

Discussion on Reinjection Geothermal Fluids into Sandstones in Tianjin P.R.C

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ABSTRACT

As renewable resource, geothermal energy is very significant to the development of the economy of the country. Re-injection of the geothermal fluids after utilization is the main means to keep the resource usable. In Tianjin area, the re-injection test and research in Sandstone re-injection has continued more than 20 years, but the re-injection can't reach the industrial level. In this report, we discussed reinjection issues from different perspectives including: reservoir configuration, aquifer characteristic, re-injection fluids temperature, drilling technique, and methods.

1. INTRODUCTION

As a clean energy source, geothermal energy has important effects in improving the social energy framework and protecting the environment. Tianjin has abundant low-medium temperature geothermal resources, which covers about 8700 km². Resources exist in two parts: tertiary and base-rock reservoirs. While tertiary closed clastic rock subsystem belongs to low enthalpy system, the geothermal fluids has good quality, low rigidity, temperature is 40 ~ 80°C, and it has been utilized diffusely for space heating, bathing, swimming pool, green house, industry, physiotherapy spa etc. in Tianjin. Furthermore, its exploitation is leading a important position throughout the whole country. From the monitor data of 2008, there are 187 tertiary geothermal well, thereinto 79 wells were in Minghuazhen formation, the annual exploitation quantity is about 390×10⁴ m³, wells in Guantao formation is 108, and the annual exploitation quantity is about 811×10⁴ m³.

With the rapid economic development in Tianjin, the scope of geothermal utilization increased very quickly, due to there is little re-injection during the exploration, the water level draw down deeper and deeper. And the rate decreasing from 1.8 to 5.5m/a, up to now, the water level is deeper than 55m.

2. TERTIARY GEOTHERMAL RE-INJECTION ACTUALITY IN TIANJIN

Geothermal re-injection is injecting the returned geothermal fluids after utilization to the reservoir by natural gravity or pressured mode. By this way, ensuring geothermal resource sustainable utilization, it's the best method for solving continuous draw down of water level and the environment pollution by the vehicle of returned geothermal water.

In Tianjin area, the geothermal re-injection research is began 1980s, has a history more than 20 years. In these

years, Tianjin government pay extraordinary attention ON the sustainable development of resource, up to the end of 2008, there were 318 geothermal wells, including 52 re-injection wells, of which 43 are basement re-injection wells and 9 are sandstone re-injection wells (Table 1). Re-injection quantity is about 562×10⁴ m³, occupied 12.36% of production, while re-injection quantity in tertiary is about 12.8×10⁴ m³, occupied 0.45% of the production. There is a large disparity between production and re-injection volumes. The reason for the clogging have not resolved at the time, especially in porous sandstone geothermal re-injection.

Table 1 Re-injection well Number in Tianjin

	Sandstone re-injection well	Bastment re-injection well	total
2002	2	12	14
2003	3	12	15
2004	3	16	19
2005	6	21	27
2006	8	30	38
2007	8	35	43
2008	9	43	52

3. TERTIARY GEOTHERMAL RE-INJECTION EXPERIMENTATION IN TIANJIN

In Tianjin area, the re-injection into sandstone reservoirs has been the subject of extensive investigations during the previous two decades, and 4 large-scale re-injection test were carried out. [2] (Table 2)

Table 2 Basic Information of the Previous Test

Test phase	Time (year)	Test site
I	1987-1989	Dagang district water and electricity factory
II	1995-1996	Tanggu district Xinkai Area
III	2003-2004	Dongli district & Wuqing district
IV	2006-2008	Dagang district

In the previous re-injection test, aquifer parameter and well casing of the re-injection well is different, detail data list in Table 3:

Table 3 Basic parameters for Re-injection Test

Re-injection well	Da gang district	Tanggu district	Dongli district	Wuqing district
Stratigraphy	Ng	Ng	Ng	Ng
Lithology granule	Silty sandstone, sandstone	Sandstone, with gravel	Sandstone, with gravel	sandstone, Silty sandstone
Cementation grade	Bad-good	bad	bad	good
Granule dia.(mm)	2-4	5-10	5-10	0.5-1
porosity (%)	29.9	20	27-32	20.1-31.6
Permeability (md)	500-600	740-1270	690-1085	171.8-874.5
Depth(m)	1900	2025.26	1360.19	2346.8
water sieve type	Monolayer sieve	Monolayer sieve	doublet sieve	doublet sieve
space between sieve(mm)	0.4 ~ 0.6	0.5-0.7	1.5(inner); 1.2(outer)	0.7(inner); 0.5(outer)
water sieve dia.(mm)	Φ 219	Φ 219	Φ 177.8	Φ 177.8
water sieve total length(m)	58.58	60.99	57.52	93.87
Fluids temperature(°C)	69.5	69.5	81.5 (70)	73°C
Flowrate (m ³ /h)	55	90 ~ 120	100	94

(1) Dagang district re-injection test

In Dagang district, 4 re-injection tests were tried in tertiary Guantao formation in R2 & R12 , over a total testing time

of 4728 h (197 days) , and a cumulative quantity of 77943 m³ (Table 4).

Table 4 Basic data of the re-injection test in Dagang

Well No.	Accumulative time(d)	Accumulative Quantity(m ³)	Re-injection Temperature(°C)	Re-injection mode
R2	54	23000	55	Single well
R12	16	8889	38	Doublet well
R12	68	23819	36.8	Single well
	31	9867	36.8	Single well
R12	6	2465	36.8	Doublet well
	15	12503	36.8	Doublet well
	7	7400	32.5	Doublet well

During re-injection, the injectivity of injection wells decreased rapidly (Fig.1); And Re-injection capacity has positive correlation with reinjection temperature too.

(2) Tanggu district re-injection testing

In the heating period of 1995-1996, re-injection test was finished in the Guantao group in Tanggu district. The test persisted 79 days, and resulted in three useful data sets. Idiographic data is list in table 5.

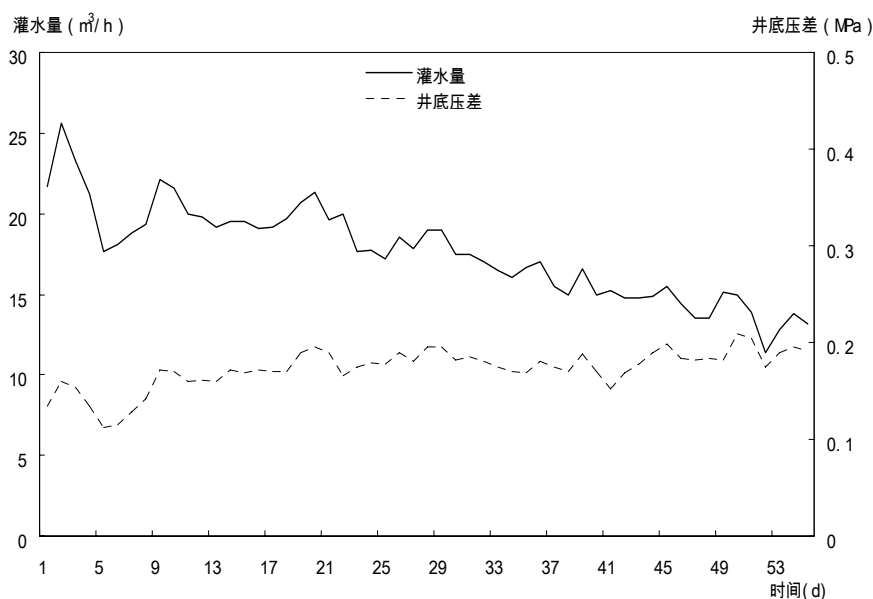


Fig. 1 Relationship curves of re-injection capacity and pressure

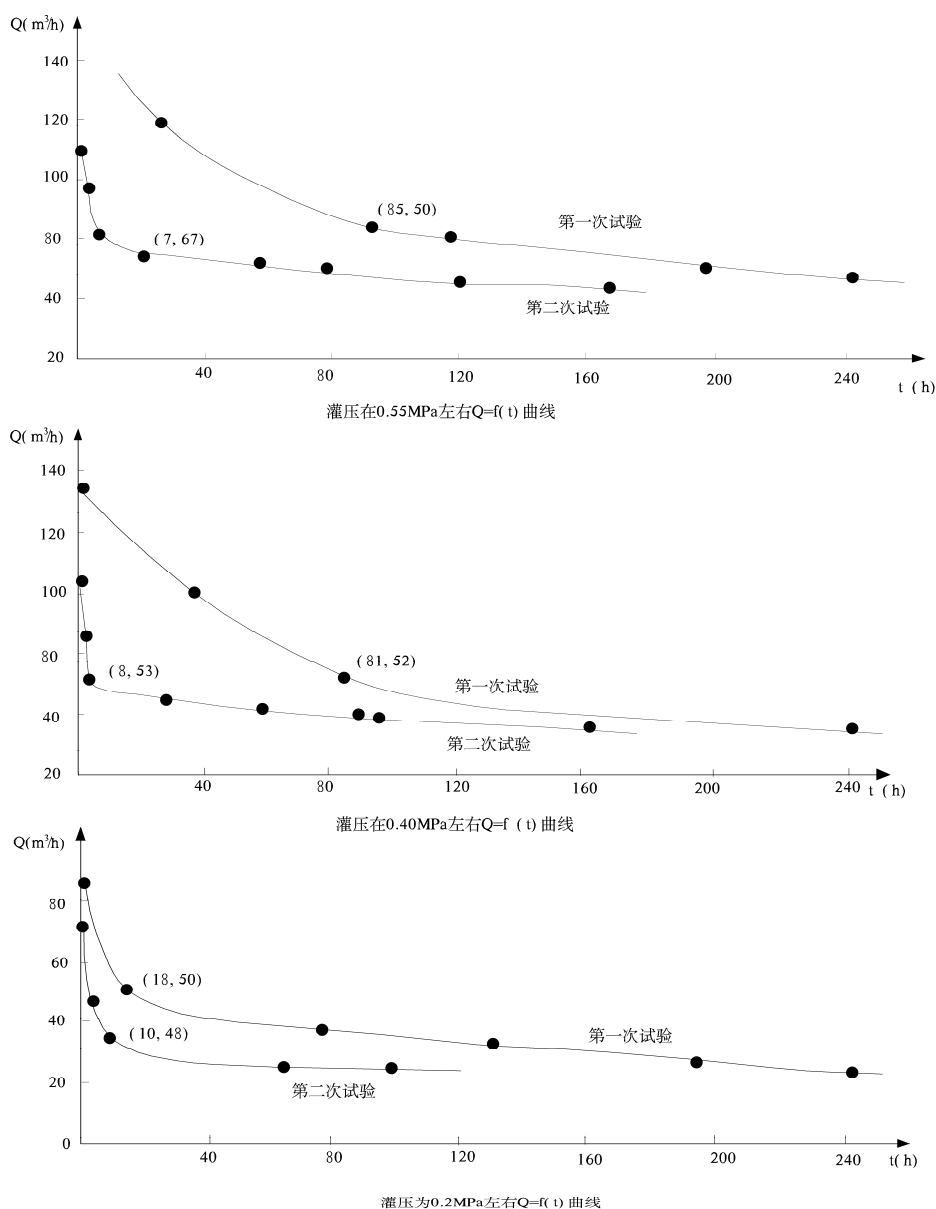


Fig.2 Relationship curves of water level and temperature in Tanggu

Table 5 Basic Information of the Re-injection Test in Tanggu

tem time	accumulative time (h)	accumulative re-injection flowrate (m ³)	Average re-injection flowrate (m ³ /h)	Daily maximal re-injection flowrate (m ³)
First time	262.95	12332	46.9	1464.8
Second time	175.25	7931	45.26	1215.7
Third time	24.7	927.3		

From this test, we can see a positive correlation between injectivity and pressure, and at a given reinjection pressure reinjection capacity decreases with the time. (Fig.2)

(3)Doli & Wuqing district re-injection test

In 2004, two re-injection wells were drilled in Doli district agricultural science and technology section and Wuqing Guohuan Inc, to finish the re-injection test. In order to

prevent physical and chemical clogging, secondary filtrating equipment were settled in the system, the primary filtration is rough, the precision is of 50 μ m, the secondary filtration is extractive, with a precision of 3-5 μ m, the test lasted 138 days, basic information of the test list in table 6.

Table 6 Basic Information of the Re-injection Test in Doli

sequence No.	Test No.	quantity (m ³ /h)	temperature(°C)	Accumulative Quantity(m ³)
1	1 st	49	45	863.4
2	2 nd	48	46	4167.1
3	3 rd	41	47	1795.9
4	4 th	43	48	10163.6
5	5 th	41	48	5087.2
	total			22077.2

4. ANALYSIS ON THE RE-INJECTION IMPACT FACTOR IN SANDSTONE

Analysis the result of different test, the factors impact re-injection capability:

(1) Stratum lithology, hydrogeology condition

The lithology , bulk of rock granule, interstice between the granule, porosity and permeabilities of the stratum impact re-injection. In Tanggu and Dongli district, the lithology is sandstone with gravel, granularity is bigger (5-10mm), osmosis is better (permeability 690-1270 md), the re-injection capability is much better than other areas.

(2) Re-injection fluids temperature

During the previous decades, Reinjection capacity has positive correlation with reinjection temperature.

(3) Re-injection pressure

Commonly, the capability re-injection in porosity stratum is about 20-30m³/h, subjoin pressure can increase the capability in a certain extent.

(4) Casing program of porous re-injection well

5. Re-injection water characteristics

5. CONCLUSIONS

Geothermal re-injection has very important practical significance. From the re-injection test research of Casing program, the main factors affecting geothermal re-injection includes: hydro-geologic characteristics, distance between the production and re-injection well, and re-injection mode. Re-injection in sandstone is a very complicated, systems engineering and advanced studies is an important and necessary part to achieve sustainable exploration & development.

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