THE REAL-TIME MONITORING SYSTEM DESIGN ON EVAPORATIVE COOLING AIR CONDITIONING UNIT

QIANG Tian-wei

School of Environmental and Chemical Engineering, Xi'an Polytechnic University, Xi'an, China, 710048

ABSTRACT

This paper presents an automation design on evaporative cooling air conditioning unit. The evaporative cooling air conditioning unit includes indirect stage （heat pipe） and direct stage （pads）. The unit and air conditioning room build up a single-chamber VAV (Variable Air Volume) air conditioning system. First, Siemens S7-200 PLC controller is used to control the air conditioning system. Then, KingView software is used to design the HMI (Human Machine Interface). The HMI can monitor all equipment's operation clearly. Monitoring data is accurate and real-time. The HMI can also conduct the animation demonstration.

1. EVAPORATIVE COOLING SYSTEMS

1.1 Introduction

In the past, evaporative cooling technology is widely used in southwest America, most areas in Australia and a lot of arid and half-arid areas in the world.

At present, the evaporative cooling technology is used in the arid region in north-west China. Evaporative cooling air conditioning unit is widely applied in hotels, office buildings, stadiums, public buildings and some industrial buildings [1].

1.2 System components

As shown in figure 1, evaporative cooling air conditioning unit includes heat pipe indirect evaporative cooling section (IEC) and pads direct evaporative cooling section (DEC). The units and air-conditioned room form a single room VAV air-conditioning system.

The schematic diagram is shown in figure 2.

The first section consists of fresh air damper (FAD), filter and preheating valve (PREHEAT). FAD has the capability of admitting outside air flow. The filter is used to keep dust fromentering the system. Dust can reduce the efficiency of the evaporative cooler. PREHEAT is used to preheat outside air in winter.

The second section is the indirect evaporative cooling section which is heat pipe section. In summer, with indoor air as secondary air, cold secondary air flow through the hot end of heat pipe to cooling the outside air which flow through the cold end of heat pipe. At the same time, water spray to cooling the hot end of heat pipe. In winter, also with indoor air as secondary air, hot secondary air flow through the cold end of heat pipe to preheating the outside air which flow through the hot end of heat pipe. In winter, do not spray water.

The third section is the direct evaporative cooling section.

The fourth section is the heating section, which consists of a hot vapor heating coil.

The final section includes supply fan, room, return fan and exhaust fan.

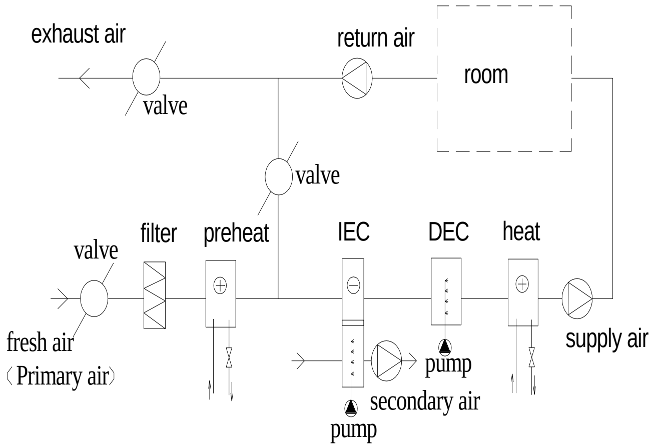

Figure 1 Evaporative cooling air conditioning system physical map

Figure 2 Evaporative cooling air conditioning system schematic diagram

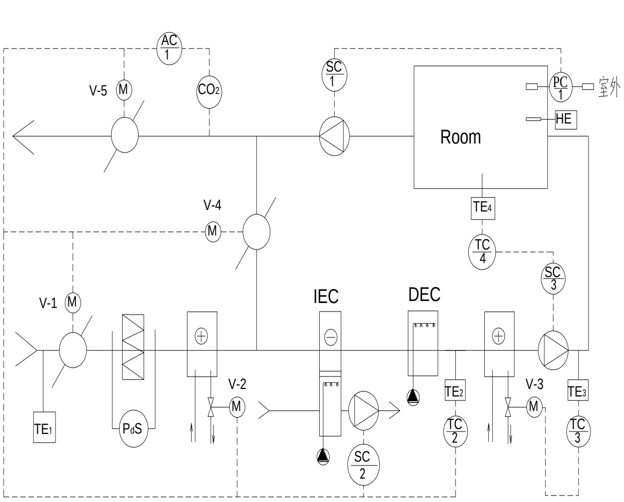

Figure 3 Analog control schematic diagram of air conditioning system

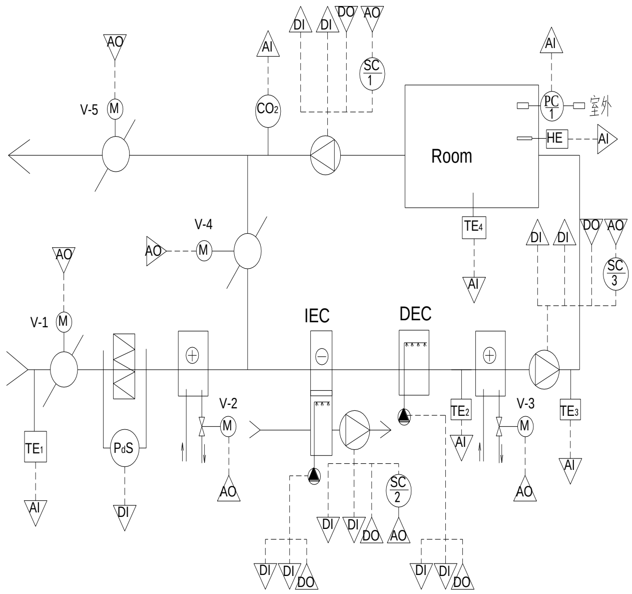

Figure4 Digital control schematic diagram of air conditioning system

2. AUTOCONTROL PROGRAM DESIGN

The control schematic diagram is shown in figure 3 (analog) and figure 4 (digital). The project uses Siemens S7-200 PLC controller system. The system is a single-chamber VAV (Variable Air Volume) air conditioning system. The building pressure is maintained by a fan and a pressure sensor comparing the inside space pressure with outside atmospheric pressure[2,3].

Meteorological parameters keep to the following criteria.

Place: Xi'an, China	
Elevation:	396.9m
Outside design- Summer:	35.2℃ DB
	26 ℃ WB
Inside design:	27.0℃ DB
Relative humidity:	55% HR
Atmospheric pressure:	959.2 mbar

2.1 Control process in summer

In summer, evaporative cooling process is shown in figure 5. Control process in summer includes direct evaporative cooling stage and indirect evaporative cooling stage. First, DEC pump is turn on, fresh air damper (FAD) remains in full open position. During this condition, if the temperature can't decline to the upper limit of the set point after running a period, then system startup indirect evaporative cooling unit (IEC) to precool the outside dry air, and then the precooled air enters the direct evaporative cooling unit (DEC). At the same time DEC unit is still running, the fresh air damper (FAD) remains in full open position [4]. In this process, the frequency converter (SC-2) is modulated under control of the temperature sensor (TE_2). SC-2 adjusts the fan speed to vary air volume to precool the outside air condition form W_x to W', to the moment, the isenthalpic line $h_{w'}$ just passes through the O_x (the temperature of O_x is always constant). Air enters DEC unit at W' and be cooled to O_x. At the moment, the temperature of O_x (the temperature of TE_2) is supply air temperature. Frequency converter (SC-3) is modulated under control of the indoor air temperature sensor (TE_4). SC-3 adjusts the fan speed to vary supply air volume to maintain a constant indoor air temperature.

2.2 Control process in transitional seasons

In transitional seasons, when outdoor air temperature is low, only the fan is turn on. Air conditioning unit only supply air. As shown in figure 6, when outdoor air temperature is high or indoor load increases, only DEC pump is turn on.

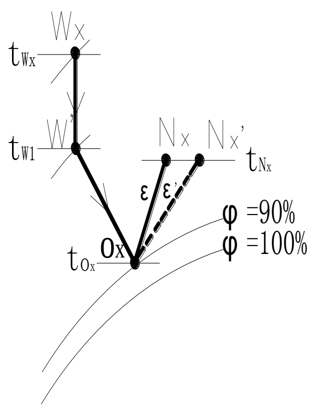

Figure 5 evaporative cooling processes in summer

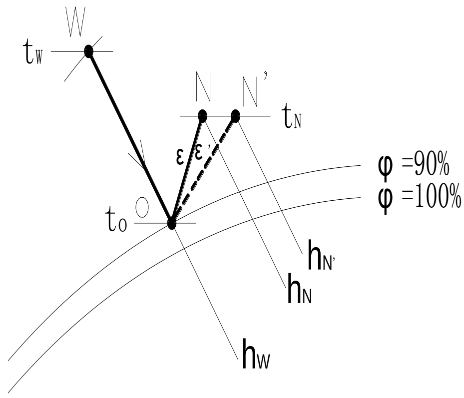

Figure 6 evaporative cooling processes in transitional seasons

Frequency converter (SC-3) is modulated under control of the indoor air temperature sensor (TE_4). SC-3 adjusts the fan speed to vary supply air volume to maintain a constant indoor air temperature.

1.3 Control process in winter

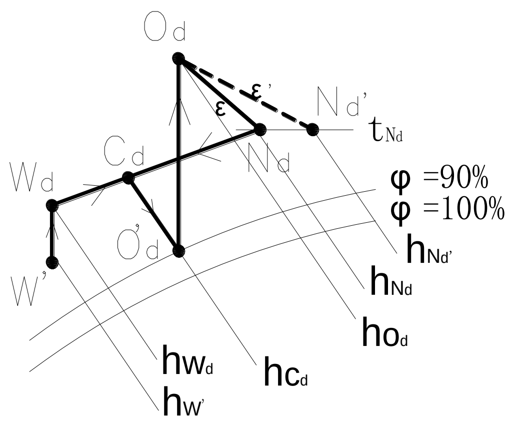

Figure 7 evaporative cooling processes in winter

Figure 7 illustrates a heating process in winter. When the outside air temperature is higher than that of the upper limit of the set point, fresh air damper (FAD) and return air damper (RAD) are modulated under control of the indoor air temperature sensor (TE_3) to produce a proper mixed air temperature. Frequency converter (SC-3) is modulated under control of the indoor air temperature sensor (TE_4). SC-3 adjusts the fan speed to vary supply air volume to maintain a constant indoor air temperature.

When the outside air temperature is blow the lower limit of the set temperature point, the direct evaporative cooling unit (DEC) unit startup, TE_2 will modulate fresh air damper (FAD) and return air damper (RAD) to make the supply air condition to O'_d. Firstly, the mixed air condition is modulated to C_d, to the moment, isenthalpic line h_{cd} just passes through C_d. Secondly, the mixed air enters DEC unit at C_d and then be cooled to O'_d along the isenthalpic line h_{cd}. At last, the heating valve (V-3) is modulated under control of the supply air temperature sensor (TE_3) to maintain a constant supply air temperature. Then, frequency converter (SC-3) is modulated under control of the indoor air temperature sensor (TE_4). SC-3 adjusts the fan speed to vary supply air volume to maintain a constant indoor air temperature.

As the outside air temperature drops continuously, FAD will be modulated to maintain the minimal outside air at 15% and RAD will be modulated to maintain the return air at 85%. If the mixed air condition point C_d is still below h_{cd} passing through design apparatus dew point O'_d, then the outside air must be preheated. Firstly, program set FAD position at 15% and RAD position at 85%. Secondly, TE_2 controls preheating valve (V-2) to preheat the outside air condition form W' to W_d, to the moment, the isenthalpic line h_{cd} just passes through the mixed air condition C_d. Air enters DEC unit at C_d and be cooled to O'_d. At last, the heating valve (V-3) is modulated under control of the supply air temperature sensor (TE_3) to maintain a constant supply air temperature. Frequency converter (SC-3) is modulated under control of the indoor air temperature sensor (TE_4). SC-3 adjusts the fan speed to vary supply air volume to maintain a constant indoor air temperature [5,6].

1.4 . The concentration of CO_2 and indoor air pressure

When the concentration of CO_2 is higher than that of the upper limit of the set point or lower than that of the lower limit of the set point, fresh air damper (FAD) and return air damper (RAD) are modulated under control of the controller (AC-1) to maintain a constant concentration of CO_2.

Frequency converter (SC-1) is modulated under control of the indoor and outdoor differential pressure controller (PC-1). When the indoor air pressure higher than that of the upper limit of the set point or lower than that of the lower limit of the set point, the frequency converter (SC-1) increases or reduces the fan speed to maintain a constant indoor air pressure.

1.5 . The real-time monitoring system

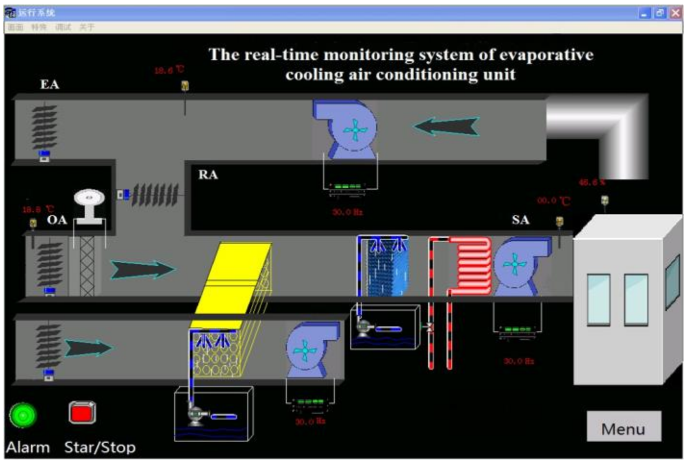

Figure 8 The real-time monitoring system of evaporative cooling air conditioning unit

A real-time monitoring system of the single-chamber VAV air conditioning units based on Siemens S7-200 PLC controller is designed. The test shows that the unit equipment and machine (PLC) communications in a timely manner.PLC can not only collect temperature, humidity and a variety of analog signals, and real-time monitoring of the air conditioning unit. Communication of bit machine (PLC) and t host computer (PC) is a little delay, but within the acceptable range of the error in the user.

Configuration software is used to design human-machine interface (HMI) of the air conditioning unit. The HMI is clear and accurate. Human-machine interface is not only real-time monitoring of various device parameters and the operational status of each device to achieve animation effects

3. CONCLUSION

In this paper, the air conditioning unit combines evaporative cooling technology with autocontrol technology. It hasn't water chiller and water pipe so that its initial investment is low. Autocontrol technology not only provides for equipments, but also can save energy consumption. In addition, the system can save manpower.

4. REFERENCE

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