



The Optimization of Heat Transfer Distribution in a Heated Room Using Convective Thermal Panels for Achievement of Thermal Comfort

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ABSTRACT

In the present study, the heat transfer, moisture distribution, air flow and thermal comfort in a residual room which is warmed by convectional thermal panels under different environmental conditions was assessed numerically. The analyzed model is the real and dynamic 3D simulation, and a virtual thermal manikin with real physiological dimensions has been added to the model. The manikin is standing at the center of room. The room has dimensions of 3*4*4 m with an inlet device that has dimensions of 1.28*0.054 m^2 and two outlet devices with dimensions of 0.054*1.02 m^2 . The inlet and outlet devices have been modeled above and under the door. To determine the optimal arrangement and number of panels, three models have been studied. The models include one panel with real dimensions of 1.242*0.81 m^2 , two panels with real dimensions 0.61*0.96 m^2 and three panels with real dimensions 0.61*0.81 m^2 , with a thickness of 20cm in all panels. The uniform distribution of temperature, velocity and moisture, and proper and symmetric arrangement of panels, inlets and outlets decrease the energy consumption and satisfy the thermal comfort of inhabitants. Thermal loss increases due to the panels under the window. It was concluded that using two panels with smaller dimensions at the left and right of the model instead of one panel under the window or three panels at the left, right and under the window significantly reduces the thermal loss.

KEYWORDS

Virtual Manikin, Thermal Comfort, Convectional Panels, Optimal Conditions, Energy Consumption Decrease

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1- INTRODUCTION

One of the most important goals of HVAC systems design is to have thermal comfort by using minimum input energy. Studies show that low temperature heating systems could increase indoor air quality in addition to thermal comfort improvement [1]. Moreover, the orientation of panels, input and output vents leads to a more uniform distribution in the space and more improved thermal comfort conditions [2]. One of the earliest and most complete studies has been done by Gukhan and Muhsin [3]. They studied a combination of heat, mass transfer and air flow for a virtual standing manikin with the real physiological aspects. They have also done the same analysis for sitting position. The results show that using improved walls and windows insulation materials could reduce input energy consumption while they substantially increase thermal comfort [4].

The objective of this study is to provide thermal comfort by reducing heat loss from the room. For this purpose, the best arrangement of convective thermal panels in a room, considering the standards of thermal comfort and heat transfer, is determined. For modeling heat transfer and the flow field, a three-dimensional computational fluid dynamics model has been used.

2- METHODOLOGY

Continuity equation

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x_k} (\rho u_k) = 0 \quad (1)$$

Momentum equation

$$\rho \frac{\partial u_j}{\partial t} + \rho u_k \frac{\partial u_j}{\partial x_k} = \frac{\partial \sigma_{ij}}{\partial x_k} + \rho f_j \quad (2)$$

Energy equation

$$\rho \frac{\partial e}{\partial t} + \rho u_k \frac{\partial e}{\partial x_k} = \sigma_{ij} \frac{\partial u_j}{\partial x_i} - \frac{\partial q_j}{\partial x_j} \quad (3)$$

Species transport equation

$$\frac{\partial}{\partial t} (\rho Y_i) + \nabla \cdot (\rho Y_i \bar{v}) = \nabla \cdot [(\rho D_{i,m} + \frac{\mu_t}{SC_i}) \nabla Y_i] + S_i \quad (4)$$

Predicted Mean Vote correlation

$$PMV = (0.303 \exp(-0.035M) + 0.028) \quad (5)$$

3- SIMULATION RESULTS

The problem is solved for three different cases. In each one the heat loss of the manikin and the room is calculated.

Case 1: one large panel below the window.

Case 2: Two panels next to the side walls. (The surface area of these panels is equal to the above).

Case 3: Three panels. Two panels are placed next to the side walls and one panel is placed below the window. (The surface area of these panels is equal to the first one).

Table 1

HEAT LOSS THROUGH THE WINDOW AND ROOM

Surface	Case 1 $Q_c(W)$	Case 2 $Q_c(W)$	Case 3 $Q_c(W)$
Window	-157.42	-1151.38	-1574.74
Room	-714.93	-444.67	-740.18

Results show that the PMV factor is the same in all three cases.

4- CONCLUSIONS

The placement of the panel under the window would increase the temperature of air around it which leads to higher heat loss from the window. This is due to low flow velocity in the room that is not possible to overcome this gradient.

Using a smaller panel instead of larger ones and not placing them under the window would achieve better thermal comfort and significantly decrease energy consumption that has been studied in this paper. If the panel is placed under the window, the temperature of the surrounding areas will be increased. The high temperature gradient in this region, where the flow velocity is low, increases the heat loss through the window.

5- REFERENCES

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