Research on Optimal Control of Air Conditioning in College Classroom in Summer

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Abstract. Transys software was adopted to study the optimal control method of summer air conditioning system in college classrooms in this paper. Three schemes including schedule control, temperature control and population control were compared with each other. The simulation results show that the average temperature of the population control scheme is closest to the 26 °C for human comfort, and the mean square deviation of the temperature is also the smallest among three schemes. Energy consumption comparisons show that the total energy consumption of the population control scheme is the lowest among three schemes. Therefore, the population control scheme is considered to be the optimal control scheme in the air conditioning system of the college classrooms.

Keywords: College; Classroom; Air conditioning; Optimization control; Energy saving.

1. Introduction
According to the International Institute of Refrigeration (IIR), 15% of the world's electricity is consumed in the refrigeration and air conditioning industry. The proportion of building energy consumption in the total energy consumption of all end users in China will reach 35% in recent years, while the proportion of air conditioning energy consumption in the total energy consumption of office buildings can reach as much as 60%. With the economic growth, the energy consumption of air conditioning is still increasing. We should pay more attention to the building energy conservation.
There are many different types of buildings in Colleges. The functional requirements of buildings are more and more complex. The characteristic determines the particularity of its air conditioning system: comfortable and healthy, flexible control and convenient operation.
There are three obvious trends in the application of air conditioning system in university teaching buildings.
(1) The application of VRV (variable refrigerant volume). VRV air conditioning system with variable refrigerant flow has the characteristics of intelligent control technology, convenient operation, flexibility, and strong adaptability to the environment. It is especially suitable for the application of teaching buildings in Colleges and universities.
(2) Development of ground source heat pump air conditioning system. Ground source heat pump air conditioning is a renewable, efficient and pollution-free new air conditioning system, which absorbs the cold and heat of the earth (including soil, well water, lakes, etc.) and then supplies cooling and heating to buildings by heat pump units.
(3) The development of ice storage air conditioning system. Ice storage air conditioning system has the advantages of shifting peak load to fill valley, balancing power grid load, improving investment benefit of power construction and saving air conditioning operation cost for users. Under the condition that the annual air conditioning power consumption increases sharply at the rate of 20% - 30%, this is a favorable measure to balance the load of urban power grid and improve the increasingly sharp contradiction between power supply and demand [8, 9].

The number of students in the classroom can be predicted in advance through the teaching management system, therefore the air conditioning system in the university classroom can be adopted. The number control scheme can realize the energy saving of air conditioning system through frequency conversion adjustment when the number of students is not large [10].

Trnsys software is widely used in the simulation of central air conditioning system [11-15]. Taking classroom 206 of a university in Shanghai as an example, a trnsys simulation model is established based on the meteorological data of Shanghai, the building structure of the teaching building, class situation and the energy consumption of the electrical appliances in the classroom. Three control models, work and rest control, temperature control and class number control, are used to simulate the operation of the air conditioning system in summer respectively. The temperature change and energy consumption change are compared and analyze. The optimal control mode is established.

2. Classroom Air Conditioning System

The layout of the classroom 206 is shown in figure 1. The whole classroom is located in the upper left corner of the teaching building, 10.8m long, 7.2m wide, with an area of 74.20m², and can accommodate up to 76 students.

![Figure 1. Classroom layout](image_url)

The air conditioning system adopts fan coil plus fresh air system, and the outdoor air-cooled chiller. The parameters of each equipment are shown in table 1 below.

| Serial number | Name             | Model  | performance parameter                                      |
|---------------|------------------|--------|------------------------------------------------------------|
| 1             | Air cooled chiller | TY-4A  | Refrigerating capacity 11.2kW, compressor power 3.2kW      |
| 2             | Chilled water pump | BYKT25-125 | Flow 4m³ / h, lift 20m                                      |
| 3             | Fan coil         | FP-238 | Air volume:2380m³/h, Refrigerating capacity: 11.1kW       |
| 4             | Return fan       | GDF3.0-4 | Air volume:2000m³/h, Total pressure 570Pa                  |
| 5             | Fresh air fan    | GDF2.5-4 | Air volume 1000m³/h, Total pressure 310Pa                  |
3. Control Plan
Based on the meteorological data of Shanghai in 2017, the operation of air conditioning in summer from June 1, 2017 to June 30, 2017 is simulated. Three different control schemes are adopted in the simulation process, as shown in table 2.

| Serial number | Control plan               | Water chilling unit       | Cooling water pump fan coil return fan                                      |
|---------------|----------------------------|---------------------------|------------------------------------------------------------------------------|
| 1             | Work and rest control      | Class time starts, except weekends and holidays                        |
| 2             | temperature control        | Same as 1                 | Same as 1, and 26 °C on / 24 °C off                                          |
| 3             | Number control             | Same as 1                 | The same as 2, and (number of students in the classroom / maximum number of people) realize frequency conversion control |

4. Comparative Analysis of Control Results
The change of classroom air temperature under the three control modes is shown in figure 2. It can be seen from Figure 2 that the temperature under the three control modes is stable between 16-30°C. Note: low and high temperatures such as 16-20°C and 28-30°C occur during non teaching hours in the classroom (including weekend rest and 19:35-8:15 of the next day every day), so they do not affect the thermal comfort of the indoor personnel in the classroom.

In order to further analyze the temperature comparison under different control methods, the average temperature of the classroom in the teaching time and the mean square deviation with time change are listed respectively, as shown in table 3.

From table 3, it can be seen that the average temperature of work and rest control is the lowest, reaching 22.3°C, followed by temperature control (25.1°C), and the number of people control is the highest, reaching 26.2°C. According to the requirements of air conditioning in summer, the temperature shall be stable at 24-28°C [16], the effect of population control and temperature control is the optimal.

From the analysis of mean square deviation, the mean square deviation of work and rest control, temperature control and population control are 2.3°C, 2.0°C, and 1.4°C, respectively. Therefore, The temperature stability of the population control scheme is the optimal.
Figure 2. Temperature change of classroom under different control schemes

Table 3. Temperature comparison of different control schemes (°C)

| Control mode          | Average | mean square |
|-----------------------|---------|-------------|
| Work and rest control | 22.3    | 2.3         |
| temperature control   | 25.1    | 2.0         |
| Number control        | 26.2    | 1.4         |

Figure 3 shows the energy consumption comparison of the three control schemes. It can be seen from the figure that the total energy consumption of work and rest control is the highest, reaching 2282kJ; the total energy consumption of temperature control is next, 1211.5kJ; the total energy consumption of population control scheme is the smallest, 793.1kJ. Therefore, the population control scheme is the most energy-saving.

Figure 3. Energy consumption comparison of the three control schemes
5. Conclusion

This paper takes the summer air conditioning system of a university in Shanghai as the research object, uses TRNSYS software to simulate the operation of the air conditioning system, and makes comparative analysis of three control schemes: work and rest control, temperature control and personnel control. The following conclusions can be obtained:

(1) Due to the fluctuation of outdoor temperature, the number of people in the classroom changes frequently, and the temperature of the three control schemes fluctuates between 16-30°C. However, the temperature of the classroom during the teaching period is concentrated between 20-28°C, which can basically meet the thermal comfort requirements of the students in the classroom.

(2) Among the three control schemes, the indoor temperature is from low to high: work and rest control (22.3°C), temperature control (25.1°C) and personnel control (26.2°C). The mean square deviation of indoor temperature is work and rest control (2.3°C) and temperature control respectively (2.0°C) and personnel control (1.4°C). So in terms of indoor comfort and temperature stability, the number control is the best.

(3) From the point of view of total energy consumption, among the three control schemes, work and rest control (2282kJ), temperature control (1211.5kJ) and personnel control (793.1kJ) are the highest to lowest energy consumption. Therefore, the most energy-saving is the number control scheme.

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