Ventilation improvement for make-up air supply system cooking-generated indoor particles

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ABSTRACT

Cooking activities generate massive fine particulate matter (number concentration). Effective ventilation system can improve the indoor air quality impacts of pollutants from residential cooking. Make-up air supply system can improve the range hood and Indoor air quality. In this study, we measured a capture efficiency of range hood with make-up air supply and indoor particles during cooking activates. For household's comfort, make-up air supply was installed the line diffuser type. Case 1 PN concentrations increased to around 60,000#/cm^3. Ratio of neat broiling emitted particles less than 0.5 ㎛ is almost 70%. Make-up air supply system could reduce particle concentrations compared in compared by using only range hood and hood+HRV supply (-41, -6%). Furthermore, Particle deposition rate constant of case3 was 0.96±0.26 (h^{-1}). It is higher than other cases (same ventilation volume)

KEYWORDS

Range hood, Make up air, Auxiliary make-up air supply system, Cooking, Particle

1 INTRODUCTION

Removal of indoor particle concentration maintain good indoor air quality and protect human health. Cooking activities are one of the largest sources of indoor pollutant such as particles, nitrogen dioxide(NO_2). Formaldehyde(HCHO)[1-4]. For this reason, the range hood is installed in almost residential in Korea. The efficiency of range hood is determined by several factors, such as fan flow rate, hood location, exhaust ducting, hood cap.

Many studies have measured the reducing air pollutions in residence with a variety of cooking method. Indoor particle concentration in cooking period can vary widely but exceed the regulations ($PM_{2.5}$, PM_{10} in ambient level). Range hood is a typical ventilation system in the kitchens to reduce cooking generated particles by eliminating sources directly in the stove before diffusing the particle to environment.

The newly residential building is installed mechanical ventilation system with auxiliary make-up air supply system in Korea because of anxiety about cooking-generated particles. Operating ventilation system could reduce pollutant concentration with auxiliary ventilation system. To our knowledge, the improvement of ventilation efficiency for range hood with auxiliary ventilation system has not been studied in experiment conditions. The objective of this study was to evaluate the efficiency of ventilation system for cooking activities in experiment.

2 METHODS

2.1 Experiments overview

Cooking experiments were conducted in the residential houses in Korea. Before the cooking, 30 min was recorded as a background concentration and operated ventilation system for well mixed condition. we conduct meat broiling 300g with soy oil 10ml at middle power level of electric stove for 12 min with free heat 3min. After cooking, 45 min was recorded for decay period.

Residential buildings typically ventilated by three methods: mechanical ventilation such as heat recovery ventilation or range hood, natural ventilation, infiltration. In this study, we used HRV (heat recovery ventilation) mechanical ventilation system. Furthermore, range hood and make-up air system were installed in the laboratory residential scale.

The volume of whole laboratory was 212.9m^3 with 3 rooms and height is 2.3m. We sealed the all of rooms because diffusion of contaminants was ignored in this study (Actual volume:101.8m^3).

we evaluated air exchange rate in this laboratory CO_2 based gas tracer gas method. Innova 1313 multi-gas analyser was installed to estimated air exchange rate (AER, h^{-1}). AER of laboratory is 0.4(h^{-1}).

Particle number concentrations were measured at four sampling points: 1) living, 2) kitchen, 3) range hood exhaust duct, 4) supply air duct (HRV and Make up air). The height of sampling was 1.4m. Particle concentrations were continuously measured using optical particle counter (OPC, Model OPS 3330; TSI Incorporated) interval 10 s and six size channels: 0.3-0.5, 0.5-0.7, 0.7-1.0, 1.0-2.5 and 2.5-10.0 μm.

Table 1. Ventilation Types

Case	**Air volume (cmh)**			**Air change rate (h-1)**
	Supply	**Exhaust**	**Make up air supply**	
1	0	0	0	0.6 (Only exhaust)
2	150	0	0	0.6
3	0	0	150	0.6
4	150	150	150	1.2

2.2 Data analysis

Particle number concentrations are analysed using material balance equation (1) in steady state conditions[5, 6].

$$\frac{dC_{in}}{dt} = aPC_{out} - (a + k)C_{in} \qquad (1)$$

Where t is time, a is the AER (air exchange rate) due to infiltration, P is the particle penetration factor, k is the particle deposition rate. C_{in} , C_{out} are indoor and outdoor concentrations. During cooking period, C_{in} concentrations During the cooking period C_{in} were extremely higher (more than 10 times) than background concentrations. In this case, equation (1) can becomes:

$$ln\frac{C_{in}}{C_{peak}} = -(\alpha + k_d) \times t \qquad (2)$$

Where C_{peak} is peak indoor concentrations, $(\alpha + k_d)$ is decay rate constant. Based on equation (2), efficiency of ventilation system determined $\alpha + k_d$. The decay rate constant means the remove the particles, coagulate the indoor particles.

3 RESULTS

3.1 Particle number(PN) concentrations

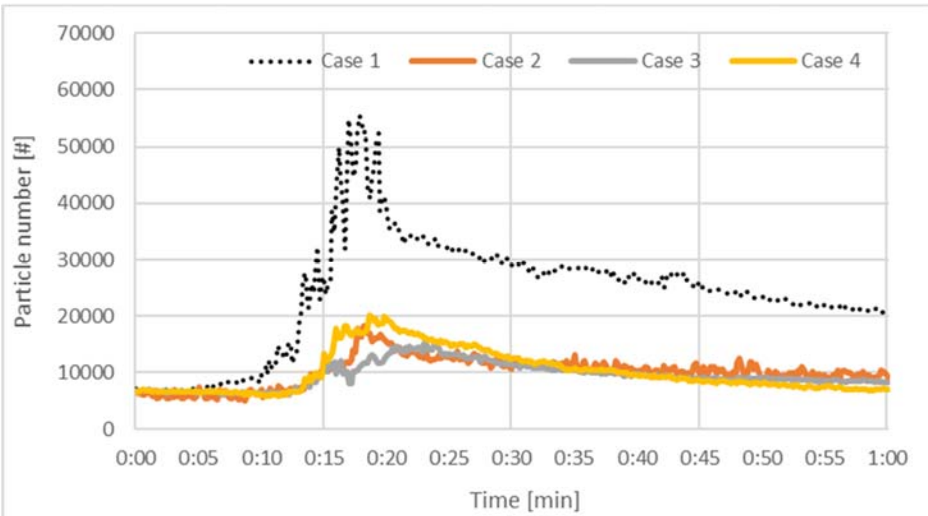

Figure 1: PN concentrations in living (0.3-0.5 μm)

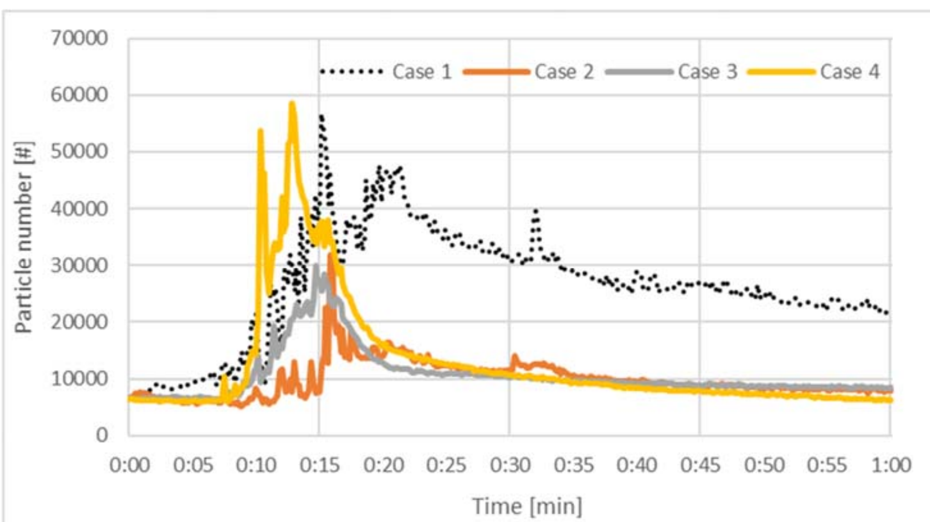

Figure 2: PN concentrations in kitchen (0.3-0.5 μm)

Reported in Figure 1-2 are PN concentrations in living, kitchen (Size: 0.3-0.5 ㎛). Case 1 PN concentrations increased to around 60,000#/cm^3. Ratio of neat broiling emitted particles less than 0.5 ㎛ is almost 70%.

Table 2: Size-resolved average PN concentrations

Case		Size-resolved optical particle counter (OPC)				
		0.3-0.5 ㎛	0.5-0.7 ㎛	0.7-1.0 ㎛	1.0-2.5 ㎛	2.5-10.0 ㎛
		Mean (x 10^4)	Mean (x 10^3)	Mean (x 10^3)	Mean (x 10^4)	Mean (x 10^2)
Case 1	Living	3.7	3.6	1.6	1.1	1.9
	Kitchen	3.5	3.5	1.2	1.3	1.7
Case 2	Living	1.7	1.6	0.7	0.4	0.7
	Kitchen	1.8	1.6	0.5	0.5	0.6
Case 3	Living	1.4	1.5	0.6	0.4	0.4
	Kitchen	1.4	1.4	0.5	0.5	0.5
Case 4	Living	1.2	1.4	0.7	0.5	0.1
	Kitchen	1.0	1.0	0.3	0.5	0.1

The average of particle deposition rate constant was reported figure 3. Particle deposition rate constant of case 1, case2 were 0.67±0.43, 0.58±0.47 (h^{-1}). The particle deposition rate constant increased definitely: 0.96±0.26. Difference of case 2 and case 3 was only supply air system with same air volume. Case 2 was supplied by HRV supply duct. However, case 3 was supplied by make-up air supply system. The average deposition rate constant of case 4 were 1.52±0.30. The air volume of case 4 was 300cmh, higher than other cases.

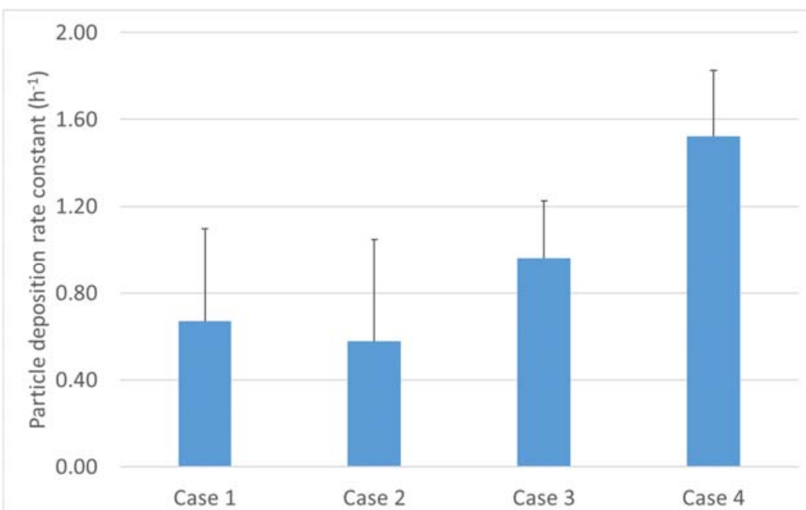

Figure 3: Particle deposition rate (h^{-1})

4 ACKNOWLEDGEMENTS

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