Part 8

RENEWABLE ENERGY SOURCES

8.1. Geothermal power plants (GPPs)

8.1.1. Geothermal power plants at the fields of steam-water mixes with back pressure turbines

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At of fields of steam-water mixes in volcanic regions (in Russia it is Kamchatka and Kuril islands) the simplest method to generate electricity is to apply back pressure steam turbines (fig. 8.1). Steam water mix, coming from the geothermal reservoir by the lifting hole *1*, enters the separator *2*, where it's separated into liquid (water with the dissolved salts and gases) and gas (water steam and tabular noncondensing gases) phases. After that steam-gas mix flows into the back pressure steam turbine with the generator *3*; waste steam with noncondensing gases is dumped into atmosphere, but the separated water after its possible use for heat supply purposes, returns to the geothermal reservoir by the pressure hole *4* (re-injective). At low salt content, dumping of discharge water in the open basins is possible.

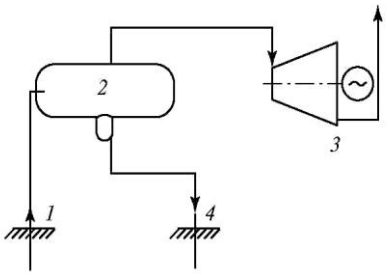

Fig. 8.1. A flow diagram of GPP with the back pressure turbine: *1* — lifting hole; *2* — separator; *3* — steam turbine with generator:

Power units with back pressure turbines are usually applied at a very high concentration of noncondensing gases in the gas phase (12…15% by mass), when their removal from the condenser becomes not beneficial from economic and ecological points of view. If by geologic reasons the lifetime of geothermal field is not enough for paying off the condensing power units, then the mining up to its exhaustion could be realized by back pressure power units. Besides, the power units with back pressure turbines are sometimes applied at mining of geothermal fields as drive of boring apparatus instead of diesels, and as starting complex of GPPs with their following possible replacement with the condensing units. Such turbines are produced in Japan, in the U.S. and Italy. Their capacity does not always exceed 10 MW.

In Russia power units with back pressure turbines are installed and operated at the lake Kunashir. Power units Omega-500, Tuman -2 and Tuman-2,5 are developed at Kaluga turbine factory and their characteristics are shown below in table 8.1.

Since construction of back pressure turbines is much simpler than of condensing ones, their price is lower. In case of condensing power units the typical capital investments make 1000…1200 dollars per the installed kilowatt (excluding costs for the mine exploration, hole drilling and provision of the necessary facilities), for back pressure units the capital investments are decreased to 600…700 dollars per the installed kilowatt. But the difference in the cost price of electricity is considerably less, because the specific steam consumption per power unit in case of back pressure turbines is approximately twice higher than in case of condensing ones.

Table 8.1. **Basic characteristics of geothermal turbines of Kaluga turbine factory**

Indicator	GPPs of the low power				GPPs of the average power			
	Omega-500	Tuman-2	Tuman-2,5	Tuman-4k				
Power, MW	0,5	1,7	2,5	4,0	6,0	12,0	20,0... (25,0)	23,0
Inlet turbine pressure, MPa	0,7	0,5	0,7	0,8	0,2	0,6	0,7	0,7
Outlet turbine pressure, MPa	0,1	0,1	0,1	0,011	0,01	0,0085	0,012	0,012
Steam consumption, t/h	10,0	38,0	44,0	32,0	75,0	90,0	147,0	170,0
Frequency, Hz	50	50	60	50	50	50	50	60