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Development and Application Analysis of Geothermal Tail Water Reinjection System

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ABSTRACT: Geothermal tail water reinjection is the key factor to determine the success or failure of geothermal resources development, and it is also an effective measure to maintain the sustainable exploitation of geothermal resources. This paper expounds the main reasons for the blockage of sandstone geothermal reinjection well, and introduces an efficient geothermal tail water reinjection system. Through the analysis of the operation data of tailwater reinjection system, it provides reference experience for the upgrading and transformation of geothermal reinjection system.

Geothermal resource is a pollution-free, renewable and clean energy. With the continuous development and utilization of geothermal resources, the groundwater level in some areas continues to decline, and there has been an obvious depression funnel of thermal storage pressure [1]. In order to effectively realize the sustainable utilization and development of geothermal resources and prevent the destruction of the ecological environment, the most effective technical measure is to use geothermal reinjection technology.

1. DEVELOPMENT STATUS OF GEOTHERMAL REINJECTION

In recent 10 years, the direct utilization of hydrothermal geothermal in China has increased at an annual rate of 10%, ranking first in the world for consecutive years. Beijing began geothermal exploration and utilization in the 1950s and 1960s, and carried out preliminary reinjection tests in the late 1990s. In 2004, the Beijing Municipal Geothermal Management Department issued a number of policies to restrict exploitation and encourage reinjection. Tianjin is rich in geothermal resources and has been used earlier. It has issued a series of laws and regulations to regulate geothermal reinjection, encouraged geothermal reinjection by means of approval control and preferential resource fees for geothermal reinjection, and established a regulatory platform. The reinjection test started at the end of 1970s and is divided into four stages. The reinjection tests were conducted on shallow Neogene pore type thermal reservoir, Jixian system Wumishan formation bedrock thermal reservoir, bedrock productive reinjection and Neogene productive reinjection respectively. In recent years, with the national emphasis on geothermal utilization and geothermal resource management, many provinces and cities have issued relevant laws and regulations, requiring geothermal tailwater to be reinjected [2].

2. MAIN FACTORS OF GEOTHERMAL REINJECTION WELL PLUGGING

Due to the reservoir characteristics of sandstone thermal reservoir, the biggest problem faced by reinjection is plugging. Relevant research shows that suspended solids blockage is the most important problem in the reinjection process, which is the most common case of blockage in the reinjection system [3]. Suspended solid particles enter the formation with the reinjection fluid and fill in the thermal reservoir to cement with the dolomite, limestone and argillaceous, thus causing reservoir plugging. In addition, in the long-term use of geothermal wells, the corrosion of pipelines and well pipes will be injected into the aquifer with the reinjection body, which is also an important factor causing the plugging of reinjection wells.

The chemical precipitation in geothermal tailwater is also one of the important factors affecting the reinjection effect. During mining and reinjection, due to the change of temperature and pressure, the chemical composition of tailwater changes: HCO_3^- the fluid with high ion content will undergo the following chemical reactions to release a certain amount of CO_2 gas, which will produce $CaCO_3$ or $MgCO_3$ precipitate:

$$Ca^{2+}(Mg^{2+})+2HCO_3^- = Ca(Mg)CO3\downarrow+H_2O+CO_2\uparrow$$

At the same time, Fe oxidation produces Fe_2O_3 precipitation. There are overlapping parts between suspended solids plugging and chemical plugging. Suspended solids contain compound components, and the substances generated by chemical reactions are mostly in the form of suspended solids.

Bubble blockage is also one of the important factors affecting the effect of reinjection. Due to the change of temperature and pressure, some gas dissolved in geothermal tail water will be released and enter the thermal reservoir, blocking the reinjection channel and reducing the reinjection efficiency.

3. GEOTHERMAL REINJECTION SYSTEM

3.1 Composition of Geothermal Reinjection System

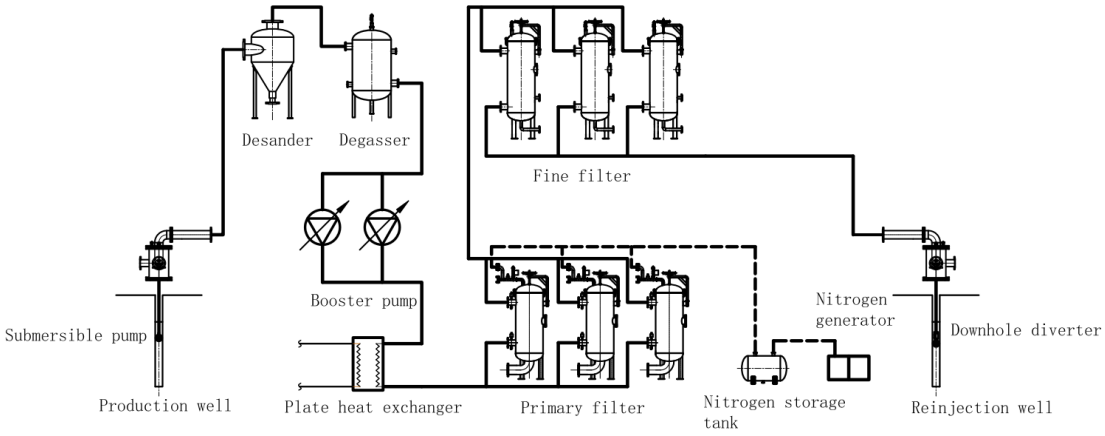

Figure 1: Composition of Geothermal Reinjection System

The geothermal reinjection system includes production wells, reinjection wells, desanders, degassing devices, filtering devices, reinjection pumps, connecting pipelines, monitoring facilities and other components.

Taking a project in Xinji, Hebei Province as an example, the mining well and reinjection well are designed as three spud structure and one spud full cement cementing, effectively isolating and protecting the interaction between deep geothermal water and shallow surface water. Full cement cementing in the second spud in section effectively forms staggered water intake, reduces geothermal water temperature loss, and improves energy utilization efficiency. The third spud in is the well completion of filter pipe. The use of perforated screen pipe can greatly improve the stability of the well wall and prevent formation collapse and other accidents in the later well flushing process.

Desander: when the geothermal water is pumped, it contains large particles of sediment. After long-term operation of the mining well, there will be some rust in the pipeline. Rust will enter the reinjection system. When the geothermal water enters the desander, large particles of sand and iron filings are deposited at the bottom of the equipment by gravity and discharged through the sewage pipe.

Degassing device: because the groundwater is isolated from the air, there is little dissolved oxygen in the water. However, because the groundwater is in the stratum for a long time, the CO_2 generated by crustal activities will be largely dissolved in the groundwater, and the CO_2 content of groundwater is usually high. In addition, if the groundwater flows through the pyrite source, it will also contain hydrogen sulfide and other gases. The amount of gas dissolved in water can be determined according to Henry's Law. The local hot water enters the degassing tank. Due to the pressure reduction, most of the dissolved gas overflows from the water and is discharged from the equipment through the exhaust valve.

Filter unit: the geothermal water passing through the desander still contains a lot of impurities. The filtration level of the filtration device is determined according to the geothermal water quality, particle size distribution, sandstone pore throat radius and test results in different regions. General primary filtration precision 25 μ m. Precision filtration precision 2 μ m。 The primary efficiency filter element adopts a wedge-

shaped metal wound wire mesh filter element, and the precision filter element adopts a non-metallic material filter element. The primary efficiency filter is equipped with nitrogen backwash device. When the working pressure difference between the inlet and outlet of primary efficiency filter exceeds a certain range, the system backwashes the primary efficiency filter. High speed nitrogen flow will remove filter cake and dirt from the surface of filter element, and discharge the equipment through the blowdown pipe at the bottom.

Reinjection pump: it is used to pressurize the filtered geothermal fluid when the pressure in the reinjection well rises (the buried depth of water level rises) and there is no natural reinjection condition. Centrifugal pumps can be selected, and the characteristics of geothermal fluid water quality shall be considered for the materials. When conditions are met, horizontal directly connected centrifugal pumps are preferred. It is equipped with frequency conversion regulation, and the pressure and flow are selected for regulating signal.

3.2 Analysis of Operation Data of Reinjection Filtration System

Through investigating the operation data of a large number of geothermal heat exchange stations, it can be analyzed that the amount of geothermal water reinjection is directly related to the filtration efficiency of the filtration system. When the filtration efficiency of reinjection decreases, the amount of reinjection water will decrease significantly. The following table shows the test data of filtration and interception efficiency of different heat exchange stations.

Table 1: Test Data of Filter Interception Efficiency of Different Heat Exchanger Stations

No.	Name of natural station	Raw water > 25 μm	Raw water > 2 μm	after primary filtration > 25μm	Before fine filtration >2μm	After fine filtration >2μm	Interception rate of primary filtration >25μm	Fine filtration interception rate > 2μm	Total interception rate > 2μm
1	Laoling Taishan Modern City	12993	729170	857	166900	69043	93.41%	58.63%	90.53%
2	Laoling Yongji Garden	2640	254950	207	26513	19047	92.17%	28.16%	92.53%
8	Boye Finance Bureau	847	102617	217	27543	4857	74.42%	82.37%	95.27%
9	Boye Court	/	50717	/	14567	5217	/	64.19%	89.71%
11	Qinghe Century New Town	1427	137820	33	38313	12037	97.69%	68.58%	91.27%
12	Bazhou Shenghao Jiangshan	/	38047	/	/	5573	/	/	85.35%
13	Bazhou Four Seasons Home	2613	658020	1497	228273	20940	42.73%	90.83%	96.82%
14	Windsor Town, Bazhou	990	133733	257	25447	7457	74.08%	70.70%	94.42%
15	Qinghe Guofu Olympic City	153	49540	/	/	15506	/	/	68.70%
16	Qinghe Xintiandi	103	26443	163	24403	14643	58.54%	40.00%	44.62%

Note: The quantity of suspended particles in the table is the content per 100ml.

According to a large number of operation data, the precision of water treatment has a great impact on geothermal

water reinjection. When the filtering precision is not enough, the reinjection water volume will continue to decrease. Measures such as pumping and well flushing should be taken to increase the reinjection volume.

4 CONCLUSION

The treatment accuracy of geothermal water in the reinjection system has a great impact on the reinjection amount. The reinjection equipment of this system can effectively filter out the sediment, iron chips, suspended particles, etc. in the geothermal water. For the sandstone thermal storage, two-stage filtration can effectively extend the service time of the reinjection well. After the degassing device is installed, the amount of dissolved gas in the reinjection water is significantly reduced, which can effectively prevent the sandstone pores from being blocked by tiny bubbles.

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