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Design of Air Conditioning Distributed Control System for an Office Building in Xi'an

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Abstract

In this paper, the system 600 APOGEE (distributed control system) of Siemens building technologies is applied to an air conditioning controlling system in an office building. Firstly, control scheme is introduced. Then, considering the problem that air conditioning system usually loses contact with control in practice, some suggestion is presented

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Keywords: Component; Air conditioning system; Distributed control system; Office building; Control scheme

1. Introduction

A building has four layers, overall area 7000 square meters. The basement floor includes hot and cold stations, water supply and drainage, power supply and so on. The ground floor is public hall, the second floor for the restaurant, the 3rd ~ 4th floor for office buildings and conference room. According to the requirements of client, setting up a air conditioning distributed control system controls the hot and cold stations, air conditioning units, fresh air units and so on.

The ground floor has three air conditioning units. The Second floor includes three air conditioning units and a fresh air unit. The Third Floor and the fourth floor respectively include two fresh units and many fan coils. From the 1st ~ 4th all ceiling installation. The basement floor includes two bromine cooler, four sets of cooling towers (one cooler corresponding to two cooling towers), three freeze pumps and three cooling pumps.

2. Control subsystem

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2.1 Fresh Air Handling Unit Control

As shown in figure 1, the fresh air unit includes fresh air damper section, filter section, heating / cooling section and air supply section.

The fresh air damper is SEIMENS damper actuator GDB161.1E, its rated torque is 5 N · m, its continuous feedback signal of valve position is O ~ 10 V DC, with auxiliary position switches. When the fresh air handling units is turned off, the fresh air damper is closed to prevent the outside cold / hot air into indoor. In winter, frost protection switch is placed to the back of coil to protect coil from frost crack.

Supply air temperature sensor is SEIMENS 544-339 (resistance-type wind tunnel temperature sensors). It is placed to the supply air section of every fresh air unit. Supply air temperature sensor measures supply air temperature and delivers the temperature signal into the unit controller (UC). Unit controller (UC) processes the signal and controls the heating/cooling water valves to keep supply temperature constant.

Filter pressure alarm switch is QBM81-3 (high-precision differential pressure switch), movement accuracy is 15 Pa. Fan filters will be dirty after being used some time there, leading to little air supply and the deterioration of indoor air. We monitor the air pressure difference of filter by air pressure switch. When pressure difference achieving the value of set point, alarm is generated to suggest that the operator should clean the filter.

Heating/cooling valve is W G41.32 (two-pass regulator valve), electric dynamic actuators is SQX61. The valve is equipped with power switch, manual operation and auto resetting function. The output signal of the valve is O ~ 1O V DC. Heating/cooling valve is modulated under control of the supply air temperature sensor to control the flow amount of chilled water.

Frost protection switch is QAF81.3 (-5℃～15℃). Usually, the switch's value is set to 5℃. Frost protection switch serve as a low limit and freeze protection device. It can position the fresh air damper or back of coil to prevent a mixed air temperature from dropping below its set point of 5℃. If the mixed air at that point does drop below 5℃ then the switch shall stop the supply fan operation. With supply fan operation stopped, the fresh air damper close fully and a return air damper opens fully. [1,2]

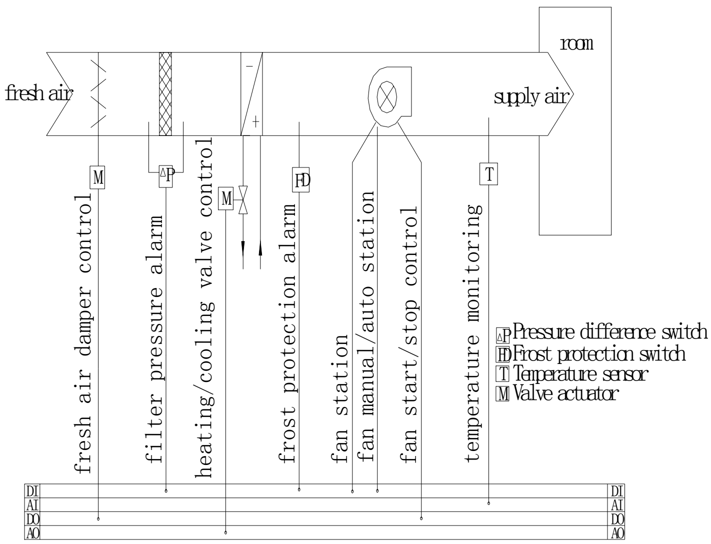

Figure 1. Control schematic diagram of fresh air handling unit

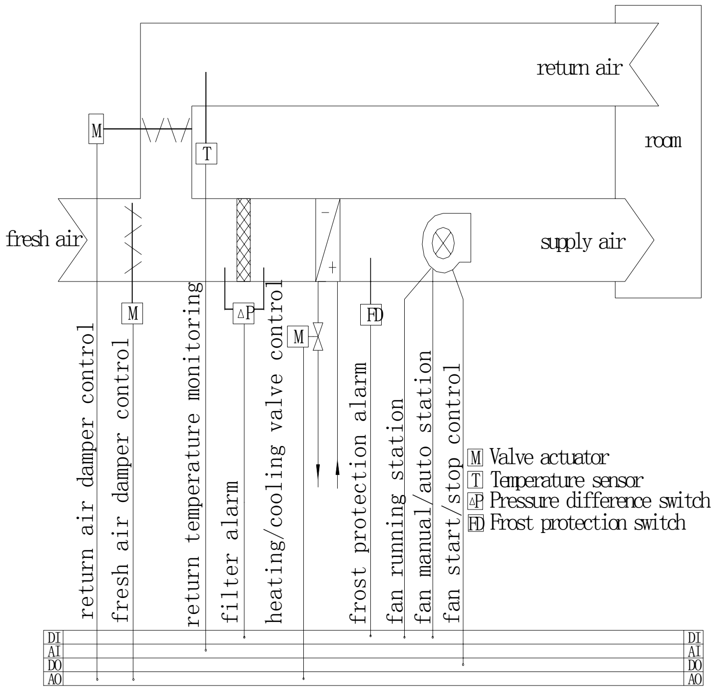

Figure 2. Control schematic diagram of air conditioning unit

2.2 Air Conditioning Unit Control

Figure 2 shows a control schematic diagram of air conditioning unit.

If the outside air temperature is above 26℃ or below 18℃, the fresh air damper will maintain its minimum position of 15%.

Return air (indoor air) temperature sensor is SEIMENS 544-339 (resistance-type wind tunnel temperature sensors). It is placed to the return air section of every air conditioning handling unit. [3]

Heating/cooling valve is modulated under control of the return air temperature sensor to control the chilled water flow to keep return air (indoor air) temperature constant.

The remained control is the same with the fresh air handling unit.

2.3 Fan Coil Control

Fan coil is SIEMENS RCV14.22. It equipped electronic thermostat, HEAT-OFF-COOL switch, HIGH-MID-SLOW fan speed control, two-way valve (SIEMENS MVE21.2O, including the actuators). Fan coil may local control in room. It not monitored by the central workstation. The room's temperature can be free to adjust by the user, and can better adapt to local environment, saving central air-conditioning energy consumption.

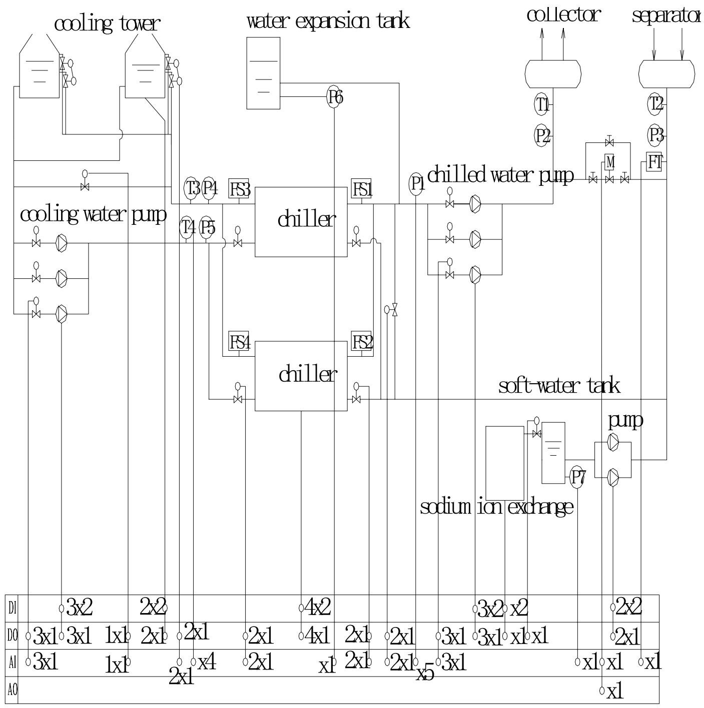

Figure 3. Control schematic diagram of hot and cold station

2.4 Hot and cold Station Control

Hot and cold station control schematic diagram shown in figure3. It includes 2 chillers, 3 refrigeration pumps, 3 cooling pumps. Refrigeration system should be open and shut down at certain time and sequence to avoid the equipment damage and impact.

Hot and cold station open process: open cooling tower electrical butterfly valve →open cooling water electric butterfly valve →open cooling water pump → open chilled water electric butterfly valve →open chilled water pumps →open chiller.

Hot and cold station shutdown process: Close chiller→ close chilled water pump till the completion of diluted lithium bromide solution (about 50 minutes) →close chilled water electric butterfly valve →close cooling water pump →close cooling water electric butterfly valve →close cooling tower electrical butterfly valve.

The chiller's status points that need monitor include running status, fault status, hand / auto status display. Status points of chilled pump, cooling pump and cooling tower that need monitor are the same as chiller. Other status points include cooling water supply water temperature, cooling water return water temperature, chilled water supply water temperature, chilled water return water temperature, chilled water pressure, return water flow rate of chilled water.

The start / stop of pump and fan must control by certain sequence. The number of operating chiller is control by the actual cooling load. The actual cooling load is calculated by means of temperature difference and return water flow rate of chilled water. The temperature difference is difference of chilled water supply water and return water.

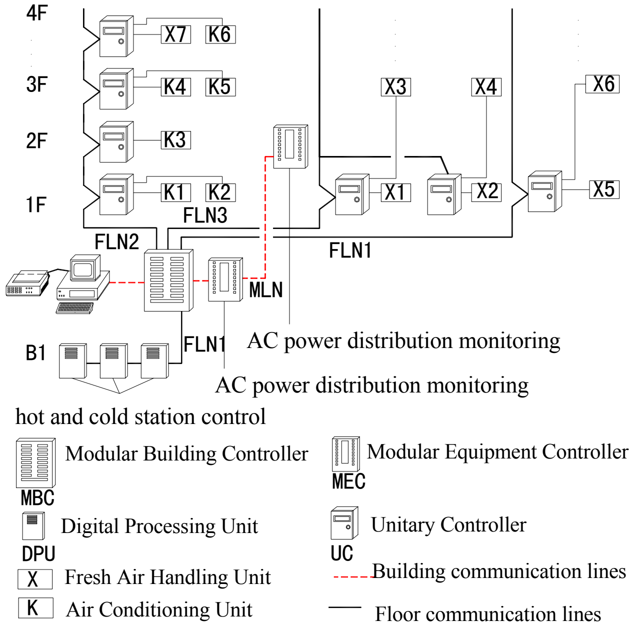

Figure 4. Schematic diagram of distributed control system

Using two-pass electrical regulator valve and pressure difference to maintain a constant pressure between supply water pipe and return water pipe. The pressure difference is difference of chilled water supply water pipe and return water pipe.

2.5 Other Control

The other status points and control points include power supply and distribution, water supply and drainage, elevators, lighting, etc. [4]

3. Schematic diagram of distributed control system

Schematic diagram of distributed control system is shown in Figure 4. Control system includes a computer workstation, a MBC (Modular Building Controller), two MEC (Modular Equipment Controller), a number of UC (Unitary Controller) and DPU (Digital Processing Unit). Hot and cold stations use DPU, whose number depend on the number of controlling points. Power distribution system is monitored by MEC (only for monitoring, not control) [5]

4. Problems

Central air-conditioning load side is mostly variable flow system, while the cold source side is constant flow system. In order to maintain constant pressure of supply and return water pipe, HVAC (Heating, Ventilation and Air Conditioning) design is used to connecting a bypass pipe between supply and return water pipe.

In figure 5, it is feasible to design a bypass pipe for non-automation system, but not for systems with several coolers and automation systems.

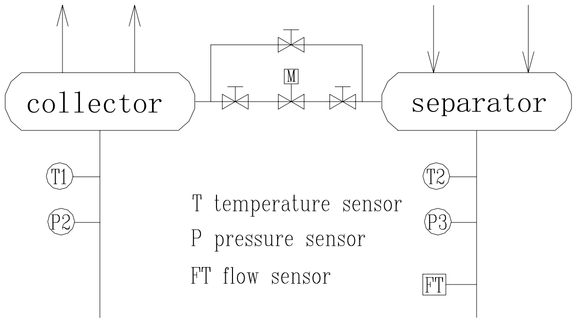

Figure 5. Unreasonable design

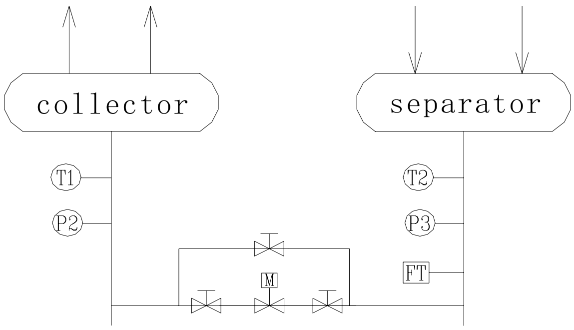

Figure 6. Reasonable design

We will never achieve automation control of multiple coolers if temperature sensor and flow sensor are placed in figure 5. We need actual flow of chilled water to calculate actual cooling load, while in figure 5, the chilled water flow measured by flow sensor is not actual flow, because some chilled water flows away through bypass pipe. This kind of error appears in a number of books and magazines, which makes flow measurement inaccurate.

formula: $Q=CG(t_2-t_1)$

Q: cooling load kW;

C: chilled water heat 4.2 kJ / kg · ℃;

G: actual flow of chilled water kg / s;

t_1 : chilled water supply temperature℃;

t_2 : chilled water return temperature℃.

The rational design is shown in figure 6. In figure 6, bypass pipe is not connected directly between water collector and water separator, but installed behind flow sensor, so that the flow sensor can measure the actual chilled water flow to control the number of coolers according to the actual cooling load.

There should be 10 times diameter and 5 times diameter of straight pipe before and after (flow direction) flow sensor installation location. The flow sensor installation location should not be installed near the right-angle elbow and valve. The temperature sensor location should be avoided interference of local cold source and heat source, and avoided installing in the dead band of airflow.

In addition, HVAC design is first finished, then, control design is carried out, so that it is difficult to give full play to the energy-saving efficiency of control technology. Example, fresh damper is manual or there is no exhaust damper, so that control design can't be achieved. Because control design require fresh, return, exhaust air damper must be electrically adjustable valve.

5. Conclusion

The control design of air conditioning system needs refrigeration, construction, water supply and drainage, air conditioning, electrical, computer, integrated wiring and other specialty to cooperate with each other, which is designed according to customer requirements by the control engineer. To ensure that the control design is relatively perfectly designed, HVAC engineer and control engineer should communicate with each other. HVAC engineer should reserve reasonable measuring points and control engineer should propose the requirements of testability and controllability for HVAC technology.

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