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Feasibility Investigation of the Low Energy Consumption Cooling Mode with Ground Heat Exchanger and Terminal Radiator

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Abstract

Due to its huge heat capacity, ground can provide heat source in winter and heat sink in summer as the so called shallow geothermal energy, which is mainly utilized by the ground coupled heat pump system. In fact, free cooling can be provided by circulating water between the ground heat exchanger (GHE) and the indoor terminal directly. Recently, radiator for cooling developed rapidly due to it possesses high energy efficiency and comfortable level, however, condensation arises if entering water temperature is lower than dew point of the ambient air. Therefore, this study proposes a low energy consumption cooling mode by combining the GHE and the terminal radiator to utilize the ground cooling directly and to prevent the condensation problem of terminal radiator. The simulation model of this novel mode is established, and the feasibility of this low energy consumption cooling mode is analyzed based on simulation results.

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Keywords: Low energy consumption; cooling mode; ground heat exchanger; terminal radiator

1. Introduction

Since its huge heat capacity, the ground obtains a nearly constant temperature equals to the annual average dry bulb air temperature just below the surface around the whole year. Compared with ambient air, the ground is warmer

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in winter and cooler in summer with temperature usually below 20℃ [1]. Ground can provide free heat source in winter and free heat sink in summer as the so called shallow geothermal energy, which is mainly utilized by the ground coupled heat pump (GCHP) air conditioning system [2]. For cooling provision of the GCHP system, the condenser of heat pump unit will reject heat into ground by circulating cooling water between the condenser and the ground heat exchanger (GHE). Then the cold water with low temperature is produced by evaporator and sent to fan coil units inside air conditioning room. In fact, the ground temperature is lower than the required indoor air temperature. Free cooling can be provided by circulating water between the GHE and the indoor terminal directly.

Recently, floor radiator for cooling which consisted with an embedded cooling pipe system integrated with the building floor construction developed rapidly due to it possesses high energy efficiency and comfortable level with entering water in relative high temperature. [3-5] Radiant cooling system directly transfer heat in order to condition a space to a specific temperature, and can also be used to directly provide heat to humans as well as to spaces. For radiant cooling mode, the same comfort level can be maintained with a higher air temperature compared with convective cooling. But disadvantage of this technology is the condensation problem for entering water temperature lower than dew point of the ambient air [6].

Therefore, this study proposes a low energy consumption cooling mode by combining the GHE and the floor radiator to utilize the ground cooling directly and to prevent the floor condensation. The simulation model of this novel mode is established, and the feasibility of this low energy consumption cooling mode is analyzed based on simulation results. The proposed cooling mode can maintain the comfortable temperature circumstance with low energy consumption for buildings located in regions hot in summer and cold in winter. It should be noticed that, the independent dehumidification equipments should be included for buildings with high dehumidification requirement.

2. System of low energy consumption cooling mode

For utilizing the ground cooling directly to obtain the low energy consumption cooling, the proposed cooling mode circulates water between the outdoor GHE and the indoor floor radiator by a low-power circulating pump. In order to diminish the effect of surrounding air, the vertical borehole GHE is selected. Besides, a heat pump unit is installed to ensure the cooling provision of system in extreme hot weathers. As shown in Fig. 1, valves 1 and 1’ are open and valves 2, 2’, 3, 3’ are close for normal low energy consumption operation to circulate water between GHE and floor radiator. In extreme hot weathers, valves 2, 2’, 3, 3’ are open, valves 1 and 1’ are close, and heat pump unit is activated to handle the cooling load. Data acquisition system consists of the temperature, the flow rate and the power consumption acquisition systems are installed. The temperature of water entering the floor radiator should be monitored for guaranteeing the cooling effect and for preventing the floor condensation.

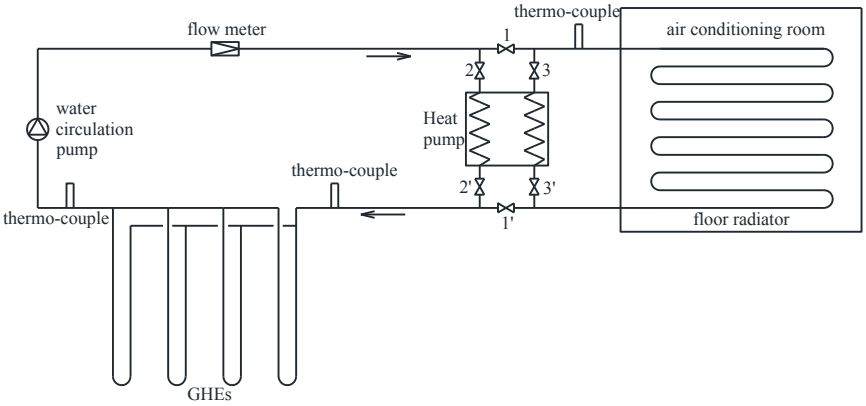

Fig. 1. System with low energy consumption cooling mode.