Advanced Materials Research *Online: 2012-05-14*
ISSN: 1662-8985, Vols. 516-517, pp 1240-1245
doi:10.4028/www.scientific.net/AMR.516-517.1240

Study of Relationship between Air Purifier Efficiency and Placement in Ventilation Environment

Xu Han[1, a], Yong Li[1,b] and Yingxin Liu[1]

[1] Engineering Institute of Crops of Engineers, PLA Univ.of Sci. & Tech.Nanjing 210007,China

[a]hanx@vip.163.com, [b]lgdxbing121@163.com,

Keywords: Air purifier, Concentration field, Placement.

Abstract. Air purifier was used more and more widely, its placement and characteristics of indoor air have a significant impact on the efficiency of air purifiers. Based on CFD software, the effect of five different ways of the placement were analyzed; according to experimental station, the effect of three cases were detected, which verified the correctness of the simulation. The results show that: the placement of the air purifier should be placed by considering the impact of air distribution, purifiers should be put in near the outlet, and far away from the return air, supply air could expand the work area of air purifier to achieve better effect It provide some basis for optimizing the use of air purifier and improving. indoor air quality.

Foreword

According to the rules of National Standard, GB/T18801-2002, Air Purifier, while testing the efficiency of an air purifier, we should put it in the center of the room. In addition, there are only air current caused by the air purifier blow and the ceiling fan used to mix the air in the testing cabin, and there are no intake air and return air in the testing cabin. Under the precondition, we can consider that the pollution distribution is even, and we can use the pollution concentration in the center instead of the whole cabin, then based on the pollution concentration to calculate the pollution elimination coefficient and the purification efficiency of the air purifier.

When used the air purifier, it's different from the text condition. There are two reasons. One is that the central draft system can usually make strong intake and return air. The other is that people chronically put the air purifier by the wall without sufficient consideration. Of course it's affected by the position of the official furnishings. Therefore there are two questions:(1)Whether the air current that engendered by the central draft system can affect the efficiency of the purifier?(2)Whether the position of the purifier in the space density field can affect the function?

Therefore, this study uses the numerical simulation to calculate the air current. The indoor air is led by the central ventilation system .Calculation includes five kinds of position effect of the purifier. We study every effect by changes of pollutant concentrations in 1.5m height for analysis. And to verify the accuracy of the calculation, we tested the role of cleaner effect by the actual experiment in different work locations of the test compartment compared with the corresponding simulation results. To focus on this problem, we do not carefully consider the pollutants distribution model, space and other aspects of natural attenuation.

Purification effort when central ventilation dominates the indoor flow field

1 Model description

The place for simulation is a good air tightness test chamber, no air exchange with the outside world. The chamber is 3.5m in length, 3.2m in width and 3m in height. In the height of 2.5m, there is a ceiling. There is a circulation ventilation system that can make full-cycle return air. There are two air outlets and a return intake. Both air openings' dimensions are 0.6m×0.4m. It takes up-inlet and down-outlet on the opposite side. Return air is sent to the upper part of ceiling to diffuse by return air duct, and then sent to the chamber through two air openings.

The model is implemented in the Airpark [6,7].First create the test model that is 4m in length, 3m in height and 3.2m in width. In the height of 2.5m, set a ceiling by a separator. Then set the air duct, arrange air outlet and air return opening. The air velocity of single outlet is 1.2m / s and the air velocity of air return opening is 2.4m / s. We filled the extra range which is 3.5m × 3.2m × 2.5m, in addition to air duct, with spot adjunct. It is shown in Fig. 1.

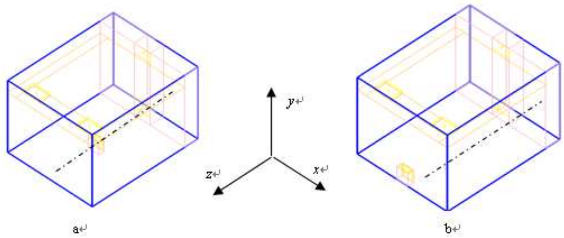

Fig.1. Purifier that is arranged along the central axis of the x-direction

2 Initial conditions of pollutant and purifiers model

We chose benzene as the indoor pollutant. The initial concentration is $1mg/m^3$. Room walls, carpets and other equipments do not emit pollutants. The purifier is placed in three different locations and each simulates the concentration distribution of benzene within one hour in breathing zone, 1.5m in height. And we compared the concentration decay rate of benzene. We considered the center of the plane can represent the plane. Purifier overall size is 0.5m×0.4m×0.2m, and takes up-inlet and down-outlet on the opposite side. The nether outlet size is 0.4m×0.3m, and the top air inlet size is 0.15m×0.2m. According to the rules of National Standard, GB/T18801-2002,《Air Purifier》, the volume of cleaner air is 10 times that of the test chamber, the $280m^3/h$. Mean speed is 1.2m/s, the same as the speed of test chamber outlet. According to Fig.1, 2 outlets distribute along x-axis, so the centerline of the test chamber along x-axis orientation will divide indoor area into two symmetrical areas. We put purifiers in five places in the test chamber between the outlet center line along the z-axis arranged in the outlet chamber wall surface and the center position, all air purifiers looking back into the air, and z axis positive contrast; along the z-axis are arranged in the wall outlet side of the midpoint, return air side. The air inlet of the purifier face the chamber, the same to the x-axis. Purification process of air pollution is known as a certain percentage of pollutants disposed of. As study time is, very short, the air purifier processing efficiency remains unchanged. In calculations we set processing efficiency as 97%.

We mark the position of the purifier with A, B, C, D, E. As shown in Tab .1.

Table 1 The number of simulation and position of purifier

Case	position of purifier
A	Center line， center point
B	Center line， parietal blast inlet
C	Parietal wall， parietal blast inlet
D	Parietal wall， center point
E	Parietal wall， parietal return inlet

3 Mesh generation

The step size of space mesh: $\Delta x = 0.16$m， $\Delta y = 0.1$m， $\Delta z = 0.2$m. The number of grid cells and nodes under five kinds of positions is shown in Table 2.

Table 2 The number of grid cells and nodes

case	A	B	C	D	E
mesh	22556	18586	16708	16778	16628

Time step: $\Delta\tau = 60$s. Computing time is 1h.

4 The results

The following fig.2-fig.6, show the benzene concentration distribution of the room from the ground level of 1.5m profiles, under five kinds of conditions, for each interval of 20 minutes. In following figures, the color from blue to red, indicates that the benzene concentration increased gradually. The black arrows indicate the air current direction.

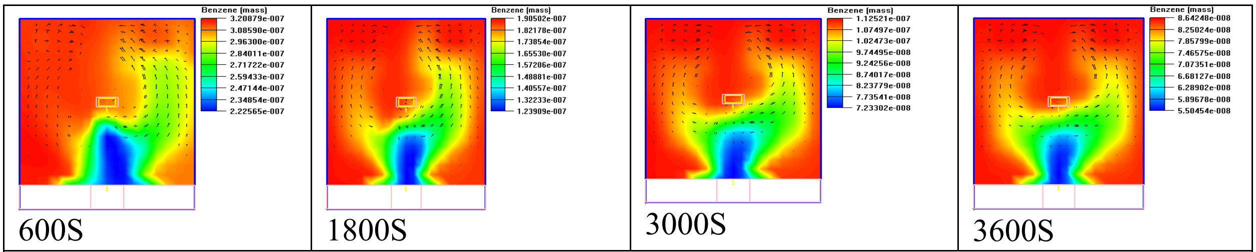

Fig.2 The result of case .A

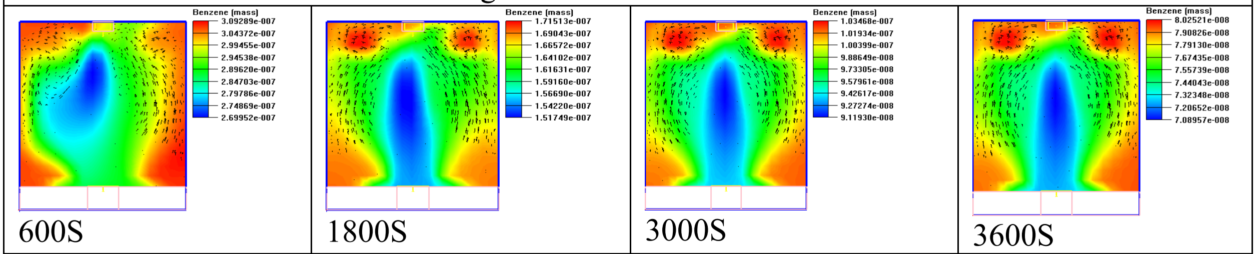

Fig.3 The result of case .B

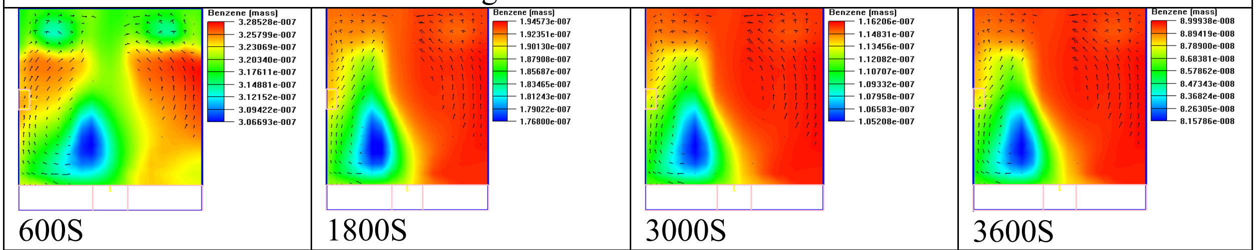

Fig.4 The result of case .C

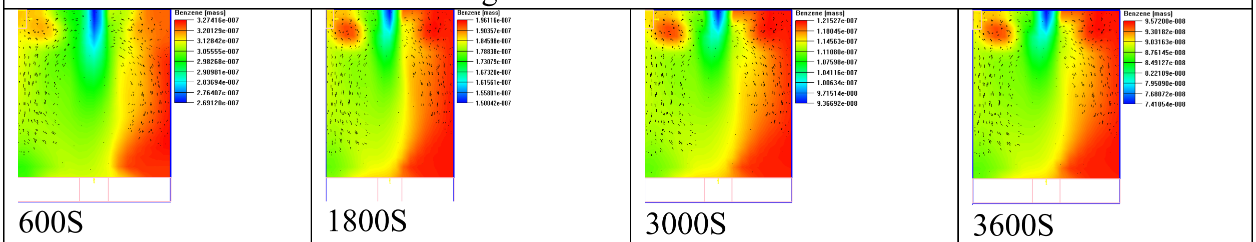

Fig.5 the result of case .D

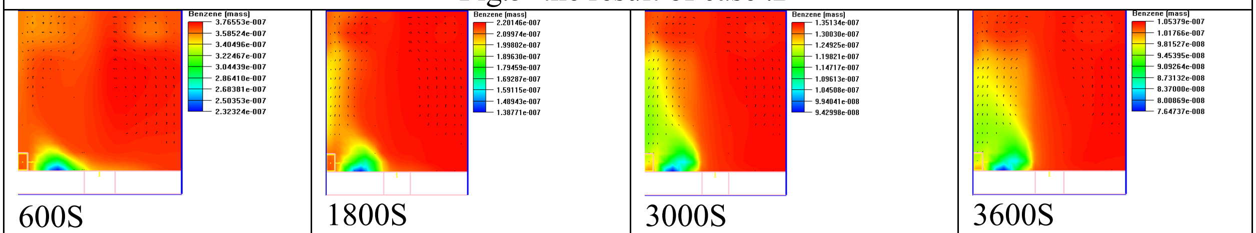

Fig.6 The result of case .E

To clearly express the causes for the concentration field, the project will be located in the purification section of the velocity field, flow field that shown in Fig7.

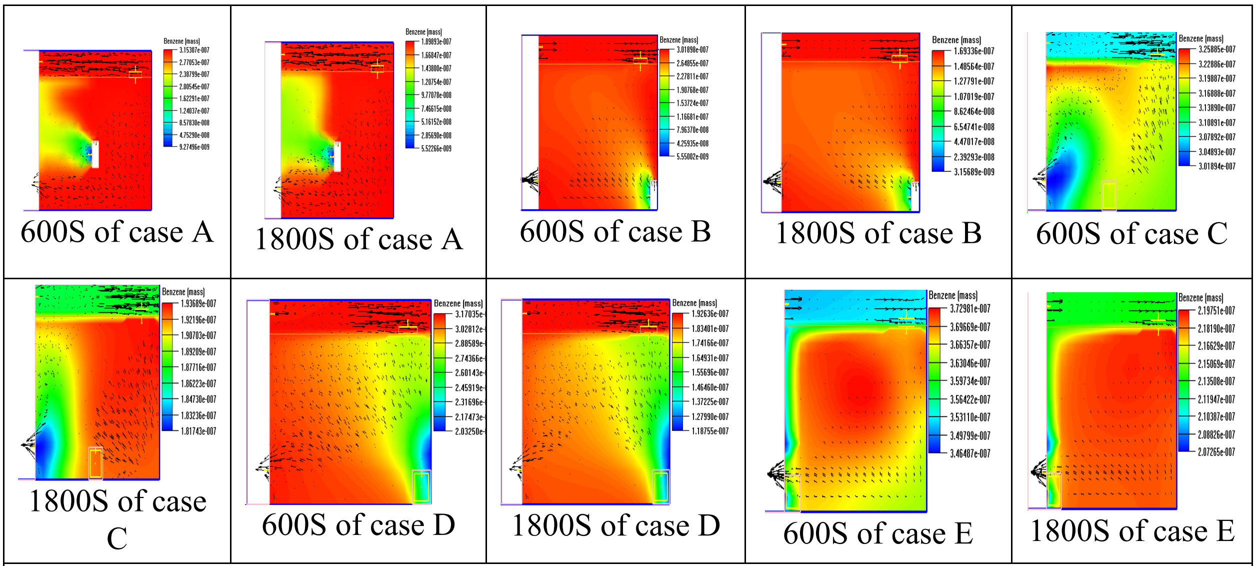

Fig.7 Velocity field, and flow field of purification

5 Analysis and Discussion

Looking at the Project A concentration distribution and flow field in Figure 2 and 7, since the impact of cabin ventilation, the clean air that purifiers blow from the top diffuse towards the return intake. After reaching the wall where the return air is, clean air continue rising along the wall promoted by the air flow. Then come into being cyclone near the return air. The diffusion zone of indoor clean air is small. And benzene concentration is relatively high in the rear half of the space. From the Project B in Fig .3 and Fig.7, as purifier is placed between the two blast inlets, the clean air from purifier promote forward, and the role of the region expanded, including the entire interior of the central area. It’s very suitable for office in the indoor centers.

Project C in Fig.4 and Fig.7 shows that the clean air affected by the airflow field in the test chamber shift toward the return intake. Part of the clean air gets into return air dust. It does not fully spread indoor. From the blast inlet to the location of the purifier, the benzene concentration is relatively high. From one side to the other side of purifier, the benzene concentration gradually increases.

Project D in Fig.5 and Fig.7 shows that the clean air affected by the air current of blast inlet diffuses to the half area where purifier locates. So, when the office is located in one side, the purifier should be better placed in this way.

Project E in Fig.6 and Fig.7 shows that when the purifier is placed in the corner of return air side, most of the clean air cannot spread to the interior. It immediately gets into the return air dust. This is the most unfavorable position of the five kinds of locations.

To compare the effort in the five kinds of mode more clearly, we select the center of the test chamber to observe the change of the concentration process.

Fig.8 and Tab.3 show that the elimination efficiency difference of the display methods is small, according to benzene concentration decay of the center. the elimination efficiency: Project B> Project D> Project C> Project A> Project E. The location between the two blast inlets is best (92.17%), followed by one blast inlet (90.36%), and the third is by the wall, locate between blast inlet and return intake (90.12 %), fourth place is the cleaning appliance center (89.76%), the worst is nearby the wall of return intake.

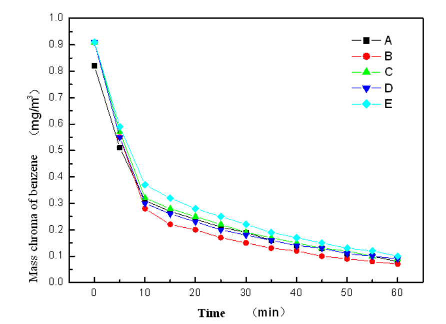

Fig.8 The chroam change of benzene

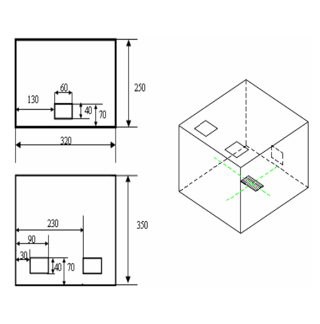

Fig.9 The test chamber

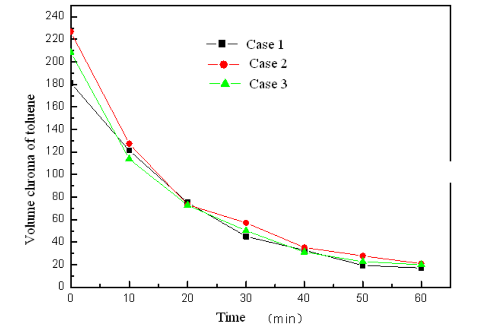

Fig.10 The test chroam change of purifier in different location

Tab.3 The benzenechroam in different location

Time (min) \ case	A	B	C	D	E
0	0.82	0.91	0.91	0.91	0.91
5	0.51	0.55	0.57	0.55	0.59
10	0.31	0.28	0.32	0.30	0.37
15	0.27	0.22	0.28	0.26	0.32
20	0.24	0.20	0.25	0.23	0.28
25	0.21	0.17	0.22	0.20	0.25
30	0.19	0.15	0.19	0.18	0.22
35	0.16	0.13	0.17	0.16	0.19
40	0.14	0.12	0.15	0.14	0.17
45	0.13	0.10	0.13	0.13	0.15
50	0.11	0.09	0.12	0.11	0.13
55	0.10	0.08	0.10	0.10	0.12
60	0.08	0.07	0.09	0.09	0.10
Elimination efficiency %	89.76	92.17	90.12	90.36	88.50

Confirmatory tests of air purifier effect associated with by central vent

To verify the accuracy of simulation, we commissioned the Institute for health related products Research, Chinese Center for Disease Control and Prevention to test the efficiency of purifier by central vent. We observe whether the change law of the pollutant concentration in the center of the test chamber is similar to the simulation.

The test chamber size is 3.5m × 3.2m × 2.5m. The frame is aluminum. The wall is transparent glass. The junction does sealing treatment. Test chamber has circulating ventilation system and air duct is equipped with a high efficiency filter. There are two blast inlets, a return intake, without fresh air outlet. Air inlet and return intake are shown in Fig.9. All dimensions are 0.6m × 0.4m. There is a sampling hole in the test bay side of wall. It is in the center of the area which is in 1.5m height. We drill a hollow metal tube through the hole to the center of the test chamber.

1 Experimental preparation

We choose toluene as contaminated gas. Although the pollutant is different from benzene in the experiment, the difference between benzene and toluene does not affect the relationship between the purifier location and attenuation of pollutant concentration, distribution character. Of course the condition is that there is no central vent and do not take into account the natural decay. We inject the standard gas into test chamber by sampling air and open the indoor fan.

2 Experiment process

After 15 minutes we put 3 purifiers of same model, same batch on the table of the 0.6m high. One is in the center of the test chamber. Another is in the lateral center position. The other is in the corner of the return air side. They are corresponding to the positions of the A, C, E. We put the experimental purifier into the test chamber, and record the toluene concentration as the initial concentration. Boot, and start the fan of the test chamber ventilation system for full return air ventilation. Sample once every 30 minutes, record the data and stop the experiment after 1h.

3 Experimental results and comparison with simulation results

When purifiers are at three locations, the change of the toluene concentration of the test chamber shows in Table 4 and Fig.10.

Tab.4 The chroam change in the test chamber

Case / Time（min）	case1	case2	case3
0	181.14	226.60	208.37
10	121.32	127.40	113.79
20	75.13	73.18	72.70
30	44.98	57.14	50.09
40	32.82	35.25	31.12
50	19.21	27.72	22.61
60	17.02	20.91	19.94
Elimination efficiency (%)	90.6	90.8	90.4

Fig.10 shows that, although we use different pollutants in the experiments and simulations, the discipline that the location affects the efficiency of benzene elimination rate is the same. In the experiment, the lateral center of the center is better than the test chamber and the test chamber center is better than the return air side of the corner. It is as same as the conclusion of simulation project that Project C is better than Project A, and Project A is better than Project E.

Conclusions

We adopt numerical simulation method to analysis the impact of the purifier location to the pollutant concentration distribution . At view of the numerical calculation result, the location of the purifier and its effect are significantly related.

In general, the purification efficiency of the purifier given by the model is constant, the ability that purifier process the pollutants is related to import concentration. To achieve better purification effect, we should put the entrance at the higher concentration areas. However, purifier's air current and shape will change the spatial concentration distribution. We are not concerned about the average concentration throughout the space, but the change of pollutant of personnel activities region. So when we put the purifier, we should consider these factors. The calculation results show that when the purifier locate near the outlet of the central vent system, away from the return intake, it can play a good purifying effect, by dint of air to expand the work area.

References

[1] BLUYSSEN P M, de Oloveria Fernandes E,GROES L. European indoor air quality audit project in 56 office buildings [J]. Idoor Air, 1996,(6):221-238.

[2] YeDan, LiLisnns Electronic air disinfection and purification machines on the observation of hospital air disinfection [J]. Modern Hospital, 2006, 6(5): 58-59.

[3] Zhu Tianle. Indoor air pollution control [M]. Beijing: Chemical Industry Press, 2002: 1-17.

[4] Yuan zhongshan, Zhang Jinchang, Wu Diyong. Indoor Environmental Pollution Study[J]. Environmental pollution control technology and equipment，2001，2(1)：9-16.

[5] Nazaroff.WE. Effectiveness of air cleaning technologies[J].In Health Buildings,2000,2:49 -54．

[6] Shanghnessy RJ, Sextro RG. What is an effective portable air cleaning device：a review[J]. Occup Environ Hyg, 2006, 3: 169-181

[7] Grinshpun SA, Adhikari A, Honda T, et al. Control of aerosol contaminants in indoor air: combining the particle concentration reduction with microbialinactivation [J].EnvironSciTechnol, 2007,41:606-612.

Electrical Power & Energy Systems
10.4028/www.scientific.net/AMR.516-517

Study of Relationship between Air Purifier Efficiency and Placement in Ventilation Environment
10.4028/www.scientific.net/AMR.516-517.1240