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YANGBAJING (CHINA) GEOTHERMAL POWER PLANT

Lui Zhijiang, Jiang Xiangjun, Han Shengliang

Thermal Power Research Institute, Ministry of Energy

Abstract

Recent operations at the Yangbajing and Langjin Geothermal Power Plants, which use low enthalpy geothermal fluid to generate electricity, are discussed.

Introduction

Exploration and exploitation of the Yangbajing Geothermal Field was financed from 1976 by the Chinese government. By March 1989, the installed capacity of Yangbajing Geothermal Power Plant was 19180 kW, which is about one third (or 1/2?) of that supplied to the Lhasa Grid. By the end of 1988, the power generated was 2.7×10^8 kWh. The Power Plant supplies heat from waste water to green houses, which are more than 4×10^4 square metres in area using and producing 5×10^5 kg of vegetables per year.

Since there is no oil, coal or electricity in Tibet, the local people welcome geothermal utilization. The local government coordinates activities at Yangbajing; the project is the first of 8 planned over the next five-years. The investment and manpower from the central government have ensured the success of the project. We are also grateful for the help from United Nations and the Italian consultants.

Location

The Yangbajing geothermal field is located 89 km northwest of Lhasa, the capital of Tibet, at North latitude 30 degrees 3 minutes, East longitude 90 degrees 26 minutes and at an elevation of 4280 to 4450 metres or an atmospheric pressure of 59.8 kPa.

Brief Description

The power plant is divided into two parts; the southern plant is close to the Zangbu River and has an installed capacity of 1x1000 + 3x3000 kW (Chinese made). The northern plant is located beside the China-Nepal highway and has an installed capacity of 1x3180 (Fuji made) + 2x3000 kW (Chinese made) · another 2x3000 kW will be put into operation before the end of 1991. The units and their matching wells are listed in Table 1.

Production wells

At the moment, the Yangbajing geothermal field is producing from 23 production wells; their distribution is shown in Fig.1. Eight wells in the southern part can sustain a discharge but the production wells in the northern part enclosed by the 150°C isotherm need stimulation. The well bottom water enthalpy is about 590 to 728 kJ/kg. The well head temperature is about 130° to 140°C and dryness is about 6%. Details are shown in Table 2.

The system

The typical system for 3000 kW unit is shown in Fig.2. The main design specifications are shown in Table 3. Cooling water for the Southern plant is taken directly from the river. The northern plant uses cooling towers to recirculate the cooling water. Fig.3 shows the system for the unit No.5 Fuji-made turbine. Initially, steam for unit No.5 was supplied from down hole pump by Zk304 but the pump has not been working for a long time. The wells in the northern part are stimulated by compressed air.

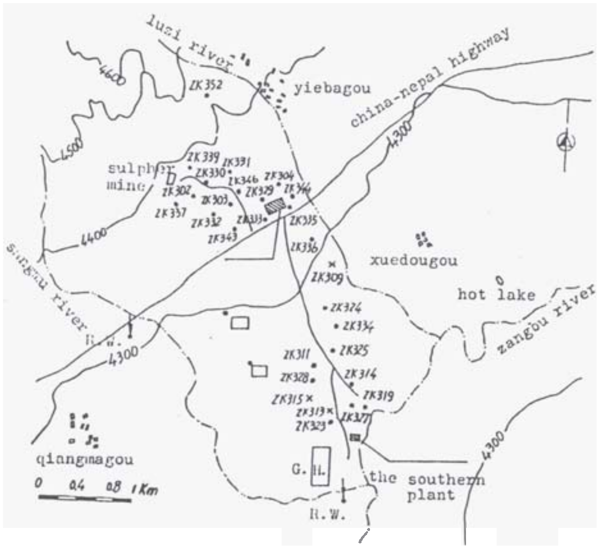

Fig.1. Distribution of production wells. (From the map of the distribution of wells supplied by the Tibet Geothermal Development Company (TGDC)).

Table 1. Units and their matching wells (data supplied by Tibet Geothermal Development Company, TGDC).

	No.of units	capacity kW	operation began	wells
southern	1	1000	Oct.1977	Zk311, Zk328, Zk319
	2	3000	Nov. 1982	Zk324, Zk334 (standby)
	3	3000	Nov.1981	22325, Zk314, Zk327
plant	4	3000	Aug.1985	
northern	5	3180	Mar.1986	Zk304, Zk335, Zk336
	6	3000	Dec.1988	Zk329, Zk333, Zk303
	7	3000	Mar.1989	Zk302, Zk332, Zk331
	8	3000	Dec.1990	Zk346, Zk330, Zk339
plant	9	3000	Dec.1991	Zk344, Zk337, Zk343

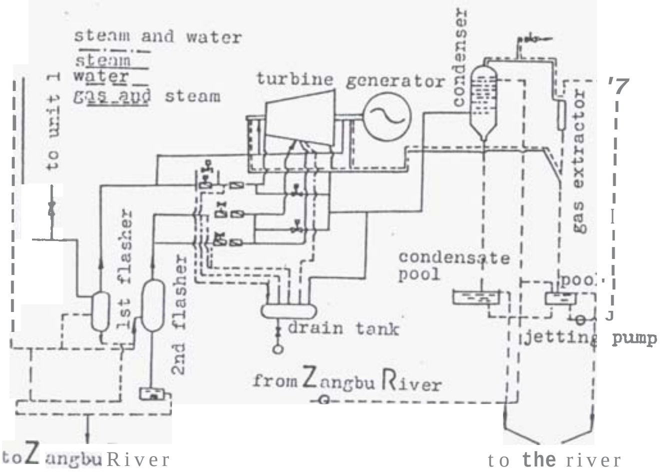

Fig. 2. The 3000 kW system (supplied by TGDC).

Table 2. The production wells (data supplied by TCDC).

well No.	depth (m)	WBT (°C)	WHT (°C)	WHP (kPa)	flowrate (t/h)	drilled
Zk311	82	157	147	446.8	164	July. 1980
Zk328	108		138	340.3	134.6	July. 1984
zk319	157	161	133	323.6	108	June. 1980
Zk324	90	160	147	431.9	163	Oct. 1982
Zk325	94.5		143	403	159	Aug.1984
Zk314	355	160	132	348	110	Nov. 1978
Zk327	118		116	255	91	June. 1984
Zk304	207	170	133	368.7	98	Sept.1978
Zk329			141	333.4	115.5	1988
Zk333	204	160	133	333.4	106	June 1985
Zk303	336	165	133	343.2	103	July 1979
Zk302	457	172	131	313.8	101	June 1979
Zk332	213	152	130	255	80	May 1985
Zk331	173	158	130	304	85	Sept. 1984
Zk346	258	169	134	304	94	1988
Zk330	213	150	132	264.8	95	Sept. 1984
Zk339	260	162	141.5	299.1	120.1	1988
Zk344	291	167	138	323.6	108.6	1988
a337	300	159	142	313.8	117.2	1988
Zk343	358.5	162	131	205	96	1988

Where WBT = well bottom temperature. WHT = well head temperature. WHP = well head pressure. Flow rate was measured by James method.

Table 3. Specifications of the 3000 kW unit (Wu and Lui, 1983).

Turbine	Type	Single-cylinder, two stage entry, impulse condensing turbine (D 3 - 1.7/0.5)
	Rated capacity	3,000 kW
	speed	3,000 r/min
	Inlet condition: first/second stage pressure and temperature	166.7/49 kPa 115/81°C
	Exhaust pressure	8.8 kPa
	steam flow	22.7/22.8 x 10^3 kg/h
	Number of stages	4 stages
Condenser	Type	Tray type mixing condenser
	Pressure	7.85 kPa
	Cooling water temperature (design value)	16°C
	Cooling water flow (design value)	1,575 x 10^3 kg/h
	Locating elevation	6.5 m
Gas extractor	Type	Waterjet air ejector(CS-185)
	Number	3
	Extraction pressure	7.65 kPa
	Discharge pressure	63.7 kPa
	Extraction flow	185 kg/h

The fluid gathering system

Steam and water are taken from the site separators and diverted to the steam and water mains respectively. Fig.4(a) shows the initial fluid gathering system for the southern plant. This system could not get enough steam to supply the units and the observed well head pressures at Zk313, Zk314, Zk319 and Zk327 went down sharply. It also caused reinjection in some wells but other wells are producing steam. In Nov.1986, pipe resistivity was used to match the measured well productivities. The production wells are divided into two groups according to well head parameters (see Fig.4(b)). The new system does not have any problems with reinjection. The output has risen from 6300 kW to 9000 kW (1).

Operation

The first pilot unit (1000 kW) has a single flash system and was put into operation in Sept.1977. Its schematic flow diagram is shown in Fig.5. It has worked for 2×10^4 hours but it is now standing by. During its working time, the mechanism of scaling has been studied and a mechanical device for removing the scale was invented (see Fig.6). This experience has been useful for future development(2). Details of operation of other units are shown in Table 4. Unit N0.2 and No.3 have a efficiency of 0.059 (environmental temperature is 10°C), the auxiliary system uses 12% of the power generated (3). These units are peak load units. The power demand in Lhasa varies very much during a day. Scaling in the flow part of units is also very serious problem. The scale thickness can reach 2 to 5 mm. Every year, every machine is overhauled. In 1988, the blades in units 2, 3 and 4 failed at their third stage, so less power was produced. The reason is not yet clear, but maybe it is associated with scaling. The southern plant had a longer working time; well head pressures have rapidly decreased. Up until 1986, the average well head pressure has been declining: Zk311, 5.3%; Zk324, 2.3%; Zk314 and Zk313 reached 9 to 10%; Zk315, Zk313, and Zk309 were shut down. Zk319 is now capable of producing steam after a shutdown period of two years.

Reinjection

The main purposes of reinjection are: (1) to stop pollution of the Zangbu River, (2) to stop invasion of cold water into the reservoir; (3) to maintain pressures in the reservoir.

Along the 45°C isothermal line, two reinjection wells have been drilled; their depths are 230 m and 180 m respectively (see Fig. 1). The designed injectivity is 250 t/h for each well. Construction of the system is scheduled to be finished by October 1989. A number of production wells will be chosen as observation wells. We have done small-scale reinjection tests in 1985 and 1986. In 1986 the test lasted for 38 days. 1.3 x 10^5 tonnes of waste water have been reinjected, which was about 38% of the total amount of the wasted water. The maximum flow rate was 200 t/h. Zk325, Zk311, Zk314, Zk327, Zk328 and Zk313 have been chosen as observation wells. No significant changes in well-head parameters have been recorded.

Present work will focus on:

Installation of another 2 x 3000 kW unit before the end of 1991.
Reservoir engineering study during reinjection
Search for higher well-bottom temperatures in Zk352
Design of 6000 and 12000 kW units which will be suitable for higher fluid temperature.
Optimization of operation of the plant.

Exploitation of other fields

During the last three years, a number of geothermal fields have been exploited, e.g Langjiu, Naqu and Yangyixiang. The Langjiu and Naqu fields are water-dominated shallow reservoirs. A well-bottom temperature of 201°C has been recorded in Yangyixiang. Drilling in Naqu, which is close to Yangbajing, is also in progress. In 1985, a 1000 kW unit was installed and commissioned in the Langjiu geothermal field. Now it is at the stage of optimization. For the Naqu geothermal field, a feasibility study for the use 110°C geothermal water to generate electricity is in progress.

Table 4. Operation hours and power generated (data supplied by TGDC)

		1983	1984	1985	1986	1987	1988
year		1983	1984	1985	1986	1987	1988
powergenerated kWh x 10^6		29.4	33.98	38.1	49.2	60	40.65
operating hours	No.2		7681	6752	7594	7397	4078 Jan-Jun
	No 3		7445	7265	7553	7390	4090 Jan-Jun
	No.4			1818	3597	6396	3234 Jan-Jun
	No.5					136	2265 Jan-Jun

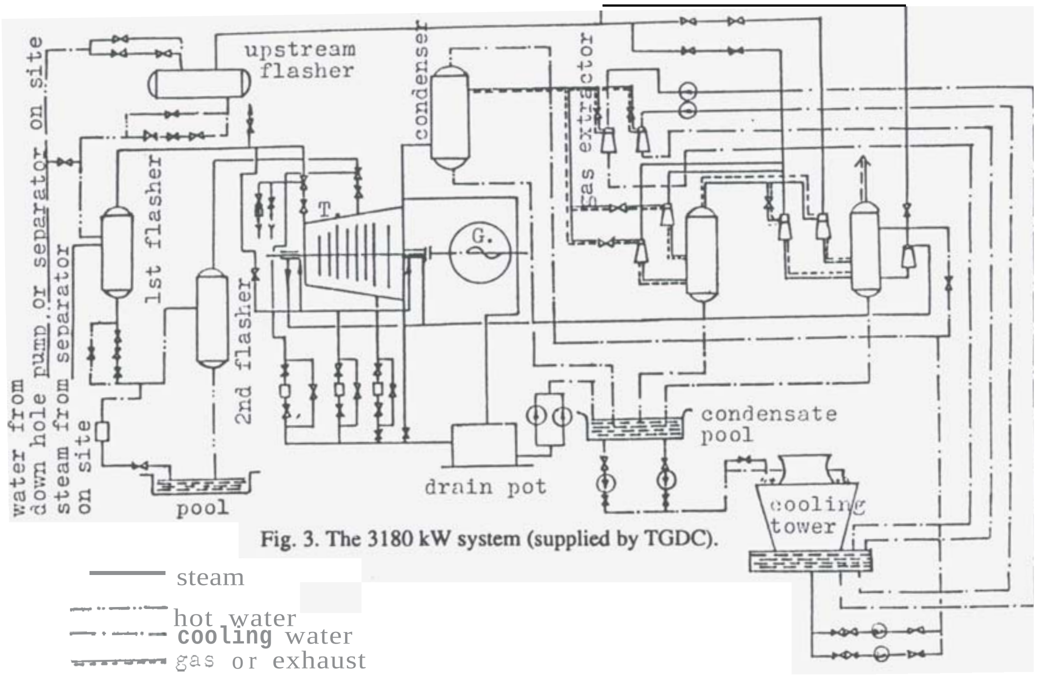

Fig. 3. The 3180 kW system (supplied by TGDC).

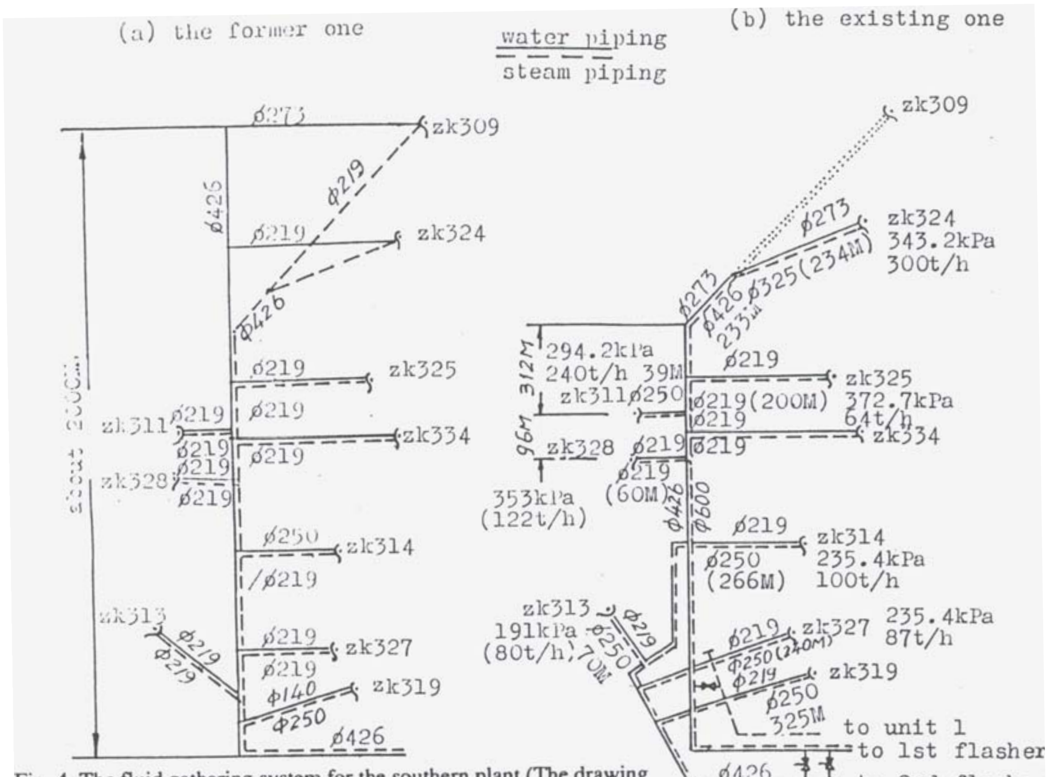

Fig. 4. The fluid gathering system for the southern plant (The drawing of design and calculation. presented in Fig. 5.and Fig. 6. (Wu and Lui, 1983))

Conclusions

1. Recently drilled wells, which have bottom temperatures greater than 200°C, will enhance the generating capacity of the units at Yangbajing.

2. The Yangbajing Power Plant has supplied a major proportion of electricity requirements for Lhasa city. In the future, the deep reservoir will be explored for higher temperature production, reinjection and reservoir monitoring purposes.

3. Exploitation of low enthalpy geothermal fields in Tibet using flashing systems will ease the power shortage.

References

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