CHEMICAL DOSING SYSTEM AT NAGQU GEOTHERMAL POWER PLANT (TIBET)

ZHIJIANG LIU, BENDA SUN & XIANGMIN LIU

Thermal Power Research Institute (TPRI), Xi'an, P.R.China

SUMMARY – The current operation status of the 1MW unit (ORMAT) at the NAGQU (Tibet) geothermal power plant, constructed with the aid from UNDP, is described. The chemical dosing system and the anti-scaling test of DR-1 type inhibitor are summarised.

1.INTRODUCTION

1.1 NAGQU geothermal plant

The 1MW binary cycle ORMAT unit was built in 1992 with the aid of UNDP. Two down-hole pumps (one for each production well) were used only for a short period, respectively, from Oct. 1993 until Jan. 1994 and from Mar. 1994 to Dec. 1994. The plant was forced out of operation as a result of the pump problems. With further UNDP financial support, it was rehabilitated for operation in Aug. 1998 with a chemical dosing system developed by TPRI, which was used to replace the original down-hole pumps.

Technical specifications for the unit follow:
Turbine 630cw, rated output 1010kW, speed 3600rpm, inlet temperature/pressure 86□/0.51 MPa, exhaust pressure 90kPa, rated flow rate 83.9t/h
Gear box N280CS, speed rate (3600 rpm, 1500rpm)
Generator AC brushless, rated output 1010kw
Feedpump flow rate 136t/h, power consumption 40kW
Condenser Induced air cooled, air flow rate 1923 t/h, fan power consumption 125kW
Down- hole pump power consumption 350kW

During the short period of operation, the gross maximum output of the unit was around 800kW, but the total power consumption of the plant was nearly 520kW. The power consumption of the down-hole pumps alone was 330 kW. The net output of the unit was actually less than 300kW. Furthermore, the maintenance of the down-hole pumps was very expensive and time consuming. Safe, economical and continued operation of the plant is the main priority.

1.2 NAGQU geothermal field

The area of the geothermal field at NAGQU is about 1 km^2 and the field lies on the outskirts of NAGQU town, which is about 330 km from Lhasa by the Qinghai-Tibet highway (Fig. 1). There are three production wells in the area, two of them, zk1202 (well #1) and zk1102 (well #2), are used for power generation and one well (zk1203) is used for district heating in the town. The relevant data for the two production wells used for power generation are shown in Table 1. Owing to the very high concentration of dissolved carbon dioxide CO_2 (Table 2), the production fluid has a very low enthalpy and causes severe scaling by $CaCO_3$.

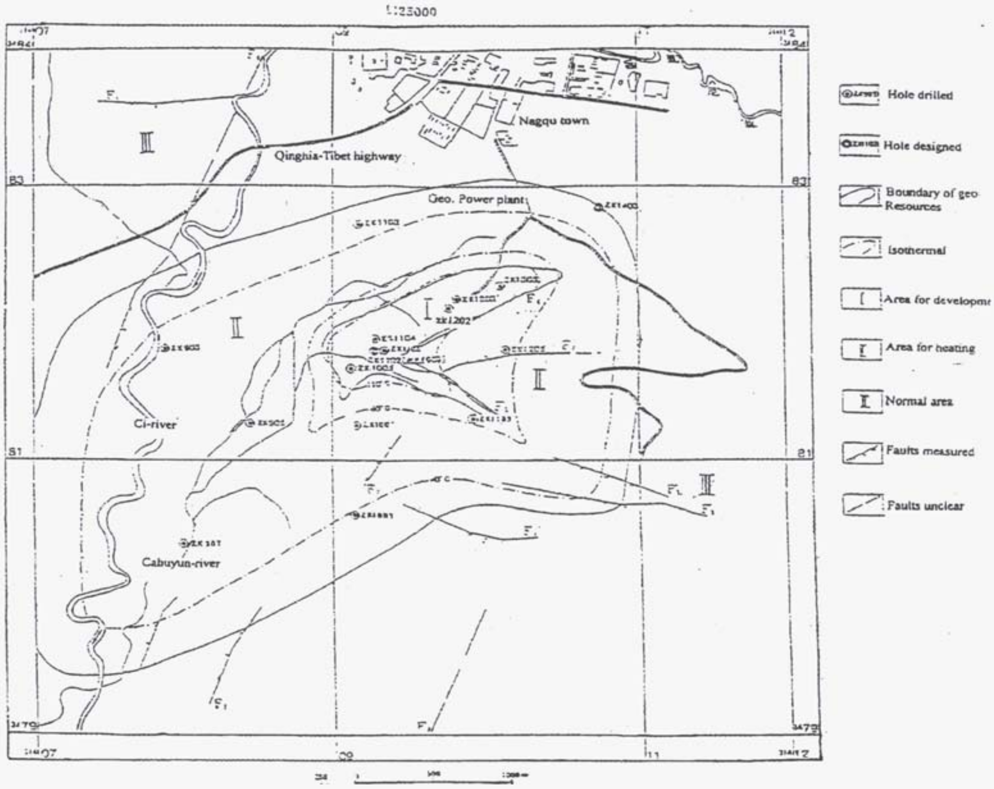

Figure 1-Nagqu Geothermal *area*

Table 1- Technical **data** of wells (GHGLT)

	Unit	Well#1(zk1202)	Well#2(zk1102)
Elevation	m	4501	4500
Casing diameter	m	340	340
Casing depth	m	162	206
Total depth	m	502	388
Feed water temp.	°C	115	117
Closed well head pressure	M Pa	0.35	0.37
Total flow rate	t/h	180	260
Ca^{++}	Mol/l	10.8 (5.3)	5.8
Mg^{++}	Mol/l	4.8 (3.8)	4.1

Table 2- Chemical **composition** of NAGQU field (Battiseli, et **al**, 1993)

pH	5.8	CO_2^{-2}	5240 mg/kg
Na	1004 mg/kg	HCO_3^{-1}	2000
K	66	SO_4^{-2}	200
Ca	22.5	Cl^{-1}	248
Mg	6.0	F^{-1}	8
Al	0.035	B^{-1}	9
Fe	0.05	NH_3^{+1}	6
Li	2.7	SiO_2^{-2}	75

2. REHABILITATION OF POWER PLANT

Apart from the above mentioned problems with the down-hole pumps, there were also other important problems that should be mentioned, including damaged pump cables and blocked exhaust pipes by $CaCO_3$. In order to solve these problems, a trial chemical dosing system was emplaced in 1996. The results showed that one complex phosphate inhibitor in the liquid state has a very good behavior. It is in accord with the Chinese industrial hygiene standard and does not pollute the environment, It is stable at the temperature 200°C.

2.1 Trial test of the dosing system

The trial test of the chemical dosing system was conducted on a heat-supply well, which is 50 m away from the production well used for power generation. The water quality and condition of this well are nearly the same as the production well. The growth rate of calcite deposition was about 3mm/day. In the chemical dosing system, there is one chemical injection point near the well head and two sampling points on the pipe line, which are 35m and 2km (at the green house) from the well head, respectively. Five types of inhibitor were chosen for trial test. The results are given in Figure 2. With type 1 (DR-1), the results indicate that no scaling in the well and pipe line ceased when the density of inhibitor reached 5mg/liter in the production fluid It also helped to remove the existing deposits in the gathering system.

2.2 Economical comparison

The NAGQU Electrical Bureau made a simple economic analysis. It showed that if the power plant operates with the down-hole pumps, 340×10^4 Yuan (RMB) would be lost in a year. However, if the chemical dosing system is used instead, the power plant would benefit 24×10^4 Yuan per year. Thus there is no incentive to continue operating the down-hole pumps.

2.3 The chemical dosing system

The thermal cycle of the power plant with the chemical dosing is given in Figure 3. In order to remove calcite scale that formed, a wellhead separator and winch-weight (for scale removal) were provided. The chemical dosing system as applied to the power plant is shown in Figure 4. The dosing system had to be durable and reliable for operation, and easily installed and disassembled. The tubing assembly to be inserted in the well, especially the gland that the tubing passes through, has to be totally leak free under normal operation. This assembly should work properly and be allowed to push in and out of the well without any leakage under pressure. The tubing assembly has a diameter of 12×2mm and a total length of 102m with a socket connection. The dosing pumps, tanks, and valves are all made of stainless steel.

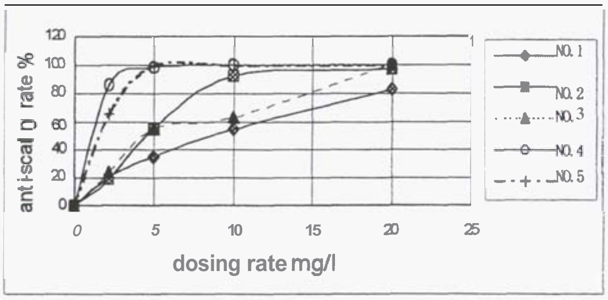

Figure 2- Anti-scaling rate vs. dosing rate.

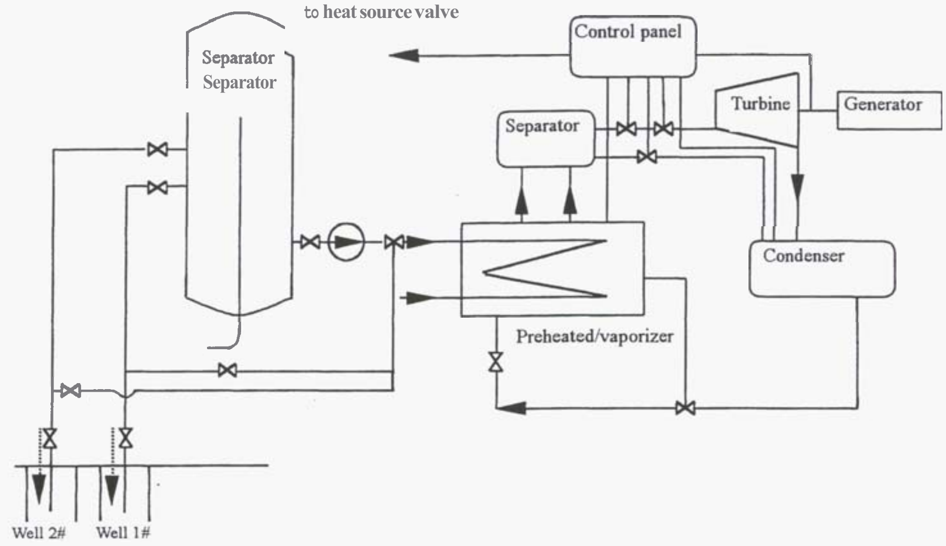

Figure 3- Cycle **of** the Nagqu power plant

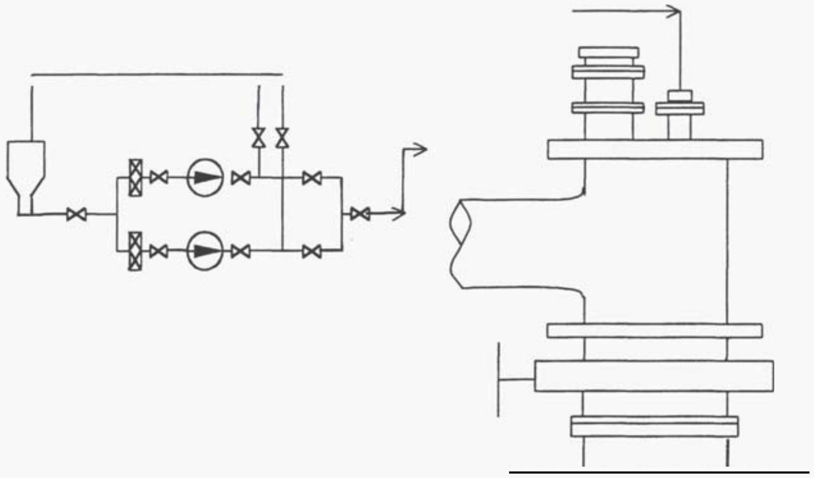

Figure 4- Chemical dosing system

2.4 Anti-scaling test

The purpose of this test is to measure the relationship between the hardness of water and the dose rate of the inhibitor. The dose rate of the inhibitor is controlled by the stroke of the dosing pump. However, the anti-scaling rate reaches a threshold at a dose rate of about 5mg/liter (Figs. 5 and 6). The test results indicate that 5mg of inhibitor per liter of production fluid is sufficient to prevent scaling when the production fluid is directly fed to the heat exchanger, but that 7 mg/l of inhibitor is required when the fluid is fed through the well head separator. This is due to the escape of CO_2 **from** the water during water-steam separation.

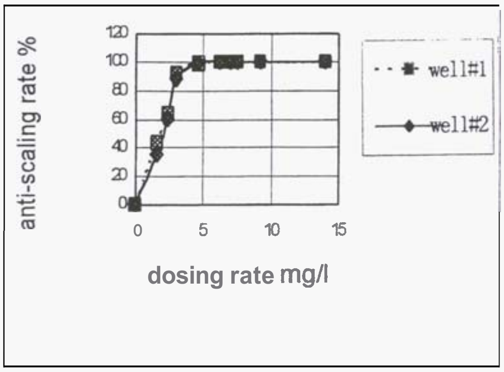

Figure 5- Anti-scaling rate vs. dosing rate

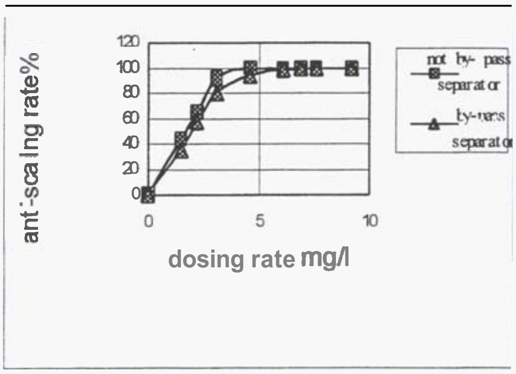

Figure 6- Anti-scaling rate vs. dosing rate with and without by passing the separator.

3. OPERATION AND BENEFITS OF THE REHABILITATION PLANT

The geothennal power plant ran for nearly two months and then was forced to stop again due to a failure in the control system after its rehabilitation. During the period of operation, the average output of the unit in a day was nearly 600kw with one well. Under the ambient temperature of -2° and with two paralleled wells in the gathering system, the maximum output of the unit is 1010kw though this has never been reached.

Based on the test and the operation data, it is estimated that the plant would have a benefit of more than 170×10^4 Yuan. The cost of inhibitor will cost less than 10% of the electric price; that is 0.5 Yuan RMB per kilowatt-hour.

4. CONCLUSIONS

4.1 The geothermal power plant at NAGQU was rehabilitated with a chemical dosing system developed by TPRI and its operation and economical benefits were greatly improved.

4.2 The DR-1 complex phosphor inhibitor not only functions to prevent $CaCO_3$ scaling, but also removes some of the existing $CaCO_3$ and $MgCO_3$ deposits from the pipe line. The dose rates of inhibitor for complete prevention of scaling in the down-hole and pipe line are 5mg/l and 7mg/l respectively.

4.3 All parts of the chemical dosing system and equipment are made of 1Cr18 Ni9Ti steel. There is no leakage when the system is under normal operation.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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