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ESTIMATION OF EXCESSIVE HVAC ENERGY CONSUMPTION DUE TO FAULTY VAV UNITS

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ABSTRACT

The present paper investigates, both experimentally and by simulation, the influence of faulty VAV units that do not affect the zone temperature on total energy consumption of a VAV system. In an experimental room, the respective total energy consumptions of both normal operation and faulty operation were measured. The results indicate that a faulty unit affects other normal units, causing an energy waste of approximately 20-50%. In addition, the present paper also discusses whether the additional energy consumption can be calculated via the simulation of the VAV system in the experimental room. The results indicate that the simulation can be used to estimate the additional energy consumption caused by the faults.

INTRODUCTION

Variable air volume (VAV) air-conditioning systems are energy efficient and are widely used in many countries. However, the possibility of fault occurrences has been reported to be high [Yoshida, 1996], and many faulty VAV units have been reported in real buildings [Qin, 2004]. The authors have previously proposed fault detection and diagnosis methods for multiple VAV terminal units [Miyata, 2004]. However, because some faulty units do not affect the zone temperature, it is also necessary to analyze how the faults affect the entire system and analyze the cost benefit of maintenance.

The present paper investigates, both experimentally and by simulation, the influence of faulty VAV units that do not affect the zone temperature. First, the operational data of normal and faulty states are measured under the same thermal conditions in an experimental room, and differences in the total energy consumption are analyzed. Next, in order to examine the possibility of applying the results of the experiment to other systems, the possibility of estimating the additional energy consumption by simulation is discussed.

EXPERIMENT

Experimental Room

The experiments were conducted in an experimental room in which the indoor and outdoor conditions can be set arbitrarily. Figures 1 and 2 and Table 1 describe the experimental room and the air conditioning system of the room. The room is air-conditioned by one air-handling unit (AHU-1) and has four VAV terminal units (Units 1 through 4). The maximum and minimum air volumes of each unit are 1150 m^3/h and 450 m^3/h, respectively. The room is enveloped by six chambers. Chambers 1 through 4 are shown in Figure 1, and Chambers 5 and 6 cover the ceiling and floor, respectively. The thermal conditions in each chamber can be controlled freely by using a separate air-conditioning system.

The supply airflow rate of each VAV unit and the water flow rate of the coil are controlled by a PI controller. The set point of the supply air temperature is also calculated automatically by a controller. If the demand airflow rate reaches the maximum value in any unit, then the set point will be decreased by 1 degree. If the demand airflow rate reaches the

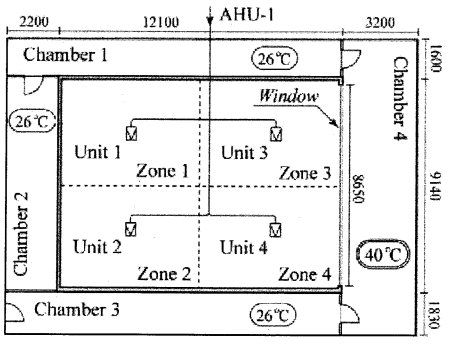

Figure 1 Plan of the experimental room

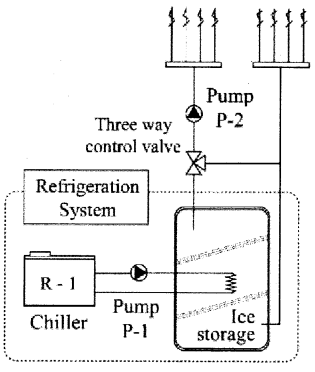

Figure 2 Primary system

Table 1 Design capacity of the system

Air Handling Unit (AHU-1)	Supply Fan	Air Flow Rate	4000 m^3/h
		Pressure Head	923 Pa
		Rotation Speed	1300 rps
		Power	2.2 kW
	Return Fan	Air Flow Rate	4000 m^3/h
		Pressure Head	421 Pa
		Rotation Speed	850 rpm
		Power	1.5 kW
	Coil	Cooling Capacity	56.98 kW
		Water Flow Rate	273 *l* /min
Pump (P-2)		Rotation of Speed	3000 rpm
		Water Flow Rate	200 *l* /min
		Total Pressure Head	24 m
		Power	1.5 kW
Refrigeration System		System COP	2.0