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GEOTHERMAL CIRCULATION SYSTEMS IS ENVIRONMENTALLY SAFE AND PURE GEOTHERMAL ENERGY TECHNOLOGY

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ABSTRACT

An analytical study of developing flow, definition of pressure distribution, flowrate, velocity and heat- transfer leakage in the underground part of the circulation systems is reported.To determine the fundamental parameters of heat-transport medium in water-yieding strata. It was solved the task of two-demensional nonstationary filtration in double wells system for porous medium. The mathematical model is solved by the integral Laplace transformation, by the method of separation of variables and by the method of Green function. This results were extended to Geothermal Circulation Sistems (GCS) with optional numbers wells.

INTRODUCTION

The use of renewable sources of energy results in the saving of organic fuel and improvement of environment ecology. The earth heat is one of the basic remewable energy sources. Progressive technology extraction of geothermal energy is connected with development of geothermal circulation systems (Figure 1). Geothermal circulation systems is environmentally safe and pure energy technology. The using geothermal circulation systems anables exploitated the geothermal deposets with maintenanse of stratum pressure and solved the problem of environmental protection.

The paper presents investigation results of the hydrodynamic processes in Geothermal circulation systems, the optimization of technological parametres, conditions of stable circulation of the heat transport medium. The optimization of parameters Geothermal circulation systems is executed on the basis of technique developed in Engineering Thermophysics Institute. Variants of circulating geothermal systems the capacity 1-5MW were considered. GCS operate in Crimea, performance date is geothermal heat-carrier ratings on the mouth of producing well: pressure,no less than - 0,3 MPa, temperature - 60-80 ^{0}C, mineralization, no more than 20 g/l; temperature of enjected heat-carrier 25-30 °C, injection pressure, no less than 1,5 MPa well discharge 60-120 m^3/h. The flowrate of circulating systems can vary in ten time, that speak about high mobility of system.

MATHEMETICAL MODEL AND SOLUTION

We consider the circulation system for two wells-injected and operation. The operation ideal well of radius r_0 with constant pressure P_s and injected well with flowrate **Q** {pointwise source}. The flow of heat-transfer is assumed to be instabulity two-demensional, time-depending, loving Darcy's law. To determine the distribution of pressure, flowrate of operation well, the leakage of heat-transport medium in water-yieding strata it was solved the task of two-demensional nonstationary filtration in double wells system for porous medium. The mathematical formulation of the problem for the dimensionless pressure function U in the cylindrical coordinate system is

$(\partial^2U/\partial r^2)+(1/r)(\partial U/\partial r)+(1/r^2)(\partial^2U)/(\partial\varphi^2)=\partial U/\partial F_0;$ (1)

$r>1;\ F_0>0$

Besides the equation (1) there are initial conditions (2) and boundary conditions (3).

$U(r,\varphi,F_0)=0$, at $F_0=0$ (2)

$U\to 0$ as $r\to\infty$, $U=U_э$ at $r=1$ (3)

$$\lim_{r_1\to 0} r_1 * (\partial U/\partial r_1) = -q,$$

$r = r/r_0$, $U=(P-P_s)/P_0$, $r_1=\sqrt{r^2+R^2-2rR\cos\varphi}$,

$q = Q_i\,\mu / 2\pi kh$, $F_o=(æ\, t)/(R_o^2)$,

where R - the distance between the wells.

The problem are solved by the integral Laplace transformation and by the method of separation of variables and by the method of Green function. To find the general solution U, we use the theorem of addition for the Beassel functions and the Fourier - Mellin formula for the inverse transform. The solution of the problem is series of integrals of liner combination by the Bessel functions.

$$\Delta U = 1/\pi \int_0^\infty \exp(Z)\,((2U_э + \pi g B_o)C_o/uD_o)\,du + 2g\sum_{n=1}^{\infty}\cos(n\varphi)\int_0^\infty \exp(Z)\,((B_nC_n)/uD_n)\,du - g/2\ln X, \quad (4)$$

where $\Delta U= U_э - U$; $Z= -U^2F_o$;

$B_n= I_n(u)\,Y_n(r_1u) - I_n(r_1u)\,Y_n(u)$;

$C_n= I_n(u)\,Y_n(ru) - I_n(ru)\,Y_n(u)$;

$D_n= I_1(u)\,Y_0(u) - I_0(u)\,Y_1(u)$;

$X= ((r_1 r)^2 - 2 r_1 r\cos(\varphi) + 1)\ /$

$/\ (r_1^2 - 2 r_1 r\cos(\varphi) + r^2)$,

where $I_n(u)$, $Y_n(u)$ - the Bassel function of the 1st and 2nd kind.

From the solution we obtain expression for the Q_0 flowrate of the operational well

$$Q_0 = \frac{2hkPo}{\mu}\int_0^\pi \left.\frac{\partial U}{\partial r}\right|_{r=1} d\varphi, \quad (5)$$

and for the $\delta_y = \frac{Q_i - Q_o}{Q_i}$ - leakage of fluid.

$$\delta_y = 2/\pi\int_0^\infty \exp(Z)\,(B_o/uD_0)\,du + \beta\int_0^\infty \exp(z)\,(A_0/D_0u)\,du, \quad (6)$$

where $\beta = 4kh(p_0 - p_i)/\mu Q_i$.

β - is comprehensive quality, take account of permeability, formation of the water-bearing horizon, facing and stratum pressure, flowrate of the injected wells, dynamics viscosity, and stratum temperature. When the leakage - tend to zero we obtain stable working regime of GCS.

Figure 2 shows distribution curves of the leakage with respect to F_0 different R; 1-300, 2-600, 3-900. The solid curves are for $\beta = -0.3$, the dashed -for $\beta = 0$; and dash-dotted - for $\beta=0{,}1$,

The solution we obtained for distribution of pressure, flowrate and leakage of fluid in the circulation system. It was shows distribution curves of the leakage with respect to time and distances.

This results was extended to Geothermal circulation systems (GCS) with optional numbers wells (injected and operational). In this case the operational wells have the central finite radius r_0; the injected wells are the pointwise sources.

After calculation and analysis of this problems it is concluded that the leakage of that systems don't connected with number injected wells.

If we have general flowrate of the injected wells their number don't influence on the quality heat-transform medium leakage from the underground geothermal circulation systems.

CONCLUSIONS

The paper presents a methods of calculation of GCS. It is obtained the analitical solution for distribution of pressure, flowrate preasure gradients, heat-transfer leakage. It was analisit the hydrad geo dynamics parameters and engineeing parametrs on the work geotermal circulation systems. It is defined the necessary condition for stabilized work geotrmal system.

NOMENCLATURE

r_0 - radius of operational well,
P_0 - facing pressure,
P_s stratum pressure,
k permeability coefficient,
μ - dynamics viscosity coefficient,
Fo - Fourier number
Q_i - flowrate of the injected well,
h - formation of the water-bearing horizon,
φ - polarity angle
æ - piezoconduction coefficien,
t - time

Subscripts
U - dimensionless pressure,
R - dimensionless distance between the wells
r - dimensionless radial coordinate

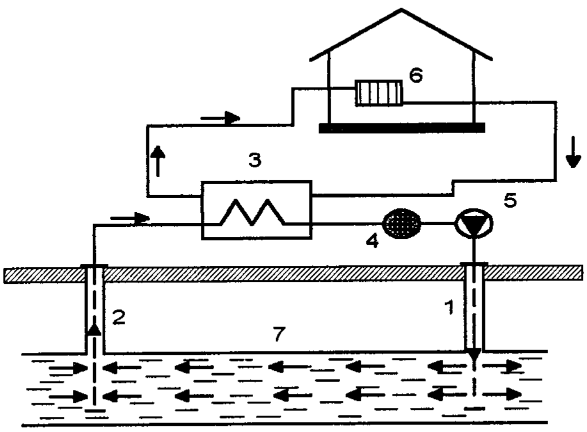

Fig1. Geothermal circulation system

1- injection well; 2- producing well; 3- heat-supply exchangers; 4- gas and slurry recovery device; 5-circulation-water pump; 6- consumers; 7- underground collector.

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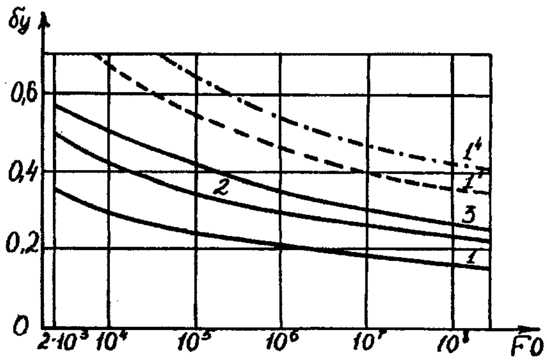

Fig 2. Curves of the leakage