NEAR-SURFACE GEOTHERMAL SYSTEMS AND THEIR USAGE PROSPECTS

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The principle of the operating cycle of a heat pump was first introduced by Carnot (Nicolas Leonard Sadi Carnot) in 1824. A heat pump is a device that can transfer heat from a lower temperature environment to a higher temperature environment with the addition of external energy. The key feature of the working principle of heat pumps is that the heat pump used for heating in winter can be used for cooling in summer. Air, soil, and water can be the heat source, while any desired environment such as residential and other production buildings can be the heating target.

As mentioned above, the heat pump system uses air, water, and soil as the heat source. Each of these heat sources has its own positive and negative aspects. For example, although air is easily accessible in all geographical conditions, the use of air-source heat pumps is not economically feasible in areas with winter or cold climates. This is because air-source heat pumps will consume more electricity in non-constant temperature environments, especially in low-temperature environments. However, this situation is not observed in water and soil-source heat pumps. Because the heat energy stored in water and soil is a certain amount and remains constant, the operating efficiency of water and soil-source heat pumps remains constant even in winter. It should be noted that soil-source heat pumps consist of three closed cycles:

- Underground heat exchanger cycle
- Heat pump cycle
- Heating cycle

Underground heat exchanger stage consists of pipes placed horizontally or vertically underground to extract heat from the energy source, often containing a heat carrier fluid, such as water or antifreeze. The heat pump stage is an enclosed stage consisting of elements of the heat pump and the working fluid. The heating stage is located in the existing environment, i.e. the living area, and consists of heat emitting water, radiators, and heating distribution equipment.

As noted, the first stage is the underground heat exchanger stage and this stage is related to the underground heat source. Geothermal heat pumps mainly use the soil as a heat source. PE pipes are arranged in open and closed loops at a specific depth in the soil. Geothermal heat pumps are used in water heating, heating of buildings or other residential complexes in winter, and cooling in summer. In winter, the system uses heat energy carried by the collector located in the soil to heat the living area. In the summer, the procedure is the exact opposite, by transporting the heat in the living area to the soil via PE pipes and storing it in collectors to cool the living area.

Geothermal heat collectors in the ground consist of multiple plastic pipes arranged in a surface shape, with a depth of approximately 1-2 meters and a length of several hundred meters (Figure 1). It should also be noted that near-surface geothermal heat pump systems are divided into open and closed systems.

The second stage is the heat pump stage. The heat pump stage is composed of several elements. The elements include the heat pump, compressor, two heat exchanger units (evaporator and condenser), and expansion valve.

In an ideal system, the working fluid first enters the compressor in a saturated vapor form at point 1 (Figure 3). It is compressed isotropically and the pressure increases, causing the temperature of the working fluid to increase in proportion to the pressure. At point 2, the working fluid enters the condenser in a superheated vapor state and releases its thermal energy to the external environment (refrigerant). This causes it to lose its temperature and transition from the gas phase to the liquid phase. However, despite losing its temperature, the temperature of the working fluid at point 3 is still higher than that of the surrounding environment. Then it enters the expansion chamber and the pressure is reduced. The working fluid loses its temperature as the pressure decreases. At point 4, the working fluid enters the evaporator with a lower pressure and temperature as a vapor. In this environment, it instantly vaporizes from the liquid phase to the gas phase and enters the compressor again in a saturated vapor state at point 1, completing its cycle.

The third stage is the heating stage. As we mentioned, this stage is located in the residential area. The heat carrier fluid transfers heat energy from the heat exchanger to radiators and heating distribution devices. Thus, there is a closed loop between these devices.

The use of geothermal energy for heating purposes requires significant initial investments. Before planning the system, measures to reduce potential thermal losses should be implemented. Thermal insulation measures are highly recommended for reducing thermal losses directly, such as insulation of roof and facade, high-quality thermal insulated windows, etc. Floor and wall heating systems significantly improve the economic efficiency of the heating system. It should be noted that a concrete-based wall with a temperature of 35°C and a floor that is insulated against heat with a temperature below 25°C are more economical than 55°C radiators (supplied by a heat pump) from an economic point of view.