Exchange Systems of Buried Ground Source Heat

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1. Introduction

We introduced the calculation method of exchange quantity of ground source heat in the exchange systems of buried ground source heat, and studied the form of heat exchanger and selection of pipe material, the determination of pipe diameter and length and the calculation of borehole distance and numbers.

Key words: ground source heat exchange system, heat exchanger

2. Underground heat exchange calculation

The amount of underground heat exchange in winter and summer can be calculated by the following equation [1, 2]

$$Q_1' = Q_1\left[1 + \frac{1}{COP_1}\right] \qquad (1)$$

$$Q_2' = Q_2\left[1 - \frac{1}{COP_2}\right] \qquad (2)$$

Where, Q_1' is the heat amount of released from the heat pump to the stratum in summer, Q_1 is the total design load of summer, COP_1 is the refrigeration coefficient of heat pump, Q_2' is the heat from stratum in winter,

Q_2 is the total thermal load of the design in winter, and COP_2 is the heating coefficient of the heat pump.

2. Underground Heat Exchanger Design Parameters

When designing an underground heat exchanger, must to accurately determine the type of underground heat exchanger, the method of connection, the material of the pipe, the diameter and length of the pipe, and the number and spacing of the borehole。

- Form and connection mode

There are horizontal and vertical types in the Underground heat exchanger types.

Based on the on-site geological survey data, we determine the installation area, geologic flow type, the cost of borehole, and the type of underground heat exchanger.

When installed horizontally, the initial burying is small because the Pipe is buried in a shallow depth, but its heat exchange performance is lower than that of a vertical installation.

In general, if the installation area is limited, the reclamation Pipe is installed vertically.

There are U Pipe (single U Pipe and double U Pipe) type and spiral Pipe type in vertical buried Pipe type, and it uses a lot of U-shaped in practically.

In the vertical burying pipe type, the deeper the buried depth of the pipe, the better the heat exchange performance. [4]

The underground heat exchanger connection method has a series type and a parallel type.

When the Pipe is connected in series, because of the diameter of the Pipe is large, which is expensive and difficult to install.

However, when the Pipes are connected in parallel, the diameter of the Pipes is small, so that the cost is low and the construction is easy.

Therefore, the parallel method is generally used.

In general, it is difficult to repair or replace the heat exchanger after it is buried in the ground, so the material of the buried

pipe should be chemically stable and not corrosive.

Also, since the length of the Pipe to be buried is long, the Pipe material whose price is relatively low should be selected.

Currently, the most widely used are poly ethylene (PE) pipe and poly butylene (PB) pipes with a service life of more than 50 years. [4]

- Pipe diameter

When using a large diameter Pipe (20 mm or more), there are deficiencies that is consumption of much energy in the circulating pump.

However, in the case of using a small-diameter pipe, there is a merit that the heat exchange effect between the fluid and the pipe wall is improved because the fluid flowing along the pipe is in a state of turbulent flow.

Therefore, a pipe with a small diameter is used in the parallel method and pipe with big diameter only used in collector pipe.

Flow velocity of the fluid in the Pipe should be guaranteed to be 1.22m / s or less.

From this the diameter of the buried Pipe should be 20mm and the diameter of the collector Pipe should be 25, 32, 40, 50mm.

When using large diameter pipes, the flow velocity of the fluid should be guaranteed to be less than 2.44 m / s [1, 2]

- Pipe length

The length of the burying pipe is determined by considering the heat exchange capacity of the pipe material.

Generally, the heat exchange capacity is 35 ~ 55W / m in vertical buried pipe and 20 ~ 40W / m in horizontal buried pipe.

For a vertical buried pipe, the lower limit of the heat exchange capacity is 35 W / m, so the pipe length can be calculated by the following equation [3]

$$\mathrm{L} = \frac{\mathrm{Q}_1' \times 1\,000}{35} \qquad (3)$$

Where, L is the length of the vertical buried Pipe $\mathrm{Q}_1'$is the heat released into the summer stratum.

The number of borehole and the number of borehole are calculated by the following formula [2]

$$\mathrm{N} = \frac{L}{2H} \qquad (4)$$

Where, N is the number of borehole, H is the depth of penetration.

In the case of using a U-Pipe, the distance between the borehole is usually 4.5m.

Depending on the Pipe diameter, the distance between the borehole is slightly different. [3]

Given condition: heating and cooling area of the house is 212m2, summer designing total cooling load is 24.54kW, winter designing total heat load is 16.38kW, and effect coefficient of heat pump is COP1 = 3.3 and COP2 = 7.3.

In this case the design parameters of the submerged underground heat exchange system are calculated as follows

① The amount of underground heat exchange calculated by using equations (1) and (2) is as follows.

$$Q_1' = Q_1\left[1 + \frac{1}{COP_1}\right] = 24.54 \times \left[1 + \frac{1}{3.3}\right] = 31.98(KW) \qquad (1)$$

$$Q_2' = Q_2\left[1 - \frac{1}{COP_2}\right] = 16.83 \times \left[1 - \frac{1}{3.7}\right] = 11.95(KW) \qquad (2)$$

② Polyethylene (PE63) pipe DN20 is connected in parallel.

③ Using the equation (3), the length of the burying pipe is calculated as follows.

$$\mathrm{L} = \frac{\mathrm{Q}_1' \times 1\,000}{35} = \frac{31.98 \times 1\,000}{35} \approx 924(m)$$

④ The depth of borehole is 50m and the number of borehole is calculated by using equation (4).

$$\mathrm{N} = \frac{L}{2H} = \frac{914}{2 \times 50} = 9.14$$

Therefore, the number of borehole is 10, and the spacing between boreholes is 4.5 m.

3. Conclusion

1) When designing a burying underground heat exchange system, the type of subterranean heat exchanger and the mode of operation should be determined according to a job site.

If the installation area is sufficient, it is economical to choose a horizontal type, but if the installation area is limited, the vertical type is reasonable.

2) The material and diameter of the pipe, the number and spacing of the borehole should be selected with a high efficiency of heat exchange even when the cost is low, and convenient for construction.

4.References

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