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PROSPECTS OF HORIZONTAL DRILLING WHEN CONSTRUCTING GEOTHERMAL POWER PLANTS

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ABSTRACT

The most prospective direction of utilization of thermal water heat is transformation of it in electric power. Existing geothermal electric power plants (GPP) are based in the most cases on natural vapour, obtained from fields in regions of modern volcanizm. But the potential of vapour fields in many countries is almost fully depleted. In Russia the works are carried out in construction of the first turn of Mutnovka GPP in Kamchatka with total capacity 200 MWt. Relative independence from consumers, economy of temperate power and special valuability of electrical power caused the prior development of GPP as the principal direction in geothermal resources development.

Enormous geothermal reserves with temperature 100-200 ^{0}C are consentrated in stratal hydrostatic head systems of sedimental basins. Characteristic peculiarities of thermal waters in stratal systems are high salinity, heightened gas content, tendency fo saline deposition when changing thermobar conditions and high corrosion activity to construction materials. Utilization of that kind recources for electrical power production connected with using of technology of two-contour GPP with low boiling working medium. Tnat GPP includes a geothermal circulating system (GCS), in confour of which thermal water circulates and a cycle of steam-turbine unit (STU), in which low boiling secondary heat-carrier circulates. Application of GPP of that sort permits to increase significantly number of regions, prospective for geothermal power engineering development. One of them the North Caucasus is, where Central, Kajasula fields in Stavropol Territory and Tarumovka, Kumukh, Jushnosukhokumsk, Jubileiny, Talovka fields in Daghestan are immediate.

The first in the world and unique in Russia two-contour experimental GPP on freon R-12 as a working medium was constructed in 1967 on Paratun geothermal field in Kamchatka. In 1974 this power plant was put out of action. In the late eighties the construction were initiate of Kajasula experimental GPP on freon R-12â in Stavropol Krai, territory which had been stopped owing to absence of financing.

The main purpose when creating the GPP is production of maximal usable electrical power. Increasing of capacity is reached by increasing of discharge of primary heat-carrier, circulating in contour of GPP and optimization of thermodynanical cycle of secondary contour. For working medium, circulating in contour of STU, the optimal temperature of evaporation exists, when usable electrical capasity on unit of discharge of thermal water reachs maximum. The optimal evaporation temperature depends on the temperature of thermal water, the temperature of condensation of secondary heat-carrier and the least temperature head in heat-exchanger-evaporator [1].

At the same time sharp rise in the cost of production when the plant capasity decreases, tipical for fuel and atom electrical power engineering, do not spread to geothermal power plants. Beginning from 10-30 MWt further grouth of their capasity do not lead to noticable improvement of their economical indices, i. e. it demands increasing of quantity of wells and lengthening of surfase pipelines [2].

For improvement of economical indices of GPP it is njecessary to create GCS with high productive wells with increased diameter. One of weys of intensification of thermal water extraction is creation of additional channels in stratum for significant increassing of filtration surface and draining zone. It reaches by creation of horizontal borehole, which spreads to hundreds meter through stratum.

That kind of formation exposing permits of the hole in the stratum and to raise the productivity of well many times.

At present the barge experience is accumulated of borehole drilling in oil production. Due to longitudinal formation exposing the hydrodynamical perfection of a well grows. Practise of horizontal wells operation shows, that their productivity is tens times higher than productivity of usual vertical wells. Drilling of horizontal wells is characterized by

deceleration of penetration rate and by rise in the cost of drilling. Owing to increasing of well length due to lengthening of borehole in productive formation, growth of number of limitations, put on technology of well drilling, and so complication of drilling and geophysical works, the cost and duration of drilling of horizontal wells is higher than usual wells. But because of more significant increase of well productivity, drilling of horizontal wells is economically profitable from point of view of ultimate aim of well construction. Economical effectivity when horizontal drilling - in is reñeived as result of obtaining the given level of production by significant less number of wells. Comparison of change dynamic of the wells cost with their production growth dynamic shows, that productivity of horizontal wells grows more intensive than their cost.

In scientific literature number of formulae are given for determination of single horizontal well output [3, 4, 5]. For estimating calculations it the approximately formula by V.G. Griguletzky [3] may be used

$$G = \frac{2\pi\sqrt{k_h k_v}\,\beta h \Delta P \rho}{\mu B_0\left[\mathrm{Ln}\frac{4R_k}{L} + \frac{\beta h}{L}\mathrm{Ln}\frac{\beta h}{2\pi R_c}\right]}$$

(1)

where B_0 is the stratal volumetric factor of fluid; μ is the viscosity of stratal fluid; $\beta = \sqrt{k_h/k_v}$; L is the length of horisontal part of borehole; R_c is the radius of a well; R_k is the radius of circular external reservoir boundary; k_h and k_v are horisontal and vertical penetrations, correspondingly; h is the width off productive reservoir; ΔP is pressure drop between pressure on boundary of circular external reservoir P_k and on wall of a well P_c; ρ is density of obtained thermal water.

In fig.1 the technological scheme of GPP with horizontal wells is given. When constructing the horizontal well, dropping from top to subface, as shown in fig.1, the stratum is the most full included in filtrational flow .

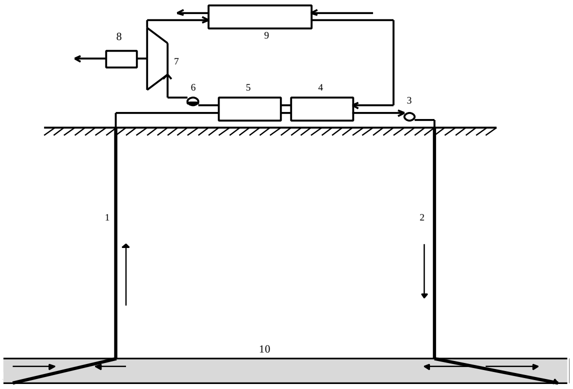

Fig.1 Technological scheme of GPP with horizontal wells. 1 - producing well; 2- injection well; 3- pump house of GCS; 4- heat-exchanger; 5- evaporator; 6- pump of secondary contour; 7- turbine; 8- generator; 9- condensator; 10- aquifer.

When constructing the GPP with vertical wells (from condition of minimum specific capital expences) the most optimal the technological scheme is with three equidistant production wells from central injection well with increased diameter [6].

The comparative analysis of GPP has been carried out for three (1,2,3) technological schemes of GCS construction : 1-one producting and one injection vertical wells; 2- three producting vertical wells and one injection vertical well of increased diameter; 3- one production horizontal and one injection horizontal wells. As low-boiling working medium isobutan is used.

As the optimum criterium it may be used the minimum of specific capital expences, which are determined by formula

$f = S/W_{\text{Ï}}$

(2)

where f is specific capital expences, \$/kWt, S is capital investment, \$; $W_{\text{Ï}}$ is usable capacity of GPP; kWt

$W_{\text{Ï}} = W_b - W_{\text{Ï}},\ W_b = GN,\ W_{\text{Ï}} = GP/\rho_H$ (3)

where W_b is the total capacity, producting by power unit; $W_{\text{Ï}}$ is the capacity, consumed to own needs; G is the mass flowrate of thermal water, circulating in contour of GCS, kg/s; N- the specific capacity (Net) of power unit, kWt·s/kg\$ P is the pressure of injection, Pa; ρ_H is the density of injection water , kg/m^3.

The mass flow rate of the secondary heat carrier m and capacity N, developed by turbine on 1 kg/s of thermal water discharge, are determined by formula:

$m(h_3 - h_2) = c_{\text{â}}[t_{\text{ò}} - (t_s + \Delta t)]$

$m(h_2 - h_1) = c_{\text{â}}[(t_s + \Delta t) - t_{\text{í}}]$ (4)

$N = [\eta_{oi}(h_3 - h_4) - (P_s - P_{\text{ê}})\nu_{\text{ê}}/\eta_p]\,m$

where h_1 is the enthalpy of condensat, KJ/kg; h_2 is the enthalpy of steam in point of evaporation; h_3 and h_4 are the enthalpies of steam before and after turbine; $c_â$ is heat capacity of thermal water, KJ/kg^{0}C; t_T is the temperature of thermal water; t_s is the temperature of secondary heat carrier evaporation; Δt is the least temerature head in heat-exchanger-evaporator; t_H is the temperature of waste thermal water; η_{oi} is relative inside efficiency of a turbine; P_S is the pressure of evaporation; P_k is the pressure of condensation; ν_k is the specific volume of condensate, m^3/kg; η_p is pump efficiency.

Equation of movement of heat-carier in circulating contour of GCS may be wrote down in the following form:

$$P = \Delta P_í + \Delta P_ä + \Delta P_{íê} + \Delta P_ô + (\rho_ä - \rho_í)gH \qquad (5)$$

where $\Delta P_í$, $\Delta P_ä$, $\Delta P_{íê}$ are correspondingly hydroulic losses of pressure in injection, produñting wells and surface pipelines; $\Delta P_ô$ is filtrational losses of pressure in formation; $\rho_ä$ is the density of thermal water in producting well; H is the depth of well, m.

Optimizational calculations for three variants of GPP building is binded with Kumukh field of thermal water. In the field at depth 4850m effectiv width 65m.The temperature of stratal water 180^{0}C, the salinity 140-160 g/l, the stratal pressure 53,3Mpa; the porozity 16%, the permeability $0,5\cdot10^{-12}$ m^2 . On field two wells are drilled with deameter 0,146m, which are shut down at present.

When considering the variant with horizontal wells, the length of perforated horizontal part of well, dropping along the stratum is assumed equal to 250m.

In tabl.1 the basic parameters for three variants of GPP are given.

Table 1. Comparative technical characteristics of GPP.

N	Name	Technological schemeof GPP		
		1	2	3
1	Depth of well, m	4850	4850	4850
2	Diameter of producing well, m	0,298	0,2458	0,3423
3	Diameter of injection well, m	0,298	0,3423	0,3423
4	Distance between wells, m	2720	2534	2750
5	Output of GCS, kg/s.	260	468	500
6	Pressure of injection, MPa.	19,0	24,0	21,5
7	Capacity of injection pump, MWt	5,24	11,9	11,5
8	Usable capacity of GPP, MWt.	13,6	22,0	24,7
9	Specific capital expences, $/KWt	1050	921	730

From given data the conclusion follows, that when further developing the geotermal power it is necessary to construction horizontal wells, using experience of oilmen, that will improve technical and economical indices of geothermal brunch and will raise its competitivenees in comparizon with traditional power brunch.

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