Study on intelligent adjustment blinds and building energy saving

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Abstract: Blinds are a common shading device in modern architecture. Air conditioning energy consumption and lighting energy consumption caused by blinds with different control method are different. This paper analyzes the influence of blinds adjustment on air conditioning and lighting energy consumption through experimental measurement and theoretical calculation, which will help this technology using in building energy saving.

1. Introduction

Blinds are a common device for preventing solar radiation and heat into building. Person can adjust the lifting and angle of the louvers according to their needs. The air conditioning and lighting energy consumption caused by the blinds of different control strategies are different, which is mainly reflected in the indoor solar heat and indoor illumination. In this paper, the effects of horizontal blinds on indoor solar heat and indoor illumination are studied experimentally by focusing on the slant angle and weather conditions. The concept, characteristics and composition of the intelligent blinds are introduced, which provides a design reference for the application of the technology in energy saving building.

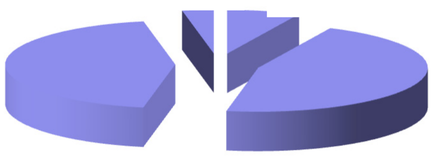


Figure 1. Distribution of solar radiation energy.

The main energy of solar radiation is concentrated in the wavelength range of 0.2 to 2 m, in which the energy of visible light and near-infrared light accounts for a large proportion (Fig. 1). The building glass system must reduce the solar radiation energy of these two sections into building to achieve energy saving in summer air conditioning building. In the conventional sense, energy-saving glass refers to summer sunshade energy-saving glass, which mainly includes heat-absorbing glass, heat-reflecting glass and low-emissivity glass. Their comprehensive performance is shown in Table 1.

Table 1. Comparison of the comprehensive performance of building glass.

Type of glass	Transparent glass	Heat absorbing glass	Heat reflective glass	Low-e glass
Shading Coefficient	0.9	0.6	0.4	0.6
Heat transfer coefficient	5.82	2.82	2.58	1.77
Visible light transmittance	highest	Lower	lowest	higher
Indoor lighting performance	best	not good	not good	better
Shading performance	worst	worse	good	good
Summer air conditioning energy saving	worst	better	best	better

Due to the shortcomings of energy-saving glass in indoor daylight performance, Shading Coefficient is fixed for the whole year that lead to the light in room is insufficient in other seasons (not including summer), so the application of blinds still has widespread use.

Many scholars have studied the behavioral patterns of personnel regulating louvers, because only by clearly understanding which factors will affect the adjustment of blinds, can we better design a louver adjustment scheme that meets the requirements of personnel. Due to individual differences, the requirements for personnel on blinds are not the same, but the main factors affecting the behavior of personnel adjusting blinds include the following: orientation, weather conditions, room illumination, and solar radiation intensity.

Lindelof and Morel experimented with estimating visual discomfort in small offices based on the use of blinds and lighting controls. The conclusion is that when the indoor illumination is less than 200 lux or more than 3000 lux, the person feels very uncomfortable. Therefore, when the illumination is less than 200 lux, the person needs to turn on the light. When the indoor illumination is greater than 3000 lux, people tend to choose to completely close the louver.

2. Experimental measurements and results

The experimental research in this paper was carried out in a university teaching building. The room had four windows, all facing south and each with adjustable blinds. The teaching building was not located in an open space, so there were some architectural obstructions around it, but the surrounding buildings were low-rise building. If the experiment was chosen after 9:00, the sunlight would not affected by the surrounding building. In order to reduce the complexity of the experiment, one of the south outer windows was selected as the research object, and the blinds of the remaining windows were in the fully closed state. During the experiment, two typical weathers were selected (cloudy and sunny) and the experimental time was April and May. Lights were not opened during the experiment.

In the course of the experiment, the end of the blinds was first fixed, and the change of the louver angle was observed to observe the change of the indoor sunlight, the illumination, and the total radiant heat. The louver blades in the south-facing room are made of aluminum, the louvers are 2.5 cm wide, and the spacing between the louvers is 2.5 cm. The blinds have a total of 48 louvers. The louver varies over a range of 15°and changes the louver angle every 10 minutes. The concrete indication of louver angle is shown in Fig. 2.

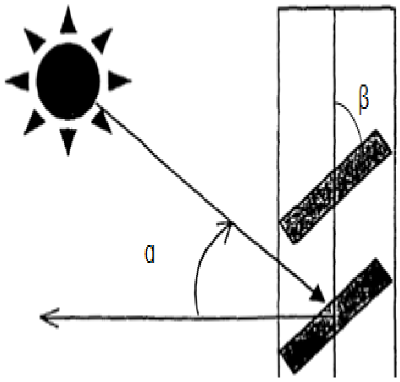


Figure 2. Louver angle

The relationship between indoor heat gain and louver inclination (cloudy weather) see figure 3.Figure 3 shows that direct light enters the room when the louver angle is 135° and 150°, and no direct light enters the room at other angles. It can be seen from the figure, when there is direct light entering, the increase in heat gain in the room is very obvious. When no direct light enters, the amount of heat gained in the room decreases substantially as the louver angle decreases. The direct light on a sunny day has a more significant effect on the daylight heat gain of the room.

Figure 4 shows the change of heat in the room at a Experimental test day (clear weather). When the louver angle is 150°, there is direct light entering the room, and the other angles have no direct solar light. It can be seen that direct solar radiation is an important source of indoor solar radiant heat, and the heat intensity of direct solar radiation is one order of magnitude greater than the heat intensity of scattered radiation. Trying to avoid or reduce direct solar radiation can greatly reduce the amount of heat generated by solar radiation during natural daylight.

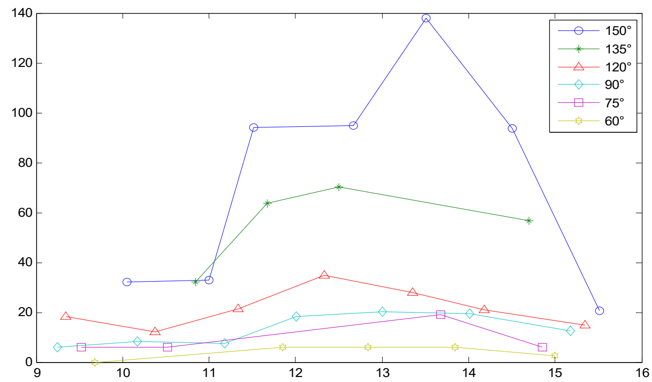


Figure 3. The heat gains change with time in a cloudy day

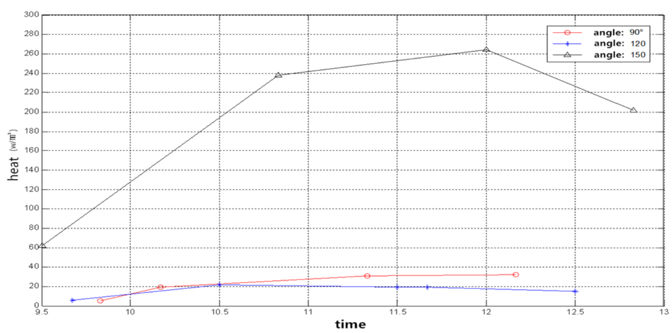


Figure 4. The heat gains change with time in the sunny day

3. Energy consumption analysis

Suppose there is a 5m × 5m × 3m (high) office room in Beijing. There is a 2×4m window in the south of the room. The lighting equipment uses 6 fluorescent lamps, each power is 36W, and there is no building covering around the building. In order to compare the influence of blinds under different control schemes on indoor air conditioning energy consumption and lighting energy consumption, different working conditions were selected for analysis.

The energy consumption calculation uses the experimental data of the above cloudy and sunny weather, and the time period is from 10:00 to 15:00. Since this paper only calculates the summer air-conditioning energy consumption caused by the sunlight radiation from the blinds, when the louver is in the fully closed state, the indoor solar heat can be set to 0W. In order to calculate the total calorific value at each moment, it is necessary to know the projected area of the window on the horizontal plane at any time. The data is obtained by calculating the solar elevation angle and the window size.

Table 2. Calculation results of energy consumption of simulated room under different conditions.

Working condition	Louver condition	Weather	Air conditioning energy consumption (kWh)	Lighting energy consumption (kWh)	Total energy consumption (kWh)
1	Fully closed	cloudy	0	1.296	1.296
		sunny	0	1.296	1.296
2	Fully open	cloudy	1.06	0.432	1.492
		sunny	1.101	0.432	1.533
3	Louver angle is 60°	cloudy	0.047	0.972	1.019
		sunny	0.084	0.756	0.84
4	Louver angle is 90°	cloudy	0.165	0.648	0.813
		sunny	0.267	0.576	0.843
5	Louver angle is 120°	cloudy	0.245	0.504	0.749
		sunny	0.272	0.504	0.776

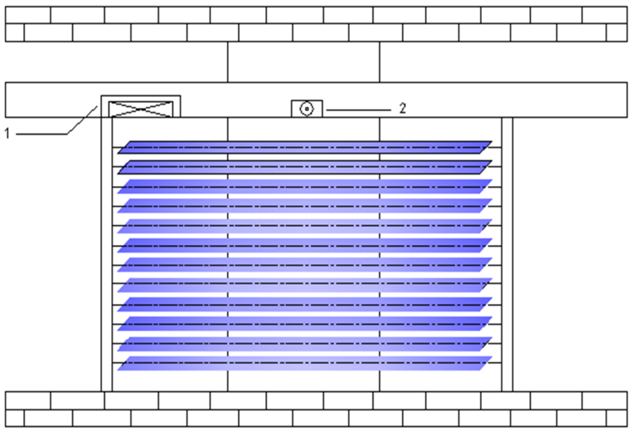
The specific calculation results of the simulation calculation are shown in Table 2. According to the calculation results of energy consumption, in the simulated room conditions in this paper, whether it is cloudy or sunny, when the blades of the blinds are fully opened, although the lighting energy consumption is the smallest, the energy consumption of the air conditioner is the largest, so the total energy consumption of buildings is the largest. When the blades of the blinds are fully closed, although there is no solar radiation hest, that is, the energy consumption of air conditioning is zero, the lighting energy consumption is the maximum, and the total energy consumption of the building will still be relatively large. Whether it is cloudy or sunny, the smaller the blade angle of the blinds, the smaller the energy consumption of the air conditioner, but the lighting energy consumption will increase due to poor natural lighting, so the total energy consumption of the building is not the minimum.

From the above simulation calculation results, it is known that to achieve the energy-saving goal of minimizing the total energy consumption of the building, the louver inclination angle of the blinds should achieve the best daylight as much as possible(but to ensure that the sunlight does not directly into the room through windows).So the air conditioning energy consumption will not be caused by direct sunlight radiation entering the room, that resulting in a large air conditioning load, and the natural lighting effect at this time can be optimized to reduce the indoor lighting power.

According to the measured and simulated room calculation results in this paper, when the blade inclination angle is 120°, the total energy consumption of the building can save about 50% compared with the working condition when the louver is fully open, so the louver inclination angle of 120° is the optimal louver inclination angle of the simulated room.

4. The intelligent adjustment blinds

To optimize the energy efficiency of the building, the angle of the louver blades should be as optimal as possible to ensure that the solar radiation does not cause excessive air conditioning load. Moreover, the natural lighting at this time can achieve the best effect, thereby maximally saving lighting energy consumption and air conditioning energy consumption. Therefore, based on the traditional blinds, intelligent adjustment blinds need to be designed and made.



1—Intelligent control module 2—Electric motor

Figure 5. Intelligent adjustment blinds

The intelligent adjustment blinds include a blind, an electric motor, an automatic controller, a temperature sensor and two photosensitive sensors. Photosensitive sensors and temperature sensor through resistance values to reflect the indoor and outdoor illumination change and the indoor temperature change. The two photosensitive sensors must be placed at indoor room and outdoor room to detect the illumination of indoor room and outdoor room, and the collected information need to be transmitted to the automatic controller. The temperature sensor set temperature information to the automatic controller. Then the intelligent control device sends information to the motor to realize the rotation of the louver angle, control the daylight to enter room, automatically control the indoor brightness and ventilation, and achieve the optimization purpose of indoor lighting energy consumption and air conditioning energy consumption.

5. Conclusion

In this paper, the effects of different louver inclination angles of blinds on indoor heat gain and indoor illumination are studied. It is found that when the angle of the louver reaches a certain value, the louver inclination of the blind can achieve the best natural light result. At this time, it can ensure that the air conditioning energy consumption will not be too large due to direct solar heat entering the room, and can ensure the natural lighting effect is optimal, and will not increase illumination energy consumption, thereby maximally saving indoor lighting energy consumption and indoor air conditioning energy consumption.

Therefore, an intelligent control module can be added by improving the existing blinds. The photosensitive control module transmits data to the intelligent control module, analyzes and processes the data, drives the blinds to rotate, and maintains the best louver angle to achieve the best energy saving effect of blinds. The intelligent blinds has an energy-saving optimization relationship with lighting energy consumption and air-conditioning energy consumption, which is in line with the current trend of energy saving and emission reduction of China, it will have great development prospects.

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