

The adjustable intelligent atrium sunshade

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Abstract. This article is focused on the specific design techniques of the adjustable atrium sunshade, on the basis of the engineering analyses and practices, it is expected to alter the conventional atrium sunshade design concepts; with its uniqueness and technical excellence, this innovative atrium sunshade system exhibits rich emotions and artistry, creates an inspiring and romantic atmosphere at the atrium area of the building.

1. Introduction

Nowadays, both interior and exterior facilities of a building are controlled by the automatic/intelligent systems in order to save energy and level up building safety. The intellectualization of the A/C and lightning system are being gradually accepted by the society, but the importance of the intelligent sunshade system are being neglected across the country, and yet the intelligent sunshade system is considered as one of the essential elements of the building management system (BMS).

Atrium, it is probably the most common existing form of the public space, many buildings use high light-transmitting glass as its atrium skylight, as the results, more energy could be wasted for cooling due to exposure to direct UV rays; few projects took this issue into consideration and adopted some kinds of sunshade systems in their building designs, but the sunshade design concepts are almost identical in many aspects such as the appearances and the operating modes, and hence weakened the architectural design elements and uniqueness of the building itself. This article is mainly focused on introducing the major factors of the adjustable atrium sunshade system.

2. The concept and features of the intelligent atrium sunshade

Apart from the conventional sunshade panels, the intelligent atrium sunshade system also includes electric motors and control system. The firmware as a part of the control system, embed in the hardware; based on the firmware algorithm, automatically adjust folding/unfolding panel angles according to the atrium temperature; the idea is to limit solar heat gain thereby lowering energy consumptions while improving occupant's comfort by reducing glare.

The intelligent atrium sunshade system is of two different control types; they are manual control and auto. ; the manual control system can be operated by the users, depends on their judgements of the sunlight angle and strength throughout the day, whereas the auto control system is totally related to the atrium air temperatures that detected by the sensors.



3. Natural ventilation and the atrium

There are two different types of micro climate effect that can be utilized at the building atrium: greenhouse effect and stack effect. In order to provide a comfortable environment, different control tactics should be applied for different conditions. A typical public building located in north-west of China, for instance, the skylight was designed as an openable glass roof with the intelligent atrium sunshade system underneath.

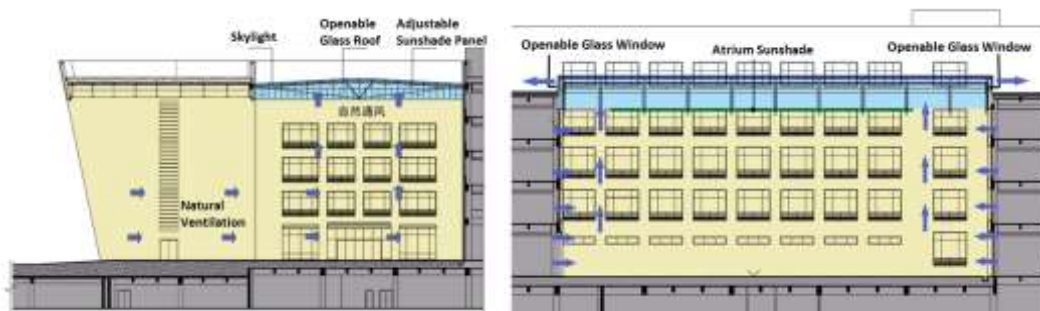


Figure 1. Natural Ventilation at Atrium

During winter daytime, the system was designed to maximize the greenhouse effect by keeping the skylight closed and the sunshade panels folded, and therefore maximize the solar heat gain; unfolded the sunshade panels at night for trapping the heat inside as much as possible. In the summer season, however, it's the opposite way; the solar heat radiations should be kept from entering the building as much as possible while the hot air should be removing continually by natural ventilating

According to the computer simulation results, a proper design of natural ventilation at atrium could lower the energy consumption by around 40%. Also, the air temperature at the atrium may decrease by 5°C if the sunshade panels were unfolded for one hour time. That indicated, the designs of natural ventilations at the atrium are quite effective at lowering the building energy consumptions, and also improve the comfort index.

4. The design concepts of the atrium sunshade

The atrium sunshade design concepts should be considered in the context of the building design styles; also, the sunshade design need to ensure natural ventilations at the atrium, and blocked the unwanted solar heat radiations in order to control the indoor temperatures, and lower the energy consumptions. Control by the intelligent firmware system, the sunshade panels are able to form different pre-defined patterns according to the temperature changes; with the lightning effects, create an inspiring and romantic atmosphere at the atrium area of the building.

5. Intelligent control systems

With intelligent/auto control technologies, the system enables each sunshade panel to rotate individually; the whole system is effective in controlling the solar heat gain throughout the day, and also improve the atrium lightning effects and the artistic expressions while lowered the energy consumptions.

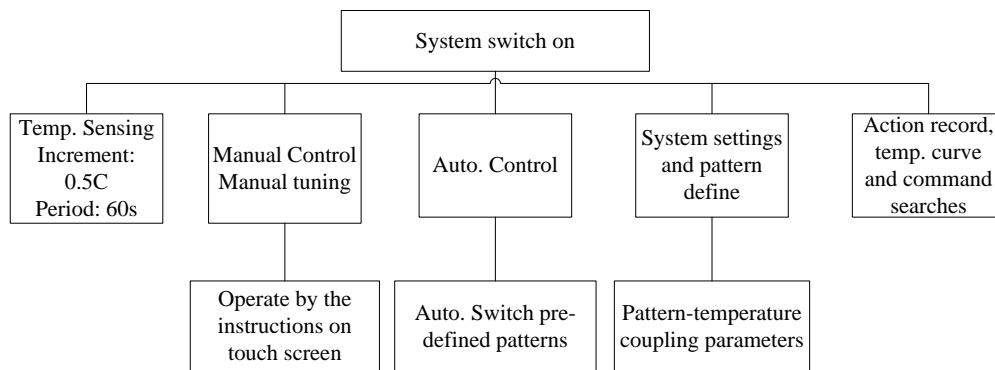


Figure 2. Intelligent sunshade control system process

There were three ways to operate the sunshade panels: first, manually handled by the operator at the control terminal. Second, control by the system based on pre-defined patterns. Third, control by the system based on temperature sensor's feedback signals. The system also kept the indoor temperature data for a calendar month for users' inquiries and control mode optimizations.

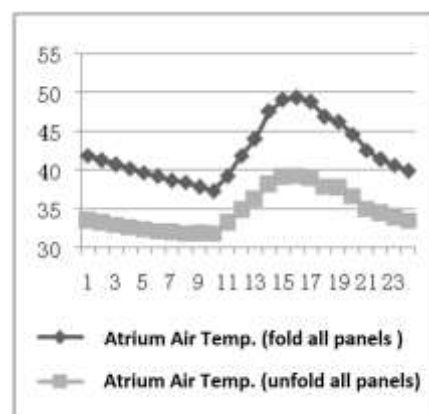


Figure 3. Average Atrium Air Temperature

The system has two separate modes for both day time and night time. With the perpetual calendar, it's convenient to pre-define different scheme on the basis of date and hours. For instance, the day time mode starts from 8:00 am in the morning, lasts 10 hours to 6:00 pm, and follow by night time mode till 8:00 am next day. In addition, the system is connected to the skylight control units, enable it to close the skylight when it's raining, and start working as soon as the sun's out; it can also response to emergency events such as fire alarms.

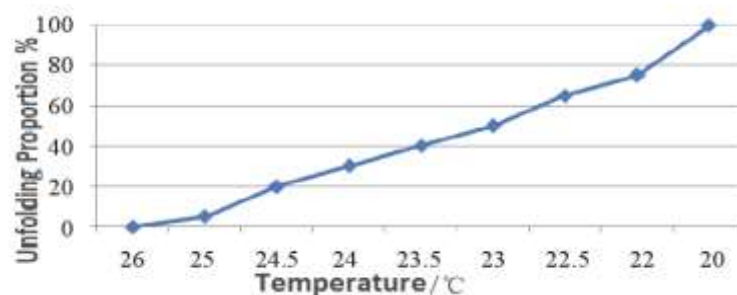
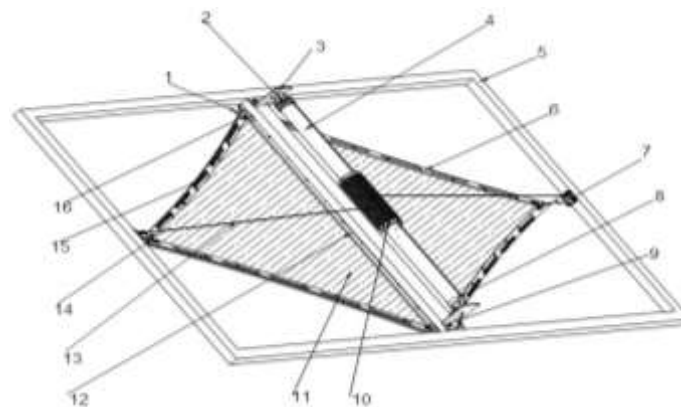


Figure 4. The coupling Curve showed the relationship of the sunshade panel unfolding proportions and the air temperature

6. Temperature curve

The most important algorithm of the intelligent control system is the temperature curve; with it, the system is able to fully control the atrium temperature by precisely describing the unfolding proportion of the sunshade panels.

The temperature curve was generated in the Design Builder software; in a number of real cases, the designers simulated the environment which affected by the sunshade panel folding proportions in different heat conditions. Compared the results to the instant air temperature data, the system controlled by the curve was more reliable in keeping the temp. Fluctuations to minimum; two real case studies proved the control system is more accurate in controlling the temperature while adopting the curve data.



1. Brace; 2. E-motor; 3. 1st Auxiliary brace; 4. Tube; 5. Steel frame; 6. Border edge; 7. Roller; 8. Rear plug; 9. 2nd Auxiliary brace; 10. Cable roller; 11. Sunshade membrane; 12. Mid. Steel frame; 13. Steel-fiber Cable; 14. Outer connection piece; 15. Flexible LED strip; 16. Inner connection piece

Figure 5. Tech. Details of the typical sunshade panel

Another computer simulation mainly analyzed the status of the atrium sunshade panels, in both 100% folding/unfolding situations. First, it simulated the environment with all the panels folded, whenever the temperature reached 26°C, the control system started getting involved; the results showed, the major working period of the system was approx. from 25th April to 22nd September of a year; and the system was most efficient (in energy saving) around 22nd July of a year. Second, the air temperature could be decreased by as much as 12°C in average if the panels were fully unfolded during the period; and there is 6-12°C lower even on the hottest days by doing so. The system limits the solar heat gain effectively.

The further analyses also simulated the conditions when the atrium sunshade system was 20%, 40%, 60% or 80% unfolded; and summarized the calculation results of all the seasons, and finally generated a coupling curve that clearly showed the relationships of the panel unfolding proportions and atrium temperatures. The diagram indicated that, when the atrium temperature is $\geq 26^{\circ}\text{C}$, it needs to unfold all panels for keeping the temperature within the comfort zone; and when the temperature is $\leq 20^{\circ}\text{C}$, it needs to fold all panels to increase the solar heat gain. The system will control the panel unfolding proportion automatically if the temperature were in between 20°C~26°C.

7. The technical details of the sunshade panel

A single sunshade panel primarily comprises the steel structure frame, braces and sunshade membranes. The braces are fixed on the steel frame, provide supports to two membranes on each side, these two membranes are connected to the steel frame by a roller on one edge, and fix to the braces on the other edge. There are two sets of auxiliary braces with separated tubes and motors above the steel frame. The membrane is of triangle shape, with LED strips on its hard edge; building up the unique visual effects.

8. The intelligent atrium sunshade system

The temperature curve is combined with modern architectural esthetics, provide the basic control logics to the system firmware, give the sunshade system the ability to form different patterns at any given unfolding proportion; the idea is to design an innovative atrium sunshade system with rich artistry and emotions and finally, create an inspiring and romantic atmosphere at the atrium area of a building.

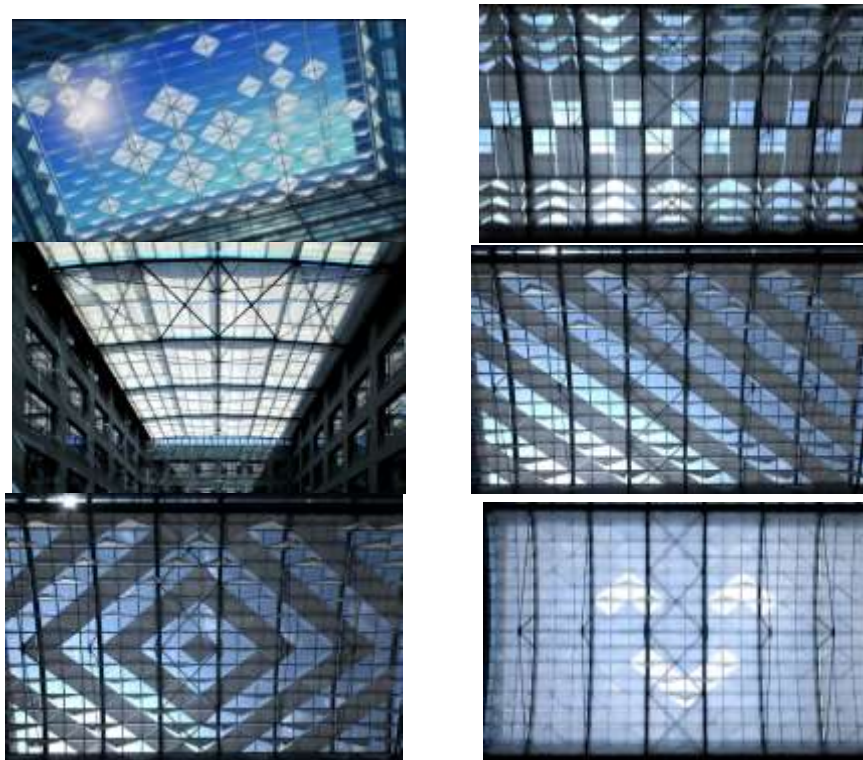


Figure 6. Intelligent Atrium Sunshade System

9. Summary

Although the atrium sunshade system is becoming a popular manifestation of the building public space, more and more atrium sunshade designs tend to be identical in many ways, which may affect the appearance of the whole building. This article emphasized the importance of the atrium sunshade design; introduced a typical intelligent atrium sunshade system, explained the principles, design details, intelligent firmware and the temperature-controlled algorithm of the system. Try to inspire more project owners and architects, to deliver more viable sunshade system designs that rich in era sensations also improve the energy efficiencies of the building.

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