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Study On Energy Consumption Of Sino - German Building In Uncertain Environment

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Abstract: According to the experience of developed countries, with the development of the city, the construction industry will go beyond the industrial, transportation and other industries and ultimately ranked first in social energy consumption, and air conditioning energy consumption is the main part of building energy consumption, reduce its operation energy consumption is of great significance to saving energy, improving energy utilization and implementing green building strategy. This paper studies the joint control of HVACs, lights, shading blinds and natural ventilation in the Sino - German Building. This paper has developed an effective environment for integrated control of HVACs, lights, shading blinds and natural ventilation in an uncertain environment. In this paper, an easy-to-use model suitable for optimization is established, and the joint control optimization problem is transformed into a multi-stage stochastic optimization problem. Using the improved Lagrangian relaxation method, the Lagrangian multiplier is used to loosen the constraints that are coupled together by air conditioning equipment such as a common machine. A new Lagrangian relaxation is shown, which can get better gradient direction. The optimal solution can be obtained by referring to stochastic dynamic programming and heuristic rules. Finally, the simulation results of the building simulation software DeST show that the joint optimization of the building end equipment can effectively reduce the building energy consumption .

Keywords: joint optimization, uncertain environment, Lagrangian relaxation, stochastic dynamic programming.

1. INTRODUCTION

Building air-conditioning system consists of a large number of equipment, including cold machines, boilers, pumps and fans. The energy consumption of the air conditioning system is related to the design selection of the air conditioning equipment, but more depending on the actual operation of the air conditioning equipment, unreasonable control will often reduce the efficiency of air conditioning equipment, resulting in energy waste, and reasonable control strategy can improve their efficiency, improve their efficiency, reduce air conditioning operating energy consumption. In addition, HVACs, lights, shading blinds and natural ventilation and other equipment, together affect the indoor temperature, humidity, illumination and fresh air volume and other comfort indicators. To meet a certain comfort requirements, you can control different devices, to take a variety of ways to adjust. However, the energy consumption of different adjustment methods is different, through a variety of equipment, joint control optimization can reduce building energy consumption. The traditional HVACs, lights, shading blinds and natural ventilation optimization control due to little consideration of uncertain factors on building energy consumption and user comfort, it is difficult to ensure the user comfort index and the dynamic balance of time, reducing the feasibility of existing programs. Therefore, it is the key to study the joint control optimization scheme of HVACs, lights, shading blinds and natural ventilation in effective uncertain environment.

The joint control optimization in uncertain environment is a problem of NP (Nondeterminstic Polynomial) under uncertain conditions. Among them, the uncertain parameter optimization method, the integrated modelling method and the optimization tangled method are the core research contents of this kind of problem. Under the uncertain condition, the joint control optimization problem is based on the uncertain parameter optimization method. For the problem of joint control optimization in uncertain environment, the Lagrangian relaxation method based on decomposition - coordination thought (ie, decomposing large scale problem into several small sub-problems and solving the original problem by solving and coordinating sub-problems) is recognized an effective way to solve such optimization problems. The problem of joint control optimization in uncertain environment is mainly focused on the model optimization method (relaxation strategy and sub-problem model simplification method) and iterative algorithm in the framework of Lagrangian relaxation.

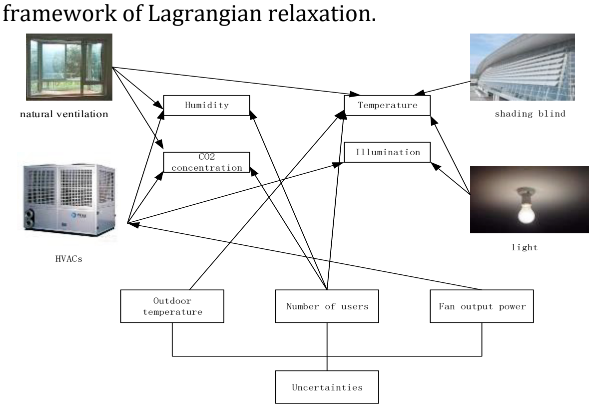

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Fig. 1. The HVACs, lights, shading blinds and natural ventilation and uncertainties on comfort.

As shown above, the indoor temperature is affected by these four types of equipment; indoor humidity and carbon dioxide concentration are affected by HVACs and natural ventilation; illumination by the impact of lights and shading blinds; uncertain factors, the number of users affect the three comfort indicators, outdoor temperature through the natural ventilation affect the indoor temperature, the fan output power will affect the fan energy consumption. As The HVACs, lights, shading blinds and natural ventilation together affect the indoor comfort, in order to meet a certain comfort requirements, you can control the different equipment, take a variety of ways to adjust. But the energy consumption of different adjustment methods will be different, through a variety of equipment, joint optimization control can reduce the total energy consumption of HVACs and lights. In summer, for example, open the window can use ventilation to reduce the concentration of carbon dioxide, but will make the air temperature rise, resulting in increased energy consumption of HVACs. The joint control of HVACs and window can minimize HVACs energy consumption. Considering uncertainties, more complex joint control methods are required. For example, an increase in the number of indoor people will affect the room temperature, humidity and carbon dioxide concentration. Opening the window will cause the outdoor temperature to change. In the HVACs system, the fan used in the alternating current itself is uncertain. AC current direction is always changing, the voltage is also around an equivalent voltage fluctuations, so when the HVACs system in the fan work, the actual power is always with the rated power there is a certain deviation. The fan does not have a constant output power, there is uncertainty, resulting in optimal configuration parameter deviation, affecting the optimal decision.

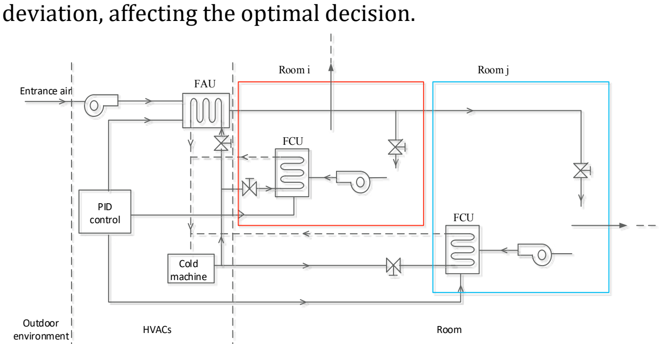

Fig. 2. HVAC system diagram.

The diagram above shows the HVAC system, which provides cooling capacity for fresh air unit (FAU) and fan coil units (FCUs). The FAU cools and dehumidifies air from the outside and provides fresh air for each room by using the cooled water. The fan coil uses the cooled water to cool and dehumidify the indoor air in each room. The FCUs uses the cooled water to cool and dehumidify the indoor air in each room. All rooms in the HVAC system share a FAU, and each room has a FCU. The HVAC system is shared by all the rooms, resulting in all rooms being coupled together. Specifically, the cooling capacity of the cold machine is shared by a new fan and multiple FCU due to the limited cooling capacity of the cooling machine. The cooling capacity of the FAU will be "competing" by multiple rooms.

2. MODEL

This paper reference the paper "Biao Sun, Building Energy Management: Integrated Control of Active and Passive Heating, Cooling, Lighting, Shading, and Ventilation Systems,2013,89:22-29".The model is shown in the section A、B and formula (1)-(13) of the paper.

3.UNCERTAIN ENVIRONMENT

3.1 Fan power

In the HVACs system, the fan used in the alternating current itself is uncertain. AC current direction is always changing, the voltage is also around an equivalent voltage fluctuations, so when the HVACs system in the fan work, the actual power is always with the rated power there is a certain deviation. The fan does not have a constant output power, there is uncertainty, resulting in optimal configuration parameter deviation, affecting the optimal decision. For the uncertainty of fan power, this paper describes the actual power of the fan according to the (0,1) normal distribution.

3.2 the number of indoor people

The people in the building are mobile, and the movement of people directly determines the situation of the interior of the building. The change in the number of rooms caused by the movement of people is one of the main causes of random changes in indoor calorific value. It is therefore necessary to accurately describe the number of changes in the number of people in the building.

In this paper, the Markov chain is used to predict the change in the number of buildings. The biggest advantage is that it can describe the autocorrelation of the number of people and the number of rooms in time, and also ensure the mutual correlation between the number of people inside and outside the building (That is, the total number of conservation), which is more reasonable and effective to reflect the random changes in the situation of indoor people but closely related to the real situation.

The core problem with the number of people in the building is to determine how the transfer matrix of the people moving. This article solves the problem through the event mechanism. Personnel movement is always accompanied by or included in a series of daily activities and events, such as work, lunch, get off work, etc, which will cause changes in personnel location. Introducing the concept of mobile events is to reflect the role of daily activities in the movement of people.

The matrix consisting of the total transition probability $P_\tau$is the transfer matrix of the Markov chain.

$$P_\tau=(p_{mn})_{(n+1)\times(n+1)}=\begin{bmatrix} p_{00} & p_{01} & p_{02} & \cdots & p_{0n} \\ p_{10} & p_{11} & p_{12} & \cdots & p_{1n} \\ p_{20} & p_{21} & p_{22} & \cdots & p_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ p_{n0} & p_{n1} & p_{n2} & \cdots & p_{nn} \end{bmatrix}$$

The transition probability P_τ is not only related to the state m, n, but also to the time k. If we know the position of the person at the initial moment and the transfer matrix P at each time k, we can get the number of people at any time by the Markov chain numerical simulation.

The figure below shows a change in the number of people in a room in the Sino - German Building. The people working from 8:00 am to 17:00 pm and lunch break from 12:30 to 13:30. It can be seen from the figure according to their daily schedule and the law of activities. We need to introduce different transfer matrix, which contain a "go to work—work—lunch—work—get off work" and so on several major activities set.