A FIELD EXPERIMENT ON INDOOR CONSISTENCY DISTRIBUTION OF COMBUSTION GAS BY VENTILATION PERFORMANCE OF RANGE HOOD

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ABSTRACT

In apartments of Korea, exhaust-only hood system is commonly installed for kitchen ventilation. However, as to resident's increasing complaints recently due to poor indoor air quality and hood noise, a careful review regarding kitchen ventilation system came to be in need. This paper presents a research that was conducted to improve ventilation problems in the existing kitchen of apartments. For this purpose, a field test has been carried out to examine the effect of range hood's exhaust airflow rates, and makeup air inlet's settings on kitchen ventilation efficiency. The results show that the proper application of makeup air inlet is useful for mediating indoor air pollution by combustion gas emitting from the cooking appliances.

INTRODUCTION

In dealing with indoor air quality in kitchen, ventilation plays a key role. However, sufficient standards have not been prepared in design or performance level for kitchen ventilation in Korea. Recently, as to resident's increasing complaints due to poor indoor air quality and hood noise, a careful review regarding this matter came to be in need.

Currently, exhaust only range-hood system is commonly installed in the kitchen of Korean apartments. However, advanced tightness of present building structures requires makeup air through Purpose-Provided Openings because of infiltration rate is not enough to balance with exhaust airflow rate. Thus, this research is proposed to improve ventilation efficiency in apartments' kitchen by conducting study of the existing ventilation mechanism. For this purpose, a field test has been carried out to evaluate the effects of range-hood performance as well as each openings for makeup air on ventilation efficiency in order to analyze given indoor air quality.

FIELD TEST

Outline of Measured Apartment

A residential building, located in Seoul, Korea, was selected for it's common style, and has been used in this research throughout. The residential building has 18 floors with 144 unit dwellings. Targetted unit dwelling is located on the 10th floor, about 106m^2 in size, southern oriented, a living room combined with dining room, a kitchen(L-DK type). The kitchen ventilation system is consisted of typical cooking ware, range-hood, with 3 level airflow adjustment attached which leads to the waste discharger through a vertical duct. The kitchen and living room is each faced to the outdoor directly, so that makes it convenient for natural ventilation in effect.

Table 1. Summary of object apartment

structure	Reinforced Concrete
heating system	central heating system
stories(object floor)	18 (10th floor)
Unit access type	Hall
house unit size (floor plan)	106m^2 (L-DK type)
measurement space	kitchen, livingroom, outdoor space
measurement period	Preliminary measurement : 1998. 2. 3 - 2. 7 (5 days) main measurement : 1998. 3. 16 - 3. 25 (10 days)

Table 2. Experimental condition

Opening condition \ Experimental condition		hood condition: fan flow rate(m^3/h)	temperature(℃)	Outdoor wind velocity(m/s)
Experiment I (kitchen)	Opening Closed	292	14.0	0.85
		450	9.8	0.9
	Living room Window opened	292	10.9	1.2
		450	12.4	2.5
	Entrance door Opened	292	11.2	0.35
		450	10.8	0.3
Experiment II (livingroom)	Openings Closed	292	12.5	1.2
		450	11.3	0.8
	Opening Opened	292	10.3	1.0
		450	9.7	0.8
	Entrance door Opened	292	11.1	0.25
		450	11.1	0.2

Measurement

In Korea, A cooking process is mainly conducted in kitchen. But, it is somtimes conducted on dining table in living room. Therefore, in this test, we have set indoor pollution source emitting in two location, kitchen cooking appliance and the center of living room. Range-hood was operated with 2 level exhaust airflow rate in each position. In addition, the effect of makeup air inlet is examined as to two cases of entrance door opened and living room window opened. Test conditions are shown in Table 2.
Before conducting the measurement, hood's exhaust flow rate and total emission rate of combustion gas was measured. Based on each case, CO_2 's measured concentration changes over the time to location, evaluated hood capture efficiency by calculating the rate of gas escaping to room and captured through hood.

Evaluation of Hood Capture Efficiency

CO_2 is used as the test medium and is produced by gas range on each location. Hood capture is determined by measuring the amount of CO_2 added to the room as opposed to that captured by the hood and removed from the room. CO_2 concentrations are measured at locations throughout the test room, and the mean value of CO_2 concentration in the room is thus determined.

RESULTS

Range-hood's Airflow Rate

Attached a fiber filter, the hood's airflow rate decreased by 7~8% compared to that without it. At the same time, in case of main entrance door shut down, the hood's airflow rate also decreased by 7~8% compared to the entrance door opened. Therefore, 15% of airflow rate was decreased in case of filter attachment, and entrance door shut down. With the addition of installation problems, the performance difference between the designed and actual airflow rate shows as much as 20% difference.

Table 3. Hood's airflow rate (m^3/h)

Objection	H apartment				designed
filters	With filter		Without filter		
Entrance	Closed	opened	closed	opened	
Low airflow rate	292	297	324	342	347
High airflow rate	450	468	461	490	530

Change of Average Indoor CO_2 Concentration over time

1) Experiment I (Kitchen)

Supposed that Cooking process is conducted in kitchen, CO_2 concentrations in each location are measured. (Figure 1) shows the locally averaged CO_2 concentration over time on low airflow rate. In case of opening shut down (case 1-1), CO_2 concentration increased steeply to 1278ppm till timing of 20 minutes. In case of the opening of living room windows (case 1-2), CO_2 concentration shows higher concentration in first 10 mintues compared to the case 1-1 due to the combination of outside natural air into the indoor.

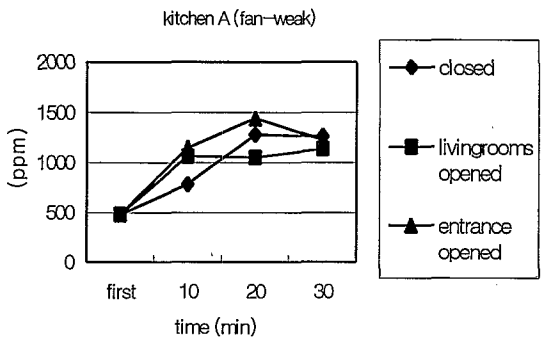

Figure 1. CO_2 gas concentration change in kithcen (fan-weak)

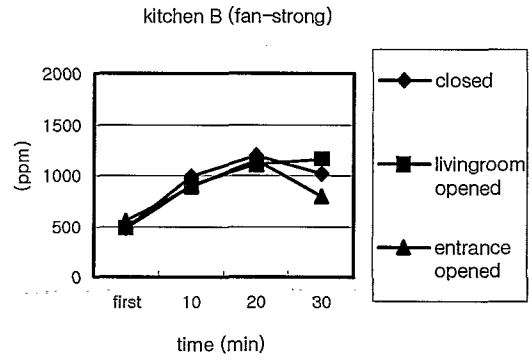

Figure 2. CO_2 gas concentration change in kithcen (fan-strong)

In case of the opening of entrance door(case 1-3), the results show ; 1148 ppm, 20 minutes ; 1441 ppm, 30 minutes ; 1228 ppm which is a highest indoor concentration among all three cases. This is supposed to be due to the short circuit on ventilation route.

(Figure 2) shows the locally averaged CO_2 concentration over times on high airflow rate. In the case of the opening shut down (case 1-4), early 10 minutes is showing higher 200 ppm compared to the same condition with the low airflow rate. Reason for the early increase in CO_2 concentration can be contributed to the occurance of air current near the surface of hood which caused the spreading of contamination. In case of opened windows (case 1-5), CO_2 concentration showed comparably good ventilation effectiveness. And in case of opened entrance (case 1-6), CO_2 concentration was controlled below 1000 ppm.

2) Experiment II (Living Room)

Supposed that Cooking process is conducted in living room, CO_2 concentrations in each location are measured. (Figure 3) shows the locally averaged CO_2 concentration over time on low airflow rate. In case of opening closed (case 2-1) , the contamination concentration change is 10 minutes ; 1206 ppm, 20 minutes ; 1856 ppm, 30 minutes ; 2088 ppm. In case of opened living room windows (case 2-2) results in : 10 minutes ; 934 ppm, 20 minutes ; 1474 ppm , 30 minutes ; 1401 ppm, and in case of opened entrance door (case 2-3) shows : 10

minutes ; 1382 ppm, 20 minutes ; 2065 ppm, 30 minutes ; 1875 ppm. This outcome indicates that large amount of contaminated gas can be remained in case of the contamination occurring in the living room. (Figure 5) is the outcome when the ventilation fan is turned on 'high' with the showing of change in contamination concentration over time when the opening is shut down (case 4-2) : 10 minutes ; 1251 ppm, 20 minutes ; 1264 ppm, 30 minutes ; 1201 ppm. And in case of opened living room window (case 5-2) shows : 10 minutes ; 849 ppm, 20 minutes ; 1187 ppm, 30 minutes ; 1192 ppm. Opened entrance door (case 6-2) results in following : 10 minutes ; 1108 ppm, 20 minutes ; 1760 ppm, 30 minutes ; 1522 ppm.

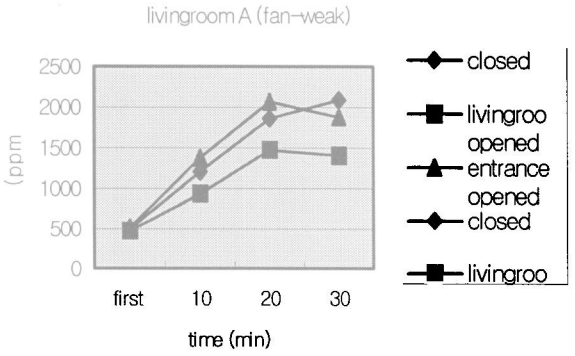

Figure. 3 CO_2 gas concentration change in livingroom (fan-weak)

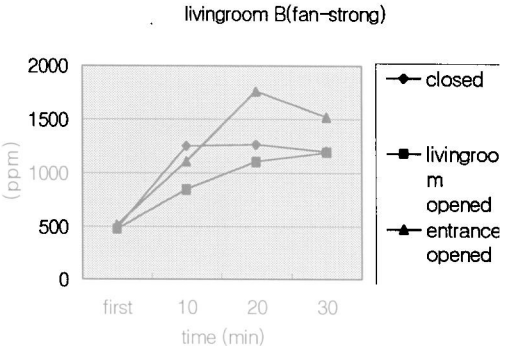

Figure 2. CO_2 gas concentration change in livingroom (fan-strong)

Evaluation of Range-hood Capture Efficiency

Table 4 indicates the results of capture efficiency calculation in each case of range-hood. In experiment I, case 3-1 (opened entrance door/'low') shows the lowest of all with collection efficiency of 50%. On the other hand, case 2-2 (living room window/'high') displays the highest of all with 85% collection efficiency. In case of experiment II, all cases were lower than 50% except for the case 4-1 (closed/'low'), and case 6-1 (opened entrance door/'low'). Case 5-1 (opened living room window/'low') was measured at the lowest of 27%.

Table 4. Hood Capture efficiency (unit:%)

opening's conditions / experiment's conditions	inlet closed (weak)	inlet closed (strong)	liv.room's window opened (weak)	liv.room's window opened (strong)	entrance door opened (weak)	Entrance door opened (weak)
experiment I (kitchen)	63	67	57	85	50	79
experiment II (living room)	53	33	27	40	55	25

CONCLUSION

1. Exhaust airflow rate of range-hood can be decreased up to 20% by filter, and existence of inlets.
2. Makeup Airflow through inlets can instantly spread the combustion gas during the early part of the occurance.
3. Insufficient makeup air can decrease the hood capture efficiency causing significant health problems to human.

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