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OPTIMAL CONTROL OF MAKEUP AIR UNIT COILS IN AN EXISTING BUILDING

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ABSTRACT

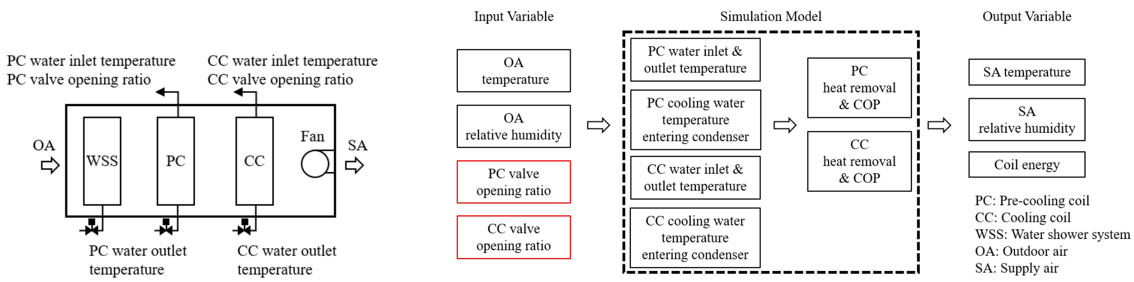
This paper reports an optimal cooling control strategy of an makeup air unit (MAU) in an existing building. The authors developed a physics-based simulation model that can predict supply air temperature and humidity leaving two cooling coils as well as cooling energy consumption of a chiller. The control variables in this study are valve opening ratios of the two coils. With the use of the simulation model, the authors could suggest energy saving by 9.1%.

1 INTRODUCTION

The performance of an makeup air unit (MAU) system influences energy consumption and indoor air quality (Tashtoush et al., 2005). In most existing buildings, the MAU system is operated as a fixed operation scheme such as keeping a constant damper opening ratio, a valve opening ratio, etc. In this study, the authors aimed to develop a simple MAU simulation model and apply it to optimal control strategies of an existing building. The MAU system in the target building is located in South Korea and is equipped with a water shower system (WSS), a pre-cooling coil (PC), and a cooling coil (CC) as shown in Figure 1.

2 MAU SIMULATION MODEL

The control variables are the valve opening ratios of the PC and CC. According to operation log data, the existing control by the building's facility team used a fixed PC valve opening ratio of 65%, while the CC valve opening ratio continuously varies depending on the building's cooling demand. In addition, the water shower and supply air fan operate all the time during working hours. For the development of the MAU simulation model, the authors used a simple UA model suggested by US DOE (2022) and the manufacturer's specification data. The coil's UA is calculated from its state as defined in US DOE (2022) such as *'Wet', 'Dry', 'Partly Wet' 'Partly Dry'* that was estimated from air dewpoint temperature, coil's water inlet temperature and air inlet coil surface temperature. Then, the chiller's COP was obtained based on the calculated coil's water outlet temperature and measured cooling water temperature entering condenser. In order to find optimal control variables, both coils' opening ratios were discretized in 5% interval from 40% to 100% and an exhaustive search method was used (13×13 = 169 control variables).

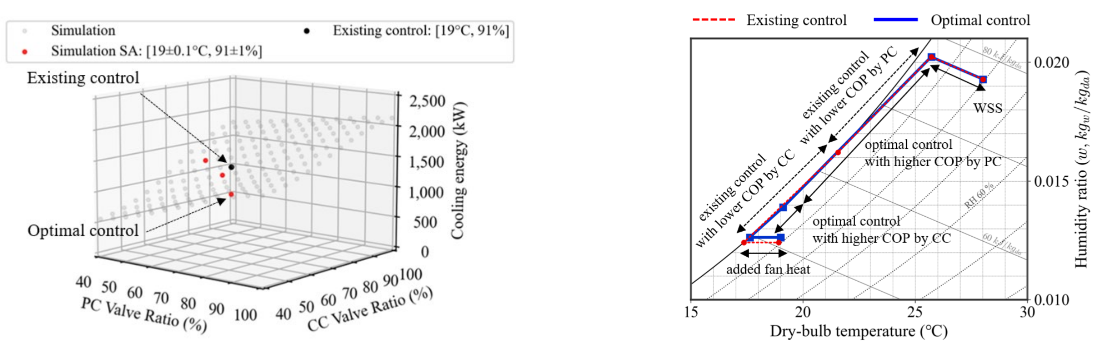


(a) MAU's physical configuration (b) MAU simulation model

Figure 1: MAU's physical configuration and simulation model (□: Control variable).

3 RESULTS AND CONCLUSION

Figure 2(a) shows an example of how the optimal control variables were chosen. The red dots in Figure 2(a) represent the possible valve opening ratios of the PC and CC that can produce the same/similar SA condition (19℃, 91% relative humidity) generated by the existing control (denoted by the back dot in Figure 2(a)). As shown in Figure 2(a), the optimal control variables (PC valve: 85.0%, CC valve: 45.0%) could save energy by 9.1%. Figure 2(b) shows the supply air's psychrometric paths of the existing and optimal controls. The physical paths of the two controls seem almost identical. The difference is that compared to the existing control, the optimal control strategies keep the chiller operating at higher COP caused by chilled water outlet temperature and part load ratio (PLR) (Table 1), resulting in energy savings of 9.1%.



(a) Cooling energy with two valves' opening ratios (b) existing control vs. optimal control

Figure 2: Optimal control strategies of MAU.

Table 1. Heat removal and energy use between existing and optimal control.

	Existing control			Optimal control		
	Heat removal	Energy use	COP	Heat removal	Energy use	COP
PC	5,235 kW	700 kW	7.5	8,257 kW	1,028 kW	8.0
CC	5,075 kW	647 kW	7.8	1,696 kW	197 kW	8.6
Total	10,310 kW	**1,347 kW**		9,953 kW	**1,225 kW**	

ACKNOWLEDGEMENTS

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