KAKKONDA GEOTHERMAL POWER PLANT

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KAKKONDA GEOTHERMAL POWER PLANT

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1. What Is a Geothermal Energy Resource?

General Cross-Section of a Geothermal Area

The earth is a sphere, about 12,700 km in diameter, containing a gigantic amount of heat within. The temperature increases gradually from the surface to the interior. It is over 1000°C at the bottom of the continental shell and several thousand degrees Celsius in the center.

The geothermal heat energy is the natural heat energy contained in the shell of the earth. The geothermal heat holding layer formed under natural conditions is the object of use as an energy resource, in the same way as oil is concentrated in a storing stratum. We can, in fact, economically utilize geothermal heat reservoirs which are very hot and located rather near to the surface.

The "magma pool" is the place in the earth's shell, from several to 10 km under the earth's surface, which contains magma from the upper part of the mantle. The "magma pool" has a temperature of about 1000°C and continues to emit heat for a period of hundreds of thousands of years. The heat of the "magma pool" is carried toward the surface gradually and heats up rain water coming down from the surface. The hot water is stored deep underground. This layer is called the geothermal heat reservoir.

The geothermal energy development project currently is the one in which we drill to reach the geothermal heat reservoir and obtain water vapor and hot water as energy resources.

2. Exploration for Geothermal Energy Resources

The Takinoue area has a totally different appearance from the Matsukawa area. That is, in the Takinoue area, the heat indications in many places are those of geothermal regions, including many weak alkali hot springs.

This is the consequence of the fact that the geothermal fluids and the complicated geological structural band which produces the hot fluids were joined together underground and issue forth as surface thermal manifestations on the earth.

The exploration of geothermal resources is done in order to find geothermal reservoirs efficiently. In the Takinoue area, JMC has been doing investigations starting with elementary investigations in the fields of geology, chemistry and physics, using the results of the Matsukawa area. Then, various kinds of precise investigations were carried out, culminating in the drilling of exploratory wells.

Specifically, JMC did geological structure investigations, hydro-thermal alteration studies, hot spring and gas investigations, and geochemical studies which examined active gas in the soil. Moreover, for physical investigations aimed at determining the extent of the geothermal reservoir and the geological structure in the deeper reservoir, JMC investigated the amount of heat emission to estimate the total geothermal heat, electric, magnetic, and gravitational investigations as well as earthquake investigations. Computers were used to analyze the data from these investigations to determine the positions and depth of the exploratory wells.

From the exploratory wells, JMC observed core samples, identified altered rocks, measured the temperature of layers, examined electrical properties of layers, analyzed the chemical properties of the produced steam and hot water, and flow-tested the wells. After these investigations, the existence of the geothermal heat resources could be established with confidence.

Location

Key

Geological Cross-Section of Takinoue Geothermal Area

3. Drilling of the Wells

Geothermal drilling is a method in which one rotates the drill pipe and thus the bit so as to break the rocks underground into small pieces. The broken rock fragments are carried to the surface by the drilling fluid which circulates in the well. Main equipment includes the draw works which move the drill pipe up and down and rotate it, a power pump which circulates the drilling mud water, the mast which supports the drill string, and blow-out prevention apparatus which prevents the geothermal fluid from gushing out suddenly.

There are many types of drill bits; the best one is chosen for each stratum. One of the characteristics of geothermal drilling is that it becomes very hot inside the well. Thus various devices have been prepared for high-temperature problems encountered while drilling. For example, drilling cannot be carried out without using heat-resistant materials, or without using a cooling tower to lower the temperature of the circulating mud water.

Recently, the air-drilling method was developed. In this method, pressured air is used instead of circulating mud water. This method has various advantages, such as: (1) increase in drilling rate; (2) extended bit life; (3) increase in steam production, and (4) check of production layer. This method is used in general when drilling in reservoirs which contain steam and hot water. Drilling efficiency is much higher than with the mud water drilling method. The air-drilling method is the one mostly used in the Takinoue area.

Drilling Rig Layout at Takinoue

4. History of the Development of the Kakkonda Geothermal Power Station (Takinoue Area)

The exploration for geothermal energy in the Takinoue area, Shizuku Ishi Town, Iwate Prefecture, was first done in the 1950's with the help of the Industrial Technological Institute, Geological Survey Department. It was confirmed that a large amount of geothermal heat existed in this area.

Since 1972, Japan Metals and Chemicals Co., Ltd. and the Tohoku Electric Company have been cooperating in the development of geothermal energy electricity generation. In May 1978, the Kakkonda geothermal power plant (installed capacity of 50,000 kW) started operation. It is the sixth geothermal power plant in Japan.

JMC was responsible for the separation of the geothermal fluid into steam and hot water, and for the transmission of the steam to the power plant through pipe lines, and for returning the hot water back underground. The Tohoku Electric Company was responsible for the generation of electricity from the geothermal steam.

JMC constructed the production and reinjection wells; from August 1974 to December 1977, JMC built 26 wells: 11 steam wells (diameter = 8.625 in., average depth = 700 m). The total depth of the 26 wells is 24,300 m. JMC started construction of the pipelines in April 1976, and finished at the end of 1977. During that period 2900 m of pipelines (diameter 12-36 in.) were built from the wells, 750 m of hot water pipelines (diameter 12-30 in.) were built, and three steam-water separation facilities were completed. These facilities are sufficient technologically for 50,000 kW of power generation and have been working well. During construction, ample attention was paid to the preservation of scenic views and the environment.

In particular, environmental monitoring was carried out for the reinjection of hot water.

Production Well Area B at Takinoue. Three separators are at center foreground; silencers at right area; two reinjection wells lie to the right of the separators.

5. Characteristics of the Geothermal Fluid at Takinoue

This area is a liquid-dominated geothermal area where geothermal steam is obtained by flashing in the reservoir or in the wells. Thus, there is very little gas, other than water vapor, and the amount of dissolved elements is very small. Approximately five times as much geothermal hot water is produced as geothermal steam at the wellheads. The hot water which

accompanies the water vapor is a sodium chloride water which is weakly alkaline. As such there is no damage to the surface facilities. The hot water contains 3 ppm of arsenic, which is currently being returned to the reservoir through reinjection wells. In the future, it is hoped that the arsenic may be removed from the hot water.

<u>Composition of main steam (% by volume):</u>					
H ₂ O	CO ₂	H ₂ S	H ₂	N ₂	CH ₄
99.943	0.0359	0.0149	0.0035	0.0018	0.0008

<u>Composition of condensed geothermal steam (mg/l):</u>										
H ₂ O	SiO ₂	SO ₄	Na	Ca	Cl	Fe	Mg	Al	K	pH
140.0	1.6	1.6	0.15	0.13	0.9	0.03	0.03	0.02	0.02	5.86

<u>Composition of separated geothermal hot water (mg/l):</u>											
Cl	SiO ₂	Na	SO ₄	K	Ca	As	H ₂ S	Fe	Mg	Al	pH
619	580	440	75.0	58.0	7.64	3.0	1.0	0.09	0.08	0.02	8.86

6. Technical Outline of the Kakkonda Facility

Power output	50,000 kW
Production wells.	11 wells 1000-1600 m depth 219 mm (8-5/8 in.) diameter
Steam production.	500-550 t/h
Reinjection wells	15 wells 600-700 m depth 270 mm (10-5/8 in.) diameter

Hot water reinjection rate	2000-2500 t/h
Piping for steam and hot water.	3500 m total length 300-900 mm diameter
Steam production control facility; Central control room; Data Logger; Computer.	
Electricity generating facility (Tohoku Electric Company)	50,000 kW steam turbine 55,600 kVA generator
Cooling towers	2 units, induced draft type

Steam Production Part

Electricity Generation Part

Schematic of Kakkonda Geothermal Power Plant

Layout of Steam Gathering System for Kakkonda Power Plant