RENEWABLE ENERGY SOURCES

8.1. Geothermal power plants (GPPs)

8.1.2. Geothermal power plants at the fields of steam-water mixes with condensing pressure turbines

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At the majority of the operating GPPs, a flow diagram with the condensing turbines is applied (fig.8.2). It is more efficient in comparison with the flow diagram with back pressure turbines. Geothermal steam-water mix or wet steam with noncondensing gases from the lifting hole *1* enters the separator *2*, from which steam flows to the condensing turbine inlet *3*, and mineralized water flows to the re-injecting hole *8* for returning into stratum. Waste steam is fed into mixing condenser *4*. Since in most cases there are no sources of cooling water (river or cooling pond) at geothermal fields, circulating system of waste heat discharge is applied. This system includes a circulating pump *6*, a chimney-type cooling tower *5* and a condensing pump *7*. Noncondensing gases, which usually contain a lot of hydrogen sulfides, are removed from the condenser by ejectors and supplied to the upper cut of water-cooling tower for dispersion in atmosphere together with the steam flame.

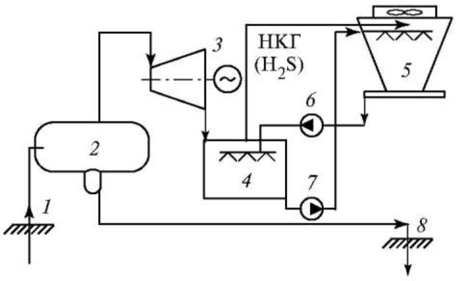

Fig. 8.2. A flow diagram of GPP with the condensing turbine:
1 — lifting hole; *2* — separator; *3* — condensing turbine; *4* —condenser; *5* — water-cooling tower; *6* — circulating pump; *7* — condensing pump; *8* — pressure hole.

Equipment for such a GPP is produced in a number of countries: Italy, U.S. and Japan. Maximum capacity of condensing power unit is 100 MW (GPP geysers, U.S.), but usually capacity of power units is between 12 and 50 MW. In Russia production of all the main equipment was mastered. This equipment is inferior, as a whole, and in a number of indicators, it surpasses the best world models. A small condensing power module of complete factory readiness Tuman 4k (operating at Verkhne-Mutnovskaya GPP) and wet-steam turbine of the average capacity of 25 MW with the separation stage (two such turbines are operating at the first line of Mutnovskaya GPP) were developed at Kaluga turbine factory.

In the OJSC “Nauka” on basis of developments of the OJSC “ENIN of G.M. Krzyzhanovskiy” on horizontal gravity separators, high-efficiency geothermal separators are suggested and developed at the Russian factories (table 8.2). These separators are installed in the module power units of Verkhne-Mutnovskaya GPP and at the first line of Mutnovskaya GPP. The separators provide the record quality of steam (humidity at the outlet is not higher than 0,5%), that significantly reduces erosion in turbine blades.

The possible total capacity of such GPPs in Russia is estimated, mainly, by a need in electricity of volcanic regions of Kamchatka and some Kuril islands (totally about 1 million kW).

Specific investments in construction of power plants of a similar type are 1000…1200 dollars per kW, and total specific investments, including expenses for exploration, hole drilling and construction of surface facilities for the geothermal mine are 2000…2500 dollars per kW. Cost price of electricity after pay off period is approximately twice lower than in case of thermal power plants, located in such regions, combusting organic fuel.

Table 8.2. **Technical characteristics of Russian geothermal separators**

Separator type	Steam pressure, MPa	Steam-content of steam-water mix, at the inlet,%	Steam humidity, at the inlet, %, before	Steam productivity, t/h, before	Hydraulic resistance	Mass, g
S-55	0,5...0,9	15...100	0,05	55,0	0,1	7500
S-85				85,0		9500
S-115				115,0		10 500
SP-180 (steam collector)				180,0		17 000
SV-45 (two-stage)				45,0		9700
R-23 (expander)	0,4… 0,8	0		23,0		7500

* Steam-water mix.