Application Study on Combined Ventilation System of Improving IAQ

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Abstract: A type of combined ventilating system is put forward in this paper. Through CFD simulation and testing of contaminant concentrations in a prototype residential room, the results demonstrate that the new ventilating system is advantageous for improving IAQ and ensuring thermal comfort of indoor environments.

Key words: IAQ; Formaldehyde; Contamination's concentration; Exhaust volume

In many civil buildings and office buildings, the uses of air-conditioning units and many decorating materials make Indoor Air Quality decrease objectively. Considering occupants comfort, only emphasizing to maintain air temperature and relative humidity by air-conditioning is not enough and the contaminations' harm to health is not ignored. It is not helpful for improving IAQ to open fan coil unit and supply fresh air unilaterally. Air exchange, reasonable air distribution and effective use of fresh air are best way to improve IAQ and decrease contaminations' harm to health in terms of energy conservation [1]. As a type of combining natural ventilation and mechanical ventilation [2], it is advantageous for improving IAQ and ensuring thermal comfort of indoor environments to apply this ventilating system.

1. INTRODUCTION

Because of the limitations of applying natural ventilation in residential room, a kind of combined ventilating system is put forward in this paper on the basis of improving IAQ and ensuring thermal comfort. In this system, the polluted air is expelled from subordinate room, while the fresh air enters into the main rooms, such as the bedroom and living room on account of the negative pressure. The characteristics of natural ventilation are shown in this system, but also it is better stability and reliability than natural ventilation [3].

2. APPLICATION STUDY ON COMBINED VENTILATION SYSTEM

2.1 Experimental station introduction

The experiments are carried through in an apartment which lies in the fourth floor and whose area is about 96m^2. The height of the floor is 2.53m. The plan of room is shown in Fig.1. Area of bedroom is 24.4m^2, Area of toilet is 5.9m^2, Area of bedroom is 17.1m^2, Area of drawing room is 42.7m^2 and area of toilet which lies in drawing room is 5.9m^2. Two mechanical air outtake lie in two toilets (*Φ80mm*) and one lies in doorway corridor (*Φ125mm*). Three natural air intakes lie in two bedrooms and drawing room window and each size is 400mm×30mm. Three air-condition units are set, one is in the drawing room , volume rating is 960m^3/h, the others are in the bedrooms, each volume rating is 480m^3/h. They can maintain the room temperature and humidity.

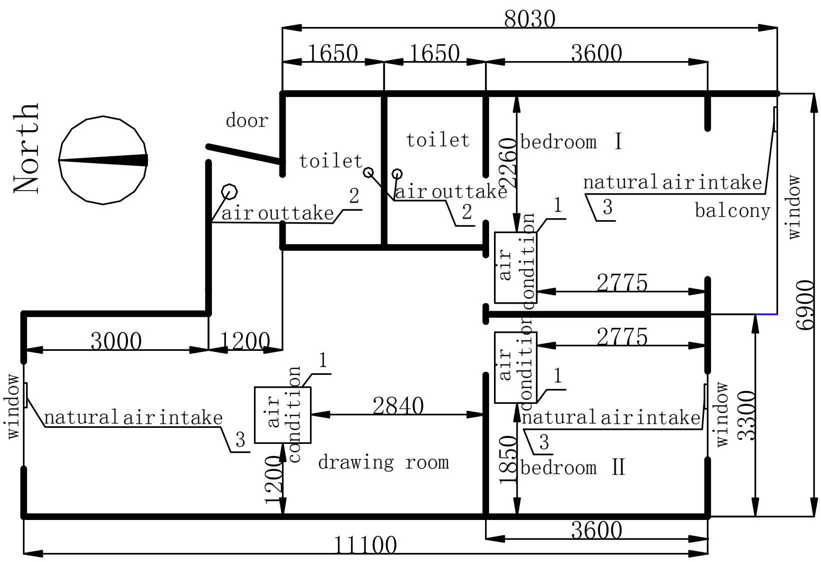

Fig.1 The experimental station plan

2.2 CFD simulation for indoor Formaldehyde concentration

As a typical contamination, Formaldehyde concentration fields are simulated by CFD in this paper. The CFD model is shown in Fig.2. Formaldehyde volatilization rate is related with environmental temperature, humidity, air velocity and Formaldehyde content of some furniture in terms of some references, Formaldehyde volatilization rate increases with higher environmental temperature. In this experiment, Formaldehyde volatilization is simulated by artificial ways, therefore, the volatilization rate is influenced only by environmental temperature and humidity because of the lower air velocity in the apartment [4].

The set indoor environmental temperature is 21 and the relative humidity is 78%. Without ventilation, the level Formaldehyde concentration field at 1.2m height is shown in Fig.3. When the exhaust volume is 80.2m^3/h and 173.8m^3/h respectively, the Formaldehyde balance concentration field at same height is shown in Fig.4. and Fig.5. From the simulating plan, the indoor Formaldehyde concentration decreases with the larger exhaust volume. For validating the rationality of simulating results, the corresponding Formaldehyde concentration is tested in the same conditions as the simulation conditions, and the data is analyzed comparatively.

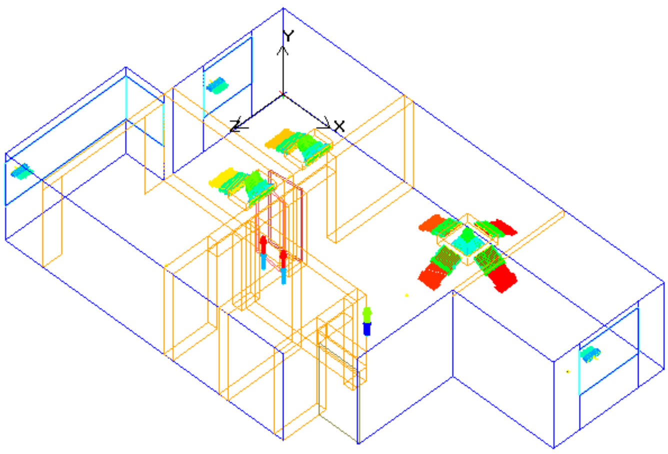

Fig.2 CFD simulation model

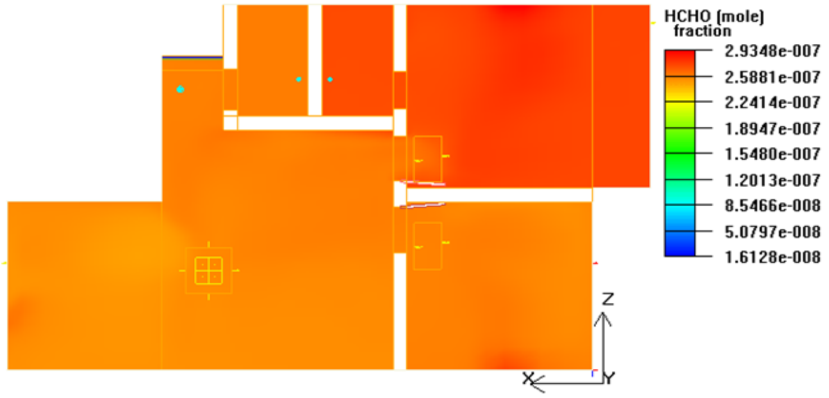

Fig.3 Closed space, y=1.2m level concentration field (LCF)

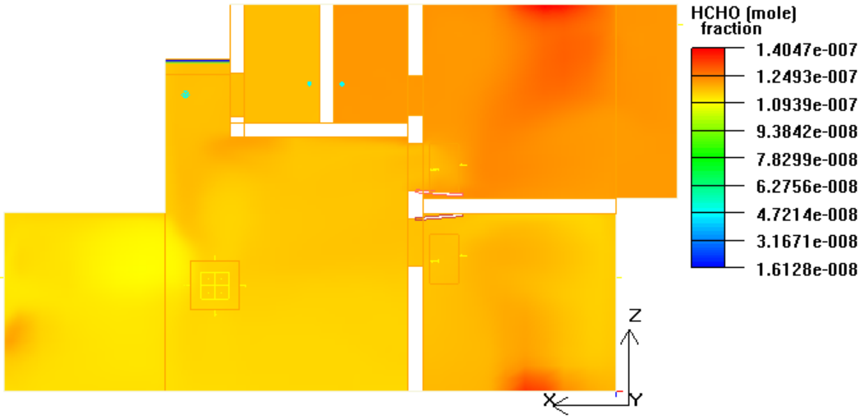

Fig.4 Air volume 80.2 m^3/h, y=1.2m level concentration field (LCF)

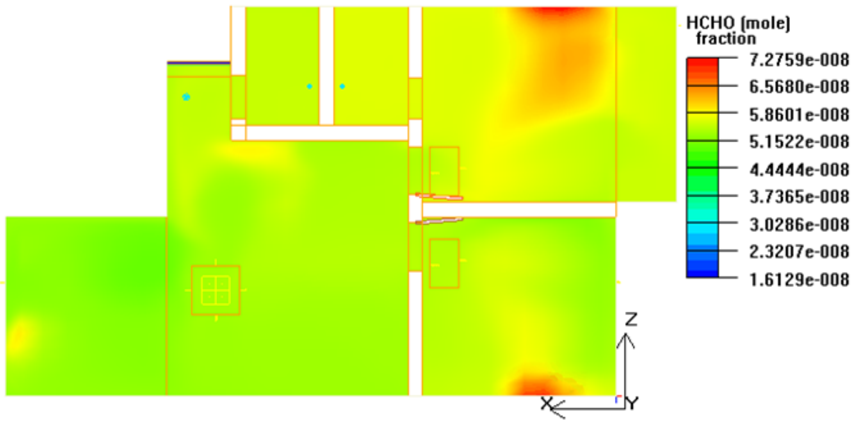

Fig.5 Air volume 173.8 m^3/h, y=1.2m level concentration field (LCF)

2.3 Indoor Formaldehyde concentration test

The test dots in the apartment are shown in Fig.6. When the exhaust volume is 173.8 m^3/h, the differences of experimental results(ER) and CFD simulating results (SR) are shown in Fig.7.

From Fig.7, the maximum difference of ER and SR is 0.016*ppm*, the minimum difference is 0.004*ppm*, and the average difference is 0.008*ppm*. The maximum difference is at dot C1 and dot C2 which lie in the area near the air inlets of veranda, the relative error is 40.9%, this is caused by influence of fresh air, and the rest is 11.9%, therefore, the simulating results should be acceptable [2].

The experimental results of Formaldehyde concentration with time at different conditions of fresh air volume are shown in Fig.8 and Fig.9. The normal concentration is from Chinese IAQ criteria (GB/T 18883-2002).

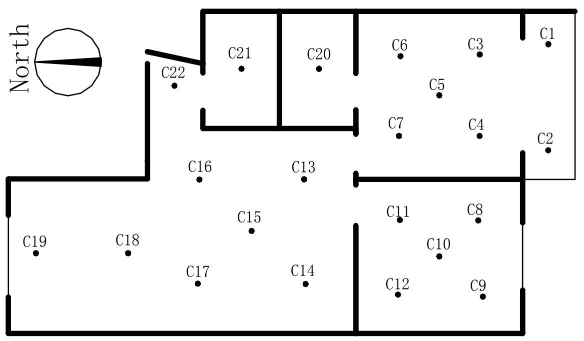

Fig.6 The plan of test dots

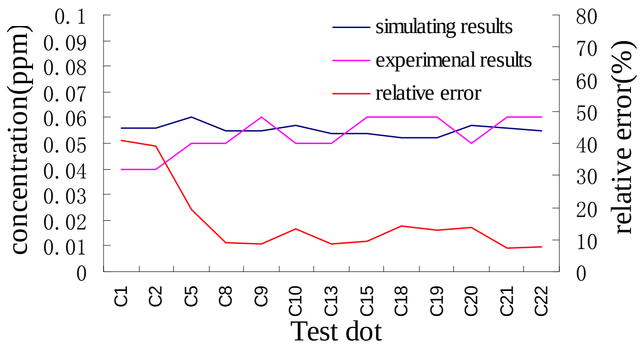

Fig.7 The differences of ER and SR

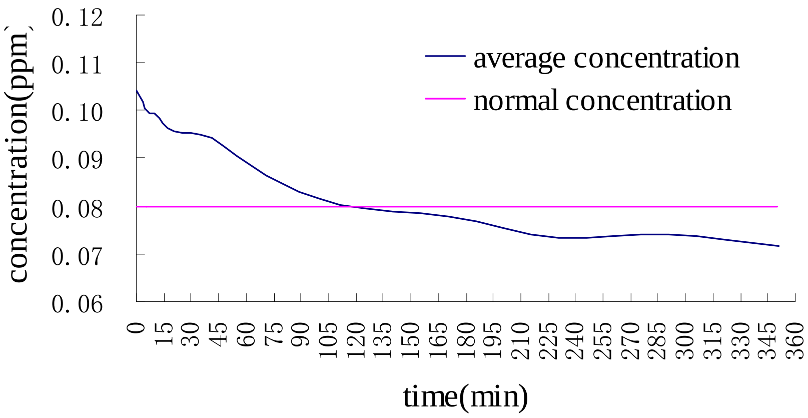

Fig.8 Air volume 80.2 m^3/h, concentration curve

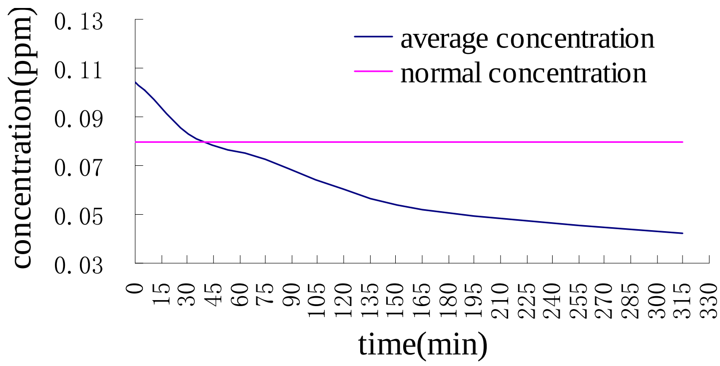

Fig.9 Air volume 173.8 m^3/h, concentration curve

From the Formaldehyde concentration variation curves, the indoor Formaldehyde concentration decreases evidently at the beginning of ventilation, and the curve is gently after a little time, which is caused by the high accumulated Formaldehyde concentration. More Formaldehyde quality is exhausted with the high concentration. Because the Formaldehyde volatilization quality is less than exhaust quality, the indoor Formaldehyde concentration decreases wholly. When the volatilization quality is equivalent to exhaust quality, the indoor Formaldehyde concentration is in the status of dynamic balance.

The time when the indoor contaminations' concentrations meet for normal concentrations is named balance time. When the flesh air volume is different, balance time and dynamic balance concentration are different. From Fig.8 and Fig.9, when the flesh air volume is 80.2m^3/h, the balance time is about 2 hours, it is 3 times as the value when air volume is 173.8m^3/h. And Formaldehyde dynamic balance concentrations are 0.07*ppm* (80.2m^3/h) and 0.04ppm (173.8m^3/h) respectively. In addition, the different Formaldehyde concentration is evident in the level, for example, the higher concentrations lie in the diagonal zones of fan coil units, and the lower concentrations lie in the zones of flesh air inlets. Therefore, the air diffusion of rooms is the key to ensuring IAQ.

3. CONCLUSION

By contrasting the data from CFD simulation and experiment, the corresponding conclusions of applying this combined ventilation system are deduced.

1) The contaminations' concentration can be decreased to meet for the IAQ criteria in this ventilation system. It is an effective way to improve IAQ of apartments.
2) The better flesh air diffusion forms in the room can be obtained, and fresh air flows from the main rooms to the subordinate rooms, which can help to exhaust contaminations and improve IAQ.
3) Flesh air is supplied to the action areas directly, which makes it not be contaminated by air duct and not be mixed with the low quality air[5]. All of measures make the using rate of flesh air higher.
4) The indoor environment is similar to natural environment and is much more comfortable than mechanical ventilation because of natural supplying flesh air. And it can run in the conditions of lower energy consume, which ensures IAQ higher.

REFERENCES

[1] Guodan LIU, Changxing ZHANG etc. Experimental study on the factors influencing IAQ[J]. HV@AC, 2006,36(2): 104-107.(In Chinese)

[2] Bichao YE. Experiment and Simulation Study of Combined Ventilation System[D]. Qingdao: Qingdao Technological university dissertation for master degree, 2005.(In Chinese)

[3] Q Chen,A Moser,P Suter. A numerical study of indoor air quality and thermal comfort under six kinds of air diffusion[J].ASHRAE Trans, 1992, 98: 203-217

[4] Chaozhen LI, Songtao HU. Combined application of residential air-condition and natural ventilation[C]. Qingdao HVAC annual meeting, 2004.(In Chinese)

[5] Songtao HU, Chaozhen LI, WANG Gang. building[C]. The 10th International Conference on Indoor Air Quality and Climate, 2005.(In Chinese)