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Study on the influence of groundwater seepage on the form of the layout of soil source heat pump

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Abstract

Using the finite element analysis software FLUENT to simulate the heat flux changes and the average changes of underground soil temperature of soil source heat pump , at the same time simulating the heat flux changes and the average changes of underground soil temperature when there is groundwater seepage, providing some guidance for engineering construction.

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Keywords: ground source heat pump;groundwater seepage:arrangement;same intervals;different intervals;

1. Introduction

According to the Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD) published 324 ground source heat pump project statistics by[1], at present in our country the soil source heat pump has the highest share in the heat pump system, the main reason is that the soil source heat pump with the characteristics of high efficiency and energy saving, without geographical restrictions and less polluting. Soil is a porous medium composed by the gas, liquid and solid, in practical engineering the heat exchanger buried depth is generally about 100m by[2],and soil is saturated in this depth, so the heat transfer of groundwater seepage to soil cannot be ignored. As the buried pipe area is limited by the practical engineering conditions, the study of borehole heat exchangers arrangement considering groundwater seepage has an important guiding significance for ground source heat pump design.

In this paper GAMBIT software was adopted to establish the model and dividing grid, the FLUENT software was

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used for the numerical simulation of the model under the condition of the soil has groundwater seepage and without groundwater seepage ,and simulated the impact on soil heat transfer in the case of different arrangement of the well and different well intervals

2. The mathematical model of saturated porous media

1) The Momentum equation of the porous media has an additional source term, source term was composed of two parts: viscous loss terms and internal loss items, the equation of homogeneous and isotropic porous medium is by[3]:

$$S_i=\frac{\mu}{\alpha}\mathcal{V}_i+C_2\frac{1}{2}\rho|\mathcal{V}_j|\mathcal{V}_j \quad (1)$$

Among them, α is permeability; C_2 is internal resistance factor.

2) The energy equation in porous media

$$\frac{\partial}{\partial t}[\phi\rho_f h_f+(1-\phi)\,\rho_s h_s]+\frac{\partial}{\partial x_i}(\rho_f u_i h_f)=\frac{\partial}{\partial x_i}(k_{eff}\frac{\partial T}{\partial x_i})-\phi\frac{\partial}{\partial x_i}\sum_{j'} h_j j_{j'}+\phi\frac{Dp}{Dt}+\phi\tau_{ik}\frac{\partial u_i}{\partial x_k}+\phi S_f^h+(1-\phi)\,S_s^h \quad (2)$$

$$k_{eff}=\phi k_f+(1-\phi)\,k_s \quad (3)$$

Among them, φ is the porous nature of the porous medium; h_f is the enthalpy of the fluid; h_s is the enthalpy of the solid; S_f^h is the source term of fluid enthalpy;S_s^h is the source term of solid enthalpy; k_{eff} is the effective conductivity of the porous region; k_f is the fluid thermal conductivity; k_s is the solid thermal conductivity by[3].

3. The establishment of the simulation problems

In this paper, the number of in-line well group amount to 25 wells, According to China's national standards, the well interval of GSHP system are set to 3m, 4m, 4.572m (minimum well intervals of ASHARE manual recommended), 5m, 6m, Respectively corresponding to the total simulation area of 18m×18m、24m×24m、27.432m×27.432m、30m×30m、36m×36m. Other parameter settings were shown in the table below.

Table 1.Parameter setting

parameters	value	parameters	value
soil density	1975kg/m^3	the soil initial temperature	9℃
soil specific heat capacity	895J/ (kg·K)	soil porosity	0.3
soil thermal conductivity	2.2W/ (m·K)	inertia resistance coefficient	181481
groundwater velocity	2.2 ×10^{-6}m/s	viscous drag coefficient	3.267 ×109

4. Analysis of simulation result

According to the parameters, studying the soil temperature by simulation calculation. Fig.1 shows the distribution of soil temperature after three months operation when there is no groundwater seepage, Fig.2 shows the distribution of soil temperature after three months operation when there is groundwater seepage, and both the well interval is the same, the same as 5m.