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The research on a group of energy piles for storing heat temperature field numerical simulation

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ABSTRACT

Energy pile heat storage technology is a system of solar energy and the concrete pile as the composite heat source heat pump, inside the concrete pile embedded in heat pipe, using solar panels store heat through the heat exchange tube concrete pile in the soil. Based on the cylindrical heat source model of concrete heat storage pile 180 days of continuous regenerative process simulation, analyze the underground soil temperature field, think in 4 m interactions between energy pile under the pile spacing is small.

KEYWORDS

Ground source heat pump; Energy pile; Heat storage for storing heat; The temperature field.

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INTRODUCTION

In recent years, soil source heat pump technology is widely used, because it has advantage of energy conservation and environmental protection technology, but the high cost of the technology, lead to hard to promote the use of the technology[1-3]. Energy technology is expected to geothermal Wells in the ground-source heat pump system with building pile foundation as a whole. Energy pile technique is a new method, this method can be effective development and utilization of underground heat energy, this technology can realize building winter heating, summer cooling, the new method can save energy of fossil energy, reducing greenhouse gas emissions[4].

At present, many scholars have a lot of research on soil source heat pump ground heat exchanger, the scholars both at home and abroad[5-7]. But for pile store heat energy, especially for energy in the process of pile group of thermal storage underground soil temperature field research is very little. The author will use the finite element analysis software simulation analysis was carried out on the energy of pile group of heat storage process.

THE RESRVOIR MODEL

Due to the heat storage process is long, energy storage volume is big, so ignore the heat exchange tube heat transfer situation, in the research of the underground energy storage body heat characteristic changes, this simplifies the computation model of the underground soil energy storage state changes can be more outstanding. The author firstly to simulate the single pile heat storage, on the basis of single pile in pile group simulation of group pile when simulating calculation does not consider the energy within the heat exchange process, as a source of heat energy pile form processing[8-10]. The author USES the heat transfer model is column heat source model when solving soil temperature field[11-15].

For column buried heat pipe heat exchanger, heat conduction equation in cylindrical coordinates for expression form

$$\frac{\partial^2 \mathrm{T}}{\partial \mathrm{r}^2}+\frac{\partial^2 \mathrm{T}}{\mathrm{r}\partial \mathrm{r}^2}+\frac{\partial^2 \mathrm{T}}{\partial \mathrm{z}^2}=\frac{1}{\alpha}\frac{\partial \mathrm{T}}{\partial \mathrm{t}} \quad \textbf{(1)}$$

The momentum conservation equation

$$\rho_0\left(\frac{\partial \mathrm{u}}{\partial \tau}+\mathrm{u}\frac{\partial \mathrm{u}}{\partial \mathrm{x}}+\mathrm{v}\frac{\partial \mathrm{u}}{\partial \mathrm{y}}\right)=\mathrm{F}_{\mathrm{x}}-\frac{\partial \rho}{\partial \mathrm{x}}+\eta\left(\frac{\partial^2 \mathrm{u}}{\partial \mathrm{x}^2}+\frac{\partial^2 \mathrm{u}}{\partial \mathrm{y}^2}\right) \quad \textbf{(2)}$$

We believe that the energy of pile and the buried pipe close contact, without considering of thermal and moisture migration under the condition of groundwater. This way of heat transfer is a kind of, heat conduction between the buried pipe and pile. Around pile unchanged in thermal and physical properties of buried pipe concrete temperature distribution can be expressed in the type.

$$T_\infty - T_0 = \frac{q}{\lambda_s L}G(z,p) \quad \textbf{(3)}$$

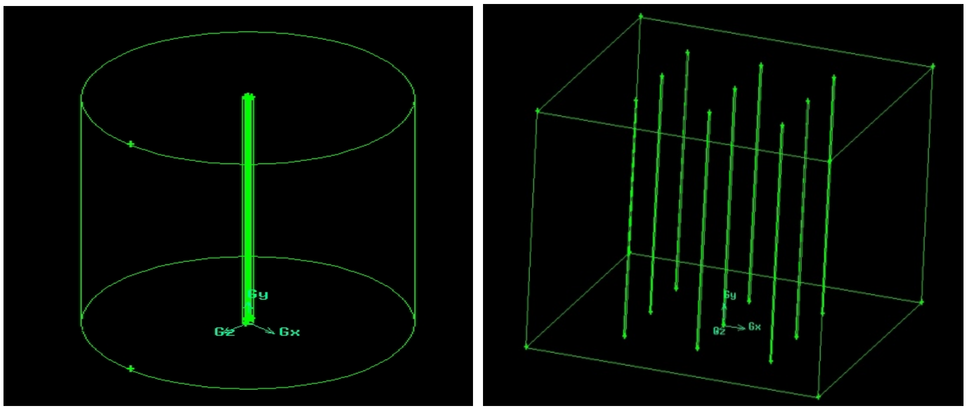
where T_∞ is the temperature of far boundary radius position ,℃ ; T_0 is The outer wall temperature, it is the ground heat exchanger of location, ℃; q is the heat exchanger of buried pipe, W ; λ_s is Coefficient of thermal conductivity of the concrete, $W/(mk)$; $G(z,p)$ is the theoretical solution of G function.

$$G(z,p)=\frac{1}{\pi^2}\int_0^\infty \frac{e^{-\beta^2 z}-1}{J_1^2(\beta)+Y_1^2(\beta)}[J_0(P\beta)Y_1(P\beta) - J_1(P\beta)Y_0(P\beta)]\frac{1}{\beta^2}\,\mathrm{d}\beta \quad \textbf{(4)}$$

$$z=\frac{a_s t}{r^2},\; p=\frac{r}{r_0} \quad \textbf{(5)}$$

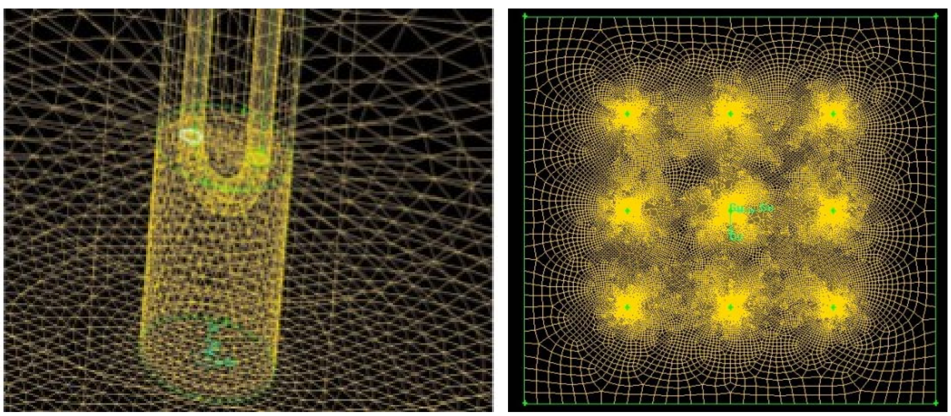
THE NUMERICAL SIMULATION OF THE UNDERGROUND SOIL TEMPERATURE FIELD

Energy pile set for 300 mm diameter, pile length is 12 m, the radius is 5 m of single pile soil area;Pile group simulation area for 9 energy pile of pile group, nine piles according to 4 m ×4 m spacing configuration, such as distance is 4 m, as shown in Figure 1. Response is more sensitive to temperature around the pile wall area is relatively dense grid, but far away from the pile wall area is relatively sparse grid, as shown in Figure 2.



(a) The model of the single pile geometry (b) The geometric model of pile group

Figure 1 : The model for the geometry



(a) The division of the single pile regenerator grid (b) The division of group pile regenerator grid

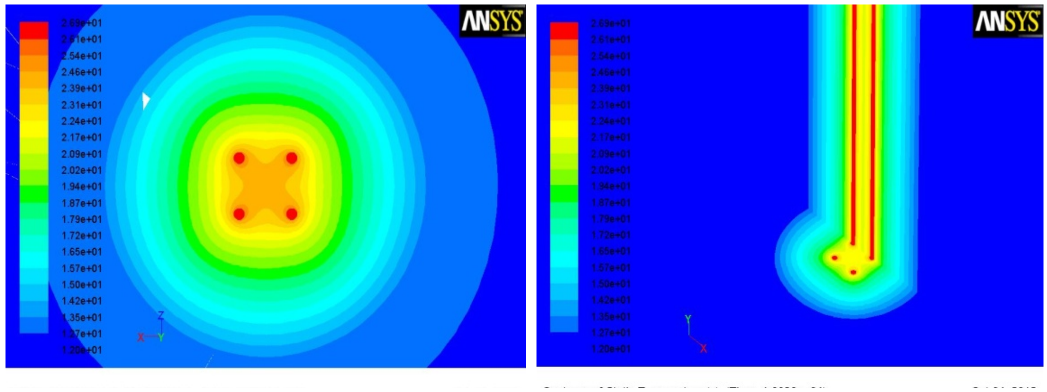
Figure 2 : The division of the grid

The energy storage process of soil temperature variation scope is limited, negligible soil coefficient of thermal conductivity, specific heat, density and other physical parameters change with temperature; Assuming homogeneous geological structure; Assume that soil temperature with depth does not change; Underground choice of clay soil thermal physical parameters; Set the underground soil initial temperature of 12 ℃, far boundary temperature is 12 ℃; Soil and concrete thermal physical parameters as shown in TABLE 1.

TABLE 1 : Parameters

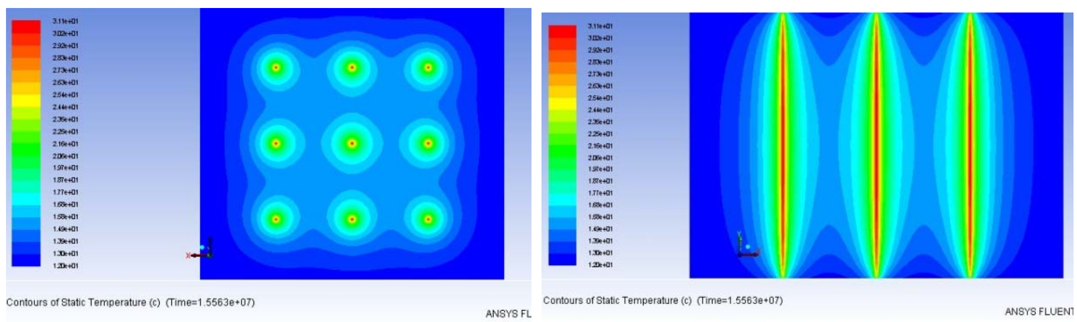
Material	**Density (kg/m^3)**	**Specific heat (J/kg.k)**	**Thermal conductivity (w/m.k)**
clay	1400	1200	1.13
concrete	2000	1100	1.51

As shown in Figure 3, Figure 4, respectively corresponding to the single pile and pile group to calculate regional horizontal and vertical plane in the continuous accumulation of heat after 180 days (4320) the underground temperature field calculation results temperature contours.



(a) Cloud Map of Temperature in the horizontal direction (b) Cloud Map of Temperature in the vertical direction

Figure 3 : Cloud Map of Temperature of single pile



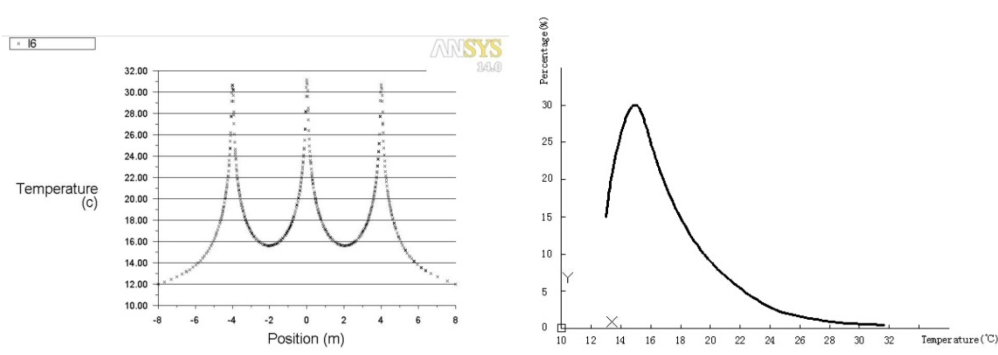
(a) Cloud Map of Temperature in the horizontal direction (b) Cloud Map of Temperature in the vertical direction

Figure 4 : Cloud Map of Temperature of a group of piles

Energy pile and double U- shaped pipe heat exchanger in the heating process, the radial distribution of temperature changes along with the U distance and the heating time tube has a significant change, from the U tube closer to higher temperatures, action radius increases gradually increase with time, but the effects were increased with time and slow down, namely thermal effect the time required to increase the per unit length.

It is shown that, the calculation of regional soil in the heating effect of the energy piles, the local temperature region be promoted. In Figure 4, in the vertical plane, namely soil profile, from the effect of energy pile, its scope is elliptical distribution. It is thus clear that it has a great gradient in the change of temperature on the middle part of the soil profile. heat storage effect. In this model, the soil depth of 12m, select the 6m regional center line in the depth of the underground temperature distribution in the horizontal direction, as shown in Figure 5.

Figure 5 shows the temperature distribution in the main calculation area between 12 to 22 ℃, higher than the range of 22 ℃ less than ten percent. In addition, by statistical calculation, the calculation area after 180 days of continuous accumulation of heat and energy of pile soil average temperature of 17.2 ℃, the temperature of 5.2 ℃.



(a) The curve of temperature distribution (b) The percentage of temperature distribution

Figure 5 : Temperature distribution in the 6 m deep place of a group of piles

Concrete pile nearby place, the highest temperature reached 31 ℃, two middle temperature is 16 ℃, far from the border of the temperature of 12 ℃, after 180 days of heat storage process, the effect of energy pile radius of 3.5 m. Near the middle of concrete pile slightly higher temperature than the surrounding concrete pile temperature 0.2 ℃.

This suggests that the energy of pile according to 4 m×4 m spacing configuration, such as running 180 days in a row, thermal interaction of the energy between pile is limited, shows that the impact of regional scope is limited.

Thus it can be seen that when the pile spacing is 4 m, the interaction between the pile is energy, after 180 days of continuous hot storage only 0.2 ℃, if the intermittent storage and its influence will be smaller, pile teenager is conducive to the influence of the energy between the long-term storage of heat and heat removing, at the same time, 4 m pile spacing in the building foundation pile is easy.

CONCLUSIONS

In the cylindrical heat source model, and through the energy pile for 180 days of continuous reservoir simulation and calculation, the author draw the following conclusions :

Heat accumulation effect influence each other is very small, between energy piles, the pile spacing is 4 m, the temperature change of only 0.2 ℃.

Piles of a group of energy overall soil temperature of underground thermal storage effect is relatively small, if the intermittent heat storage mode, in intermittent period, the temperature of the soil will resume, thus increasing the energy between pile and soil temperature, will further improve the efficiency of energy piles.

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