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Basok B. I., Corresponding Member of the NAS of Ukraine, Doctor of Science, Professor
Novitska M. P., Candidate of Engineering Sciences
Belyaeva T. G., Candidate of Engineering Sciences
Riasnova E. V., Postgraduate
Institute of Engineering Thermophysics, NAS of Ukraine, Ukraine

HEAT TRANSFER AND HYDRODYNAMICS OF VERTICAL GROUND PILE HELICAL HEAT EXCHANGER

Recently, low-potential natural heat sources usage for buildings heating has significantly increased. Horizontal and vertical ground heat exchangers are integrated as an additional heat source. One of the types of these technologies is called "energy piles", which is a kind of the vertical ground heat exchanger, as part of the building pile foundation for significant reduction of overall capital costs of setting up such a system. Benefits of vertically located ground heat exchanger include feasibility of using less land area for installation and reducing the weather influence on the thermal state of soil.

Thermal capacity defining is considered to be a major problem in the design of such piles systems. Heat exchanger capacity depends significantly on various factors: hydrogeological conditions of the area, pile depth, numbers of heat exchangers, their location, etc. Most of the known engineering calculation methods use approximate values of specific linear thermal power, which can vary from 20 to 70 watts per meter of pile depth. This wide range of data makes problems whit heat pumps selection.

The goal of this study is to determine temperature-time dependence in vertical heat exchanger, which is coiled in the energy pile in the helicoids form by numerical simulation. The problem has been solved in a three-dimensional transient adjoin formulation. The solution was obtained for one pile positioned in soil array. Array dimension was determined by the nearby piles location. Symmetry conditions for all of the array side faces were specified. At the bottom of the boundary the ground temperature was assumed to be constant and equal the corresponding average annual soil temperature. At the initial time, temperature of soil mass was assumed to be the average annual soil temperature, as well as the temperature of the liquid in the heat exchanger inlet. The liquid temperature in the heat exchanger inlet at each subsequent time step was assumed to be an outlet temperature minus 2 °C, as close as possible to the real heat pumps operation conditions. The pile was placed in an array of clay and loam soil. As a result, the temperature in the collector outlet and temperature field of soil mass were determined.

As the simulation shows internal energy pile temperature reach 1,0 °C on the eighth day of heat exchanger operation with mass flow rate of heat transfer fluid G = 0.095 kg/s. Such condition is unacceptable for energy piles, in view of the fact that internal pile temperature must be higher than 0°C (higher than wet freezing point) for reasons of concrete strength. To prevent pile freezing, heat pump equipment must be occasionally stopped for reaching more uniform heat extracting from soil. Besides that, the equality of input and output heat of soil mass can be obtained via changing of pile locations.