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STUDY ON PERFORMANCE OF INSULATING GLASS WITH BUILT-IN LOUVERS IN BUILDINGS

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Abstract. This paper mainly studies the shading problem of shutters in typical rooms of buildings in winter. In order to further study the performance of the built-in louver insulating glass, the built-in louver insulating glass was simulated under the standard operating conditions and throughout the year through software such as THERM and Windows, and the key parameters such as total heat transfer coefficient, solar transmittance, and solar heat gain coefficient were obtained. The heat transfer coefficients of the built-in louver insulating glass when the louvers are placed at 0°, 45°, 90°, -45° and without louvers are 3 W/m2•K, 2.75 W/m2•K, 2.38 W/m2•, respectively. K, 2.55 W/m2•K and 2.66 W/m2•K. The solar transmittance of the built-in louver insulating glass at different angles of the louver is obtained. The maximum value is 0° and no louver, followed by the angles of 45° and -45°. Zero at 90°.

Keywords: energy, shutters, glass, radiation, consumption

1 Introduction

The thermal performance of the window is the worst among the three building envelope components, and it is one of the most important factors affecting the indoor thermal environment and building energy consumption. Because traditional cloth curtains fail to block the heat outside the envelope structure in summer, Therefore, more and more buildings will consider using energy-saving exterior windows in the future. The new type of louvered shading glass is rich in functions and can be adjusted, the shading ability can be adjusted in summer, and the window insulation can be increased in winter, and it is gradually applied in the office and residential fields. In the theoretical research of louver shading, foreign research is relatively mature. Klems [1][2][3] and Wright [4] have fully studied the theoretical calculation of the solar heat gain coefficient of louver shading, and obtained the calculation formula. Simulation study on optical and thermal performance of inner sunshade. Deng Tianfu obtained through simulation that active external shading can reduce HVAC energy consumption [5] and increase lighting energy consumption [6]. Zhang Qiang [7] used DOE-2IN simulation to obtain the shading coefficient of Chongqing's exterior windows ranging from 0.26 to 0.46, and the optimal heat transfer coefficient was 1.9 to 2.5 W/m2•K. Wang Yunxin [8] used WINDOW to calculate that the built-in louver insulating glass is more suitable for areas with hot summer and cold winter. Optical and thermal performance analysis of inner sunshade for experimental study. The measured solar heat gain coefficient decreases as the shutters are closed [8]. Guo Xiaoqin [9] used experiments to test the solar transmittance under different louver inclination angles.

2 Built-in louver insulating glass window model

The built-in louver insulating glass window is shown in Figure 1. The difference between it and ordinary double-layer insulating glass is that the louver is placed between the two glasses, which has the functions of

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shading and anti-glare.

Fig. 1. Built-in louver insulating glass products and schematics

this paper, the total heat transfer coefficient of the double-layer insulating glass with built-in louver under different louver states is studied by simulation. The metal louver has good thermal conductivity. When closed at 90°, it will increase the number of air layers. To study the light transmission performance of glass, at different louver angles, louver glass has different solar transmittance. The solar transmittance is the ratio of the energy directly passing through the glass or other light-transmitting materials to the incident energy within the range of solar radiation. This parameter is an important indicator to measure the solar energy entering the room through the external window.

2.1 Introduction of built-in louver insulating glass window

The fixed shading device can reduce the solar radiation heat gain in summer and also reduce the solar radiation heat gain in winter. The new built-in louver insulating glass has the feature of adjustable middle louver. Window radiative heat gain and convective heat transfer have a significant impact.

The difference between the built-in louver insulating glass window and the ordinary double-layer insulating glass is that the louver is placed between the two glasses, which has the functions of shading and anti-glare. The adjustment block on the right can adjust the retraction degree of the louver, and the adjustment block on the left can adjust the angle of the louver. Compared with traditional cloth curtains, it can block solar radiation to the outside, and does not require periodic cleaning, and there is no need to consider fire hazards.

2.2 Calculation model of total heat transfer coefficient and light transmission performance

According to GBT 22476-2008 Section 6.5.1, the heat flow meter method was formulated to measure the total heat transfer coefficient in this experiment.

$$R = 2A(T_1 - T_2)/\varphi \qquad (1)$$

In this formula, R is the thermal resistance of the insulating glass, m2•K/W; T1 is the average temperature of the hot surface of the sample, K; T2 is the average temperature of the cold surface of the sample, K; Heating average power, W

$$\frac{1}{U} = R + \frac{1}{h_e} + \frac{1}{h_i} \qquad (2)$$

In this formula, He is the outdoor surface heat transfer coefficient, W/m2•K; Hi is the indoor surface heat transfer coefficient, W/m2•K.

The solar transmittance is calculated according to Equation 9 in Section 3.4 of GBT 2680-1994.

$$\tau_e = \frac{\int_{300}^{2500} S_\lambda \cdot \tau(\lambda) \cdot d_\lambda}{\int_{300}^{2500} S_\lambda \cdot d_\lambda} \qquad (3)$$

In this formula, S_λ is the relative spectral distribution of solar radiation; τ(λ) is the solar spectral transmittance of the sample.

3 Simulation method and verification of heat transfer performance

THERM was developed at Lawrence Berkeley National Laboratory (LBNL) to model 2D heat transfer effects in building components such as windows, walls, foundations, roofs and doors. THERM's 2D conduction and heat transfer analysis is based on the finite element method and can model the complex geometries of building products. THERM can be used with Berkeley Lab WINDOW's glass center optical and thermal models to determine total window U-value and solar transmittance. The temperature distribution and heat flow inside the sample glass under experimental conditions were calculated by THERM simulation. Finally, the heat transfer coefficient of the built-in louver insulating glass is calculated using the standard winter conditions.

3.1 Simulation results of temperature distribution

The simulation setting parameters on both sides of the glass under various calculation conditions in THERM software are shown in Table 1. According to the actual situation, there is no solar radiation. The outdoor side is only the convection boundary, the inner measurement is only the convection boundary, and the upper boundary of the glass system The same as the outer boundary of the outdoor, the lower boundary of the glass system is set as the adiabatic boundary according to the actual situation during the experiment.

Table 1. Indoor and outdoor boundary conditions during the THERM simulation experiment

Louver state	Heating power	Internal surface temperature	Outdoor temperature	Outdoor heat transfer coefficient
0°	37	38	8	13
45°	38	40	8	13
-45°	92	40	8	48
90°	80	35	10	50
closed	114	40	10	18

The temperature and heat flow of the built-in louver insulating glass during the experiment were simulated by THERM software, as shown in Figure 2 below. Because the electric heating power and outdoor air temperature used in the U value experiment are different, the surface temperature obtained by THERM when simulating the experimental state is slightly different. The experimental conditions simulated by abcde are 0° for louvers, 45° for louvers, 90° for louvers, -45° for louvers and no louvers.

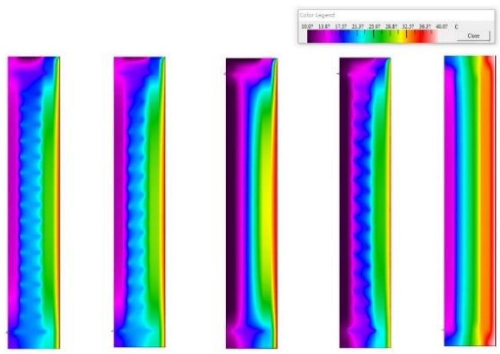

Fig. 2. Temperature distribution in the vertical section of the THERM simulated glass system

3.2 Overall heat transfer coefficient in standard condition

According to JGJ T20151-2008 Section 10.1.3, the calculation of heat transfer coefficient should use winter standard calculation conditions. According to the selected summer outdoor meteorological parameters and the heat transfer calculation model, the window frame is made of plastic, with a width of 5 cm. The following data are obtained through simulation calculation.

Table 2. THERM simulates the total heat transfer coefficient in the standard state

Louver angle	0	45	-45	90	No shutters
Whole window	3.00	2.75	2.55	2.38	2.66
Grass	3.46	2.73	2.55	2.83	2.88

4 Simulation method and verification of light transmission performance

This section simulates and calculates the solar transmittance of the sample glass when the louvers are placed at different angles throughout the year. At the same time, due to the limitation of experimental conditions, the accurate heat flow of the inner and outer surfaces of the sample glass could not be obtained through actual measurement. Therefore, the solar heat gain coefficient and the shading coefficient of the built-in louver insulating glass were calculated by using WINDOW combined with the standard and standard winter working conditions. In this paper, WINDOW software is used to simulate and analyze the built-in louver insulating glass. WINDOW is a commonly used glass simulation software, which can simulate and calculate the parameters listed in Table 3.

Table 3. WINDOW calculation parameters

Parameters	Meaning
Solar Total Transmittance *SHGC*	The ratio of the fraction of solar radiation that passes through the glass into heat in the room to the solar irradiance projected on the glass.
Shading coefficient *SC*	The total sunlight transmittance of the glass is the ratio of the total sunlight

	transmittance of the standard glass (3mm thick transparent glass) with the same area under the same conditions.
	solar transmittance Tsol
Solar transmittance *T*sol	The ratio of the intensity of solar energy directly transmitted through glass to the intensity of incident solar energy in the wavelength range from 300 nm to 2500 nm

4.1 Solar Radiation Transmittance Simulation Results

This chapter uses WINDOW software to simulate and analyze the built-in louver insulating glass. WINDOW is a commonly used glass simulation software.

The model of the sample glass adopts the same structure as the actual one. The indoor and outdoor environmental parameters are selected as the measured parameters around the Shanghai Winter Solstice during the experiment. The solar transmittance Tsol value of the glass is 0.804, the visible light transmittance Tvis value is 0.890, the heat transfer coefficient is 1.0 W/m2, and the emissivity is 0.84. For the setting of the shading layer, the four louver states are that the louver angle is placed at 0°, 45°, 90°, -45° and no louver. The louver width is 16 mm, and the vertical spacing of the louvers is 12 mm.

After simulation calculation, Shanghai (121.5° east longitude, 31.2° north latitude) is selected for longitude and latitude, and the calculation results of direct solar transmittance when the height is 20 meters are shown in Figure 3 to Figure 7. The solar transmittance is louver no> louver -45°> louver 45°> louver 0°> louver 90°. The solar transmittance is distributed hourly throughout the year in a bow-shaped distribution in the east-west direction, and an hourglass-shaped distribution in the south direction.

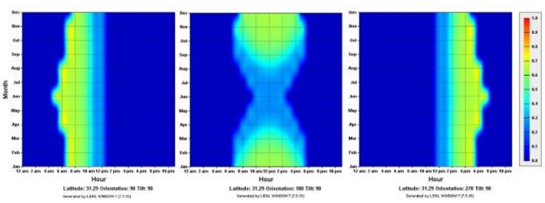

Fig. 3. Hourly solar radiation transmittance throughout the year - no louvers (south, east, west)

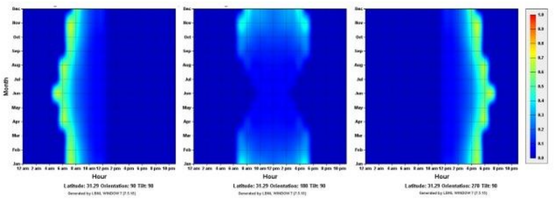

Fig. 4. Hourly solar radiation transmittance throughout the year - louver 0 (south, east, west)

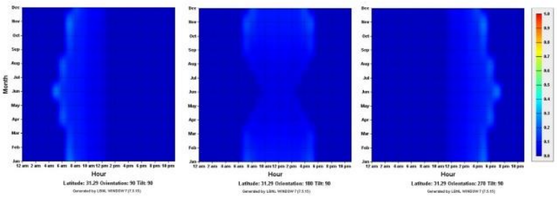

Fig. 5. Hourly solar radiation transmittance throughout the year - louver 45 (south, east, west)

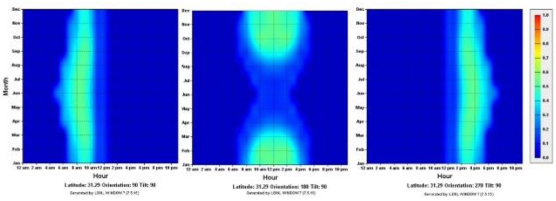

Fig. 6. Hourly solar radiation transmittance throughout the year - louver -45 (south, east, west)

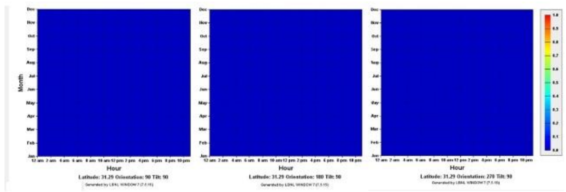

Fig. 7. Hourly solar radiation transmittance throughout the year - louver 90 (south, east, west)

4.2 Light transmission performance in standard state

The purpose of this subsection is to simulate and calculate the light transmission performance of the built-in louver insulating glass under the conditions of standard calculation of meteorological parameters. In the previous section, the solar transmittance obtained by the experimental test is compared with the results obtained by the simulation calculation, which shows that the simulation has a certain reliability. It is convenient for parameter setting of simulation software in Section 5.3. Among them, when calculating the light transmission performance of products such as louver shades, according to JGJ T20151-2008 Section 10.1.3, the calculation of heat transfer coefficient should use the summer standard calculation conditions. According to the summer outdoor meteorological parameters determined by the standard and the light transmittance calculation model built in the previous section, the data obtained through calculation are shown in Table 4.

Table 4. WINDOW simulates the light transmission performance of the built-in louver insulating glass in the standard state

Louver angle	0	45	-45	90	No shutters
Tsol	0.65	0.22	0.20	0	0.65
SHGC	0.837	0.374	0.371	0.1	0.843
SC	0.728	0.43	0.426	0	0.843

5 conclusion

This chapter uses the special simulation software THERM and WINDOW to calculate the heat transfer and light transmission performance of the built-in louver insulating glass under the experimental conditions and standard calculation conditions. The following conclusions are obtained: Combined with the calculation conditions in winter and summer in the standard through THERM and WINDOW calculations, respectively, the heat transfer coefficients of the built-in louver insulating glass when the louvers are placed at 0°, 45°, 90°, -45° and without louvers are 2.9 $W/m^2 \cdot K$, 2.75 $W/m^2 \cdot K$, 2.38 $W/m^2 \cdot K$, 2.55 $W/m^2 \cdot K$ and 2.66 $W/m^2 \cdot K$, solar transmittance of 0.65, 0.22, 0, 0.20 and 0.65, respectively, SHGC were 0.837, 0.374, 0.1, 0.371 and 0.843 . When the height of Shanghai is 20 meters, the transmittance of direct sunlight is: no louvers > louver -45° > louver 45° > louver 0° > louver 90°.

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