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Energy Efficiency Analysis Of Middle-Deep Hydrothermal Geothermal Heat Pump Heating System

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ABSTRACT

With more and more application cases of the middle-deep hydrothermal heating technology, in practical applications, the energy efficiency issues of the heating system are increasingly prominent, and the heating heat pump system is the core of the entire heating system, and its energy efficiency has directly affected the economics of the heat system. This paper mainly analyzes the energy efficiency of the heating system for the one side temperature and host side temperature of the plate change system and the heat pump system, and uses the selection software provided by the heat pump unit manufacturer, combines the operation data of the actual engineering case, and analysis of the effects of comparison of different into and out of water temperature on the energy efficiency of the heat pump unit, summarizes the energy-efficient inlet and outlet temperature range with the energy efficiency of the heat pump system, and provides reference to the actual engineering application of the middle-deep hydrothermal heating heat pump system.

1 INTRODUCTION

According to the "China Building Energy Conservation Annual Development Research Report (2021)"[1], in 2019, the total energy consumption of buildings in China was 1.02 billion tons of standard coal, accounting for 21% of the country's total energy consumption, of which the energy consumption for heating in the north was 213 million tons of standard coal, accounting for 21% of the total building energy consumption. In order to alleviate the contradiction between environmental protection, economic development and energy consumption, renewable and clean energy represented by geothermal energy has received more and more attention. Geothermal energy can be divided into three types: shallow geothermal energy (within a depth of 200 meters), middle-deep geothermal energy (depth 200-3000 meters) and deep geothermal energy (depth greater than 3000 meters). The utilization of deep geothermal energy is mainly dry heat Rock power generation is still in the exploratory stage; the average temperature of shallow geothermal energy is relatively low, and the cooling and heating loads are easily unbalanced, which restricts the development of shallow geothermal energy heating; with the advancement of exploration technology and the reduction of drilling costs , middle-deep geothermal energy heating has broad application prospects[2].

My country is actively promoting middle-deep geothermal energy heating technology. The National Energy Administration's "Notice on Doing a Good Job in Renewable Energy Heating According to Local Conditions", Guo Neng Fa Xinneng [2021] No. 3[3], proposes to focus on promoting middle-deep geothermal energy heating. According to the principle of "fixed mining with irrigation, balanced collection and irrigation, and balanced water and heat", the middle-deep geothermal energy heating is promoted in a combination of centralized and decentralized methods. The National Energy Administration's "Several Opinions on Promoting the Development and Utilization of Geothermal Energy (Draft for Comment)"[4], proposed that by 2025, the area of geothermal energy heating (cooling) will increase by 50% compared with 2020, and by 2035, geothermal energy heating (Refrigeration) area doubled from 2025. In terms of engineering application, as of the end of 2017, the national hydrothermal geothermal energy heating area has exceeded 150 million m2, of which the hydrothermal heating area in Xiong County, Hebei Province has reached 4.5 million m2, which can meet 95% of the county's heating demand. It is expected that by 2023, there will be an additional 100 million m2 of hydrothermal geothermal heating area, ranking first in the world in terms of volume.

My country is rich in middle-deep geothermal energy resources and develops rapidly. In practical applications, the energy efficiency of the heating system is increasingly prominent. As the core of the entire heating system, the energy efficiency of the geothermal heat pump system directly affects the economy of the heating system. This paper mainly analyzes the energy efficiency of the heating system based on the primary side temperature and the host side temperature of the plate exchange system and the heat pump system, and provides a reference for the practical engineering application of the middle-deep hydrothermal heat pump system.

2 MIDDLE-DEEP GEOTHERMAL WATER HEATING TECHNOLOGY

The principle of hydrothermal geothermal central heating is to obtain geothermal water through the development of geothermal resources, extract the heat of geothermal water for heating through cascade utilization technology, and return the tail water after the heat extraction to the ground. No water is taken from the heat, the system is closed and the water quality does not change. The project mainly includes geothermal resource exploration, heat source well drilling, system anti-corrosion and anti-scaling, cascade utilization, low-temperature heating, reinjection in the same layer, dynamic monitoring of geothermal resources, remote automatic monitoring of heating stations, and low-temperature geothermal power generation. The hot water is extracted from the heat source well, and after removing impurities in the water through a cyclone desander, it enters the titanium plate heat exchanger in the station building, and exchanges the softened water in the secondary pipe network through plate exchange. Finally, it is sent to the residential room for heating. The well water after heat exchange is filtered twice by the coarse efficiency filter and the precision filter, and then injected back to the same underground thermal reservoir. The whole process is sealed, realizing 100% of the geothermal water resources in the same layer of the project, achieving the sustainable renewable utilization of geothermal resources, and truly realizing heat without water. The principle is shown in Figure 1.

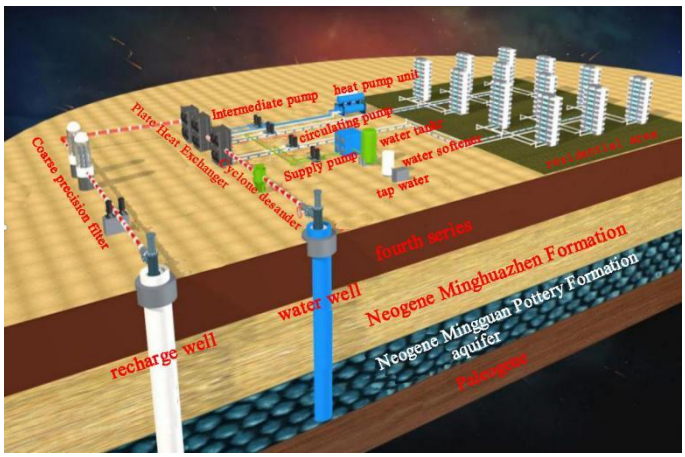


Fig. 1 Schematic diagram of the principle of middle-deep hydrothermal geothermal heating technology

3 ENGINEERING CASE ANALYSIS

3.1 Project Overview

The project is located at the intersection of Changjiang Road and Taibaishan Road, Luohe City, Henan Province. It adopts medium-deep hydrothermal geothermal heating technology to provide heat source for a residential area with a construction area of 121,000 square meters and a heating area of 100,000 square meters. The project is designed with 1 water extraction well , 2 recharge wells, the well depth is 1300m, and the well spacing is about 300m. The project is divided into high and low areas. The system adopts cascade utilization. The first-stage plate is replaced with direct heat supply. When the heat load demand is large, the second-stage plate exchange and heat pump unit are turned on to jointly supply heat for users. The heat exchange station adopts 2 sets of water source heat pump units with a rated capacity of 650kW, the design supply and return water temperature is 45/35℃, the design pressure is 1.6MPa, and the terminal adopts floor radiant heating. The main equipment technical parameters are shown in Table 1.

Tab1 Main equipment of hydrothermal geothermal heating system

Device name	Amount（tower）	Stand-alone rated power	Technical parameter
Water source heat pump unit	2	129	Rated heat: 625kw
High zone circulating water pump	2	11	Flow 70m³/h, lift 30m
Low zone circulating water pump	2	18.5	Flow 120m³/h, lift 30m
Intermediatecirculating water pump	2	7.5	Flow 120m³/h, lift 14m

3.2 Application Analysis

From November 15, 2021 to March 15, 2022, the heating system will operate normally, including the two time periods from November 15, 2021 to December 8, and March 5, 2022 to March 15, 2022. , the heat pump unit is not turned on, and the heating system is directly heated by geothermal water through the first-level plate heat exchange. The following data were obtained through field testing:

(1) The calculated outdoor heating temperature in this area is -4.7°C. The number of days when the heat pump unit is on in the 120-day heating season of this project is 85 days. In the 35 days of the first cold and the last cold, the heat is directly supplied by the groundwater after heat exchange. The power consumption of the heating system is only Power consumption for the pump.

(2) The average temperature of geothermal water production wells is 54.9°C, and the heating season is basically constant; the average temperature of the user-side water supply in the low area is 40.21°C, and the average temperature difference between the supply and return water is 4.97°C; the average temperature of the user-side water supply in the high area is 39.88°C, the average temperature difference between supply and return water is 4.64℃; the average indoor temperature is about 21℃, which meets the relevant regulations of GN50736-2012 "Code for Design of Heating, Ventilation and Air Conditioning in Civil Buildings".

(3) The average inlet temperature of the evaporator side of the low-zone heat pump system of the project is 20.14°C, the average outlet temperature is 14.71°C, and the temperature difference is 5.43°C; the average inlet temperature of the condenser side of the unit is 36.52°C, and the average outlet temperature is 42.09 ℃, the temperature difference is 5.57 ℃; the average performance coefficient of the heat pump system heating is 6.024, and the temperature change of the inlet and outlet of the evaporator and the condenser side when the heat pump unit is turned on is shown in Figure 2.

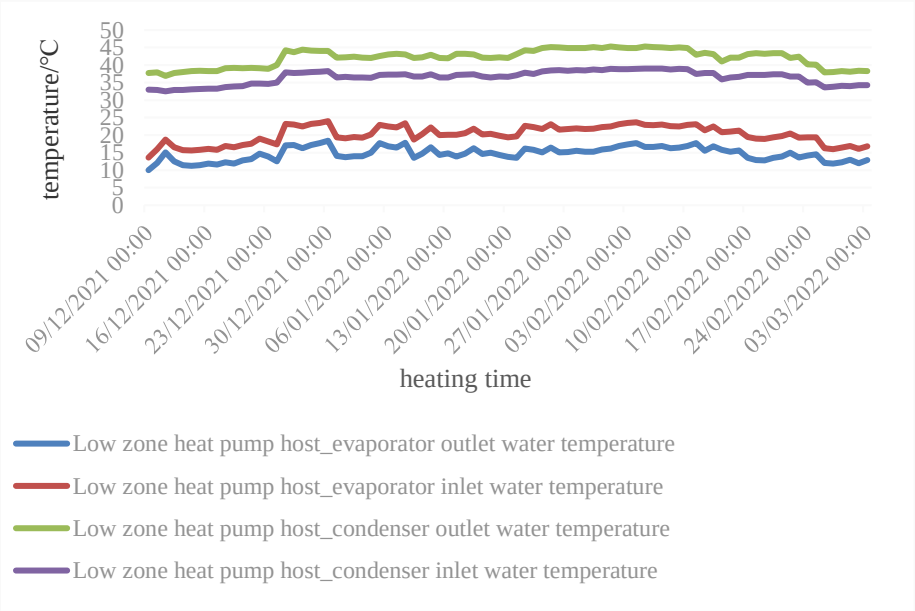


Figure 2 The inlet and outlet temperatures of the evaporator and condenser side of the heat pump unit

4 EXPLORE

(1) The energy saving effect is good. For the heat pump unit, compared under the same working conditions, the higher the outlet temperature of the evaporation side, the greater the heating capacity of the unit, and the higher the coefficient of performance of the unit;

(2) Long-term operation stability assessment. The initial investment of medium and deep geothermal heating technology is relatively large. In order to obtain good economic benefits, it is necessary to ensure the long-term stable operation of the heating system. Under this premise, it is very important to evaluate the safety and stability of the mid-deep geothermal heating system under long-term operating conditions

5 COMPLIMENTARY CLOSE

(1) The temperature of the low temperature heat source is high. For the mid-deep hydrothermal geothermal heating project, the drilling depth is 1300m, the average temperature of the geothermal water production well is 54.9℃, and the heating season is basically constant.

(2) Energy-saving and economical. The first cold and the last cold are directly heated by geothermal. When the heat pump is turned on, the average performance coefficient of the system heating is 6.024, and the comprehensive operating cost of the system in the heating season is 10.1 yuan/m2.

(3) The application prospect is broad. my country is rich in geothermal energy resources, and the state has issued a series of policies to support the development of this technology. However, in the process of promotion, it is necessary to do a good job in preliminary survey and design and long-term operation stability assessment according to local conditions to ensure the sustainable development of the technology.

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