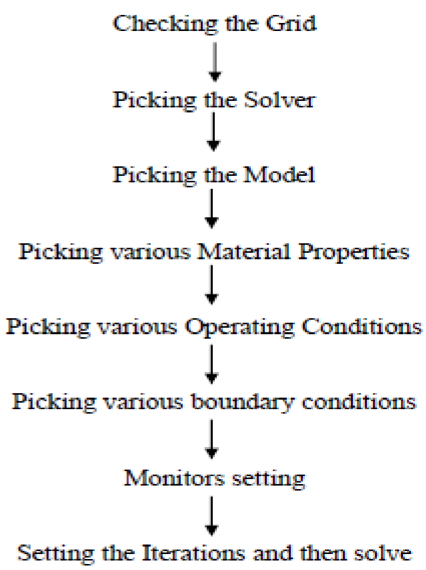


Fig.2.2: Steps followed in Ansys to obtain the solution

The basic steps are used to solve a model in Ansys software a by considering input of the boundary conditions shown in fig.2.2.

3. Modeling and Meshing

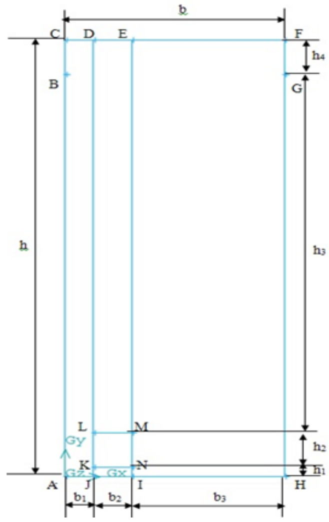


Fig.3.1: Model of Trombe wall system

Table 3.1: The dimensions of the Trombe wall model

Components	Dimensions (m)
Overall height (h)	2.92
Overall breadth (b)	1.15
Air space breadth size (b_1)	0.15
Interior wall breadth size (b_2)	0.2
Living space breadth size (b_3)	0.8
Interior wall height size (h_1+ h_3+ h_4)	2.69
Air space height size (h_a)	2.69
Living space height size (h_L)	2.69
Bottom vent height from the roof (h_1)	0.065
Distance between GM (h_3)	2.395
All openings size	0.23×0.6

The model of trombe wall system which is created in Gambit software shown in fig.3.1 and its dimensions are in the table 3.1.

3.1 Material properties

The material properties used for summer cooling and winter heating shown in table 3.2 and table 3.3 resp., B.CS in 3.4.

Table 3.2: The material properties for summer cooling

Properties	Air			Concrete	Units
	312 K	310 K	308 K		
Density	1.1312	1.138	1.1459	2306	Kg/m³
Specific Heat	1006.9	1006.8	1006.7	669	J/kg-K
Thermal Conductivity	0.02700	0.026856	0.02671	0.07788	W/m-K
Viscosity	1.91e-5	1.9e-5	1.85e-5		Kg/ms

Table 3.3: The material properties for winter heating

Properties	Air			Concrete	Units
	298 K	296 K	294 K		
Density	1.183	1.198	1.213	2306	Kg/m³
Specific	1006	1006	1006	669	J/kg-K
Thermal	0.02620	0.02570	0.02544	0.04783	W/m-K
Viscosity	1.83e-5	1.8e-5	1.79e-5		kg/ms

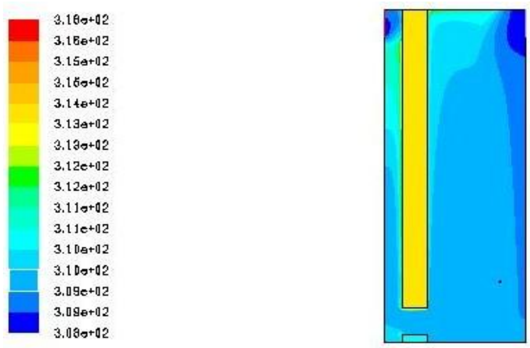
Table 3.4: input values given for various boundary conditions

Zone	Type	Boundary Conditions	
External Vent	Pressure inlet	Zero gauge Pressure	
Cooling Vent	Present outlet	Zero gauge Pressure	
Roof	Wall	---------	
Floor	Wall	---------	
Glazing	Wall	---------	
Trombe wall	Constant Heat flux	Summer cooling	Winter heating
		210 W/m²	125 W/m²
External vent	Temperature inlet	Summer cooling	Winter heating
		312 K 310 K 308 K	298 K 296 K 294 K

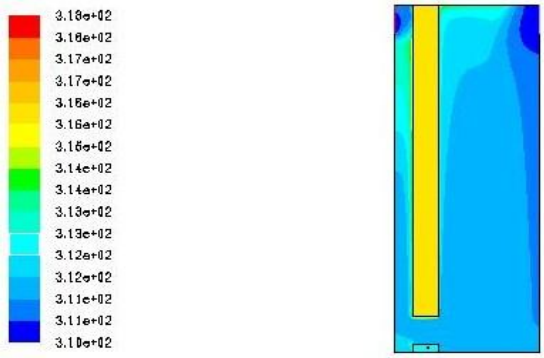
4 Results and Discussions

4.1 Study of Summer Cooling System

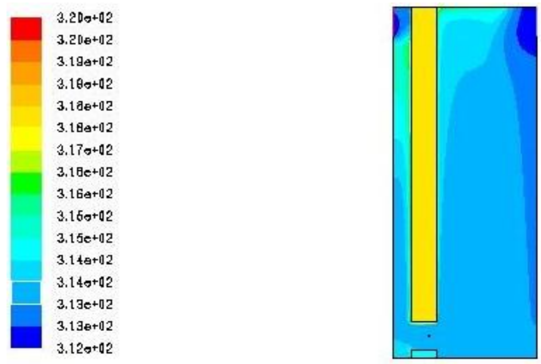
In summer cooling system the inlet vent present at top of the right side wall and outlet vent at the top of the left side glass has to be considered. The warm air always tries to move upwards, because of less dense compared cool air. Here the velocity of air circulation decides the cooling effect or ventilation. The temperature distributions and plots are shown below in fig. 4.1 & 4.2 respecively.



Case a): 2D, T_{in} = 308 K



Case b): 2D, T_{in} = 310 K



Case c): 2D, T_{in} = 312 K

Fig.4.1: Filled contours of Static temperature of case (a), (b) & (c)

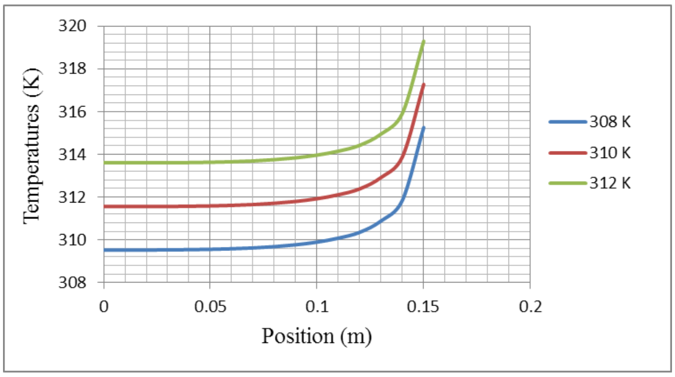
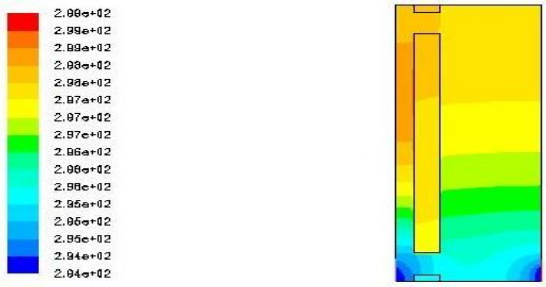


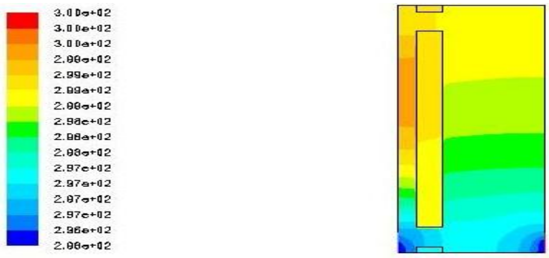
Fig.4.2: Profile of different static temperature variations at position of x = 0 to 0.15 m, y = 1.46 m

4.2 Study of Winter Heating System

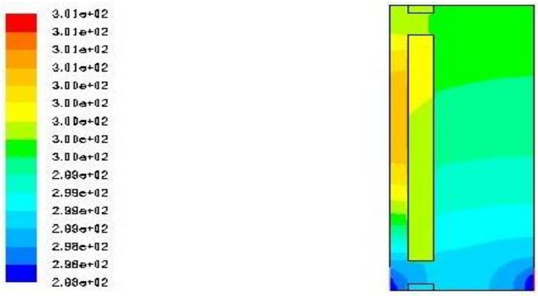
In winter heating system the inlet vent present at bottom of the left side wall and outlet vent at the bottom of the right side glass has to be considered (for effective results). In this system the outdoor air comes from the inlet and moved upwards in air space between glass and wall. The warm air always tries to move upwards, because of less dense compared cool air. Here the velocity of air circulation decides the space heating effect and warm air circulates in living space, here warm air cannot escapes easily. The temperature distributions and plots are shown below fig.4.3 & 4.4 respectively.



Case a) 2D, T_{in} = 294 K



Case b) 2D, T_{in} = 296 K



Case c) 2D, T_{in} = 298 K

Fig.4.3: Filled contours of Static temperature of case (a), (b) & (c)

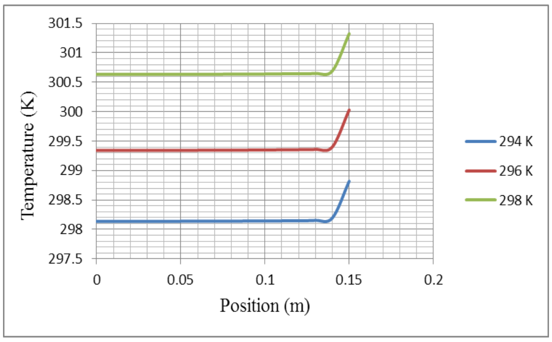


Fig.4.4: Profile of different static temperature variations at position of x = 0 to 0.15 m, y = 1.46 m

5. Conclusion

The study shows that the computer code advanced can be used for the prediction of buoyant air flow and temperature variation in the room by consideration of Trombe wall geometries. The operation of a Trombe wall is simulated with the FLUENT software. These simulations have provided a better understanding of air circulation in the Trombe wall.

For summer cooling, to increase the rate of ventilation, the inner surface of storage wall should be insulated. Also this prevents unwanted overheating of air present inside the room because of heat transfer by radiation and convection from the wall.

From the results of 2D analysis showed that the hot air entered the living space and it gives the heating effect in case of winter heating mode. The temperature of wall is directly proportional to the quantity of heat flux hits on the wall. The presence of buoyancy effect was seen heating effect in winter heating case and improves of ventilation rate in case of summer cooling.

The efficiency of winter heating system can vary with the position of the outlet vent and the outlet vent position at bottom is better compared at top and centered. The velocity of air played a vital role both winter heating and summer cooling system and the velocity of air in the Trombe wall system is dependent on temperature of wall and glazing.

Finally we can conclude from 2D results that former can be used for faster.

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