ENHANCEMENT TECHNOLOGY OF UNDERGROUND WATER FLOW FIELD IN COAL MINE TO IMPROVE ENERGY EFFICIENCY OF HEAT PUMP SYSTEM IN GEOTHERMAL ENERGY DEVELOPMENT

by

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In order to solve the problem that the cold/heat released from the underground pipe of coal mine into the soil layer is difficult to dissipate in a short time, the technology of enhancing the underground flow field of coal mine in geothermal energy development to improve the energy efficiency of the heat pump system is proposed. In this paper, based on the ground source heat pump project located in a coal mine, the energy efficiency enhancement technology of the artificial flow field ground source heat pump system is studied and tested. The test results show that when starting work at about 8:00, due to the increase of heating load, the accumulation of cooling capacity around the buried pipe increases gradually, and the return water temperature at the ground source side decreases gradually. At 14:05, the water was pumped for the operation of the artificial groundwater flow field. It can be seen that the temperature of the return water at the ground source side began to rise gradually, indicating that the accumulation of cold water around the buried pipe was relieved to a certain extent. In conclusion, the artificial groundwater flow field can alleviate the accumulation of cold water around the buried pipe heat exchanger to a certain extent, improve the return water temperature of the buried pipe heat exchanger, and improve the energy efficiency of the ground source heat pump system.

Key words: *artificial flow field energy efficiency enhancement technology, ground source heat pump, buried pipe, geothermal field, system energy efficiency*

Introduction

The purpose of refrigeration and heating is achieved by means of electricity [1]. Based on the related data, according to the development and progress of the existing underground pumps, the underground pumps can utilize shallow geothermal energy to cool and heat within one square km in winter and summer, and the energy of the coal structure can reach

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24-28000 tons per year, that means we can reduce emissions of pollutants annually, such as about 245000 tons and 20000 tons of CO_2 emitted from nitrogen oxides, the emissions of tobacco [2].

In winter, when we use ground source heat exchanger for heating, it not only reduces the combustion process, but also reduces the pollution of pollutants such as CO_2 produced in the combustion process. In summer, when we use ground source heat pump for refrigeration process, it also reduces the loss of tower water from cooling tower. Ground pump has a great improvement from both economic and environmental perspectives. The groundwater is pumped out through the construction of pumping wells, after the heat is extracted or released, the groundwater is reinjected into the ground by the reinjection wells.

As a new sustainable utilization mode of geothermal energy, groundwater ground source heat pump energy extraction technology, since the mid-1980's, it has been widely used in Europe, America and other countries, and has been gradually popularized in China since the 1990's. The spacing between pumping and irrigation wells is limited, and the groundwater level and temperature between pumping and irrigation wells will interfere with each other, in the areas where groundwater is pumped and reinjected intensively.

The influence range and level of different pumps on groundwater and groundwater level are also different. Taking the coal mine source heat pump as the research object, the energy saving heat transfer technology of underground power supply is studied and experimented. Ground water source heat pump has been paid more and more attention in the field of building heating and cooling because of its advantages cannot be replaced. It uses groundwater as heat source, and realizes the heat exchange process of groundwater and air from groundwater and reclamation.

The specific heat of water is higher, and the heat transfer is better. The water temperature is not affected by outdoor change in four seasons. Sustainable operation, and energy conservation and environmental protection benefits obvious. However, since most water supply heaters require large quantities of pumps and injectors, the number of pumps and injectors and the installation of the injection wells are more conducive to the overall heat transfer process. But due to the limitation of various factors in the practical engineering, such as limit the size of building sites, temperature and aquifer recharge, the limitation of initial temperature difference and the system initial investment how much restrictions and so on. Not adopt the reasonable arrangement and operation mode, lead to pumping well between the groundwater flow field and temperature field will interfere each other, for the centralized pumping irrigation area, the impact of the interference will be more prominent, serious can cause pumping wells pumping temperature lowering, if the layout mode of pumping wells is not appropriate, will produce *heat transfixion* phenomenon.

The operating efficiency of the heat pump will be reduced. In order to improve the utilization rate of energy resources and promote the sustainable development of energy. China will promote and utilize clean and renewable energy to ease the current energy pressure in the country. Sustainable energy consumption is of great significance to energy conservation and social development. Wind, solar and geothermal energy are all RES. Because of its sanitary and pollution free characteristics, the scientists have attracted the attention of scientists. Scientists are using high tech and high technology to use this new cleaner energy source as a coolant and heat source for air conditioning systems. Proper application can ensure the efficiency and low power consumption of air conditioning system.

Heat pump technology is a technology that uses cleaner renewable energy to convert low energy energy into high energy energy through thermal cycling. In this process, the heat energy that cannot be directly used is converted into heat energy, so as to achieve the purpose

of saving building energy. Because the underground water source heat pump project is mostly developed in recent years, the adverse impact on the environment is not obvious. However, with the continuous operation of the system and the widespread use of groundwater heat pumps. The adverse environmental effects of the system will be more pronounced and more difficult to recover from.

Therefore, through the analysis of the domestic underground water source heat pump system the prevalence of adverse effects in the process of actual operation, to discuss the cause of the problems and put forward solutions, software is used to simulated the grind Gui, put forward a reasonable well pumping wells swarm optimization arrangement scheme, this system to guarantee smooth operation is of great significance for a long time, from two aspects of the economy and environmental protection.

This provides a strong theoretical basis for the effective long term utilization of hot olive oil in groundwater in the future. It is difficult for the heating and cooling of underground pipe line in coal mine to burst into the stratum in a short time. Resulting in further expansion of the air conditioning/heating system near the underground pipes. The problem of energy saving effect of ground source heat pump is reduced, and the optimization technology of underground water flow in coal mine is put forward to improve the energy saving efficiency of heat pump in geothermal power plant.

Groundwater artificial flow field of energy efficiency enhancement by groundwater flow around the buried pipe pile up cold quantity or heat exchanger is relatively evenly transferred to the whole region in the soil, shallow geothermal energy between the buried pipe by make full use of.

This paper takes the ground source heat pump (GSHP) project located in a coal mine as the research object, and carries on the research and test of energy efficiency enhancement technology of artificial flow site source heat pump system. Experimental results show that: when to start work at 8 p. m., due to the heating load increase, around the buried tube cold quantity accumulation is gradually increasing, ground source side return water temperature gradually decline, in this case, in order to ensure sufficient heat, ground source heat pump units will reduce the ground source side of the water temperature, this will cause the loss of unit to reduce the COP, levels of energy efficiency.

At 14:05, pumping was started for operation of the artificial groundwater flow field. It can be seen that the backwater temperature at the ground source side began to rise gradually, indicating that the cold accumulation around the buried pipe was relieved to a certain extent.

In 1824, after Carnot published the Carnot theory, after 30 years of vigorous development, many researchers focused on the study of the Carnot cycle, through unremitting efforts, researchers have opened up a wider range of applications of the Carnot cycle, among many researchers Kelvin and William. More prominent was Thomson, who proposed the bold idea of using the inverse Carnot cycle for heat pump systems.

But because later in the implementation process, restricted by energy cost and energy efficiency, and did not reach the expected effect, therefore, has not received extensive attention of people, contribute to the development of heat pump and tends to slow, until 1912, Swiss scientist broke the deadlock, successfully developed the first set in the water as a heat source heat pump equipment. Figure 1 shows geothermal energy series 1 geothermal energy utilization ground source heat pump.

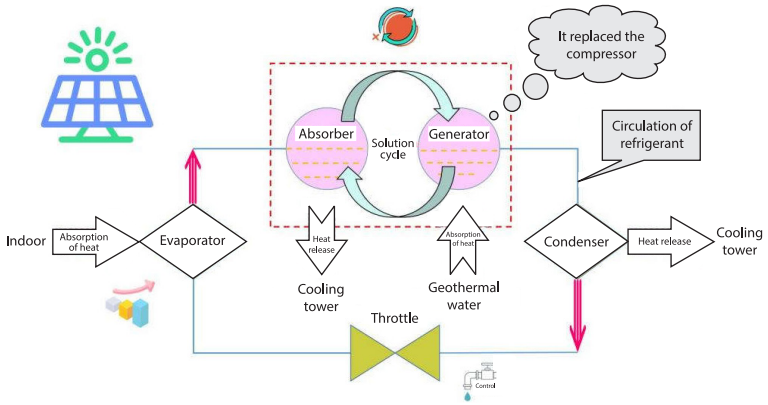

Figure 1. Geothermal energy series a ground source heat pump using geothermal energy

Research methods

Test project operation monitoring

By monitoring the key parameters of the ground source heat pump system, an effective basis is provided for the analysis of the project operation effect. The monitoring frequency of each parameter is 1 time per minute [3].

Artificial flow field test scheme

The test and research work will be carried out in the heating season from 2016 to 2017, tab. 1 [4] .

Table 1. Operation scheme of ground source heat pump system

Date	Start time	End time	Duration	Average flow [m^3h^{-1}]	Research objective
January 10	14:05	23:05	9:00	7.7	Effect of different duration and flow rate on heat transfer and settlement
January 10	23:47	4:48 the next day	5:01	8.2	
January 11	4:54	8:38	3:44	5.2	
January 14	14:02	17:02	3:00	8.1	
January 16	11:33	13:33	2:00	7.04	
February 11	16:00	20:00	4:00	8.5	
March 16	15:00	19:00	4:00	8.13	
March 18	17:00	21:00	4:00	8.44	
March 22	13:00	21:00	8:00	8.43	
March 29	10:00	22:00	12:00	8.42	Influence of different duration and flow on settlement
April 1	10:00	14:00	4:00	10.95	
April 3	13:00	17:00	4:00	11.08	
April 6	9:30	21:30	12:00	10.88	
April 9	13:00	1:00 the next day	12:00	10.78	

Water source heat pump has stronger environmental benefits, but also can save on the economy in the process of system operation cost, thus promoted by country and widely used, but due to system design in practical engineering and theoretical basis of imperfect, of hydrological, geological conditions and other kinds of ecological environment and the lack of rational analysis, in the process of the application of water source heat pump, there are a variety of problems:

Environmental issues: Mainly refers to the pollution and pollution of groundwater by using water heater. Chemical pollution mainly refers to that during the long term operation of a water heater, groundwater may be in contact with a long term heat pump, and the water is easily oxidize with iron, copper and other substances. Because of the pump quality, when the pump is good, the temperature changes of the water will cause changes in microorganisms and various chemical components. The thermal pollution is mainly caused by the large difference of recovery temperature and initial temperature of reservoirs.

Groundwater waste: Due to increasing water consumption in China and other cities, water resources have increased sharply. Therefore, the government has strengthened the management of water heater recycling process, requiring the groundwater to be 100% recycled into reservoirs when the water heater works. However, in the practical engineering application, due to the insufficient consideration in the design and the unreasonable management in the process of water well operation, the recharge rate decreases and even fails. And does not reach 100% recharge, will also cause the waste of water resources.

Land subsidence: rational design and management of the use of underground water source heat pump, is not going to happen subsidence land subsidence problems, such as buildings, only in a few will be slightly on the ground subsidence in soft soil area, it is because of the soft soil, the surrounding ground plane may be due to the pumping of groundwater and make the ground to form a *funnel* change, thus produce ground subsidence phenomenon. But for areas with hard soil, almost no land subsidence will occur.

Risks for air conditioning systems are similar: In recent years, the state and local governments have been supporting water heater pumps in many areas, and heat pump systems have been widely used in cities with rich water resources. In these cities with higher distribution, the interaction between water level and temperature of suction well group will make the ground heating in nearby areas not work well.

Result analysis

Operation without artificial flow field

The original operation of the project presents a typical intermittent operation mode. According to statistics, on average, it runs once every half an hour [5]. The water supply temperature at the ground source side of the project is relatively high in the heating season, which can reach 18-19 °C under operation, indicating that the load of the project in the cooling season is relatively high, the total heat discharged to the underground soil in the whole cold supply season exceeds the total cold discharge to the underground in the whole heating season, and the annual average temperature of the underground soil increases year by year [6].

Since the system operates intermittently and the circulating pumps at the ground source and load side operate continuously when the system stops heating, in order to effectively analyze the energy supply effect of the ground source heat pump system, the temperature difference between the supply and return water at the source side of the ground is greater than 1 °C as the threshold to judge whether the system is heating, based on this, the system operation effect in each operation cycle is analyzed. See fig. 2 for the average unit COP change on a typical day under the original operation state [7] .

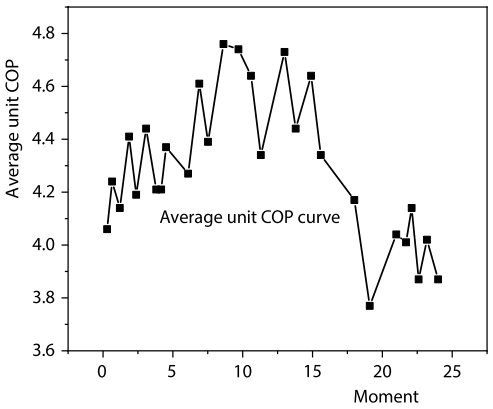

Figure 2. The COP curve of a typical daily average unit in original operation in heating season

Under the original operation state, the average unit COP is basically higher during the working period (8:00-16:00) and lower during the off duty period (16:00-8:00 the next day), this is due to the relatively high load rate during the working period and the relatively high unit COP [8].

Operation under artificial flow field

The utility model can strengthen the convection heat transfer of the buried pipe, reduce the cooling pressure around the buried pipe in the heating season, improve the heat transfer coefficient between the buried pipe and the soil, so as to improve the overall heat transfer efficiency. According to the work data of January 10, the influence of material flow rate on thermal performance of ground source heat exchanger was analyzed [9].

At about 8:00, at the beginning of operation, due to the increase of heat, the air conditioning around the buried pipe gradually increases, and the water return rate from the groundwater level gradually decreases.

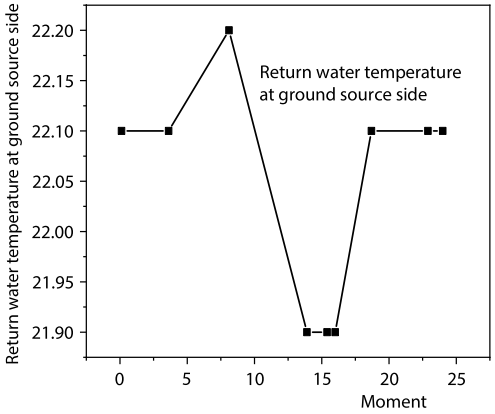

Figure 3. Return water temperature curve at the ground source side on January 10

At the same time, in order to ensure adequate heat supply, the GSHP will reduce the outlet temperature of the underground space, thereby reducing the COP rating and achieving energy saving. At 14:05, the groundwater system began to operate in vacuum, and it can be seen that the backwater temperature in the underground space began to rise gradually, indicating that the mixed cooling around the buried pipe has also been optimized to a certain extent, fig. 3.

Since it is impossible to directly calculate the energy saving level of ground energy sources from the water returned from the temperature field at ground level, in order to quantitatively analyze the effects of the air flow on the energy saving level of ground energy sources. pump unit, data center in the monitoring period of the project are selected as the control group to calculate the average COP change of the unit in different process conditions.

Figure 4 shows the impact of pumping capacity of artificial flow field on average COP of unit under artificial flow field. There is basically a positive correlation between the average COP of the unit and the pumping capacity of the artificial flow field [10].

The groundwater is pumped out through the construction of pumping wells, after the heat is extracted or released, the groundwater is reinjected into the ground by the reinjection wells. As a new sustainable utilization mode of geothermal energy, groundwater ground source heat pump energy extraction technology, since the mid-1980's, it has been widely used in Eu-

rope, America and other countries, and has been gradually popularized in China since the 1990's.

Conclusion

In heating season, underground power plant can reduce the cold accumulation around buried heat to a certain extent, improve the water return rate of buried heat, and improve the energy efficiency of underground power plant. The material flow rate of power generation improvement technology of deep geothermal energy is different from that of underground power supply with low capacity (less than 10 m^3 per hour). In order to ensure enough heat, the ground source heat pump unit will reduce the ground source side of the water temperature, which will lead to the loss of the unit. At 14:05, pumping of the artificial groundwater flow field began. It can be seen that the temperature of the backwater on the source side of the earth gradually rises, indicating that the cold accumulation around the combustion pipe is emphasized to a certain extent. The artificial underground water flow field can make the cold accumulation around the coking heat pipe heat exchanger reach a certain extent, improve the hot water temperature of the coking heat pipe heat exchanger, and improve the energy.

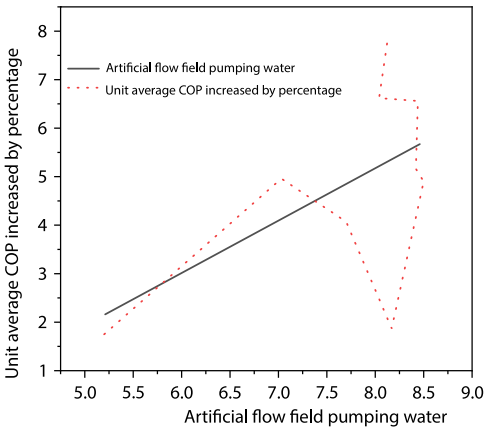

Figure 4. Influence of pumping capacity of artificial flow field on the percent increase of unit average COP

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