

Application of Fuzzy Control in Central Air-conditioning Terminal Units Energy-saving

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Abstract

After introducing the central air-conditioning terminal units system, established a fuzzy control system based on Lonworks. System focuses on the design of fuzzy controller with intelligent nodes, Input signal of fuzzy controller were the concentration and concentration rate of CO₂, output signal was the volume of fresh air change, designed a two-dimension fuzzy controller. Based on the search results table, select adjust the fan speed or adjust fresh air valve opening, so as to minimize the amount of fresh air and meet the demands CO₂ concentration indoor, so as to achieve the objective of reducing energy consumption and improve air quality. Finally, the fuzzy control algorithm which offline calculated was downloaded to intelligent node, and through experiment verification of the control effect is good.

Keywords: fuzzy control, central air-conditioning system, terminal units, energy-saving

1 Introduction

In recent years, China's energy shortage will be the construction of energy-efficient referred to a crucial position, greatly promoted the central air-conditioning energy saving control technology development. Big, medium-sized central air-conditioning system by the refrigeration system, station, central air-conditioning unit; air conditioning water system; air conditioning terminal device (fresh air machine, air handlers, fan coil) is composed of three parts, the whole system

power consumption mainly concentrated in the refrigeration system, station, central air conditioning, air conditioning terminal units. The refrigeration system of central air conditioning unit, pump stations and power consumption accounted for about 60%-65% of the total energy consumption of air conditioning, air-conditioning system energy consumption is the main part, so the research of energy saving control relatively mature; fresh air machine, air handlers, fan coil air conditioning system terminal equipment energy consumption accounts for about 35%-40%^[1], and the terminal equipment main energy saving from material and structure and manufacturing aspects to improve the heat transfer efficiency of terminal equipment, therefore, the application of scientific method to control the air-conditioning equipment, effectively reduces the operation energy consumption, energy saving requirements in intelligent building and rapid development of the environment, it has practical significance^[2].

2 Terminal device of the central air-conditioning installation overview

2.1 The composition and working principle of air machine

Four common control of fresh air machine is mainly composed of fresh air valve, filter, heater, hot water coil, antifreeze switch,

chilled water coil, a humidifier, blower parts. Schematic diagram shown in Figure 1 below.

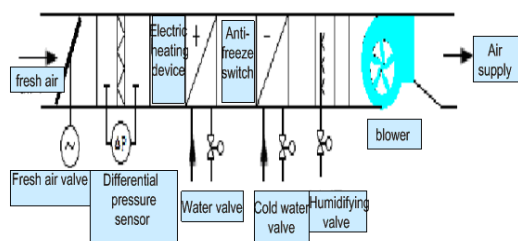


Fig.1 Schematic diagram of composition four control ventilator

Its working principle is: the operation of refrigeration, air valve opening, due to the fan suction effect, in the fresh air inlet to produce less than atmospheric pressure in the negative pressure, the external fresh air is inhaled fresh air machine, first through an air filter to filter, after the coil and coil cold water in the heat exchanger, cool air into oxygen, from the blower to the pressure after the wind pipe to the air conditioning room fan coil.

Fresh air unit control including CO₂ concentration control, air temperature control, temperature control, indoor air relative humidity control, antifreeze control as well as various interlocking content.

Air conditioning system in the operation, the room heat and moisture load and air quality with climate and indoor personnel changes, thereby causing the air to air demand are also different. Therefore, according to the load and air quality changes were adjusted to achieve the minimum fresh air volume, dynamic control, can ensure the indoor comfort requirements and achieve economic operation. The minimum fresh air volume may be determined according to the air conditioner end region of CO₂ concentration to set. In addition, the new air treatment means, the temperature and humidity independent control air conditioning system and.

2.2 The composition and working principle of air processor

Air processor in central air conditioning is one of important terminal equipment,

air-conditioning room cold caloric requirements and the cold and heat source heat supply plays an important role in. At the same time, air conditioning room air through the air processor to control parameters. Air processor principle and structure as shown in Figure 2 below:

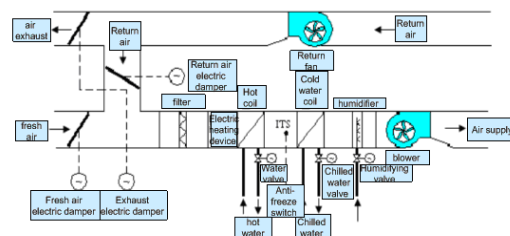


Fig. 2 four controls a return air processor structure diagram

Primary return air system in summer air handling process is: to indoor air absorption room waste heat, residual wet, the return air duct to discharge to a part, another part back to the mixing tank and the outdoor fresh air mixture, and then after cooling treatment, release heat, and then by the blower into the air conditioning room, forming a cycle.

Air processor needs to consider the factors controlling the indoor CO₂ concentration changes induced by air quality change; air conditioning cold, heat load changes caused by indoor temperature; air humidity load changes induced by indoor air humidity changes^[2-3].

3 System design

For air conditioning system monitoring nodes, control process of complex features, using the most popular LonWorks field bus network. To establish a set of fuzzy control system based on Lonworks algorithm. System overall plan design as shown in Figure 3 below.

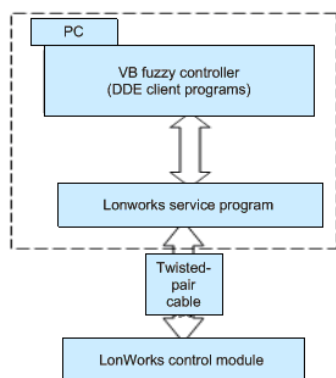


Fig. 3 the structure of fuzzy control system

As of VB visual programming, event driven, object-oriented programming method and the support for DDE, using VB in PC development monitoring interface and fuzzy control procedures, so that the control system according to the change of load adjustment of cooling water pump and a freezing water pump and other operating parameters, to achieve the purpose of energy saving.

Machine with Neuron C language simple fuzzy control procedures for the control of air conditioning equipment, to achieve the purpose of energy saving at the end. VB application in node remote control system functions are: the use of data bound controls from the network database to read out the control information, and sends the information to the input network variable form through the DDE Server passed to the Lon network nodes of the Neuron C control procedures, and the Lon network nodes can also be output through the DDE network variable Server upload to the network database, real-time refresh each node equipment information.

4 Design of fuzzy controller of intelligent node

Central air-conditioning end should have temperature control, humidity control, volume control, air purification and other functions. In order to make these loads can be stable and efficient, we in the LonWorks control module is embedded in the neuron chip on the development of air conditioning terminal

fuzzy control procedures, so that the control system can be separated from the PC machine work independently, can also be used by network variables and PC Lonworks DDE service program communication.

4.1 Design of fuzzy controller is offline

According to the different design parameters, three offline fuzzy query table, this thesis focuses on the introduction of CO₂ concentration control fuzzy controller design. Summer cooling, air wet heat treatment energy consumption greatly, in the protection of indoor air quality under the premise, if the fresh air volume is small, the more economy. Therefore, the fresh air volume is just equal to the interior demand, namely to meet air quality requirements of minimum fresh air volume determination, usually according to zone CO₂ concentration to set.

According to the indoor air quality standards "GB/T 17094-1997" in regulation, indoor CO₂ concentration should be less than or equal to 1000ppm, "GB16153-1996" specified in the restaurant CO₂ concentration should be less than or equal to 1500ppm^[4]. Therefore, according to the area of the air conditioning function feature set a CO₂ concentration value as air quality control target, and in the air region of the appropriate positions in the set CO₂ concentration detector. The concentration of CO₂ target value is set to 800ppm. Set air conditioning terminal region of CO₂ concentration is C_{co}, then, when the detection of CO₂ concentration C_c>C_{co}, improve blower operating frequency, increase the quantity of fresh air, making the concentration of CO₂ decreased; when detecting the concentration of CO₂ C_c<C_{co}, reduce the blower operating frequency, reducing new volume, so that the increasing of CO₂ concentration. By dynamically adjusting the control, which can meet the demand of the minimum fresh air volume of fresh air supply, thereby greatly reducing the energy

consumption of fresh air handling and transportation energy consumption.

Air quality control: when the detection of CO₂ concentration $C_c > C_{co}$, CO₂ concentration according to the size of the deviation, increasing the air valve, exhaust valve opening, while reducing air valve opening, to increase the quantity of fresh air, reducing the air supply volume, improve the fresh air ratio, the concentration of CO₂ decreased, until the $C_c = C_{co}$; when detecting the concentration of CO₂ $C_c < C_{co}$ the concentration of CO₂, according to the size of the deviation, the appropriate reducing new air valve, exhaust valve opening, while increasing the return air valve opening, to cut new volume, increased back to the air, reducing fresh air ratio, the concentration of CO₂ increased, until $C_c = C_{co}$. According to the concentration of CO₂ the size of the deviation, control of fresh air, exhaust air, return air three air valve opening, to regulate fresh air, return air volume mixing ratio, it can control the concentration of CO₂, to meet air conditioning comfort on air quality requirements^[5].

The system is based on the CO₂ concentration and CO₂ concentration change rate as input, to the new air change rate of output, the design of a two-dimensional fuzzy controller. According to the above parameters, the control rules of fuzzy controller, and then through the fuzzy and fuzzy decision, fuzzy control table. Concrete structure diagram as shown in Figure 4 below, according to a look-up table results, namely new air change volume selection to regulate fan speed or regulate fresh air valve opening, wherein the air valve and air valve opening design for linkage control, when the fresh air valve opening is increased, corresponding reducing return air valve opening.

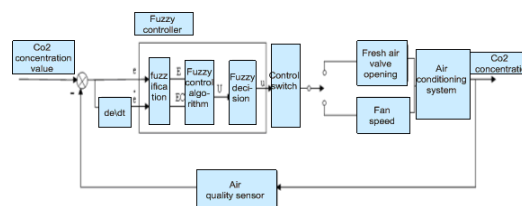


Fig. 4 CO₂ concentration control fuzzy controller

4.2 Fuzzy controller for download

Application method of look-up table of fuzzy control, the off-line calculated from the terminal equipment of the fuzzy control algorithm is downloaded to the nodes, the fuzzy control table is stored in the CPU Flash Rom, realize the so-called local autonomous control, each internal node has made the realization of specific functions of the software, the device can adjust the parameters, each intelligent node can communicate with the network in the form of variables, forming site coordination control, and through the network interface to the PC real-time data transmission^[6].

The fuzzy controller is made up of five placed directly at the site of the nodes, sensor input node completes the temperature, humidity and the concentration of CO₂ network variable output, controller node receives from the sensor node on-site detection signal, the realization of three kinds of fuzzy control algorithm, and outputs the correction network variables; the actuator to drive the end air valve, to reach the proper opening or change the rotating speed of the fan. Nodes with twisted pair physical connection node communication, information may also be transmitted to the host PC to achieve real-time monitoring^[7]. Node fuzzy controller network variable connection and function distribution as shown in Figure 5 below:

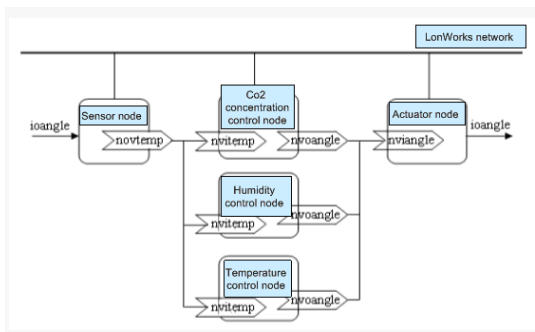


Fig. 5 node fuzzy controller network variable connection and function allocation

4.3 The effect of fuzzy control

In summer, the designed fuzzy controller used in central air conditioning system of experiment, the indoor temperature setting target value is 26 °C, CO₂ concentration target value is set to 800ppm, the fresh air valve opening degree of setting an initial value of 20%, return air valve opening of the initial value of 80%, set the indoor relative humidity control is in the range of 45%~65%. Control effect as shown in Figure 6 below.

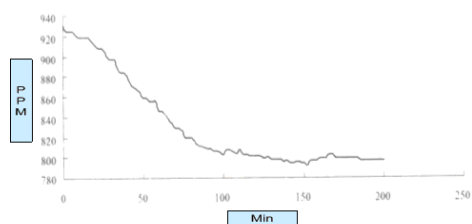


Fig. 6 CO₂ concentration fuzzy control curve

Figure 6 shows, in 100 minutes, indoor CO₂ concentration close to the 800ppm, and basically stable in the vicinity of. The control results show that, by use of the fuzzy control can make the concentration of CO₂ stability in near a predetermined value, small steady-state error, good control effect.

5 Conclusions

With the development of intelligent control theory and the energy conservation and environmental protection requirement, the construction of a high energy consumption of air conditioning system has put forward higher requirements. As a result of fuzzy control and LonWorks technology advanced, they increasingly wide range of applications. The

project will be the two technologies are combined, the intelligent node using fuzzy control technology for air conditioning terminal system for good and efficient operation, the system achieved a full range of energy saving.

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