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Geothermal Resource Integration in Tianjin, China

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ABSTRACT:

Tianjin is the earliest city of geothermal exploration, development and utilization in China, but large-scale extraction of geothermal water has caused a rapid decline of water level and increased mining costs in the geothermal field, especially in the urban city. In order to protect geothermal resources, geothermal reinjection has been required in Tianjin. While geothermal production-reinjection doublet systems are new well, most of the old single geothermal well is still mining in urban area which population and construction are very dense. The method of geothermal single well integrated or rebuild recharge wells to build production-reinjection doublet systems , which can effectively alleviate the drawdown rate , while applying new technologies such as using heat pump can increase level of geothermal resource utilization, reduce the tale water temperature , and promote the sustainable development and utilization .In recent years we have made a detailed investigation and research in geothermal resource integration and optimization configuration , and also completed a lot of practical engineering cases. In this paper, two successful examples of these projects are mentioned.

1. INTRODUCTION

Earlier development and utilization of geothermal resources in Tianjin, is abundant, geothermal resource which have explored contains two types of porosity and karst fractured geothermal. Tianjin is the earliest city of geothermal exploration, development and utilization in China, the heating area is 15.53 million square meters by 2012, and showed a trend of rising year by year. In recent years, due to concerns over the ecological environment, especially the impact of the haze weather .Tianjin government decided to shut down the existing coal heating boilers step by step, at the same time, more environmental clean protection energy are used for the residents heating in winter. At this point, environmental advantages of geothermal resources gradually are accepted by people. With the increasing of the geothermal resources development and utilization, large scale of production has already resulted in a rapid drawdown of water level, affecting the sustainable development and utilization of geothermal resources.

In order to protect geothermal resources, geothermal reinjection has been required in Tianjin. Reinjection has been widely used in geothermal management (Axelsson&Stefansson, 1999) .Geothermal production-reinjection doublet was demanded by government (Wang, 2008). While geothermal production-reinjection doublet systems are new well, most of the old single geothermal well is still mining in urban area which population and construction are very dense. If it is built up recharge wells, mostly constrained economy, construction sites and geological conditions, the implementation is very difficult. The method of geothermal single well integrated or rebuild recharge wells to build production-reinjection doublet systems , which can effectively alleviate the drawdown rate , while applying new technologies such as using heat pump can increase level of geothermal resource utilization, reduce the temperature , and promote the sustainable development and utilization .

In recent years we have made a detailed investigation and research in geothermal resource integration and optimization configuration, and also completed a lot of practical engineering cases. In this paper, two successful examples of these projects are mentioned.

2. THE MODE OF GEOTHERMAL RESOURCE INTEGRATION

In recent years, with the development and utilization of geothermal resources widely used, geothermal exploitation of resource integration of single well gained more attention and have completed several projects by the support of Tianjin geothermal management department, these project has done in Nankai district and Hedong district. At the same time, we explore three kinds of the integration mode in the process of geothermal resource integration.

2.1 Mode of “Hezhong- Yazhong”

This mode is summarized from the integration project of Hezhong well and Yazhong well. It is means that two or more geothermal production well which are not far apart are selected in concentrated mining area. Doublet system of “Reinjection –production” or one reinjection well for many production wells is built by pipe connected under or above ground .The heating area of transformed reinjection well is converted to other production wells. The aim of production and reinjection balance is achieved; however the total production rate is still instant.

The advantage of this mode is that project has obvious economic environmental benefits in low capital investment and without requirement enough space for geothermal well drilling.

The difficulty is that two or more geothermal exploitation company is difficult to coordination, especially when it comes to income distribution after integration.

2.2 Mode of supplement reinjection well

Reinjection –production system is formed by drilling new reinjection well for old production well .The company of the production well need to have enough funds and willing to supplement geothermal injection well. The surrounding of the production well must have site conditions. Government will also give support to drilled the reinjection well in policy and fund.

The advantage is not need to coordinate the relationship because the owner of the injection well is same as production well. The Difficulty is this mode need a lot of money and enough space to drilling injection well.

2.3 Constructed new geothermal system to improve the old one

For single-well which hasn't adjacent geothermal well and not have conditions to drilling new geothermal well. If some company have space heating load and want to drill new geothermal well in this area, management of geothermal always suggest that the new geothermal well must connect with old single well not far away to from a system of one reinjection well for two production well and achieve the goal of geothermal resources protection eventually.

The advantages are that the new heating system is always the cascade utilization; single well can also realize cascade utilization of tail water together. This mold has very good maneuverability.

The difficult is that geothermal mining right have to set according the heating load around the single well. Applying connection pipe routing is the biggest problem.

Former geothermal integration mode in Tianjin has practical engineering project the third application engineering is still in construction, the all purpose is to make the development and utilization of geothermal resources with balance of reinjection and production.

3 EXAMPLES OF GEOTHERMAL RESOURCES INTEGRATION

3.1 Mode of" Yazhong -Hezhong"

3.1.1 Introduction of the original heating system

24 # and 33# drilled earlier are dolomite carbonate reservoir in Proterozoic satrata. All the water temperature is about 80 ℃. 24 # and 33# Wells is apart about 490 m, respectively for residential space heating which heating area is relatively small. Data of geothermal and space heating system is shown inTable1.Flow chart of space heating system is shown in Figure 1. The geothermal well is used for production; the spent water is discharged in to municipal pipe network. Decreasing range of geothermal water level is already 4～8 meters.

Table1 ： Data of geothermal and space heating system(Shen&Zhao,2012)

Borehole NO.	Drilled time	Location	Drilled depth (m)	Temp (℃)	Production rate（m^3/h）	Space heating area
24#	1994	Yazhong graden	2656	84	146.7	80,000m^2（radiators for70,000m^2 and fan-coil unit for 10,000 m^2）
33#	1997	Building of Hezhong	2762	81	100	50,000m^2（radiators for 35,000$m^2$and fan-coil unit for 15,000 m^2）

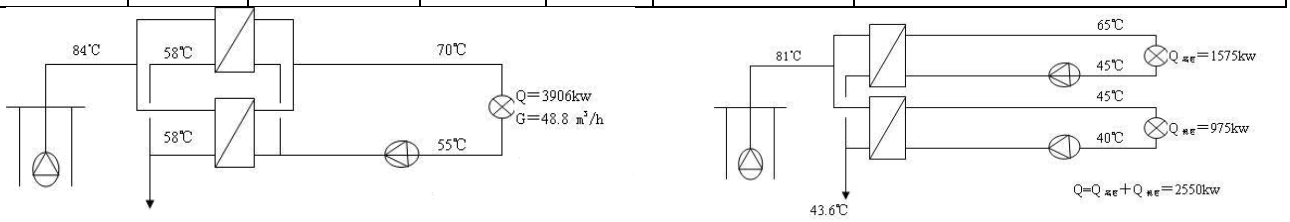

Figure1 ： Flow chart of HX-24(left) and HX-33（right）space heating system

3.1.2 Integration of project

24# geothermal welll which belong Yazhong energy technology development co., LTD ,Tianjin and 33# geothermal Well which belong to Hezhong property management co., LTD , Tianjin, that two geothermal wells are integrated though connecting with pipe under ground to form doublet system of "Reinjection –production". 33# geothermal well is change to reinjection well. Its space heating load is converted to 24#. All the spent water of 24# can inject into 33# though the integration. Flow chart of space heating system after integration is shown in Figure 2.

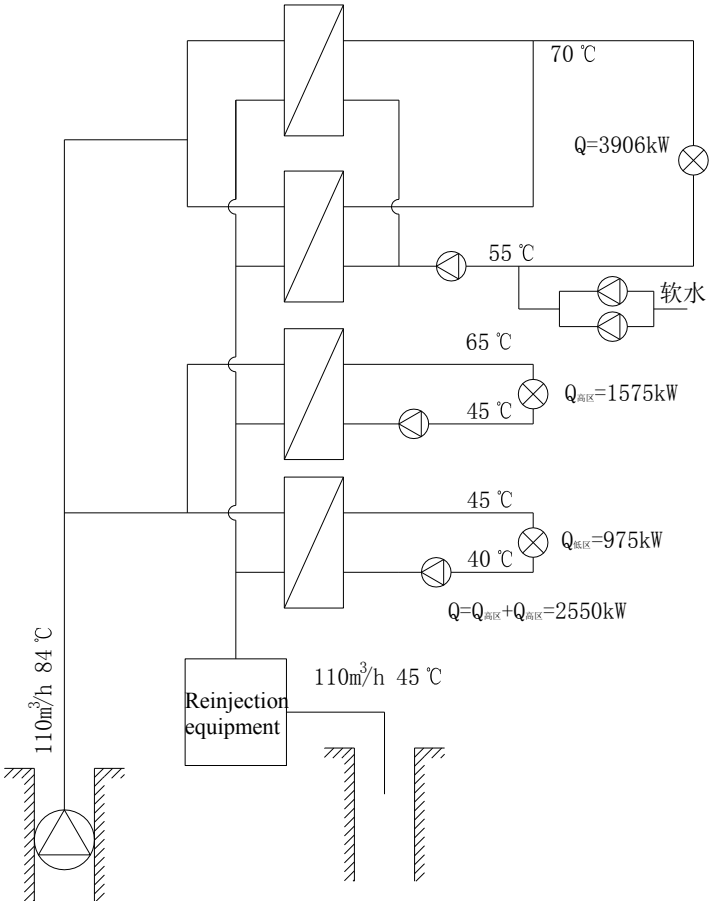

Figure 2 ： Flow char of space heating system after geothermal resources integration

3.1.3 Overall analysis of economic benefits

After completing the integration project, 2.18million RMB is cost in the project (Table 2). However every year 190000 cubic meters spent water is injected to the geothermal reservoir saving cost nearly 500,000 RMB every year. There is no spent water discharged in to municipal pipe network again. This project is the first integration project in the centre urban city in china and it is good example to promote the geothermal resources integration of the city and even for the whole China provides a good demonstration effect.

Table 2： Itemized fee of integration project

Item	Cost of pipeline	Equipment of reinjection	System improvement	Others	Total
Fee(thousand RMB)	1629	98.7	330.6	125	2183.3

3.2 Mode of supplement recharge well

3.1.1 Introduction of the original heating system and geothermal well

9# and 13 # is also old geothermal well which drilled into dolomite carbonate reservoir in Proterozoic satrata.The water temperature is about 90℃， 9# is used for space heating however 13# is not use on account of small production rate and is maintained by the owner for new space heating load . The max production is about 70 m^3/h. The geothermal wells are only used for production; spent water which temperature is 38 ℃ is discharged in to municipal pipe network or to river. Decreasing range of geothermal water level is already 3～4 meters. Data of geothermal and space heating system is shown in table 3.

Table3： Data of geothermal and space heating system (Zhao & Shen)

Borehole NO.	Drilled depth (m)	Temp (℃)	Production rate（m^3/h）	Space heating area
9#	2400	97	100	Radiators for 120,000m^2
13#	3470	94	70	Maintained well waiting for new space heating load

3.1.2 Integration of project

9# and 13# is production for space heating, the load of space heating is enough for the ability of geothermal well separately. So the only method to solve reinjection problem is to drilling reinjection well. 9B# is the reinjection well which drilled in 2102 and its reservoir is same as 9# and 13#.The structure of this well is shown in figure 3.Base on operation rules of geothermal reinjection in Tianjin; the reinjection well must install filtrating equipment and exhaust before the spent water entering reinjection well to remove large materials some gas. The aim is to improve reinjection effect and provide support for reinjection well using. The filter accuracy is 50μm.

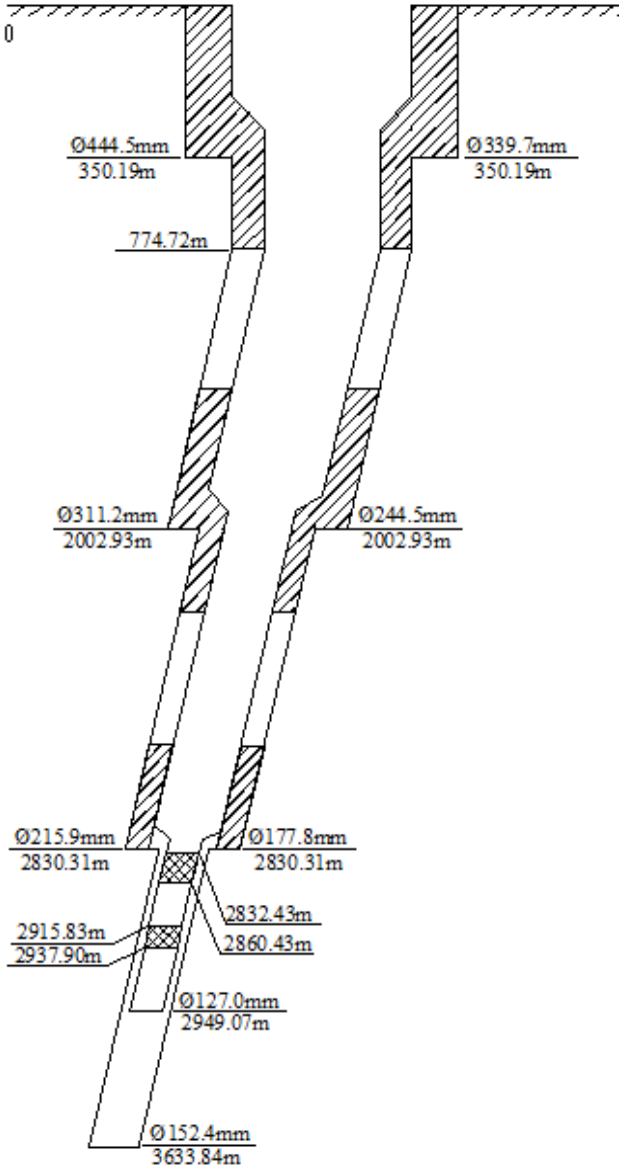

Figure 3: Sketch map of geothermal reinjection well

The pipe connecting the tree geothermal well is another important factor, pipe laying which need damage and recovery the road, lawn and meet some problem of avoiding Underground pipelines and cables. So the pipe laying adopted the manner of pipe jacking. The total length of pip laying is 2060m, 640m pipe jacking among them.

3.2.3 Geothermal spent water reuse

The spent water of XQ-09 and XQ-13 which is 38 ℃ and 150 m^3 / h in total is reused though exchanger and heat pump system to extract heat from spent water and providing heat to floor heating. The temperature of reinjection water is 10℃ .space area was increased to 142 thousands square meters.

3.2.4 Overall analysis of economic benefits

The temperature of spent water is reduced from 38℃ to 10℃ for increasing space heating area .10.8million RMB is cost in the project(Table 4). This project can make 568 thousands RMB economic income every year. Meanwhile, Mineral resources compensation fees and sewage charge are saved up to 654 thousands RMB ever year. After completion of this project, the income is 1.2 million RMB.The most important is that spent water is injected into geothermal reservoir to delay the downtrend of geothermal water level for increase geothermal reserves.

Table 4： Itemized fee of integration project

Items	Cost of drilling well	Cost of pipeline	Equipment of reinjection	Space heating system improvement	Others	Total
Fee（Thousand RMB）	6670	2680	150	1120	200	10820

4 CONCLUSION

After the implementation of the integration of geothermal resources, geothermal spent water basically achieves zero emissions, reducing the geothermal heat pollution to the environment, protecting geothermal resources greatly. Enterprises of geothermal development not only achieve sustainable use of resources, but also get good economic returns.

For the old single well in Tianjin, geothermal resources department organize the preparation of integrated scheme combined layout of development and utilization of geothermal resources. In order to increase geothermal reinjection efforts and encourage the development of construction of recharge wells to carry out the integration , Tianjin formulate a corresponding incentives for geothermal well integrated to give some funds to support and promote the integration of geothermal resources.Integration project adopted a " policy guidance, business operations , mutually beneficial win-win , intensive use " geothermal resource integration model for the smooth implementation of the project has a significant role in promoting .

Accordance with the “Geothermal Resource Development and Utilization Planning of Tianjin (2011-2015)”(LIN and LI,2011), geothermal resources conservation is a top priority in geothermal management. That 18 geothermal production wells will gradually completed integration of geothermal resources to changing by a “single well production” to “one production well and one reinjection well”. There are also some policies to encouraging more social funds to participate in the integration of geothermal resources to enhance the level of sustainable utilization of geothermal resources in the city.

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