2022 21st International Symposium on Distributed Computing and Applications for Business Engineering and Science (DCABES)

Design of Automatic Exhaust Control System of Central Heating System Based on S7-200 SMART PLC

Qi Feng[1]
College of Information and Control Engineering
Jilin University of Chemical Technology
Jilin, China

Tian-le Sun[2]
Electric instrument center of Jilin Petroche mical Company
Jilin, China

Zhang Zhuo[3]
Water Treatment Department
Gongzhuling Drilling Machinery Plant
Jilin, China

Gang-fu Lv[4]
Equipment Department Jilin Jiafeng
Environmental Protection Equipment Co., LTD.
Jilin, China

***Abstract*—In the central heating system, air accumulation in the heating pipe caused by hydraulic and thermal imbalance and other faults. In this paper, Siemens S7-200 smart PLC is adopted as the core to design the automatic exhaust device, including water, vacuum, drainage automatic control system. The air accumulated will be discharged timely and effective with touch screen interface, PLC control program and monitoring system combined to implement the control mode. Through the using automatic exhaust device and equipped with automatic control system to discharge dissolved gas in water, improving the stability of heat network equipment operation and achieving ideal heating effect.**

Keywords-S7-200 smart PLC; Automatic exhaust device; Touch screen

CLC number: TP29

I. INTRODUCTION

At present, the majority of heating in buildings uses hot water heating systems. Air accumulation in hot water heating system is the most common failure of hot water heating system [1]. When existing air accumulation in the pipeline, the harm is to reduce the hot water flow of the radiator riser for air accumulation, affect the normal circulation of hot water, reduce the heat dissipation capacity of the pipeline for air accumulation, resulting in some parts of the cold when hot or even not hot; Secondly, the system produces strong noise, affecting people's normal sleep and rest; In addition, oxygen in the air is the main reason for metal corrosion. Over time, it will corrode the pipeline and cause water leakage. Therefore, designing a balanced network management system and effectively eliminating the accumulated air in the system is the key to ensure the normal operation of the heating system.

When existing air accumulation in the pipeline, the collecting tank, automatic exhaust valve or manual exhaust valve are usually used in the heating system to remove the gas in the system [2]. In addition, some researchers design exhaust devices, such as automatic exhaust devices for heating systems [3,4], which make use of open water tank, water pipe and various valves to design an automatic exhaust device. As a programmable logic controller, PLC is widely used in various industrial production, heating system and other production practices [5]. This design determine the control scheme through analysing the working principle of automatic exhaust device, and design water control, vacuum control and drainage control system. S7-200 smart PLC achieves control function as the controller at the same time and collect the system status information with the touch screen achieve real-time monitoring. Through the automatic exhaust device can effectively discharge dissolved gas in the water, thus eliminating the gas plug phenomenon, and effectively improve the hydraulic

2473-3636/22/$31.00 ©2022 IEEE
DOI 10.1109/DCABES57229.2022.00027

balance and thermal balance. Due to the discharge of a large amount of dissolved gas in the water, it can reduce the corrosion effect of gas on pipes, heat exchangers and other equipment, thus improving the service life of the equipment and reducing the failure rate of the system.

II. DESIGN OF AUTOMATIC EXHAUST DEVICE

The process of automatic exhaust device is shown in figure 1. System obtain water to secondary net return water pipe, make the water into the set inside the tank, and then open the vacuum pump to form negative pressure inside the tank, thereby lowering the boiling point of water. the water in the collecting tank is boiled to remove water and dissolve air, after the exhaust is completed, the degassed water can be pumped into the backwater pipeline through the pressurized pump, so the circulation can complete the exhaust work in the system.

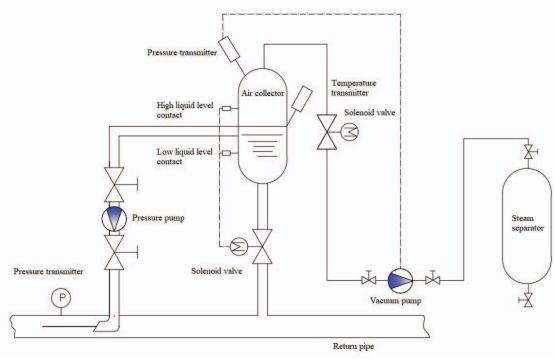


Figure 1. Process diagram of automatic exhaust device

III. CONTROL SCHEME OF AUTOMATIC EXHAUST SYSTEM

Automatic exhaust device system needs to control its peripheral equipment in order to achieve ideal degassing effect.

A. Feed water control system

Feed water control system is composed of solenoid valve and two liquid level contact signals. When the internal liquid level of the gas collecting tank is lower than the low liquid level signal, the solenoid valve will be automatically opened. Then the water in the backwater pipe of the heating secondary network will enter the gas collecting tank. When the internal liquid level of the gas collecting tank is higher than the high liquid level signal, the solenoid valve will be closed and the water will stop.

B. Vacuum control system

When the collecting tank is filled with water, it is in a fully closed state. Opening the solenoid valve on the top of the collecting tank, and starting the vacuum pump to extract the air inside the collecting tank. The internal collecting tank will be in a negative pressure state. When the water temperature reaches the boiling point at this time, a delay of a period of time, the dissolved gas in the water can be all precipitated. Because the vacuum pump will be accompanied by water vapor extraction, so the end of the system is equipped with soda water separation tank, the tank is installed at the bottom of the trap, so as to achieve the purpose of automatic drainage.

C. Drainage control system

Drainage system is the process of pumping the degassed water inside the collecting tank to repulse back to the original system pipe. The internal pressure of the secondary network backwater pressure is greater than the internal pressure of the gas collection tank, so the drainage process needs to be completed by a pressurized pump. The degassing back row water pump runs automatically. When the liquid level inside the gas collecting tank is lower than the low liquid level inside the gas collecting tank, the drainage pump automatically stops.

IV. DESIGN OF AUTOMATIC EXHAUST DEVICE CONTROL SYSTEM

A. Design of hardware

(1) Design of PLC hardware

For 28 digital quantities and 3 analog quantities collected by the system, S7-200 SMART PLC is selected as the system control unit [6]. The key hardware configuration is shown in Table I:

TABLE Ⅰ. LIST FOR MAIN HARDWARE PURCHASE

Serial number	Name	Model	Quantity	Art.No.
1	CPU	SR40	1	6ES7 288-1SR40-0AA0
2	Analog input module	EM AE04	1	6ES7 288-3AE04-0AA0
3	Touch screen	TPC 7062Ti	1	MCGS

(2) Design of collection tank

The design of the collecting tank is mainly based on the water quantity, and because the dissolved oxygen in the water is related to temperature, set the water temperature is 20℃, at this time, the parameters of water dissolved oxygen calculation of various types of tank configuration, specific indicators are as follows:

TABLE Ⅱ. CORRESPONDING RELATIONSHIP BETWEEN TREATED WATER QUANTITY AND ACTUAL PHYSICAL QUANTITY

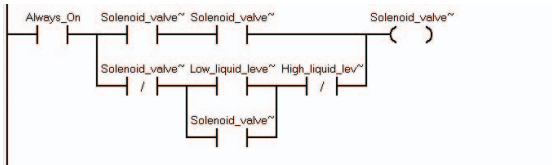
Serial number	Treatment of water (t/h)	Inner diameter of tank (mm)	Oxygen dissolved in water (g)	Mole number (mol)	Oxygen volume at 20 ℃ (m^3)	Ratio of actual to designed air space
1	3	200	0.00015	4.688E-06	0.000112692	11.390574
2	5	250	0.00025	7.813E-06	0.000187821	10.073216
3	7.5	250	0.000375	1.172E-05	0.000281731	15.096213
4	10	300	0.0005	1.563E-05	0.000375641	12.725213
5	12.5	300	0.000625	1.953E-05	0.000469551	15.208612

According to the parameters above, users can choose the corresponding treatment water amount according to the characteristics of their own industry.

B. Design of lower computer

(1) Feed control system

The water in the backwater pipeline of the secondary network is introduced into the gas collecting tank. The actuator is a solenoid valve, and the high and low limits of liquid level are used as control signals. The program is shown in figure 2.

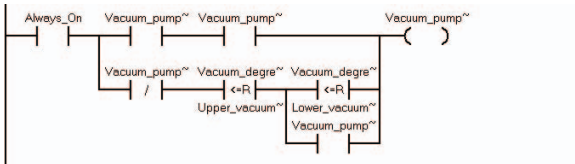


Symbol	Address	Comment
Always_On	SM0.0	
High_liquid_level_of_gc	I0.0	
Low_liquid_level_of_gc	I0.1	
Solenoid_valve_manual	V0.0	
Solenoid_valve_manual_a	V0.1	
Solenoid_valve_to_open	Q0.0	

Figure 2. Program of feed water control system

(2) Vacuum control system

The solenoid valve of the vacuum pump is controlled according to the level of the gas collecting tank, and the opening and closing of the vacuum pump is controlled by the vacuum degree inside the gas collecting tank. The program is shown in figure 3.



Symbol	Address	Comment
Always_On	SM0.0	
Lower_vacuum_limit	VD58	
Upper_vacuum_limit	VD54	
Vacuum_degree_of_ct	VD50	
Vacuum_pump_drive	Q0.2	
Vacuum_pump_manual_auto	V0.2	

Figure 3. Inlet water control system

(3) Drainage control system

Drainage exhausts the water back to the secondary network backwater pipe. The executor in the drainage process is the drainage pump, and the delay program and the low liquid level signal of the

gas collecting tank are the control signals [7], as shown in figure 4.

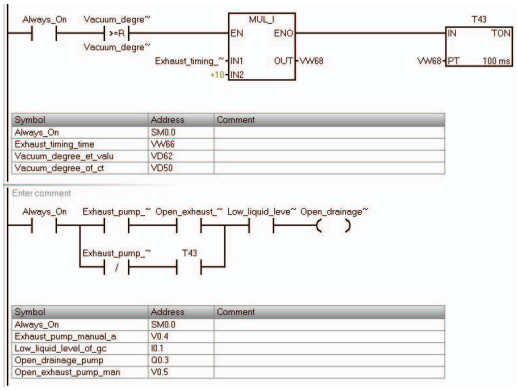


Figure 4. Program of drainage control system

C. *Development for upper computer system*

Collecting and saving the status information of water inlet control system, vacuum control system and drainage control system to the touch screen, and creating a process flow chart [8] on the touch screen, as shown in figure 5.

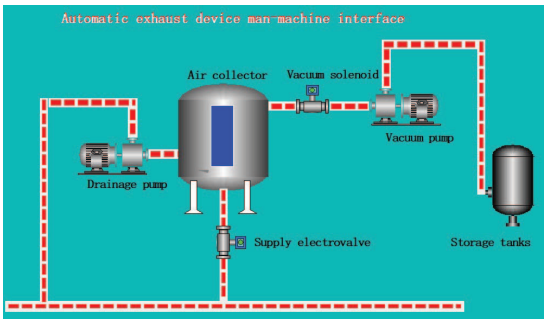


Figure 5. Touch screen of automatic exhaust system

V. Conclusion

S7-200 SMART PLC is the control unit in this paper, using automatic exhaust device to exhaust the water in the heat supply network combining with PLC programming and human-computer interaction system. Finally making the most of the gas in the system from the education in heat supply network, improving the stability of heat supply network equipment operation, and increasing the service life of equipment, to achieve the expected effect. It provides some reference for the operation process improvement of heat grid.

REFERENCE

[1] Gao Guiliang. Hydraulic Balance and Air Discharge of hot water heating Pipe Network [J]. Design and Research,2001(4):1-2.

[2] SHI Yongwen. Discussion on Exhaust Mode of Floor Heating System [J]. Architectural Design,2015(21):163-164.

[3] ZHANG Baoheng. Automatic Exhaust device for heating System :CN201020178521.2010-04-10.

[4] Liu Lihui et al. A Heating System Exhaust Device: CN201120198748.9[P].2011-12-21.

[5]MENG Y N,QI F,WANG W Q. The design of gas station controlling system based on S7-400 PLC[J]. Journal of Physics: Conference Series,2019(5),1176-1178.

[6] Meng Yanan, ZHOU Xueyang, ZHAO Wenbin. Design of heat exchange station control system based on PLC [J]. Chemical Automation and Instrumentation, 201,48(06):541-544+561.

[7] Qi Feng, Yun Tao, Wang Xinyu. Design of Waste Heat Recovery Control System based on S7-200 SMART PLC [J]. Journal of jilin institute of chemical industry, 2021, 38 (7) : 5-8. DOI: 10.16039 / j.carol carroll nki cn22-1249.2021.07.002.

[8] WEI Z G. Design of transmission and sorting system based on S7-1200 and MCGS [J]. Electronic test, 2022 (03) : 121-122 + 27. DOI: 10.16520 / j.carol carroll nki. 1000-8519.2022.03.028.