MONITORING SYSTEMS FOR THE LONG-TERM PERFORMANCE ASSESSMENT OF GEOTHERMAL HEAT PUMP SYSTEMS IN KIGAM

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ABSTRACT

Three geothermal heat pump (GHP) systems were installed in recently constructed buildings in Korea institute of geoscience and mineral resources (KIGAM). The first GHP system and its monitoring system were installed in the A2 building, and they have operated and been monitored since 2006. This vertical closed-loop GHP system comprises 79 heat pumps, 4 fluid pumps, and 28 borehole heat exchangers (BHEs). The second GHP system installed in the A1 building have operated since 2015 and been monitored since 2017. This vertical closed-loop GHP system comprises 10 heat pumps, 5 fluid pumps, and 50 BHEs. Each BHE consists of a closed circuit with a single U-tube in a grouted borehole 200 m deep. The newest GHP system installed in the KIGAM SPOREX building is currently under construction and will be finished soon. This experimental hybrid open/closed-loop GHP system consists of two heat pumps, one circulation pump for the closed-loop system, one well pump for the open-loop system, and three boreholes without grout.

Keywords: geothermal heat pump system, monitoring

1. INTRODUCTION

Geothermal energy, one of the new and renewable energy, has until recently had little economic potential except in areas where high-enthalpy geothermal energy resources, i.e. thermal water or steam, are found. This has lately changed with developments of geothermal heat pump (GHP) systems, sometimes referred to as ground-source heat pump (GSHP) systems, using low-enthalpy geothermal energy resources for heating and cooling purposes. They use the almost constant temperature of the shallow ground as the exchange medium instead of the outside air temperature. This allows that the electrical efficiency of the GHP system is better than that of the air-source heat pump (ASHP) system because ground temperature is higher than air temperature in the heating season and is lower than air temperature in the cooling season.

There are three basic types of GHP systems: (1) closed-loop systems; (2) open-loop systems; (3) standing column well systems. The closed-loop GHPs (Figure 1) circulate a mixture of water and antifreeze through a closed loop that is buried underground. The loop tubing can be installed horizontally as a loop field in trenches or vertically as a series of long U-shapes in boreholes. The open-loop GHP system produces groundwater directly from wells. Once the produced groundwater has circulated through the system, it returns back to the ground through injection wells or is discharged into the surface. The standing column well (SCW) system is a specialized type of open loop system. Groundwater is produced from the

bottom of a deep well, passed through a heat pump, and injected back to the top of the well, where flowing downwards it exchanges heat with the geologic medium or groundwater. Figure 1 shows schematic diagram of the GHP system with three core components, boreholes and pipes, heat pump, and circulation pump.

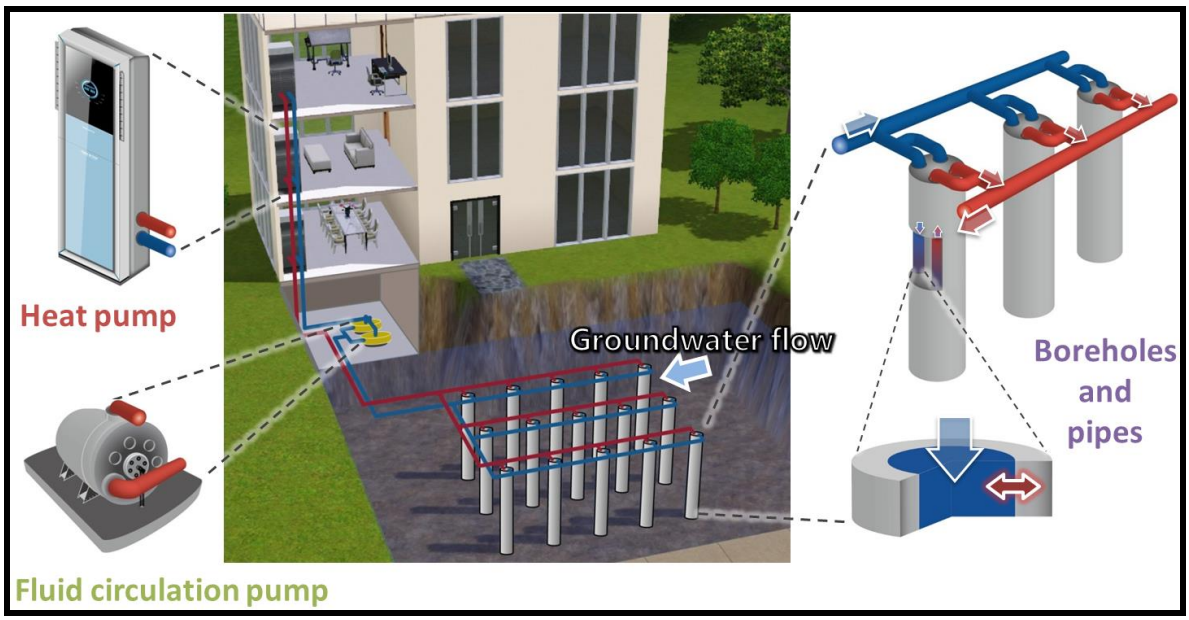

Fig. 1 Schematic diagram of the vertical closed-loop GHP system with three core components. Simulations of the vertical closed-loop GHP system that consists of multiple BHEs can be feasible

2. GHP SYSTEMS IN KIGAM

The Korean government has adopted subsidy programs and Mandatory Acts for the new and renewable energy. As a result of government funding and regulations, three GHP systems were installed in recently constructed buildings in our Institute (Figure 2). The first GHP system and its monitoring system were installed in the A2 building, and they have operated and been monitored since 2006. This vertical closed-loop GHP system comprises 79 heat pumps, 4 fluid pumps, and 28 BHEs. There are 16, 31, and 32 heat pumps on the first, second, and third floors of the A2 building, respectively. Three fluid pumps supply the circulating fluid to the heat pumps on each floor and to the BHEs. The fourth fluid pump is an auxiliary fluid pump. There are 8, 10, and 10 BHEs connected to the heat pumps on the first, second, and third floors, respectively under the yard of the A2 building. The dimensions of the BHE field are 35 m from east to west and 42 m from north to south. Each BHE consists of a closed circuit with a double U-tube in a grouted borehole 200 m deep. To measure the temperature and flow rate of the circulating fluid at the BHE inlet and outlet, monitoring equipment has been installed for three BHEs. The second GHP system installed in the A1 building have operated since 2015 and been monitored since 2017. This vertical closed-loop GHP system comprises 10 heat pumps, 5 fluid pumps, and 50 BHEs. Each BHE consists of a closed

circuit with a single U-tube in a grouted borehole 200 m deep. The monitoring system for the A1 building consists of thermometers and flowmeters to measure temperatures and flow rates of the circulating fluids connected to each heat pump and wattmeters to measure electric powers of each circulation pump and heat pump. The newest GHP system installed in the KIGAM SPOREX building is currently under construction and will be finished soon. This experimental hybrid open/closed-loop GHP system consists of two heat pumps, one circulation pump for the closed-loop system, one well pump for the open-loop system, and three boreholes without grout. A borehole named "Geothermal well" is equipped with both the U-tube for the closed-loop system and well pump and pipes for the open-loop system.

Fig. 2 Three buildings (A1, A2, and SPOREX) equipped with GHP systems for cooling and heating purposes in KIGAM