Assessment of geothermal resources for the Qichun geothermal field, Shanxi, China

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Abstract

The current situation and features of the Qichun geothermal field, Shanxi province are introduced in the paper. LUMPFIT is used to simulate pumping test data and predict water level changes of the system under different production scenarios as well as temperature changes. Based on the simulation, suggestions are drawn to improve management of the geothermal system.

***Keywords**: Qichun geothermal field, simulation, prediction.*

1 Introduction

The Qichun geothermal field is located in Qichun village of Shanxi Province, in the north of China where 14 sanatoriums have been constructed so far. It is a low-temperature system covering an area of 3 km^2. In all 19 geothermal wells had been drilled producing water with a temperature between 40-92°C by the end of 2002. The production rate of the system is increasing, from 4 l/s in 1972 to 23 l/s in 2002.

This paper presents the features of the system on geology and geothermal water regime. LUMPFIT is used to simulate pumping test data, and change of water level and temperature are predicted under different production scenarios.

2 Features of the Qichun geothermal field

2.1 Geological settings

There are 6 thin geothermal reservoirs located in the Quaternary formation in the system, bottomed by dolomite and phyllite. Due to the presence of a deep fault, hot water moves upward, mixing with cold water in the geothermal reservoirs (Liang, 1989).

2.2 Features of geothermal water regime

The Qichun geothermal field has been developed for more than 30 years. The total production rate is increasing, particularly since 1991, which caused continual water level drop. Water level of the system dropped for 1.8 m during 1992-2002. Water level is lowest in July, and then recovers from October to March next year.

Temperature drops quickly due to cold-water intrusion. Longterm over-extraction causes regional water level drawdown, which results in cold-water intrusion in some places. Taking one well as an example, the temperature was 63° C in 1990 but dropped to 45° C in 2002. Similar cooling occurs in several wells due to over-production.

The chemical components in the geothermal water are also changing. The contents, such as of Cl, Na, and SO_4, are decreasing according to the results of analysis of samples taken from the same well at different time.

3 Geothermal resources assessment

3.1 Simulation by LUMPFIT

A LUMPFIT simulation tackles the simulation problem as an inverse problem. It automatically matches analytical response functions of the lumped model to the observed data by using non-linear iterative least-squares technique for estimation the parameters (Bodvarsson and Axelsson, 1986). Observed water level from a pumping test, which lasts about 40 hours, is applied to the simulation. Figure 1 shows the result of the simulation. Quite good agreement is obtained, and parameters produced from the simulation are similar to those obtained form the pumping test.

The purpose of carrying out the simulation is to predict water level change under different production rates. Two production rates are adopted to predict future water level variations, one with production rate remaining the same (9 l/s) as in the pumping test, while the other assumes doubling of the production. Water level drop will be 0.5 m for 10 years running under the first scenario, while 1.2 m under the second as shown in Figure 2. The upper line represents the water level simulated under the first production rate, and the lower one under the second production rate. The simulated water lever indicates that the Qichun geothermal system is an open system, which receives recharge quickly.

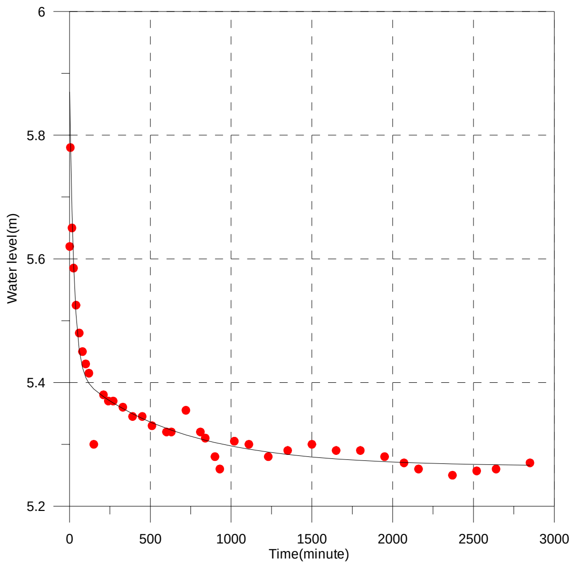

Figure 1: observed and simulated water level by LUMPFIT.

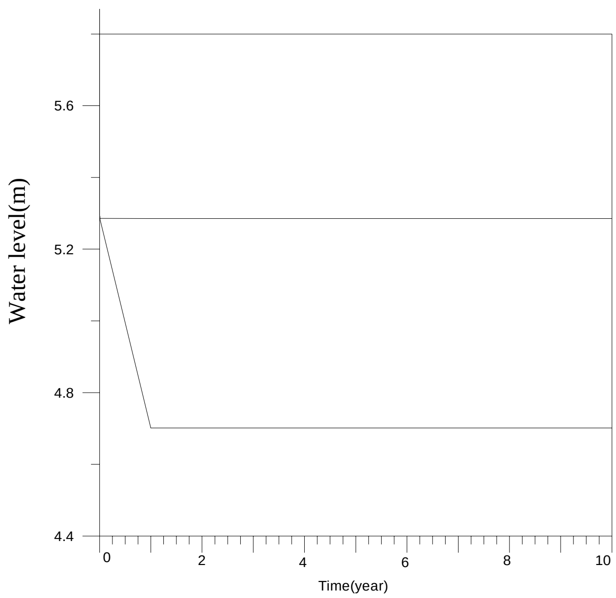

Figure 2: Predicted water level by LUMPFIT.

3.2 Prediction of temperature change

Based on the above simulation, water level is not a troublemaker for the Qichun geothermal field, but the temperature of the system might be a problem. As mentioned before, temperature drops quickly, and even worse some wells have been abandoned due to cold-water intrusion (Huang, 1992). The following formula is used to predict temperature of the system roughly:

$$E_p = \frac{P_{cw}}{P_t} E_{cw} + \frac{P_{hw}}{P_t} E_{hw} \quad (1)$$

where E_p, E_{cw} and E_{hw} are enthalpies of water from production wells, cold water and hot water respectively. E_p is the enthalpy of 87°C water, which is a typical temperature of production wells in 2000, and E_{cw} is that of 17°C, which is the temperature of the cold water outside the geothermal system, and E_{hw} is the enthalpy of water at 108°C, which is the estimated unperturbed reservoir temperature based on geothermometry. If P_t is the production rate in 2000, 13 l/s, and then P_{hw} can be calculated form equation (1), and temperature prediction is performed under different production rates, assuming that the hot water (108°C) gives constant contribution, independent of the pump rate. Figure 3 shows the results, which indicates that temperature drops roughly by °C if the production rate increases 1 l/s.

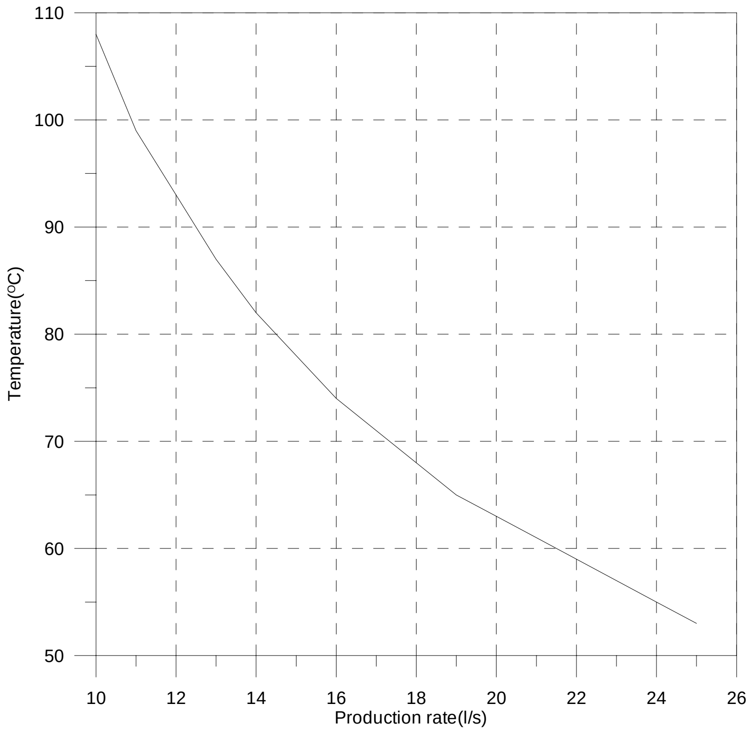

Figure 3. Predicted temperature under different production rate.

4 Conclusions and suggestions

- The Qichun geothermal field is a low-temperature field. Based on prediction by LUMPFIT, water level drop will be 0.5m after 10-years if production rate is kept the same as at the present (13 l/s), but it will drop by 1.2 m if the production rate is doubled. Temperature drop will be roughly 2°C if the production rate is increased by 1 l/s.
- Improvement on geothermal field management is needed. Systematic monitoring is crucial for updating the exiting model, and parameters needing to be monitored include water level, production rate and temperature.
- Numerical modelling is strongly recommended to update the current rough estimation on temperature, which is a key issue of how to run the system.

Acknowledgements

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5 References

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