THREE-DIMENSIONAL MODEL OF HYDRODYNAMICS AND HEAT TRANSFER IN THE SOIL SYSTEM - HORIZONTAL GROUND HEAT EXCHANGER - HEAT CARRIER

Bozhko I.K., Basok B.I., Davydenko B.V., Nedbailo O.M., Tkachenko M.V., Novitskaya M.P., Moroz M.V.

Institute of Technical Thermophysics of the National Academy of Sciences of Ukraine, Str. Bulakhovskogo, 2, of. 101, Kyiv, Ukraine, +380444242527

In the application of heat pump plants in the system of heating supply preference is given to low-temperature systems of water underfloor heating. In addition, floor heating provides the most comfortable sanitary and hygienic conditions for the presence of a person in the room.

The aim of the study is to improve the existing and to create a new method for calculating the basic parameters of horizontal ground-based heat exchangers (accumulators) of shallow occurrence, which gives an opportunity to calculate the optimal design and hydraulic mode of operation of the heat exchanger, depending on the type of soil, the power of the heat pump, the available depth of occurrence and the climatic zone.

A three-dimensional numerical model of the temperature state of a soil mass is developed in the course of the work of a ground collector, in which the calculated region having the shape of a rectangular parallelepiped with sides x_{max} = 17 m, y_{max} = 34 m is considered; z_{max} = 7 m. The total length of the collector pipe is 269 m. The inner diameter of the polyethylene pipe is d = 0,028 m. The thickness of the pipe wall δ = 0,002 m. The heat carrier is a 30% water solution of propylene glycol. The values of x_{max}, y_{max} and z_{max} were chosen so that the heat transfer processes to the soil collector minimally affected the temperature conditions on the boundaries of the calculated region.

Results The temperature fields are calculated and built on the height of the soil mass and the temperature distribution along the width of the soil mass at the step between the axes of the adjacent pipelines is 0.95 m. It was found that at such an inter-tube step, the interference of neighboring pipes is small. On the surface of the soil, above the intertubular space, the temperature is reduced by only 0.5 ^{o}C.

In order to evaluate the efficiency of the horizontal collector, it is proposed to use the value of the linear coefficient of heat transfer of this collector as a criterion. The linear heat transfer coefficient is calculated as the ratio of the amount of heat brought to the coolant in the soil per unit time, to the length of the pipeline and the difference in soil temperature at the boundary of the calculated area and the coolant at the inlet to the collector.

Conclusions The three-dimensional model of the soil condition of the soil mass is developed using a horizontal collector, which can be used in the design of the low-temperature contour of heat pump heat supply systems.