Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Development and Protection of Geothermal Resources in Tianjin

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Keywords: Geothermal resources Development Protection

ABSTRACT

The exploitation and utilization of geothermal resources in Tianjin can be traced back to the 1930s. Since then, the number of geothermal wells have grown from 1 to 466. Depth of geothermal reservoirs from shallow (700m)to deep (4000m). Resource from single to multiple layers. Development and utilization from simple to intensive. It has promoted the economic development of Tianjin and promoted the exploration and development of geothermal in the whole country, which has attracted the attention of the world.

With the development and conservation of geothermal resources, The Tianjin Bureau of Land and Resources has successively issued the documents for the management of geothermal resources in order to promote the sustainable utilization of geothermal resources. It is clear that the policy of encouraging supplement recharge wells which requires the heating projects to be approved strictly according to the examination and approval of the double wells (production and rejection).

1. INTRODUCTION

Old Xikai geothermal well was drilled on October 1935. The depth of the reservoir is 715-744 m (Minghua Zhen formation, Neogene), the self-flow rate is 32.6 m^3 / h, and the temperature is 34 ℃. Since then in the 50's last century found the north-east direction of the geothermal anomaly area in seismic monitoring work (Figure 1).This stage of geothermal water is mainly used for hot spring recure bath.

Figure 1: Geothermal anomaly distribution

The geological tectonic background of geothermal in Tianjin has been found out through the investigation and exploration of geothermal resources in the exploration and development (1970s to 1990s). It is considered that a series of NE structural faults constitute a channel of water. conduction, which makes the deep hot water enriched to the tectonic uplift to form several geothermal anomaly areas. There are several geothermal reservoirs Minhuazhen formation(Nm), Guantao formation (Ng)of Neogene System, Ordovician System(O), Cambrian System (∈)and Wumishan formation (Jxw)of Jixian System which distributed vertically in each geothermal anomaly area (Figure 2).This stage of geothermal water is mainly used in hot spring recuperation bath, fishery farming, agricultural cultivation and other uses.

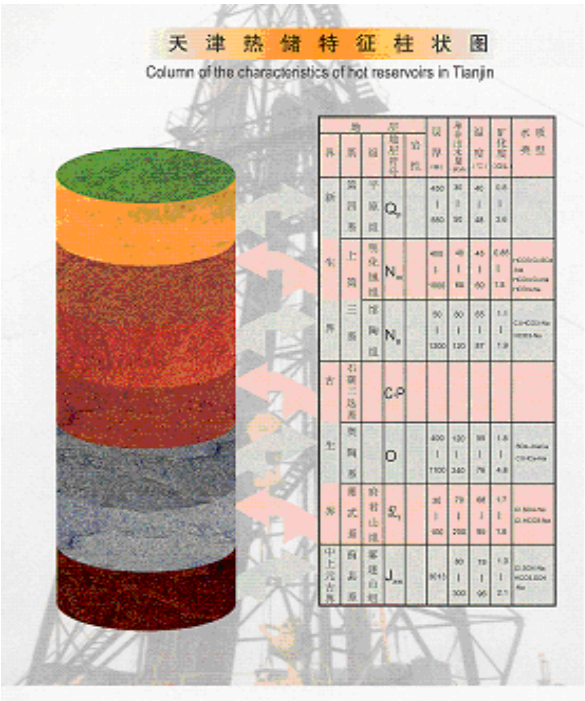

Figure 2：column of reservoirs

With the development of geothermal resources, there is a problem of reservoir pressure reduced. Scientific research and intensive utilization began to expand the scale of geothermal resources development in the 1990s, thermal reservoir pressure decreased quickly. Reinjection experiment of pore reservoir and karst fissure reservoir was carried out in Tinjin. The result obtained the prize of science and technology of Land and Resources Ministry of China in 2005. This stage of geothermal resources development mainly uses in heating system. Geothermal heating area are more than 20 million square meters. Tianjin Land and Resources Bureau has successively issued the following documents for the management of geothermal resources: ‘Circular on further standardizing the way of developing and utilizing geothermal resources to improve the utilization rate of geothermal resources’. It is clear that the policy of encouraging supplement recharge wells. ‘Notice on further strengthening the work of Geothermal reinjection’ requires the heating projects to be approved strictly according to the examination and approval of the double wells (production and rejection). The intensive cascade utilization test and popularization were carried out by using heat pump technology. The results were awarded the first prize of Tianjin science and technology progress and the second prize of national science and technology progress.

2. APPLICATION EXAMPLE

In Hedong fangguan heating station, two geothermal wells in Wumishan formation of Jixian system are used for heating. HD-27 is a production well and HD-27B is a rejection well (Figure 3). The wells bottom distance is 838.76m, which can avoid the interaction. After heat exchange, the reinjection temperature of geothermal tail water is 9 ℃, and the reinjection rate is 97.6%, which realizes the sustainable utilization of geothermal resources

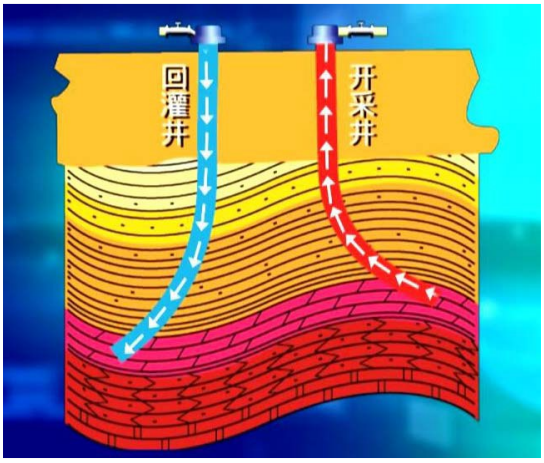

Figure 3： HD-27、HD-27B development mode

The development mode is one production and one reinjection. The geothermal water is recharged to the reinjection well after the heat exchanged. The geothermal water is removed sand by sand remover, and entered into the heat exchanger of heating station. The circulating water of heating system absorbs the heat of geothermal water through heat exchanger. The geothermal well pump and the circulating pressure pump of the heat system are adjusted with frequency conversion. According to the the heat load and the outdoor temperature, the geothermal water is adjusted that power consumption of the geothermal water resources and the submersible pump is saved. When the outdoor temperature is lower in the cold period, which the heat provided by geothermal water cannot meet the requirements of heating users at room temperature, the heat pump system is turned on, and the heat pump operating capacity is according to the requirements. The circulating water of the system is reheated which the temperature reaches indoor design of heating user. The heat of primary heat transfer of geothermal water is the basic heat load of heating, and the heat of tail water extracted by heat pump is used as peak heat load. The water source of heat pump is provided by geothermal tail water that enters the heat pump evaporator through heat exchanger. After the heat pump further reduces the temperature, the geothermal water can be reinjected in the same layer of reservoir that realize the two step utilization of geothermal resources. (Figure 4)

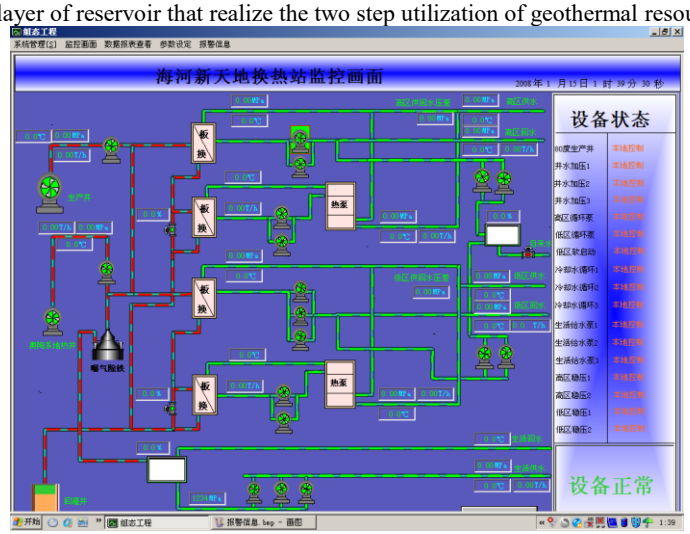

Figure 4: technological process of the system

The total heat load of heating system is 10215.7kw, and the heat transfer of geothermal water is 4650kw, which is only 45.5% of the designed heat load of heating system. The heat provided by heat pump is 54.5% under the peak load of winter heating.

In this project, the design load ratio of peak load is 54.5%. It can be calculated that the cumulative geothermal load accounts for 63% of the total heating consumption in the whole heating season, and the cumulative heat load accounts for 37% of the total heating consumption in the whole heating season (Figure 5).

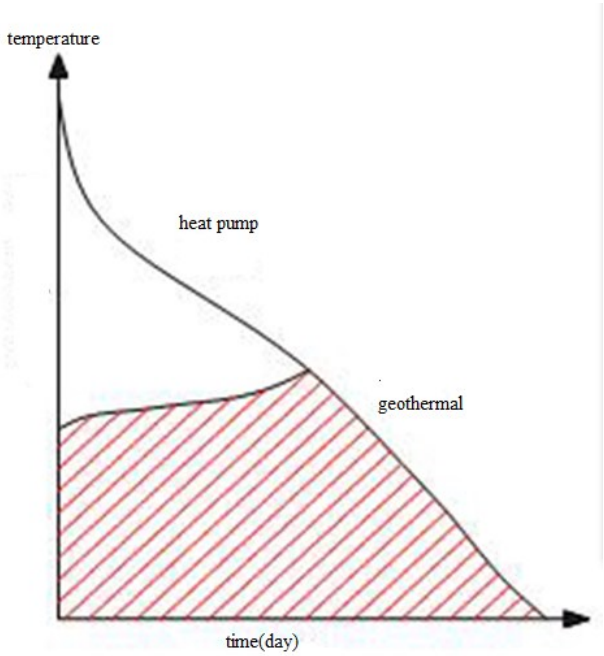

Figure 5: heat load with time

3. ECONOMIC BENEFIT ANALYSIS

In this project, geothermal resources are reasonably developed and utilized, and heat pump technology is adopted to effectively expand the heating area from 15.7 × 10^4m^2 to 24 × 10^4m^2, which satisfy the heating requirements of residential areas. In the case, the geothermal energy is used to 63% of the basic heat load, and the heat pump is used to peak about 37% of the heat load, which can effectively improve the utilization rate of resources.

The initial investment of geothermal heating system is higher, but its operation cost is lower, which is suitable for basic load. On the contrary, the initial investment of peak load facilities is lower and operation cost higher, which is used in peak load. Combined with certain heat pump peak load, geothermal well can effectively improve the economic benefit of heating, and the utilization rate of geothermal well in the whole heat supply period can also be greatly improved.

4. ACHIEVEMENTS AND FUTURE PROSPECTS

The project has established a demonstration project for the utilization of geothermal resources in Tianjin, which is of guiding significance for the development and utilization of the same model of geothermal resources in Tianjin. Take a new well must build a reinjection well. By 2018, there are 474 production wells, with an annual production capacity of 50.35 million cubic meters and a recharge well 235, with an annual recharge capacity of 27.96 million cubic meters recharge rate 55.54%(Figure 6).

Figure 6: recharge rate

5. CONCLUSION

A large number of single wells use for heating system over a long period which reducing the pressure of geothermal reservoir.

The government must manage the development of geothermal resources, guide the rational development and make efficient use of geothermal resources.

Automatic control，reinjection and heat pump technology are key technologies for rational development and efficient use of geothermal resources.

The model has established a demonstration for the utilization of geothermal resources in Tianjin, from 2008 to 2018, reinjection rate is 22.5 to 55.54%.