Study on solar - ground source heat pump and combined heating system in severe cold area

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Abstract: This paper studies the operation strategy and economy of solar-ground source heat pump gas heating system in severe cold region. Two operation modes of the system are introduced: series operation and parallel operation, and the two operation modes are simulated. This paper compares and analyses the heat exchange of the ground pipe, the change of the water temperature at the inlet and outlet of the ground pipe heat exchanger, the heating efficiency coefficient COP and the refrigeration efficiency coefficient EER of the heat pump unit during the five-year operation of the combined heating system, and studies the change of the soil temperature. Finally, the economic analysis is made from the initial investment cost and operation cost of two different heating schemes. The results show that the maximum heat transfer efficiency of the parallel system is 2.5 times that of the serial system, and the total heat transfer between the parallel system and the heat network is 83.2% higher than that of the serial system. The inlet and outlet water temperature of the buried pipe decreased under both operation modes. After five years of operation, although the operation cost of the parallel combined heating system is higher than that of the serial combined heating system, the parallel combined heating system has more advantages than the serial combined heating system in terms of the overall heating effect of the system and the influence degree of the system on soil temperature.

1. Introduction

Ground source heat pump is a new technology to use shallow geothermal energy. This paper studies the combined heating of solar-ground source heat pump and heat network. Compared with the single use of solar energy or heat pump system, it can not only make full use of natural and clean solar energy, but also improve the imbalance of soil heat caused by single operation of heat pump[1].

2. Design and operation of the system

The system is mainly located in severe cold zone II, the main heat source of heating is heat pump, and the auxiliary heating equipment is solar collector system. The heat supply network is used to maintain the stability of water supply temperature of the system and ensure the water supply demand of buildings under the most unfavorable conditions (low solar radiation and intermittent heat pump heating). The system can be roughly divided into two schemes: the series operation of ground source heat pump and solar collector system and the parallel operation of ground source heat pump and solar collector system. In the series system, the building heating return water flows into the heat pump unit after passing through the solar collector system. In the parallel system, the building heating return water flows into the above two parts respectively.
3. Establishment of Main Module Model of System

The models established in this paper are simulated by TRNSYS software, and the models of the main modules are: solar collector model, heat pump unit model, and ground heat exchanger model. The solar collector model is flat plate collector Type1, heat pump unit module is water-water source heat pump unit Type668, ground heat exchanger module is Type557a. According to the above design of the complementary heating system, the simulation model is established in TRNSYS software.

4. Simulation result analysis

4.1. Buried pipe heat exchange

It can be seen from Fig. 1 that the heat transfer fluctuation between the ground heat exchanger and the soil is large, which is caused by the frequent start / stop of the heat pump unit in the heating process. By comparing Fig. 1 and Fig. 2, it can be seen that the maximum heat exchange efficiency of buried tube heat exchanger and soil in the tandem system is 19.8 % higher than that in the parallel system. In the whole heating season, the total amount of heat taken from the soil by the buried pipe heat exchanger in the parallel system is 8.6 % lower than that in the series system. It can be concluded that the series system is more obvious than the parallel system in terms of the decrease of soil temperature caused by the operation of the system.
4.2. COP of heat pump unit

Comparing Fig. 3 and Fig. 4, it can be seen that the COP of the heating performance coefficient of the tandem combined heating system and the parallel combined heating system decreases with the delay of time, but the decrease of the COP of the heat pump unit of the parallel heating system is smaller than that of the heat pump unit of the tandem combined heating system. The refrigeration performance coefficient EER of the tandem combined heating system and the parallel combined heating system increases with time delay, but the increase in COP of the heat pump unit of the parallel heating system is greater than that of the heat pump unit of the tandem combined heating system.
4.3. Changes of inlet and outlet temperature of buried pipe

Figure 5 and Figure 6 are the changes of the inlet and outlet water temperature of the ground heat exchanger during the operation of the series system and the parallel system within five years. The initial soil temperature in Shenyang is 12°C. It can be seen from the figure that after five years of operation of the serial system, the outlet water temperature of the buried pipe decreased from 8.34°C to 1.48°C, and the inlet water temperature decreased from 6.69°C to 0.03°C. After five years of parallel system operation, the outlet water temperature of buried pipe decreased from 8.34°C to 2.78°C, and the inlet water temperature decreased from 6.69°C to 1.26°C.

Fig.5 The change of inlet and outlet water temperature of buried pipe in series system for five years of system operation

Fig.6 Changes of inlet and outlet water temperature of parallel system buried pipes in five years
4.4. Soil temperature disturbance rate

![Figure 7](image1.png)

Fig. 7: The change of soil temperature in the five-year serial system of system operation

![Figure 8](image2.png)

Figure 8: Changes in soil temperature in a five-year parallel system

Comparing Figure 12 and Figure 13, we can know that in the heating process of the same building, the decrease of soil temperature caused by the series system is greater than that caused by the parallel system, that is, the soil ‘cold accumulation’ caused by the series system is greater than that caused by the parallel system. Therefore, after many years of operation, the heating performance of the parallel system heat pump unit is better than that of the series system heat pump unit.

5. Conclusions

- The phenomenon of cold accumulation caused by ground source heat pump heating alone is serious, which seriously affects the continuous operation of the system. The necessity of solar-ground source heat pump combined heating is obtained.
- The heat transfer between the parallel system and the heating network is relatively concentrated compared with the serial system. The maximum heat transfer efficiency of the parallel system is 2.5 times higher than that of the series system. The total heat transfer between the parallel system and the heat network is 83.2% higher than that of the series system.
- After five years of operation, the outlet water temperature of the buried pipe decreased from 8.34 °C to 1.48 °C, and the inlet water temperature decreased from 6.69 °C to 0.03 °C. After five years of operation of the parallel system, the outlet water temperature of the buried pipe decreased from 8.34 °C to 2.78 °C, and the inlet water temperature decreased from 6.69 °C to 1.26 °C.
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