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110 MW GEOTHERMAL POWER STATION IN JAPAN - COMPLETION OF HATCHOBARU No.2 UNIT -

Takuji Fujikawa(1) Masatoshi Ikegami(2)

(1) Deputy Manager, Power Plant Engineering Department
(2) Project Manager, Land Turbine Designing Section
Mitsubishi Heavy Ind., Ltd. Nagasaki Shipyard & Machinery Works
1-1, Akunoura-machi, Nagasaki 850-91, Japan

ABSTRACT

Hatchobaru No.2 55 MW unit of Kyushu Electric Power Co. was completed in June 1990, realizing Japan's largest geothermal power station at 110 MW together with No.1 55 MW unit.

This paper introduces the design features and the operating results of Hatchobaru No.2 unit in comparison with those of No.1 unit which was completed in June 1977.

Basic design of Hatchobaru No.2 unit that is double flash cycle with steam-hot water mixture transmission system is the same as that of No.1 unit. However, some of the results of technological development during 13 years after completion of No.1 unit were applied for the improvement of efficiency and reliability.

DESIGN FEATURES OF HATCHOBARU No.2 UNIT

Hatchobaru No.1 unit was completed as the first double flash cycle geothermal power plant with steam-hot water mixture transmission system in the world and has been operating satisfactorily since then. Based on the success of Hatchobaru No.1 unit, construction of No.2 unit was planned and the development of geothermal wells was continued by Kyushu Electric Power Co. at the same field.

Then, No.2 unit was completed in June 1990 and started commercial operation at 55 MW.

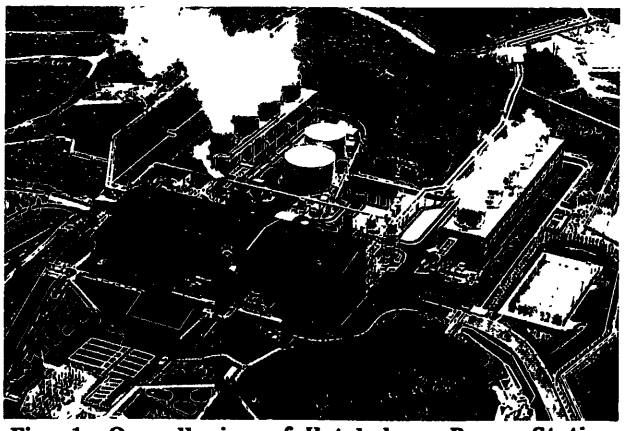

Fig. 1 Overall view of Hatchobaru Power Station

Design specifications of Hatchobaru No.2 unit are shown in Table 1 in comparison with those of No.1 unit.

In the design of No.2 unit, the recent advanced technologies, such as high efficiency turbine design and automatic control were adopted and operation results of No.1 unit were reflected.

Overall view of Hatchobaru Power Station is shown in Fig. 1.

Followings are the special features of Hatchobaru Power Station.

(1) Generating output is increased by 20% with the adoption of the double flash cycle with steam-hot water mixture transmission system.
(2) Generating output is increased by 3% with the adoption of a motor driven radial blower instead of a steam jet ejector for the gas extraction system.
(3) Unattended remote controlled operation is possible from Otake Power Station which is 2 km away.

Followings are examples of the improvements for No.2 unit as compared with No.1 unit.

(1) Turbine efficiency is improved by 7% (relative value) with the adoption of advanced 25 inch last row blade, twisted nozzle, integral shroud blade and multiple seal fins, while the interchangeability of the rotor with the nozzle diaphragms between No.1 and No.2 unit is maintained.
Fig. 2 shows cross section of No.2 turbine and outline of No.2 turbine generator is shown in Fig. 3.

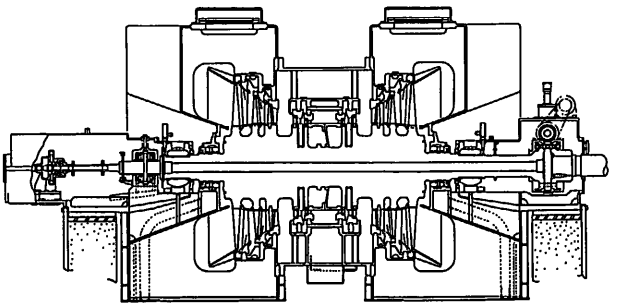

Fig. 2 Cross section of No.2 turbine

Table 1 Design features of Hatchobaru No.1 and No.2 units

Equipment	Item		Unit	No.2 Unit	No.1 Unit
Turbine	Type		—	Double Pressure Double Flow Impulse-Reaction Condensing Turbine	Double Pressure Double Flow Impulse-Reaction Condensing Turbine
	Rated Output		kW	55,000	50,000
	Maximum Output		kW	55,000	55,000
	Speed		rpm	3,600	3,600
	Steam Condition at MSV Inlet	Pressure	kg/cm²g	6.0/0.3	5.52/0.43
		Temp.	°C	164.2/106.6	161.3/109.4
		Gas Content	wt.%	0.6	0.45
	Exhaust Pressure		kg/cm²a	0.10	0.10
	Steam Consumption at Rated Output		t/h	329/110	312/107
	No. of Stage		—	5 x 2	5 x 2
	Last Stage Blade Height		mm	635	635
Generator	Type		—	Air Cooled	Hydrogen Cooled
	Capacity		kVA	62,000	62,000
Condenser	Type		—	Spray Type Jet Condenser Common with Concrete T/G Foundation	Spray Type Jet Condenser Common with Concrete T/G Foundation
	Shell Pressure		kg/cm²a	0.10	0.10
	Cooling Water Temp.		°C	28.1	26.1
	Hot Water Temp.		°C	43.5	43.5
	Water Quantity		m³/h	14,190	12,300
Gas Extraction System	Type		—	Four Stage Radial Blower & Steam Jet Ejector	Four Stage Radial Blower & Steam Jet Ejector
	Suction Pressure		kg/cm²a	0.095	0.095
	Discharge Pressure		—	Atmosphere	Atmosphere
	Capacity		m³/h	33,190	20,600
	Required Power of Blower		kW	415	315
	Steam Consumption of Ejector		kg/h	12,500	10,000
Cooling Tower	Type		—	Counter Flow Mechanical Draft	Counter Flow Mechanical Draft
	No. of Cell		—	5	4
	Water Quantity		m³/h	15,000	12,722
	Hot Water Temp.		°C	43.5	43.5
	Cold Water Temp.		°C	28	26
	Design Wet Bulb Temp.		°C	20	17
	Fan Motor Power		kW	246	213
Hot Well Pump	Type		—	Vertical Centrifugal Double Suction	Horizontal Volute Single Suction
	No. of Set		—	2	2
	Capacity		m³/h	7,500	7,000
	Motor Capacity		kW	820	950

(2) Air cooled generator is adopted to simplify the operation and maintenance.
(3) The number of cooling tower cells is increased from 4 to 5 in order to maintain the maximum output during the summer season.
(4) Type of the hotwell pump is changed from the horizontal to the vertical in order to reduce the installation area.
(5) Steam purity is improved by the combination of the separator, flasher and demister.
(6) Automatic operation such as the change-over of the gas extraction system between the steam jet ejector and the motor driven radial blower is adopted.

Fig. 4 shows plant layout of No.1 and No.2 units and Fig. 5 shows plant system diagram.

Fig. 3 Outline of No.2 turbine and generator

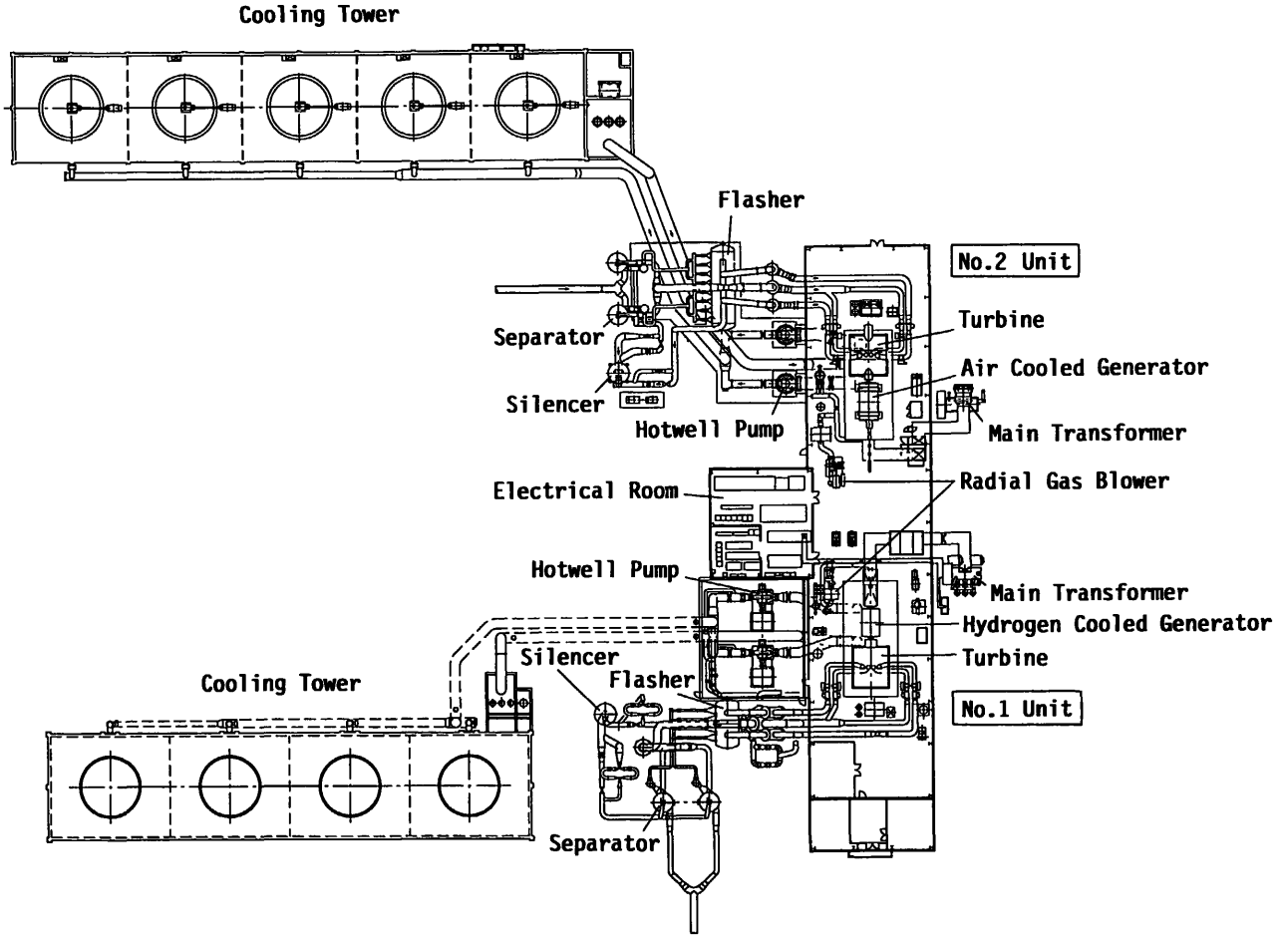

Fig. 4 Plant layout of Hatchobaru No.1 and No.2 units

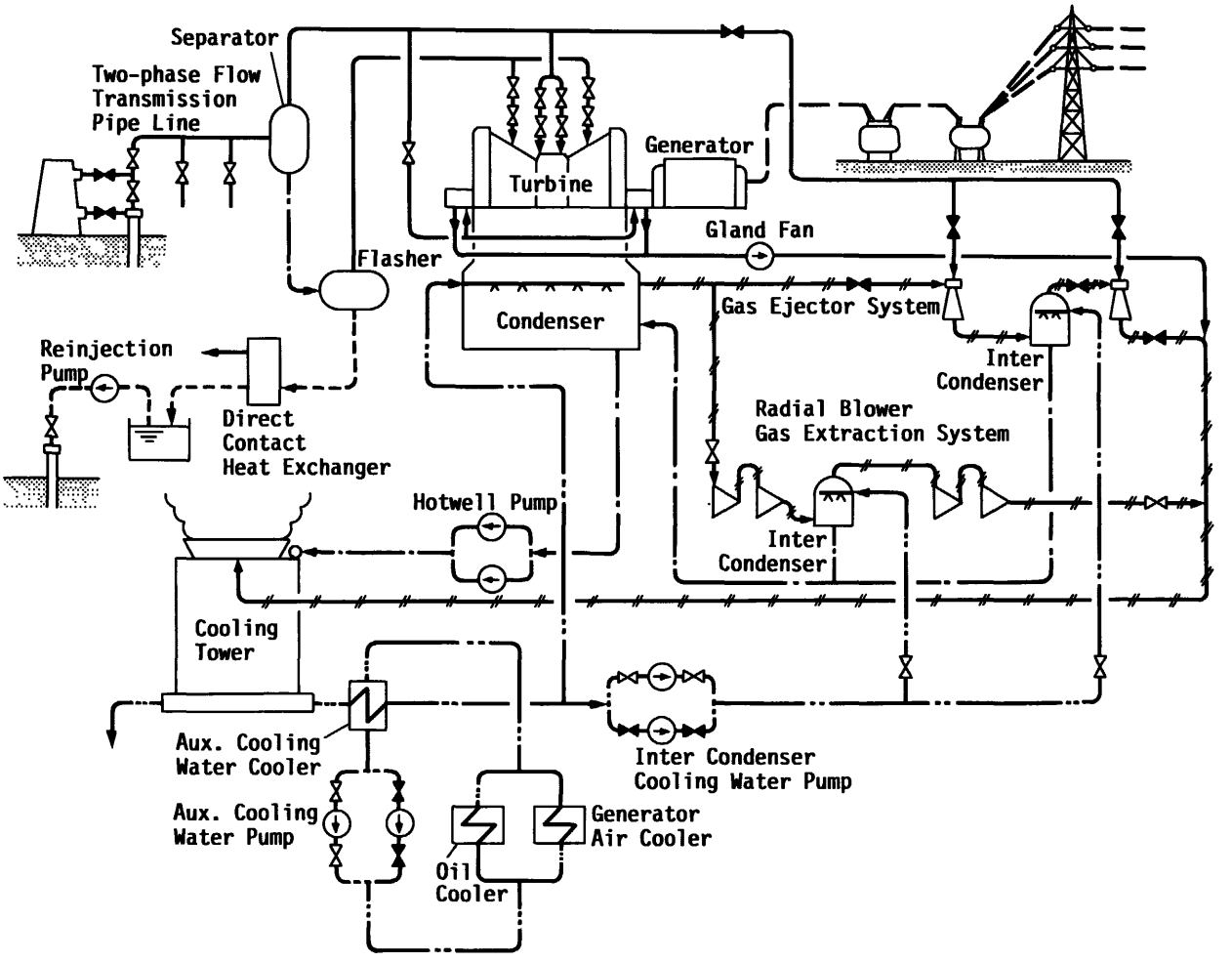

Fig. 5 System diagram of Hatchobaru Geothermal Power Plant

OPERATION EXPERIENCE

Hatchobaru No.2 unit has shown very good operation results. Availability and capacity factor during the first year are 99.6% and 95.0% respectively, while those of No.1 unit during 13 years are shown in Fig. 6.

The performance test result was 1.7% better than the guaranteed heat rate as shown in Table 2.

The operating vibration value of the turbine and generator is good as shown in Fig. 7.

In September and October 1991, the first scheduled overhaul inspection was executed, proving that all the equipment works as expected without serious problem.

Fig. 8 shows turbine internal parts at the first overhaul.

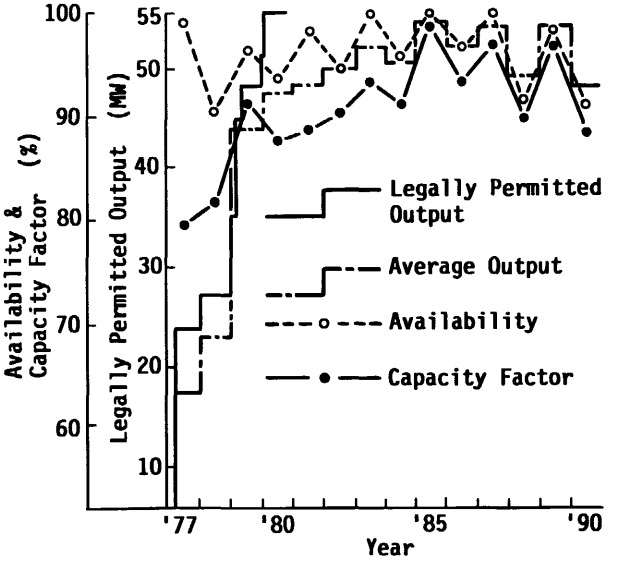

Fig. 6 Operation record of Hatchobaru No.1 unit

Table 2 Performance test result of No.2 unit

Item	Value
Guaranteed Heat Rate	5,227 kcal/kWh
Test Result	5,138 kcal/kWh
Evaluation	1.7 % better

$$\text{Heat Rate} = \frac{h_1 \cdot G_1 + h_2 \cdot G_2}{kW}$$

h_1 : Primary Steam Enthalpy (kcal/kg)
h_2 : Secondary Steam Enthalpy (kcal/kg)
G_1 : Primary Steam Flow Rate (kg/h)
G_2 : Secondary Steam Flow Rate (kg/h)
kW : Generating Output (kW)

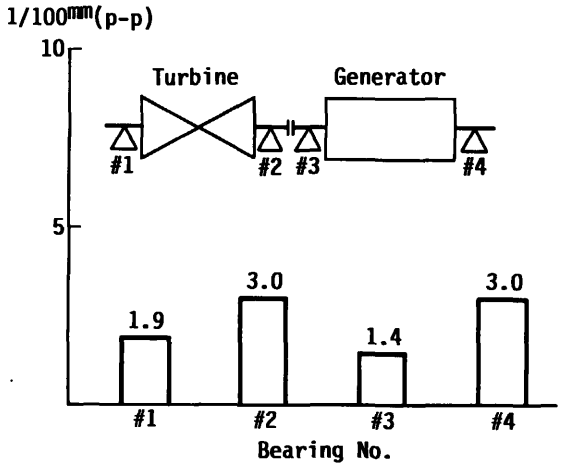

Fig. 7 Shaft vibration of turbine and generator

Fig. 8 Turbine internal parts at the first overhaul

CONCLUSION

Hatchobaru Power Station proved the reliability and economy of the double flash cycle geothermal power generation and consequently No.2 unit was constructed based on the good operation result of No.1 unit.

Hereafter we intend to continue the development of new technology in order to realize more reliable and more economical geothermal power plant.