Thinking and Analysis on intelligent operation of geothermal heating station

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Key words: geothermal heating station, standardization, intelligence

Abstract: In this paper, through the analysis of the standardized design of geothermal heating station HVAC process, automatic control system measuring point layout, electrical automatic control cabinet standardization, control strategy optimization, intelligent platform construction and other aspects, a set of suitable for the intelligent construction and operation of geothermal heating system is established. Through standardized design, the standardization construction of geothermal station is completed, which has important guiding significance for the design, construction, production operation and data analysis of geothermal heat supply station.

1. Standardized design of process flow

Different from the traditional centralized heat supply stations that take cogeneration, industrial waste heat and coal-fired boilers as heat sources in the past, geothermal heating stations are mostly distributed small system heat supply stations based on the principle of "cascade utilization and indirect heat transfer". The main equipment includes submersible pump, cyclone desander, plate heat exchanger, heat pump unit, two network circulating pump, water pump and pressure pump for recharge and other equipment.

According to the particularity of geothermal heating station, the standard technological process is established, as shown in Figure 1.

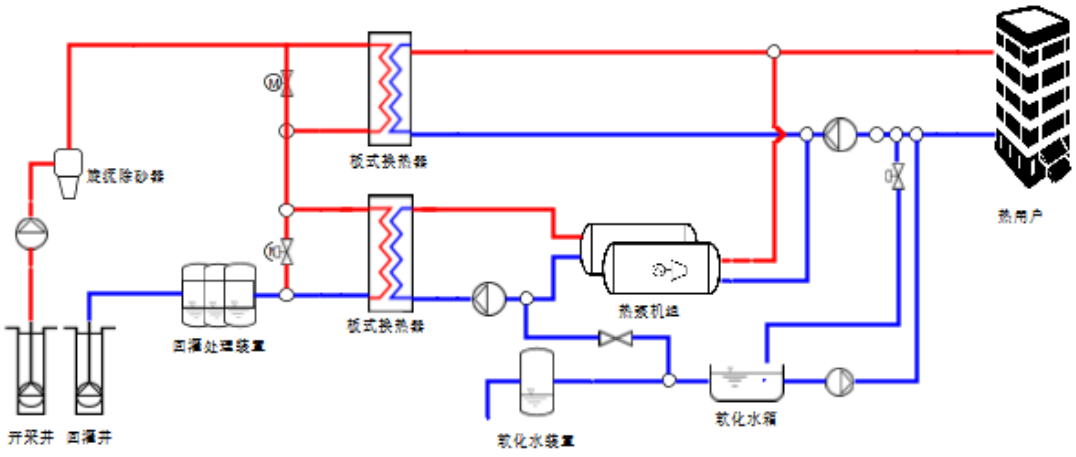

FIG. 1 Standard process flow chart

The process is divided into two parts: primary side and secondary side. The primary geothermal water is mined by the submersible pump and then transported to the heat supply station, which is purified by the cyclone desander and then transported to the plate heat exchanger (titanium plate heat exchanger is required for the plate heat exchanger due to the corrosiveness of the geothermal water to some extent). The geothermal water passes through the primary plate for heat exchange and cooling, and then enters the secondary plate for heat exchange again. After heat exchange, the trailing water is pumped back to the recharge well through the filter device. Through the comprehensive cascade utilization of primary and secondary plate replacement, the geothermal resources can be fully explored and energy waste can be reduced. As the whole process of the primary side is closed system, it truly

realizes "heat consumption without water consumption" and realizes sustainable development and use. The secondary side water is the tap water softened by the softening water device, which is completely isolated from the geothermal water. The softened water after the heat exchange of the primary plate is directly transported to the thermal user through the secondary network circulating pump; Because the temperature of the secondary plate is low after heat exchange, it needs to be transported to the heat user after the temperature of the heat pump unit.

2. Automatic control system standardized measuring point layout

In order to realize the remote production scheduling of the heat supply station in the above standardized process, the corresponding instrument measuring points should be arranged. The layout of measuring points is shown in Figure 2.

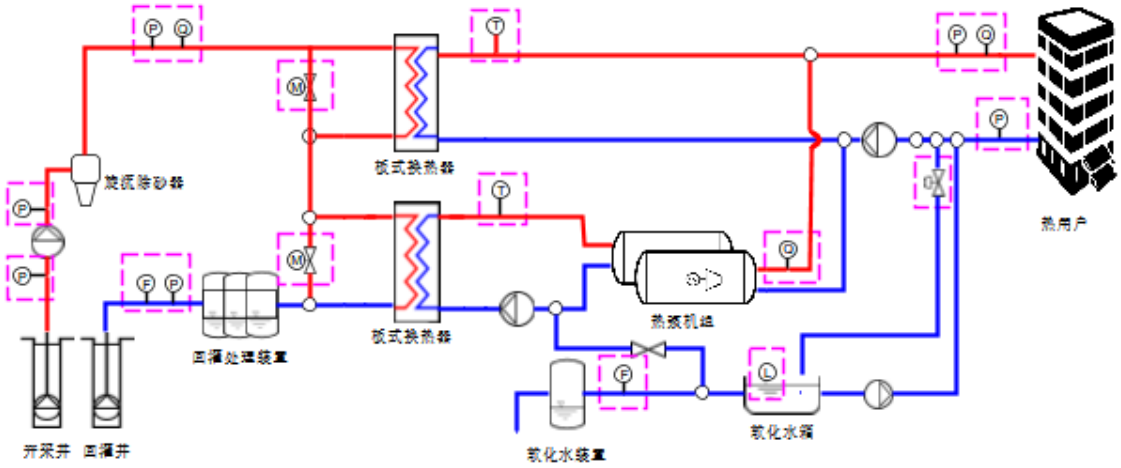

FIG. 2 Layout of measuring points

Main collection contents:

Temperature: primary supply temperature, primary return temperature, secondary supply temperature, secondary return temperature, plate outlet temperature;

Pressure: primary pressure supply, primary back pressure, secondary pressure supply, secondary back pressure, circulating pump inlet and outlet pressure;

Heat: heat of a network (because the geothermal water of a network contains more gas, it is recommended to use electromagnetic calorimeter), heat of two networks, heat pump unit condensate side heat;

Flow rate: water supply pipe refill flow rate, recharge flow rate;

Liquid level: water level from the water tank;

Electricity: production well pump, heat pump unit, circulation system.

Table 1 shows the statistical table of single system instrument with heat pump unit.

Table 1 Instrument statistics table of single system with heat pump unit

Serial Number	Instrument Name	Specifications and Models	Installation Site
1	Primary water supply temperature	0-100℃ 4-20mA	Primary water supply pipe

2	Primary water supply pressure	0-1.6MPa 4-20mA 4-20mA	Primary water supply pipe
3	Primary return water temperature	0-100℃ 4-20mA	Primary water return pipe
4	Primary return water pressure	0-1.6MPa 4-20mA	Primary water return pipe
5	Primary water supply heat	MODBUS RTU	Primary water supply pipe
6	Secondary water supply temperature	0-100℃ 4-20mA	Secondary water supply pipe
7	Secondary water supply pressure	0-1.6MPa 4-20mA	Secondary water supply pipe
8	Secondary return water temperature	0-100℃ 4-20mA	Secondary water return pipe
9	Secondary return water pressure	0-1.6MPa 4-20mA	Secondary water return pipe
10	Secondary water supply heat	MODBUS RTU	Secondary water supply pipe
11	Remote water meter	MODBUS RTU	Softening water pipe
12	Water tank level	0-3m 4-20mA	Softening water tank
13	Electric control valve	DC24V 4-20mA	The secondary plate changes the bypass once pipe
14	Secondary plate change secondary outlet temperature	0-100℃ 4-20mA	Secondary plate for secondary outlet pipe
15	Heat pump unit heat meter	MODBUS RTU	Heat pump units condensing side outlet pipe

3. Standardization of electrical automatic control cabinets

According to the station standard process and measuring point layout, the electrical cabinet and automatic control cabinet standardized design.

The frequency conversion cabinet of the circulating pump adopts a drag-one control mode, and the replenishment pump adopts a drag-two control mode. Frequency conversion cabinet has local remote, operation, fault, frequency setting, frequency feedback, current feedback, start and stop remote control interface.

The PLC module of automatic control cabinet selects the Siemens 1200 series with strong universality to collect the analog input, analog output, switching input, switching output, RS485 and other signals of the instrument equipment in the control station.

4. Control policy optimization

For the geothermal heat supply station, the main control equipment includes the submersible pump of the mining well, the regulating valve of the first network, the circulating pump of the second network, the supplementary pump of the second network, and the pressure relief valve of the second network. For different equipment, according to the process flow, configure the corresponding control strategy.

(1) Control strategy of submersible pump of mining well

0: manually given: manually delivers the given frequency.

1:Time segment fixed frequency: automatically deliver frequency according to different time periods;

2:Climate compensation: adjust frequency according to outdoor temperature.

(2) Electric control valve control Strategy

0: Manually given: manually delivers the given opening value.

1:Fixed secondary supply temperature: according to the secondary water supply temperature value to deliver the opening;

2:Climate compensation: adjust the opening according to the outdoor temperature.

(3) Circulating pump control strategy

0: manually given: manually delivers the given frequency.

1:secondary constant pressure: frequency control is carried out according to the secondary water supply pressure.

(4) Control strategy of water refill Pump

0: manually given: manually delivers the given frequency.

1:intermittent water refill: the secondary return water pressure is lower than the set value to start, higher than the set value to stop;

2:fixed secondary back pressure: frequency control is carried out according to the secondary backwater pressure value.

(5) Pressure relief valve control Strategy

0: manual switch;

1: Automatic switch: according to the secondary return water pressure value for automatic valve opening and closing action.

(6) Control strategy of heat pump unit

0: manual given;

1:Climate compensation: intelligent calculation and setting according to outdoor temperature changes.

2: Time segment: the temperature value is automatically delivered according to different time periods.

5. Smart platform construction

The intelligent platform is composed of three parts: the automatic control system of the heat supply station, the communication network and the host computer platform.

5.1 Automatic control system of heating station

The automatic control system in the heating station is mainly composed of automatic control instrument, frequency conversion cabinet, PLC automatic control cabinet and video monitoring system. PLC automatic control cabinet collects and controls the automatic control instruments and equipment in the heating station; The video monitoring system collects the real-time pictures in the heating station to meet the security requirements.

5.2 Communication Network Construction

According to the different conditions of the heating station and geothermal well house, the appropriate network environment is selected. In heat supply station, optical fiber special line is preferred for networking, real-time transmission of PLC data and video monitoring signals; Because geothermal well houses are mostly located in a relatively off-site location with unchanged networking, 4G VPN can be selected to build the network. Through the network construction, the data sharing between the geothermal heat supply station and the dispatching command

center is realized.

5.3 Establishment of the upper computer platform

The host computer platform preferentially selects the mainstream B/S system to build. In addition to realizing the data docking with the heat supply station, it also needs to collect the indoor temperature of the corresponding heat users. The intelligent platform shall be equipped with GIS map, remote control, load prediction, AI algorithm, intelligent analysis and other functional modules to achieve accurate and intelligent heating of the heating station.

The functions of each module are as follows:

(1) **GIS Map Module**: The map displays the location of each heat supply station and the official website, as well as the main operation data of the station.

(2) **Remote Control Module:** The intelligent platform can automatically control the pump, valve and other equipment in the station according to the operation of the heat supply station.

(3) **Load Forecasting Module**: based on previous years' operating conditions and future weather forecast, accurate prediction of heating load can be achieved.

(4) **AI Algorithm Module**: Through big data analysis such as heating effect and indoor temperature of users over the years, the AI algorithm is optimized to realize the control of the terminal to the heat supply station.

(5) **Intelligent Analysis Module**: Conduct in-depth analysis of historical operation data, generate visual curve reports, and guide the next operation.

6. Conclusion

Through the analysis and research of four parts, such as the standardized design of geothermal heat supply station process, the standardized measuring point arrangement of automatic control system, the optimization of control strategy and the intelligent platform, a set of special scheme suitable for the intelligent control of geothermal system is established. This scheme can be comprehensively promoted for geothermal heating stations, and has important guiding significance for geothermal heating station design, construction, production and operation, data analysis and so on.

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