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ScienceDirect

Procedia Engineering 146 (2016) 251 – 256

Procedia Engineering

www.elsevier.com/locate/procedia

8th International Cold Climate HVAC 2015 Conference, CCHVAC 2015

Thermal Environment Dynamic Simulation of Double Skin Façade with Middle Shading Device in Summer

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Abstract

Double-skin facade (DSF) can be thermal insulation either in summer or winter. While building shading devices can reduce the solar radiation heat gain through windows effectively, save building energy consumption and improve indoor thermal environment quality in summer. Based on the dynamic simulation of the indoor environment, this paper puts the blinds inside the intermediate cavity, simulates the effect of different locations and inclinations, analysis their influence on ventilation effect, intermediate cavity temperature and indoor temperature. And finally, a relatively optimal design and utility plan is summarized to provide some references for middle shading device design and evaluation of this field.

Peer-review under responsibility of the organizing committee of CCHVAC 2015

Keywords: Double-skin Facade, shading device, CFD, thermal environment

1. Introduction

Extra solar radiation heat gain through windows in buildings with highly glazed facades have increased the risk of overheating in summer, while blinds can absorb and reflect the solar radiation, reduce indoor heat gain and cooling loads significantly, which is one of the effective building energy saving measures[1~2]. Blind device installed between two glass skins of DSF system yields a new mode of shading—the middle shading. With the wide application of the DSF, middle shading have got more and more attention and acceptance by its excellent shading effects, minimum dust accumulation, zero indoor space requirement and good regulation functions. Therefore, how to improve its effects in reducing energy consumption, as well in creating a more comfortable indoor environment is the ultimate goal and the forward research direction of the middle shading technology.

In recent years, scholars have made many explorations and researches in middle shading, for example, Elisabeth Gratia and Andre De Herde[3] tested the effects of different middle shading positions and colors; Stec WJ [4] used the wall greening inside the DSF system as the research subject, and discussed the impact of the thickness of the air

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doi:10.1016/j.proeng.2016.06.384

layer which selected blinds and plant shading in the intermediate cavity; By simulating some different factors such as positions of middle shading inside DSF, widths of the intermediate cavity, sizes of the DSF openings and the inlet pattern, Zhen Zeng [5] analyzed their influences to indoor thermal environment. Yiran Cao[6] tested the shading effects of three different shading patterns which included exterior, middle and interior sides by calculating the solar heat gain coefficient respectively.

All above studies have provided a reliable theories and reference for middle shading design. However, computational dynamic simulation of their influence to indoor thermal environment is relatively low. To fill this research gap, this paper have carried out the following studies: choose an energy saving experiment center equipped DSF with middle shading devices in Tianjin as the physical model, based on the dynamic simulation of the indoor environment, simulates different blind locations and inclinations, analysis their influence on ventilation effect, intermediate cavity temperature and the indoor temperature. And the results can provide some useful reference to designer of DSF with middle shading in cold areas.

2. Physical model

Choose an energy saving experiment center adopting DSF with middle shading device inside in Tianjin (which is the representative city of the cold areas) as the research subject. Considering the inner wall of is adiabatic, to simplify the model, choose a certain room as the simulation model. The glass skin adopts two glazing skins with a distance of 500mm. The outer skin is 8-mm-thick single layer glazing, and dual-sealed insulating glass units which adopt colorless highly transparent glass are used in the inner skin. The blind of the middle shading which shown in Figure 1 is 3.5m long and 50mm wide with the thickness of 2mm. The room which shown in Figure 2 is closed and non-conditioned. Dynamic simulation method is used to analyze the influence of the location and inclination of the middle shading inside DSF buildings on indoor thermal environment.

Set the summer daily average temperature tw，p=29.3° C in Tianjin as the initial temperature, and 24 hours is set as the calculated outdoor temperature changing period. After iteration converged, the ventilation rate of openings, average temperatures of the room and the DSF intermediate cavity are all recorded. Finally, analyze of the influence of all these factors on indoor thermal environment are plotted. Based on these calculation results, variety laws of all these factors and their influence to indoor thermal environment are summed up.

Fig. 1. Middle shading device inside DSF