

A study on Control of Geo-thermal System for Efficient Operation

Si-Wan Yu¹, Soo-Hyun Kang¹, Jae-Hun Jo², Yong-Shik Kim³, Young-Hum Cho^{4*}

¹Department of Architectural Engineering, Kumoh national institute of technology, Gu-mi, Gyeongbuk, Korea,

² Division of Architecture, Inha University, Incheon, Korea

³ Department of Architectural Engineering, University of Incheon, Incheon, Korea

⁴ School of Architecture, Kumoh national institute of technology, Gu-mi, Gyeongbuk, Korea,

ABSTRACT

An energy scarcity problem is a topic all over the world. According to this point, attempts are being made to decrease energy consumption. Usage of renewable energy is continuously increasing, but the energy is not operating properly. Therefore, in this study, we offered an improvement and implemented simulation of offered improvement after selecting one building installed geothermal system and finding the problem on operating system. The result of the simulation is that existing operation method was more consuming energy than offered operation method.

KEYWORDS

Geothermal system, proportional control, valve position

INTRODUCTION

Renewable energy diffusion is increasing because of energy scarcity. But we can't insist on decreasing energy consumption by increasing renewable energy diffusion. Most geothermal systems have a problem. The main cause of problem is separation of geothermal system and existing system. This study is basic phase for improving use of renewable energy. The object of this study is to find operational problems and offer improvement.

RESEARCH METHODS

To figure out the operational problem of geothermal system, we first select a building installing GSHP, and analysis current operation of GSHP. Then we offer an improvement to operate efficiently. To prove the effect of the improvement that we offered, we simulate it by using TRNSYS program. According to the simulation results we will find out that existing operation is more consuming energy and offered operation method works.

* Corresponding author email: yhcho@kumoh.ac.kr

RESULTS

Building summary

The building we select is located in chilgok-gun, gyoungbuk, korea, and is large scale hospital. As **Table 1**, The building area is about $9,737\text{m}^2$, and total floor area is about $81,928\text{m}^2$. This hospital is composed of three buildings, first one of the buildings is cancer center and second one is main building, the other is for older people. The in front of the hospital is curtain-wall system. This building has been operated since 2010. GSHP and absorption chiller-heater are using for heating and cooling. **Figure 1** shows the exterior of this hospital.



Figure 1. The exterior of hospital

Table 1. Summary of the hospital

Building name	Gyoungbuk university hospital
Building area	$9,737\text{m}^2$
Total floor area	$81,928\text{m}^2$
Use	Medical facility
Number of bed	502

Analysis of existing operation condition and improvement

Heat source system of this building is GSHP and Absorption chiller and gas boiler. But each system is totally separated. The operation of heat source system is controlled by BEMS (Building Energy Management System). In case of GSHP operation is controlled by supply water (chilled or hot) temperature as shown **Figure 2**. The control by supply water temperature is reflecting conditioning space's load indirectly. But, in case of this control, GSHP is continuously operating under very light building load to meet set-point even if thermal loss is caused by chilled or hot water pipe. Also the narrow range of set-point causes many on/off phenomenon of each heat pump. Therefore cooling and heating energy is wasting continuously. Actually, building facility operators turn on/off GSHP checking coil valve's open and close status. Through field study, we also found that there's frequent on-off status. This phenomenon may make heat source system malfunctioned.

Based on existing condition, we offered an improvement on operational side. It is that GSHP operation is controlled by valve's open and close status automatically.

This method is using BEMS data. Because valve's open and close status is monitored by BEMS, and GSHP is able to be controlled by valve position. If valve position is lightly open, just one GSHP would operate. And if valve position is almost open, all GSHP would operate. I expect this method can save energy consumption.

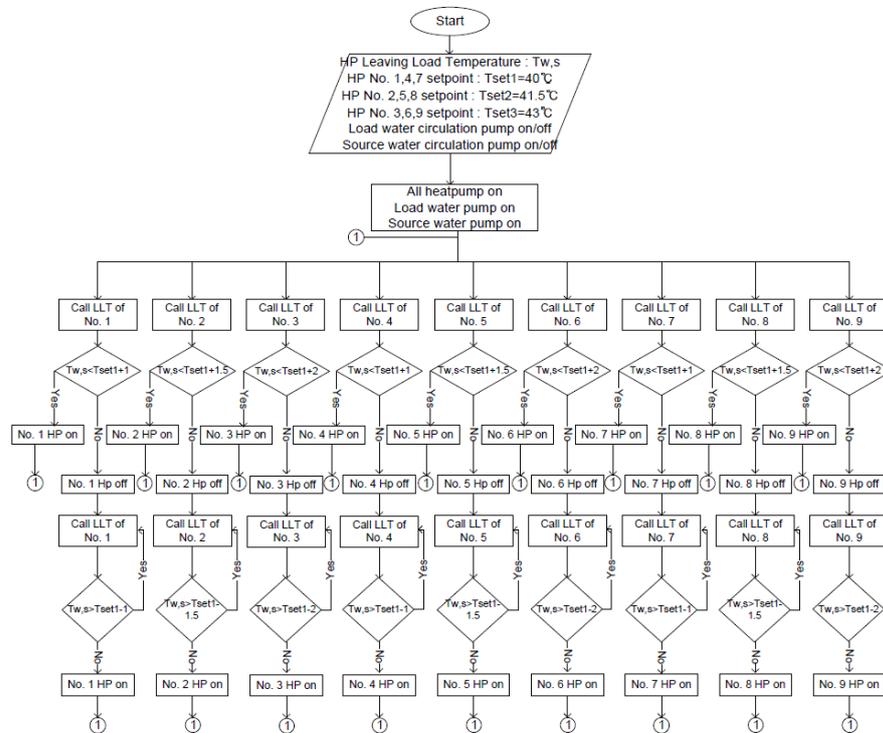


Figure 2. Control algorithm of GSHP

Simulation & Results

For simulations, TRNSYS tool is used. Simulation period is winter, because we only have heating operation data of the hospital. With Sketch up program by Google, we modelled the building and only GSHP system as **Figure 3**. The weather data is Ulsan, Korea.

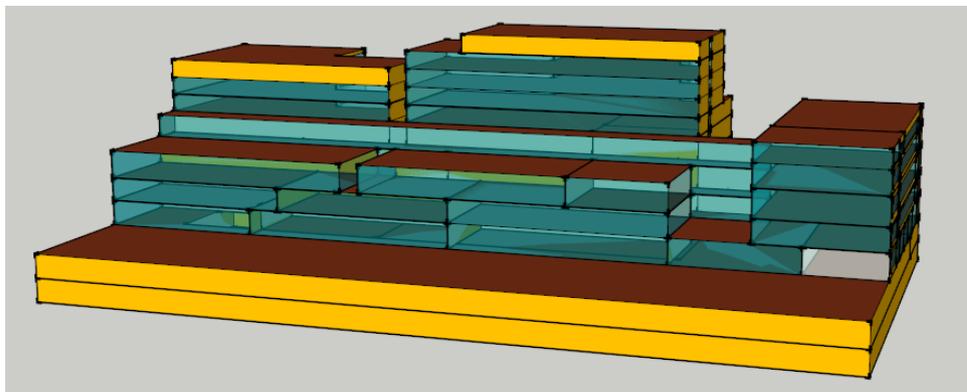


Figure 3. Building modelling by sketch-up

We have three simulation models as follows.

The first simulation is to model existing operation condition as shown **Figure 4**. As above **Figure 2**, each GSHP is controlled by supply water(chilled or hot) temperature. To model this control, Type 2d of TRNSYS is used. And to model AHU system, Type753d(Heating coil) and Type3c(Fan) is used. Type557a is a vertical ground heat exchanger. In case of water to water heat pump, Type927(Water-water heat pump) is used. To control valve position, Type1669(Proportional controller) is used. In short, the supply water from heat pump distributes to cooling and heating coils of AHU system. Each heat pump is controlled by supply water temperature. For the first simulation, total conditioning energy consumption is about 6,613,906 MJ. Also there's a lot of frequent on/off as I expected.

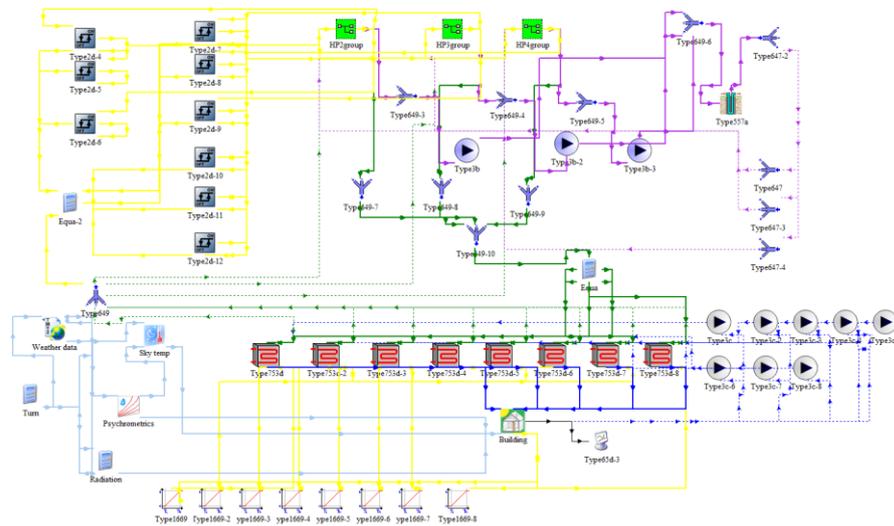


Figure 4. Trnsys modelling of first simulation

The second simulation is to model based on the first simulation model adding the second simulation model as shown **Figure 5**. An equation component was added compared to the first case. Operation number of heat pump is controlled through the added equation which getting signals from all Type1669. This case is a combination supply water(chilled or hot) temperature and valve position control. Compared to the first simulation, this simulation operates depends on building load. Therefore, total building load is divided to specific heat pumps while the first simulation operates all heat pumps all the time. Proper operation number of heat pump made energy consumption decreased. Total conditioning energy consumption of second simulation is about 5,909,340MJ.

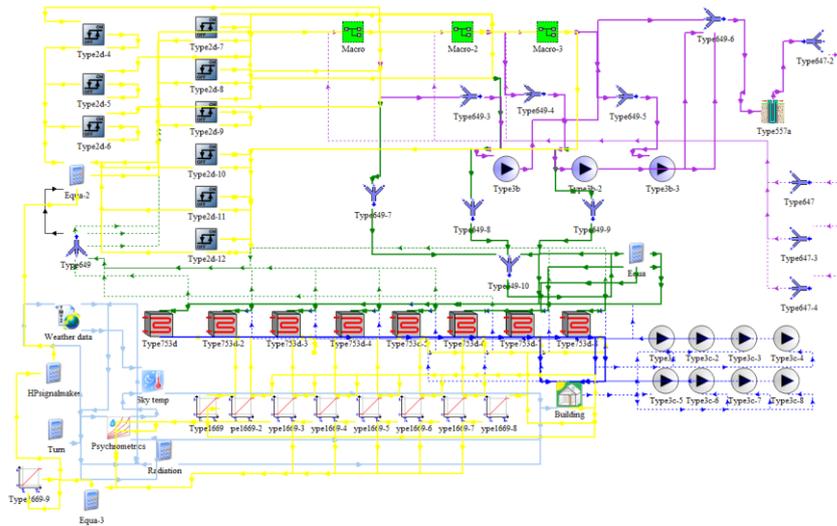


Figure 5. Trnsys modelling of second simulation

The third simulation is to model offered operation condition like **Figure 6**. Contrary to the first simulation causing lots of heat pump on/off (because of difference set-point and range of each heat pump), GSHP control of this simulation fixed set-point of each heat pump. Number of operation is in order by valve position with time delay. The third simulation uses valve's open and close status, time delay. To implement this proportional and time delay control, Type 1669 and 973 of TRNSYS is used. Total conditioning energy consumption of the third simulation is about 5,552,327MJ. There's no big decrease compared with second simulation. But, this second simulation had a few heat pump's on/off because proportional control by valve position was performed.

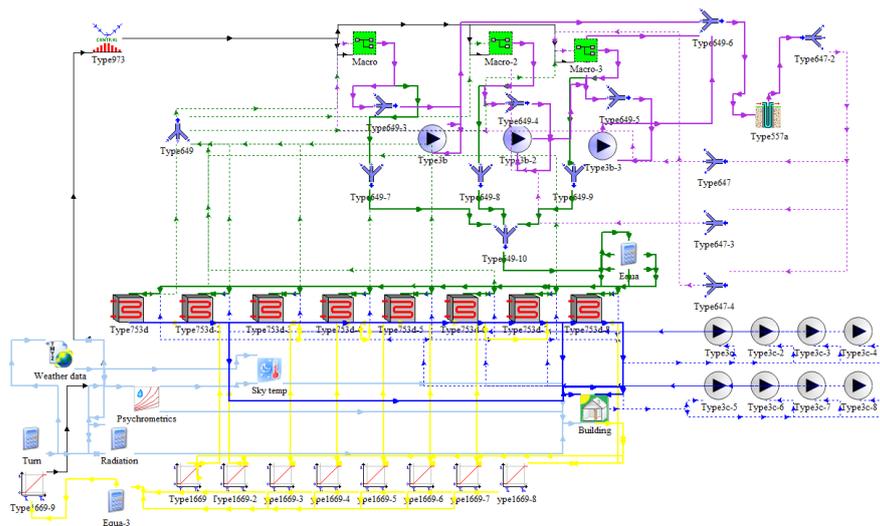


Figure 6. Trnsys modelling of third simulation

The main result of three simulations is that the energy consumption of second simulation was about 6% and third simulation was about 13% less than existing operation condition as shown **Figure 7**. The frequent on/off of GSHP is also decreased because offered condition operates GSHP in consecutive order while existing condition operate GSHP independently based on each supply water(chilled or hot) temperature.

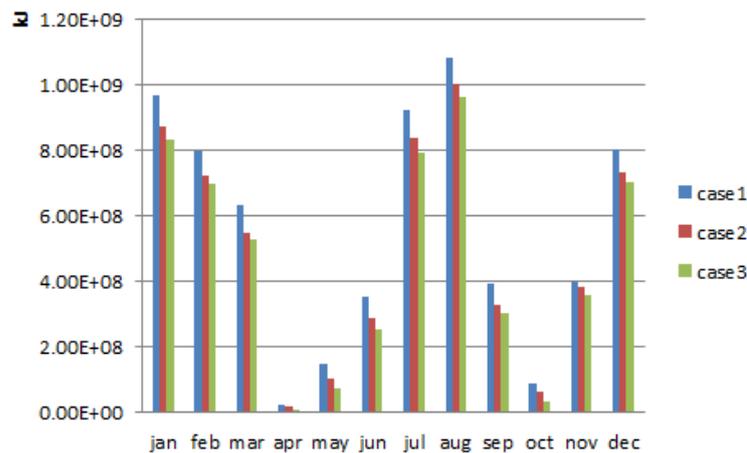


Figure 7. Energy consumption of each simulation

DISCUSSION

In this study, we found the problem of current operational condition. Although under very light building load, the heat source system operates continuously. So, we have to recognize that we are wasting energy and find a better way to decrease energy consumption and use GSHP efficiently.

The operation method we offered may have a problem in system's efficiency. COP of each GSHP may fall because this method is regardless of supply water temperature. In a short way, for heating condition, if return water temperature is high, GSHP would often operate. In next study, we must check and consider COP of GSHP for efficient operation.

CONCLUSION AND IMPLICATIONS

In many places, geothermal system is used, but almost system operates inappropriately. Therefore we need to change the operation condition to improve use of geothermal system. We offered operation condition, and we assured that had an effect on energy consumption.

This study is a basic phase to use complex heat sources system efficiently. Based on this study, we will study on optimal utilization of renewable energy such as wind, geothermal and solar energy with other heat source and electric source systems.

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