Effect of Intermittent Operation of Ventilation System on Indoor Air Quality in Apartments

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Abstract

This study analyzed the effect of intermittent operation of ventilation system on changes of indoor air pollutants' levels through field measurements. The changes of indoor air pollutants' levels, such as, CO2, PM10, TVOCs, and HCHO were monitored during 24 hours at each ventilation condition. One group was the operation time: 2 hours, 8hours, and 24 hours. The other group was the changes of start time of ventilation, before noon, after noon, and night, while the ventilation was operated only two hours. From these results, it was found that the operation time of ventilation significantly affects the levels of pollutants. However, the start time of ventilation did not showed the significant differences between conditions, because of time variations of sources of pollutants. From these results, it is suggested that rational strategy for operation of ventilation system will be developed for indoor air quality and energy savings in the apartments.

Keywords: Apartment, Ventilation system, Intermittent Operation, Indoor Air Quality, improvement.

Introduction

Increasing of mechanical operating of newer apartment has contributed to increasing ventilation energy consumption since the 2006 building standard law on ventilation in Korea.

Many studies had been done on the effect of ventilation system in apartments on indoor air quality and decreasing energy consumption by mock-up tests and computer simulations. As a result in Choi study[2] is to find optimum ventilation time in a newly-built apartment house at which the ventilator installed. It is found that the HCHO and toluene concentrations are remarkably decreased with the elapse of ventilation time and the concentration reduction rate is increased with increment of air change rate after one hour after operating the ventilator. And also, in Hwang study[3], three types of mechanical ventilation system of apartment house including HRV were simulated by multi-zone modeling. Simulation results suggest an appropriate and economical renovation method of apartment house ventilation system for reducing indoor air contamination. Lee study[4] was to evaluate the possible control modes of hybrid ventilation system in applying to general apartments by using TRNSYS simulation program. But there are not many studies on a real-time measurement of ventilation and indoor air quality. In this study, ventilation equipment was installed and actual residents was living in apartment, changes in operating hours and operating times due to changes in indoor air was measured changes in environmental factors and propose an efficient ventilation operation.

Method

Table 1 shows outline of the apartment. It was attempted to select the apartment that was built after the law about the installation of the ventilation system in apartments had legislated. Therefore the apartment that was built before 2007 and has ventilation system was selected. The occupants have moved into the apartment in October 2007 and about 1007 households have lived. These area of residence consisted of from 70 ㎡ to 146 ㎡. The apartment is heated by district heating system.

Table 1 Description of the apartment 1

Item	Contents
Location	GyeongGi-do
Completion	October. 2007
Filed test period	21 Apr 2009 ~ 1 may 2009
Area and Number of occupants	106m^2 / 4 people
Ventilation system	Mechanical supply air / Natural exhaust

Table 2 Ventilation operating condition and IAQ measurement

Condition	Case	Test Period	Ventilation operating condition	Measurement factor	Measurement equipment
Changes of operation time	Case A Case B	5day	① Non-operating ② 2hour operating (18:00 ~ 20:00) ③ 8 hour operating (15:00 ~ 23:00) ④ 24 hour operating (00:00 ~ 24:00)	Temperature [℃] Humidity [%] CO_2 [ppm] PM10 [mg/m^3] TVOCs [μg/m^3] HCHO [μg/m^3]	espec R-11 Q-track Dust track Mini pump (GC/MS)

Changes of start time of ventilation	Case C Case D	4day	① Non-operating ② Before noon (10:00 ~ 12:00) ③ After noon (18:00 ~ 20:00) ④ Night (20:00 ~ 22:00)	Temperature [℃] Humidity [%] CO_2 [ppm] PM10 [mg/m^3]	

The apartment ventilated by mechanical supply fan and there is no exhaust fan. The ventilation rate was over 0.7 ACH. Result of airtightness measurement in 4 households is similar that airtightness and air change rate 4 households are similar to that result of measurement airtightness and air change rate. IAQ measuring point decided in the middle living room to minimize the supply air effect by using simulation. Table 2 shows ventilation operating conditions and IAQ measurement. It was maintain a constant occupant's presence in test households while during IAQ measurement period. Ventilation minimum operation set 2hour with the result that CFD simulation and mass valance

Results

Results of Indoor pollutant concentration of change by ventilation non-operating

Fig 1 shows change of CO2 concentration and temperature during the one day while ventilation not driving. CO2 average concentration of A and B households exceed the CO2 criterion but C and D households to maintain the CO2 criterion concentration. PM10 measurement in 4 Households maintains that to below PM10 criterion concentration 0.15μ

g/m^3. In all household CO2 and PM10 concentration shows that at morning(07:00 ~ 09:00) and evening(18:00 ~ 22:00) has the high concentration patterns. The average temperature of all households was measured from 23.6℃to 24.8℃ and the average humidity was measured from 45% to 61%.

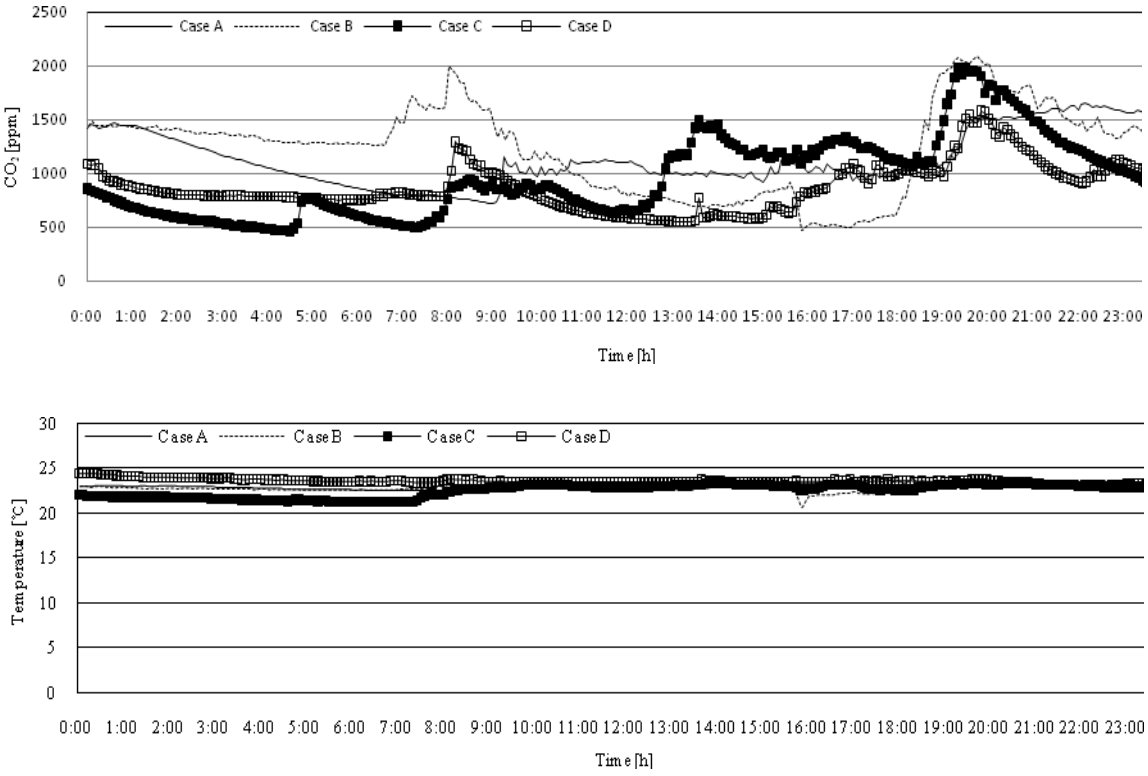

Fig. 1 CO_2 concentration and temperature changes when Ventilation was non-operating

Results of TVOCs and HCHO measurement In A and B household maintain to below TVOCs and HCHO criterion concentration when ventilation not are driving.

Results of IAQ measurement according to increasing ventilation operation time

Fig 2 show change of CO2, PM10 concentration and ventilation operating schedule in A, B households while it is according to increasing ventilation operation time. Avera

ge daily CO2 concentration was exceed the criterion concentration by only non-operati ng and 2hour operating of ventilation. Average daily concentration of PM10 maintains below the criterion concentration 0.15μg/m^3 by all ventilation conditions.

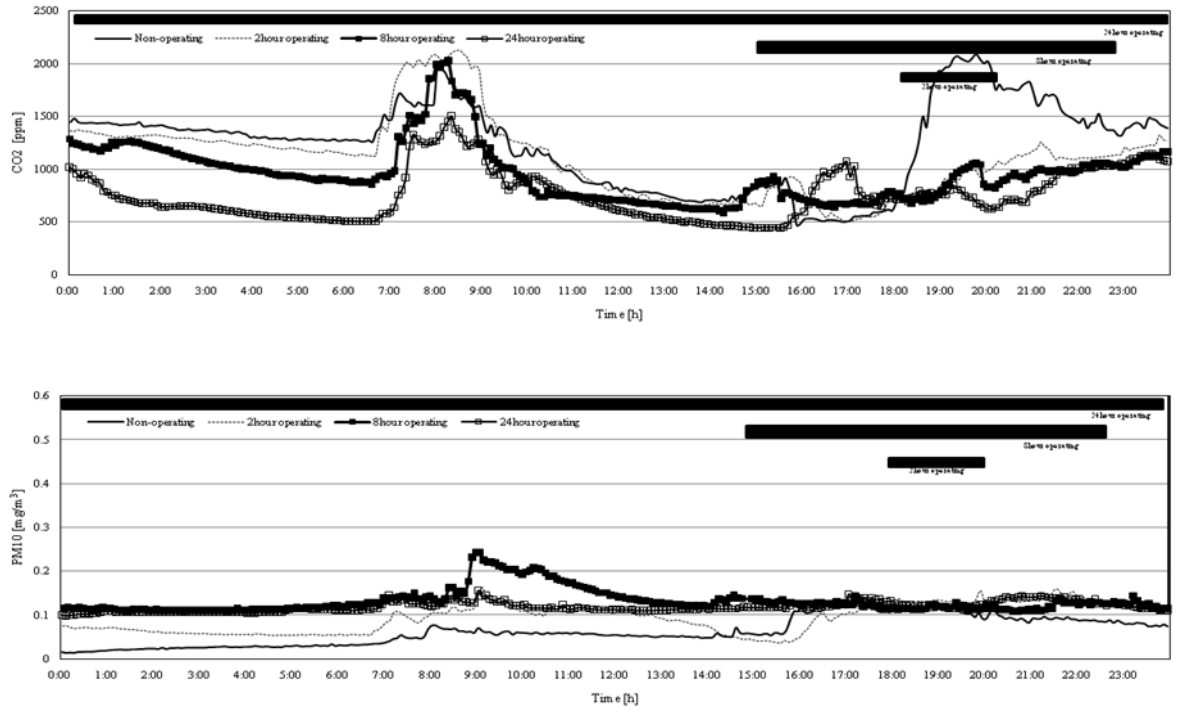

Fig. 2 CO2 and PM10 concentration change by ventilation increasing operation time

According to increasing ventilation operation time in Fig 3 as below, shows overtime of daily by CO2 and PM10 criteria concentration. Criteria pollutant concentration set a CO2 concentration 1000ppm and PM10 0.05mg/m3 for judge the concentration chan ge of pollutant.

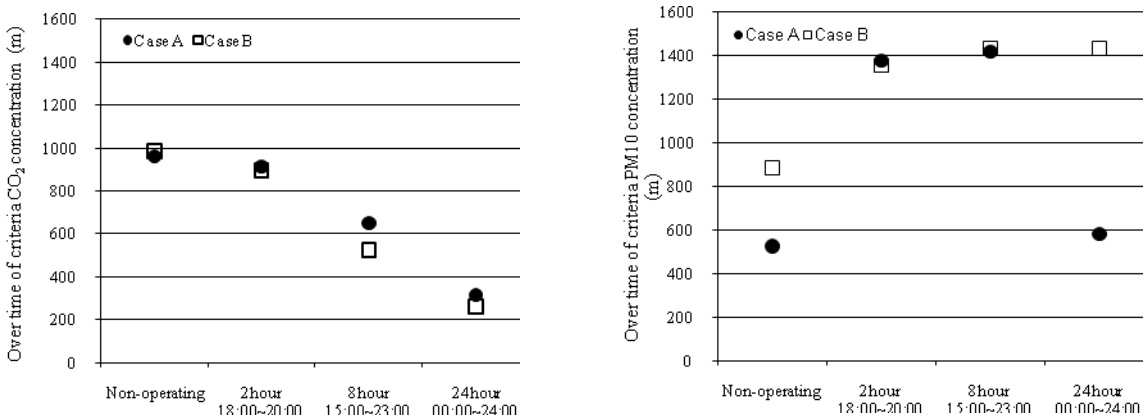

Fig. 3 Overtime of criteria concentration by change of ventilation increasing time

Overtime of daily by CO2 and PM10 criteria concentration analysis shows the CO2 c oncentration shows decreasing trend but PM10 concentration not shows decreasing tren d in A, B households while according to increasing ventilation operation time. The re duction effect of co2 concentration is judged to be effective while according to increa sing ventilation operation time. Fig 4, 5 shows change of VOCs and HCHO concentr ation when before and after operate ventilation. As a result of VOCs and HCHO con centration reduction effect analysis were less effective while ventilation operation time was increasing

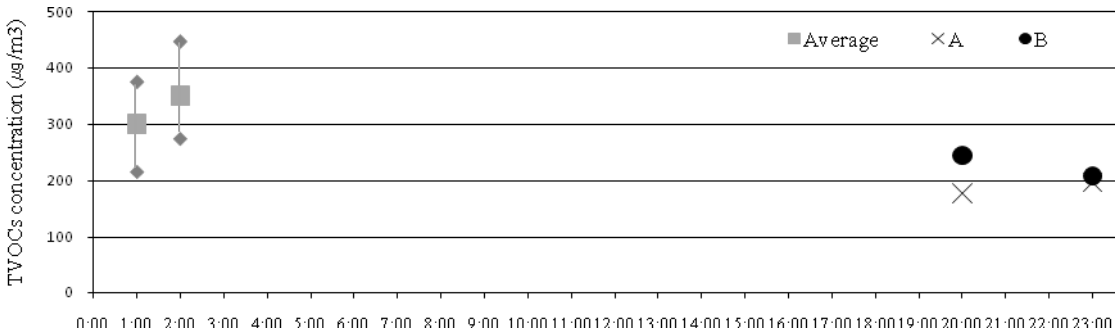

Fig. 4 TVOCs concentration of according to increasing ventilation operation time

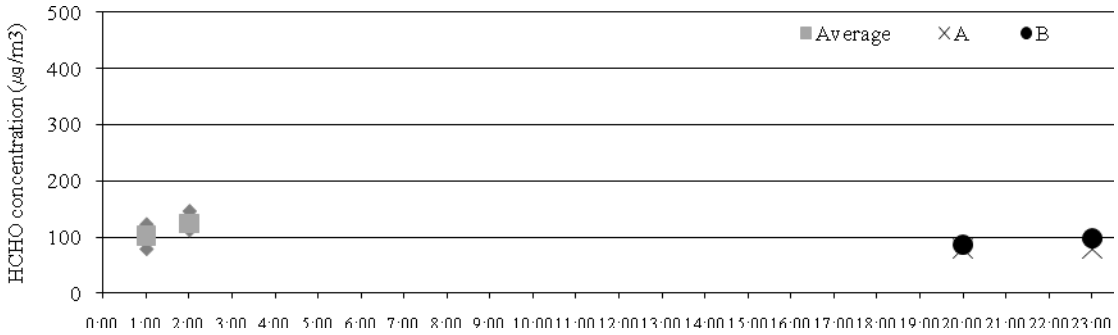

Fig. 5 HCHO concentration of according to increasing ventilation operation time

IAQ measurement according to variation ventilation operation time period

Fig 6 shows change of CO2, PM10 concentration and ventilation operating schedule i n C, D households while according to change of start time of ventilation. CO2 and P M10 concentration is higher at before noon, after noon and daily concentration of PM 10 shows below criterion concentration. CO2 and PM10 concentration was decreases when after ventilation operating at before noon, after noon. According to change of st art time of ventilation in Fig 7 as below, shows overtime of daily by CO2 and PM1 0 criteria concentration. Over the measure period, difference of overtime on CO2 conc

entration has produced similar results while according to change of start time of venti lation. As a result of PM10 concentration is higher when ventilation operation at after noon. According to change of start time of ventilation shows less effective the effect of PM10 concentration decreasing.

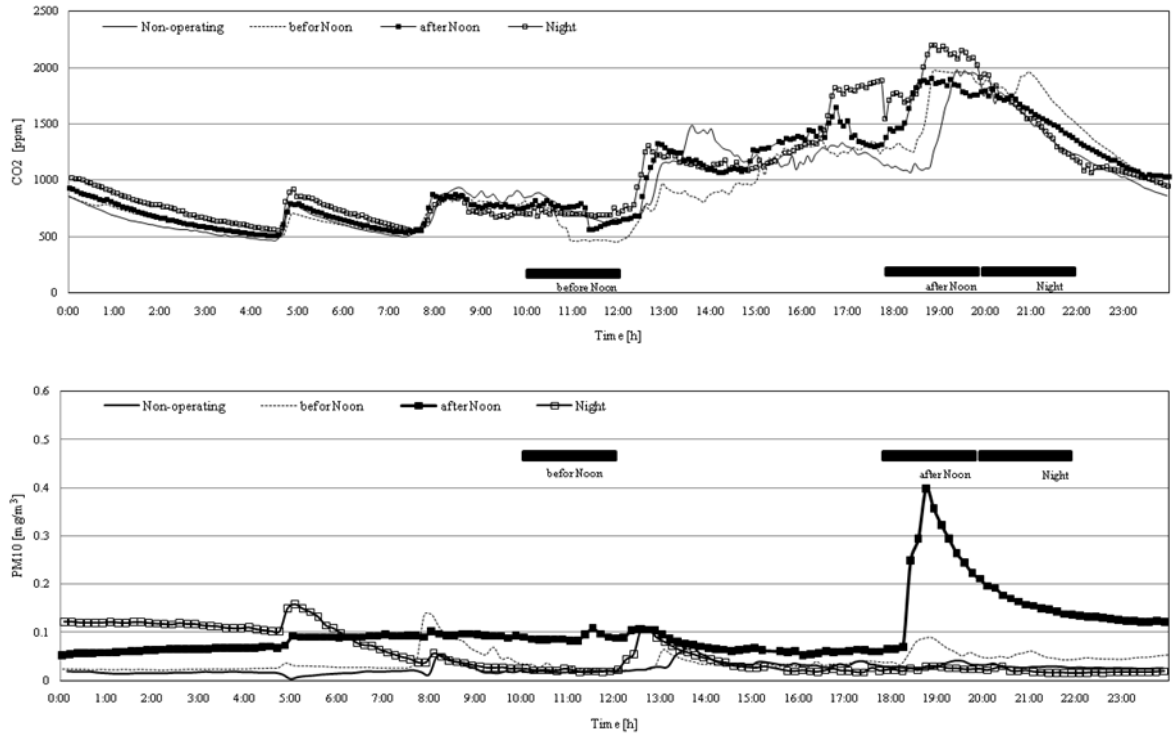

Fig. 6 CO2 and PM10 concentration change by change of start time of ventilation

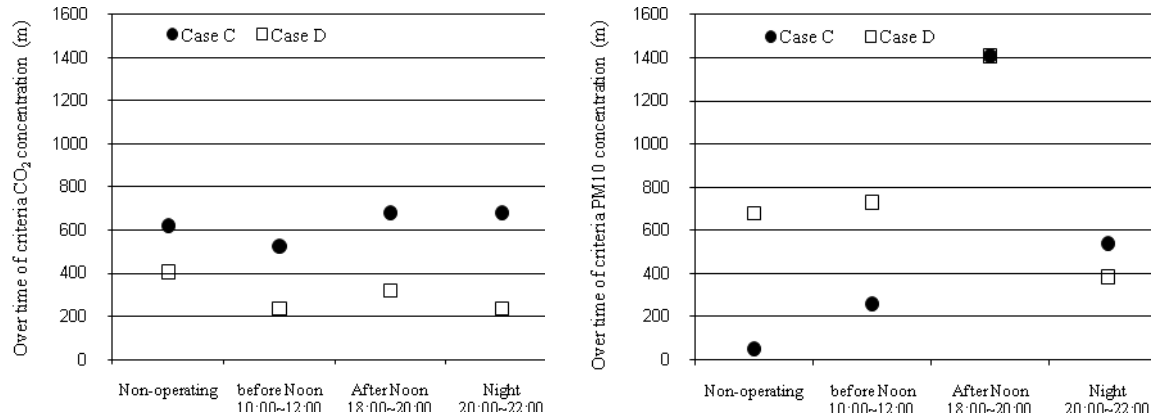

Fig. 7 Over time of criteria concentration by change of ventilation start time

Discussion

Indoor CO2 concentration is higher standard concentration when ventilation operating. For the reason, set 2 hour of ventilation operation time not make a bird of enough ventilation for removal of indoor pollutants. Change of ventilation condition was less effect PM10 concentration change during experimental time. It was not found that effect of occupants activity pattern was lager effect than change of ventilation condition when experimental period. Indoor TVOCs and HCHO concentration change was maintain steady state because apartment had been built 2 years later. It was found that change of ventilation condition had not influence pollutant concentration change.

Conclusions

In this study, the effect of intermittent operation of ventilation system on changes of indoor air pollutants' levels through field measurements was analyzed. And the results of this study are summarized as follows. According to the operation increasing time of ventilation significantly affects the decreasing of CO2 average concentration. Change of ventilation condition less affects the indoor PM10 concentration change. TVOCs and HCHO concentration could maintain regardless of ventilation conditions just by over 2 hour ventilation operating. IAQ

Acknowledgments

This work was supported by Sustainable Building Research Center of Hanyang University

which was supported the SRC/ERC program of MEST (R11-2005-056-02002).

References

1. Hyung-Jun Kim., Jun-Seok Park., "Effects of Ventilation System Operation on Annual Energy Consumption in Apartments," Proceedings of the AIK, Vol. 29, No. 1, 2009, pp.757~760.

2. Seok-Yong Choi., Sang-Hee Kim., Jung-Jae Yee., "The Effect on Indoor Air Quality Improvement by Ventilation Rate in Newly Built Apartment," Korean journal of the SAREK, Vol.18, No.8, 2006, pp.613~687.

3. Tae Chul Hwang., Hyun Woo Lee., Sang Gon Choi., Jin Kwan Hong., "The Study on the Renovation Method of Apartment House Ventilation System for Reducing Indoor Air Contamination," Korean journal of the SAREK, Vol.20, No.6, 2008, pp.409~415.

4. Yong-Jun Lee., Jong-Seo Won., Seung-Bok Leigh., Kyung-Hoi Lee., "An Evaluation of Performance of Hybrid Ventilation System in Apartment focused on Indoor Air Quality," Korean journal of the AIK, Vol.21, No.9, 2005, pp.205~212.