A Study on the Operation Method of Geothermal Heat pump system for Improvement of Energy Efficiency

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ABSTRACT

The objective of this study is to show the operation method of geothermal heat pump(GHP) system to improve energy efficiency through the TRNSYS simulation. The case study building is a hospital with a GHP total capacity of 530RT. Existing operation method of GHP is to set temperature of supply chilled water to 7℃ in summer. This paper proposed two operation methods: (1) GHP control according to COP(coefficient of performance), (2) GHP control according to indoor temperature, (3) GHP control according to indoor temperature.The result of the simulation is that proposed operation method was less consuming energy than existing operation method. (3) GHP control according to indoor temperature. The result of the simulation is that proposed operation method was less consuming energy than existing operation method.

KEYWORDS

Geothermal heat pump system, Absorption chiller-heater, Hybrid-operation, TRNSYS, Building energy

INTRODUCTION

The supply rate of renewable energy has been increasing under the influence of an energy scarcity. Government has supported the use of renewable energy by government subsidies. The operation of renewable may not been operating appropriately, although increasing the use of renewable energy. Geothermal system among the renewable energy is getting the spotlight now that it is highly efficient and safely operable without effect of outdoor air. Also, it is one of the oldest renewable energy resources in the world, it supplies the most energy. However, we found out some problems of the operation of renewable energy and offered some improvements. Geothermal energy is only in charge of the part load of the building due to the high initial installation cost and it is reduced efficiency due to use independent of existing

heat sources. Accordingly, A study on geothermal heat pump (GHP) systems is on-going research about increasing the efficiency of the underground heat exchanger and performance evaluation. However, complex operations about renewable energy and an existing heat sources is insufficient research. Complex operations combined solar heat and GHP is studying in Korea and abroad. Other people study (Hwang 2006, Nam 2012, Ozgener 2004) on solar heat and GHP systems suggested efficient way of operation through performance analysis. (Jeon et al. 2010)'s study showed use of the GHP system energy-efficient should be a priority but study on methods of complex operation was inadequate. In this study, after selecting the building installed actual GHP, maximize use of excellent GHP systems in terms of energy efficiency and will propose and evaluate control methods of complex operation about existing heat sources systems and GHP systems.

RESEARCH METHODS

In this study, buildings were selected where a GHP was applied, and a study of a hybrid operation method with an existing heat source was conducted. This study evaluated the operational problems and offer improvement of the buildings with a geothermal system. These problems and potential solutions were evaluated by simulations. This study evaluated the hybrid operation plan of a geothermal source heat pump system used as the heat source and an absorption-type chiller-heater. The building was located in a large university hospital. The proposed improvements for one building with an installed geothermal system were assessed by simulation.

BUILDING INFORMATION

Figure 1. *Exterior of the building*

The building is K-university hospital located in Chilgok, Gyeongbuk, and figure 1 shows Exterior of the building. As shown table 1, the building is with three stories below and nine above the ground and is installed geothermal heat pump 530RT as renewable energy. Tables 2 list the heat pump equipment used.

Table 1. *Summary of the building*

Building name	Gyoungbuk university hospital
Building stories	A building with three stories below and nine above the ground
Building area	9,737 m^2
Total floor area	81,928m^2
Geothermal heat pump system area of installation	2,263 m^2
Installed capacity of geothermal heat pump systems	530RT

Table 2. *Heat pump data information*

Equipment number	GH-1		GH-2	
Quantity	11		1	
Capacity(RT)	Cooling	Heating	Cooling	Heating
	46.24	48.86	9.86	9.99
EST(℃)	31	5	31	5
Supplied temperature(℃)	7	45	7	45
Return water temperature(℃)	12	40	12	40

DEVELOPMENT OF THE CONTROL STRATEGY

Operation method is suggested that use maximize as energy efficiency of GHP systems increase.

(1) Existing operating status (case 1-1*)

The problem with the existing operation method due to oversizing of the air handling unit fan airflow not maintained the indoor set temperature(24℃±1 C). Afterward, the phenomenon super cooled occurred in operating space. The solution using equation 1 make fan air flow according to cooling load in the summer reset, set the case 1. Table 2 presents reset points of fan air flow. where m is airflow, Qmax is indoor load, C is specific heat and ΔT is Supply air temperature difference.

$$m = \frac{Q_{max}}{C\Delta T} \qquad (1)$$

where m is airflow, Q_{max} is indoor load, C is specific heat and ΔT is Supply air temperature difference.

Table 3. *Reset the air conditioner fan air flow*

Unit: kg/hr	AHU1	AHU2	AHU3	AHU4	AHU5	AHU6	AHU8
Design airflow	51840	19200	32640	49200	38400	25200	36000
Airflow Reset	42000	24000	14000	27000	28000	17000	24000

(2) Reset of AHU air flow (case 1-1)

Indoor set temperature(24℃±1℃) and make being maintained as AHU supply air flow reset. GHP of the building operates to fit return water temperature to the set point and accordingly operates on/off control. However, unnecessary energy is wasted to fit set temperature of cooling water although load of room not be occurred.

Geothermal Heat Pump System Independent Operation Plan

Operating in existing method, regardless of the outside temperature when the air conditioner and heat pump to the load side of the return temperature is fixed to be 7℃. However, the return temperature in the load side in order to keep the unnecessary energy is generated. Thus increasing the efficiency of the heat pump system to reduce energy consumption and propose operation plan.

(1) Outdoor Reset Control (CASE1-2)

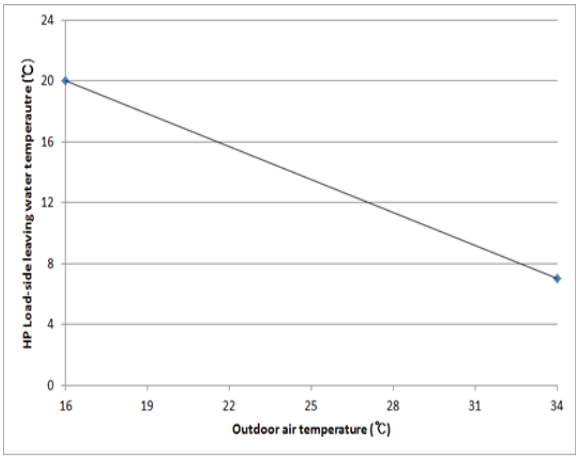

Figure 2. *Outdoor reset control curve*

As the outside air temperature changes in temperature of the cooling supply water supplied to the room proportionally changing outdoor reset control of the single-case propose. Figure 2 is caused by a change in outside temperature chilled water supply temperature change of the set value is shown in Figure. Outdoor temperature(16℃~34℃) by the change of the load side return temperature(7℃~20℃)is changed. This temperature change is inversely related to the outdoor reset control characteristics.

(2) The Sequential Control According to COP (CASE1-3)
Each geothermal heat pump was the best on the basis of the COP. And sequential control of the geothermal heat pump depending on COP monitoring is performed. Energy consumption of geothermal heat pump and on result analysis the relationship between COP, using less energy and high efficiency are revealed when the COP is 3.8. So when maximum COP exceed 3.8, sequentially turn on the heat pump heat pump efficiency for each to be in good condition.

(3) The Sequential Control According to room temperature (CASE1-4)
If return temperature of geothermal heat pump is controlled, operated irrespective of the load in the room. When that case waste of energy generation or IAQ problem can occur. So if temperature of room set 24℃ mistime setting temperature, One each to add a heat pump to operate the proposed scheme. Monitoring the interior temperature of the heat pump is operating if the sequence, can be controlled to match the actual load. So reduce wasted energy also IAQ are able to fit.

SIMULATION RESULTS AND DISCUSSION

Simulation Tool

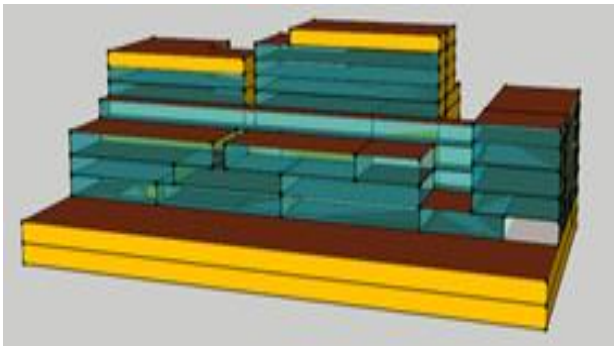

Figure 3. *\ Building modeling using the Sketch Up program*

Building modeling was modeled like Figure 3 used TRNSYS 3D of Google Sketch up. Using the TRNBUILD modeling and TRNSYS Studio modeling, the details of building are entered. So HVAC system was implemented.

Simulation Result

Figure 4 shows in each case the energy consumption of GHP. Comparing to the existing operation method, case 1-2 was reduced approximately 16% energy and case 1-3 was reduced approximately 32%. In the case 1-4 of a sequential control according to the room temperature reflects directly the room load, energy consumption of approximately 56% was reduced comparing to the existing operation method.

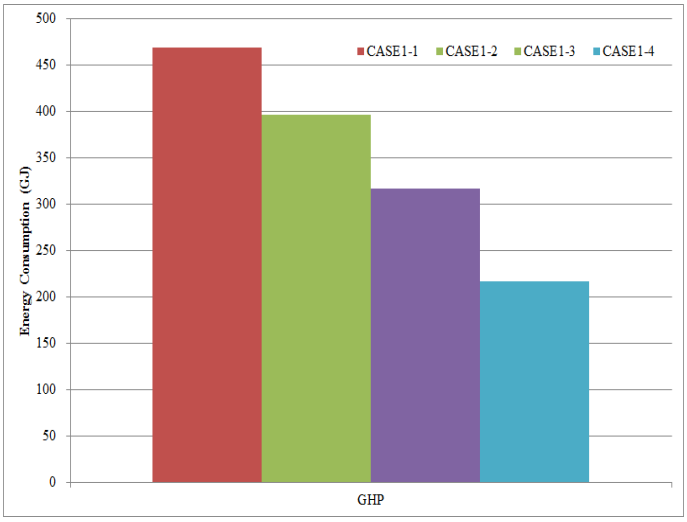

Figure 4. *Comparison of the energy consumption for a single geothermal system.*

Figure 5 shows the result of analyzing COP of GHP in each case. In the case 1-1 COP is maximum 3.1. Now that energy waste occur in order that the cold water temperature set to 7℃, outdoor reset control is applied. Consequently, in the case 1-2 is COP maximum 3.8 appears to be higher than the existing. In the case 1-3 is COP according to the sequential control one each on the basis of 3.8. Therefore, CASE1-3 geothermal heat pump COP is maximum 3.8. In the case 1-4 directly reflect the room load, COP is maximum 4.2. The good performance of the device goes from CASE1-1 to CASE1-4. In addition, Since the control method for directly reflect the load is expected to increase the efficiency in terms of energy saving.

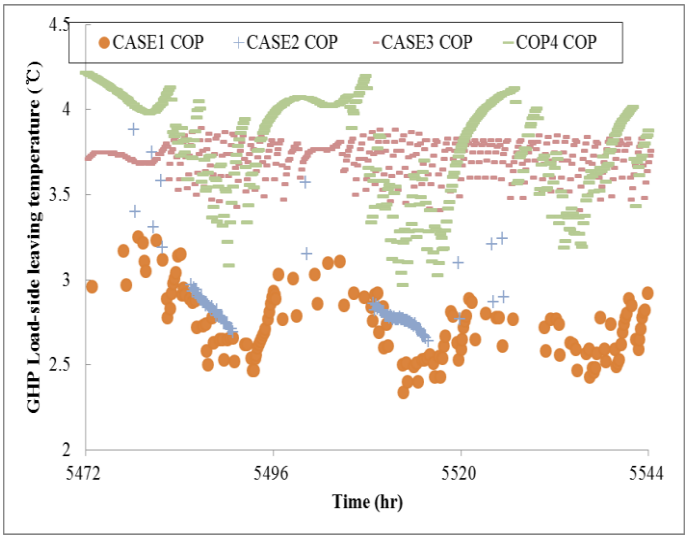

Figure 5. *Comparison of the COP for a single geothermal system.*

CONCLUSION AND IMPLICATIONS

Operation of the current problems of geothermal heat pump system is investigated. Results, efficient application was not done. In this study, the efficiency of a geothermal heat pump system to maximize the operation plan is suggested. And

evaluation was performed through simulation, the conclusion of this study is as follows.

(1) Existing operating plan was not right to maintain the set temperature in the room due to air conditioner fan airflow exaggeration design. So over cooling phenomenon occurred in the room at air-conditioning. The solution of fan airflow to the cooling load was reset.

(2) The Geothermal Heat Pump Building operates to fit the setting to the load side return temperature. Accordingly, on / off control was performed. But even if no air-conditioning load to fit in the chilled water temperature setpoint operated. Therefore, unnecessary energy was consumed. Control plan is needed to solve.

(3) According to outside air temperature changes, temperature of the supply water(chilled) proportionally changing outdoor reset control is proposed. Therefore, the proposed plan in comparison with existing plan was possible to save energy.

(4) Based on optimal COP of each geothermal heat pump, sequential control of geothermal heat pump was performed according to COP monitering. Energy consumption of geothermal heat pump analyzed the relationship with COP. Result, when COP is 3.8 less energy use and high efficiency appeared. The simulation results, compared to the existing operation plan can be 32% energy saving.

(5) In case of the return temperature of the geothermal heat pump be controlled, a waste of energy occurs regardless of the indoor load operation. Therefore, the actual load directly reflects the room temperature monitoring control is proposed. As a result, the high energy consumption was reduced in the heat pump control system.

(6) The proposed control plan is evaluated after apply to the building. The efficient operation of geothermal heat pump system should be to enable .

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