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2010

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Experimental Investigation of Purification Function of Air Conditioner

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ABSTRACT

The purification functions of air conditioner used to improve IAQ (Indoor Air Quality) are introduced. And these functions are experimented and analyzed in this paper. The different functions of the same air conditioner and the same function of different air conditioners are compared and analyzed to confirm effective technique.

The experimental results show, the effect of combined function is better than single function. The air exchange function has rather good effect on TVOC (Total Volatile Organic Compound), and there is positive correlation between purification effect and air flow volume. The ionization function has rather good effect on PM10 (Particle with Diameters of 10µm or less), HCHO (Formaldehyde) and ABC (Aerobic Bacterial Count), and oxygenation function improves the purification effects of air conditioners.

1. INTRODUCTION

According to statistic, people stay indoors for 80%~90% of all the lifetime. For the sake of energy-saving, the buildings enhance air tightness and reduce the fresh air volume. Indoor contamination increases quickly because of new material and new facility, which results in the Sick Building Symptom (SBS). Now the research of indoor air quality (IAQ) is more and more important, and consumers begin to recognize this issue. The purification functions become an important factor influencing air conditioner in sales. But the actual effect of some products is worse than the advertisement and misleads consumers to a certain extent.

The purification functions of air conditioner used to improve IAQ (Indoor Air Quality) are introduced. And these functions are experimented and analyzed in this paper. The different functions of the same air conditioner and the same function of different air conditioners are compared and analyzed to confirm effective technique.

2. COMMON PURIFICATION FUNCTIONS

Because of structure limitation of product, the purification functions of air conditioner include air exchange, ionization, oxygenation, and purification filter, etc.

2.1 Air exchange

Air exchange function is an effective manner to improve IAQ, including exhalation, inhalation and dual-direction air exchange, it dilutes or exchanges indoor pollute air, including CO₂, and adjusts the humidity of indoor air.

2.2 Ionization

The ionization function adopts manner of corona discharge. Large quantity of ion is generated when

electric-field intensity heightening. The ion absorbs dust of air to purify indoor air. Ionization technique is used in negative ion generator or plasmas generator.

2.3 Oxygenation

Oxygen concentration declines in an airtight room where people feel discomfort, so oxygenation function is necessary. The oxygenation function includes oxygen-enriching membranes and Pressure Swing Adsorption (PSA).

2.4 Purification filter

With purification material added, a filter purifies air passing through it. Purification filter includes lots of kinds, such as argentine ion, photocatalyst, cold catalyst, catechin and electret filter, etc.

2.5 Ultraviolet lamp

The theory of ultraviolet lamp purification is the energy of ultraviolet photon can destroy DNA structure of virus or bacteria. There are few air conditioners using this technique.

3. EXPERIMENT MEASURE AND PROCEDURE

3.1 Referenced standard

GB/T18801-2008• Air Cleaner• •GB 4789.2-1994• Microbiological examination of food hygiene• • Detection of aerobic bacterial count• •

3.2 Test instrument

Some typical indoor air quality parameters are chosen, including PM10 (Particle with Diameters of 10µm or less), HCHO (Formaldehyde), TVOC (Total Volatile Organic Compounds) and ABC (Aerobic Bacterial Count). The test instruments and models are showed in table 1.

Testing parameter	Unit	Instrument	Model
PM10 (Particle with diameters of 10µm or less)	mg/m ³	PM10 testing instrument	P-5L2C
HCHO (Formaldehyde)	mg/m ³	HCHO concentration testing instrument	4160-2
TVOC (Total Volatile Organic Compounds)	mg/m ³	TVOC concentration testing instrument	PGM-7240
ABC (Aerobic Bacterial Count) cfu/m ³		Impingement microbe sampling instrument	JWL-• C

Table 1: Test instrument and model

3.3 Test Procedure

• • • Air conditioner and testing instrument are prepared.

• 2• •To measure elimination rate of PM10, HCHO and TVOC, five cigarettes are ignited in a airtight chamber, sampling 4 points around the air conditioner and calculating the average of them in the operating time 0, 0.5h, 2h and 4h respectively.

• 3• • To measure elimination rate of ABC, sampling 3 points in the diagonal line of a airtight chamber, and calculating the average of them in the operating time 0, 0.5h, 2h and 4h respectively.

• 4• The Elimination rate of testing parameter (%) can be calculated as listed Equation (1)

$$y_t = \frac{C_0 - C_t}{C_0} \times 100$$
 • 1• •

Where, y_t , elimination rate of a certain time, %; C_t , concentration of the certain time, mg/m³ or cfu/m³; C_0 , initial concentration, mg/m³ or cfu/m³.

The elimination rate of PM10, HCHO, TVOC and ABC in 0.5h, 2h and 4h are calculated according to Equation (1).

3.4 Testing production

All the testing productions are wall mounted air conditioners, and their purification functions and production are showed in table 2. Because of business secret, the testing air conditioners are mentioned by serial number only.

Air conditioner serial number	Purification function	Made in		
	Air exchange			
No.1	Ionization(plasma)			
	Ionization(plasma) & Air exchange			
No.2	Purification filter(photocatalyst)			
	Purification filter(photocatalyst) & Air exchange			
	Purification filter(photocatalyst) & Air exchange(powerful)			
	Purification filter(photocatalyst) & Oxygenation			
	Purification filter(photocatalyst) & Air exchange & Oxygenation			
	Purification filter(photocatalyst) & Air exchange(powerful) & Oxygenation			
	Ionization• negative ion• •			
No 3	Air exchange(inhalation)			
INO. 3	Air exchange(exhalation)	Japan		
No.4	Ionization(plasma)			
	Purification filter	Japan		
No.5	Air exchange	China		
	Ionization(plasma)			
No.6	Ultraviolet lamp	China		
No.7	Ionization(negative ion)	China		

Table 2:	Testing	production	and	purification	function
		p			

4. RESULTS AND ANALYSIS

4.1 Experiment results and analysis

(1) Air conditioner No. 1

The experiment data of testing parameter of air conditioner No. 1 are showed in table 3.

10010 5.	Time	v_t of testing parameter (%)			
Function	(h)	PM10	НСНО	TVOC	ABC
Air exchange	0.5	52.44	53.24	49.11	72.11
	2	71.53	93.01	60.52	79.87
	4	87.68	96.69	69.44	83.91
Ionization	0.5	52.54	59.69	44.96	75.44
	2	85.12	90.79	60.10	82.01
	4	98.67	93.41	68.01	86.49
Air exchange & Ionization	0.5	54.25	48.16	56.98	85.11
	2	89.01	90.79	70.05	92.94
	4	98.56	96.05	80.24	96.87

Table 3: Experiment data of air conditioner No. 1

Elimination rate of air exchange function changes with the time change is showed in figure 1. It shows the elimination rate of all the testing parameter increase with time passing. The other function of different air conditioner has the same regular pattern; the elimination rate of 4h is the best. The elimination rate of 4h (similarly hereinafter) is compared, and the subsequence experimental data are elided.

The Comparison of elimination effect for 4h of air conditioner No.1 is showed in Figure 2. It shows that, on elimination of PM10, ionization and air exchange & ionization effect better than single air exchange. The air exchange and air exchange & ionization function has rather good effect on elimination of HCHO. The air exchange & ionization function has best effect on TVOC. The air exchange function has better effect on ABC than ionization function, and the air exchange & ionization function has best effect on the air exchange & ionization function has best effect on ABC. The air exchange & ionization function has best effect on ABC. The air exchange & ionization function has best effect on ABC.



(2) Air conditioner No.2

The Comparison of elimination rate for 4h of air conditioner No.2 is showed in figure 3.



Figure 3: Comparison of elimination rate of air conditioner No.2

Figure 3 shows elimination effect of triplex function (ionization & air exchange (powerful) & oxygenation) is the best effect with single or double function. The air exchange has obvious effect on TVOC. The oxygenation function improves the purification effects of air conditioners. The elimination rate of ABC and PM10 maintains the consistent regular pattern. The more powerful the air exchange is, the better elimination effects are.

(3) Air conditioner No.3

The Comparison of elimination rate of air conditioner No.3 is showed in figure 4. Figure 4 shows inhalation and exhalation function has the same elimination effect on PM10 and HCHO. And the exhalation function has effect better than inhalation on TVOC. The exhalation air volume $(15m^3/h)$ is greater than inhalation air volume $(8.8 m^3/h)$, and the effect is in positive correlation with the air flow volume.

(4) Air conditioner No.4

The Comparison of elimination rate of air conditioner No.4 is showed in figure 5. Figure 5 shows purification filter (photocatalyst) has the better effect than ionization on PM10 and ABC, but the effect on HCHO and TVOC is rather worse.



(5) Air conditioner No.5

The Comparison of elimination rate of air conditioner No.5 is showed in figure 6.



Figure 6 shows air exchange function has the better effect than ionization on PM10 and TVOC, and has the same effect on HCHO, but the effect on ABC is worse.

(6) Air conditioner No.6

The Comparison of elimination rate of air conditioner No.6 is showed in figure 7. Figure 7 shows ultraviolet lamp function has rather effect on HCHO, PM10 and ABC, and the elimination effect on TVOC is worse.

(7) Air conditioner No.7

The Comparison of elimination rate of air conditioner No.7 is showed in figure 8. Figure 8 shows ionization (negative ion) function has obvious effect on PM10, HCHO and ABC, and the elimination effect on TVOC is worse.



of air conditioner No.7

4.2 Comparison and analysis

(1) Comparison of air exchange function

Air volume of different air conditioner is showed in table 4.Comparison of air exchange function of different air conditioner is showed in figure 9.

Table 4. All volume of different an conditioner				
Air conditioner serial number	Air volume	Air exchange manner		
	(m^{3}/h)			
No.1 air exchange	8.83	Inhalation		
No.3 air exchange (inhalation)	8.83	Inhalation		
No.3 air exchange (exhalation)	15.02	Exhalation		
No.5 air exchange	20.00	Inhalation		

Table 4: Air volume of different air conditioner

Table 4 and figure 9 shows No.1 air exchange, No.3 air exchange(inhalation) and No.3 air exchange(exhalation) has the analogous elimination effect on PM10,HCHO and ABC. The elimination effect on PM10 and HCHO of No.5 is better than the other air conditioners. All the air conditioner has the same elimination effect on ABC. The elimination effect on TVOC of No.3 (exhalation) is the best of all. Thus it can be seen, the elimination rate of ABC is independent of the air flow volume, and elimination rate of TVOC is in positive correlation with the air flow volume, and the exhalation manner better than inhalation manner.

(2) Comparison of ionization function

Ionization is a common purification function of air conditioner. Comparison of different ionization function is showed in figure 10.



Figure 10 shows ionization function has better

elimination effect on PM10, HCHO and ABC, but has worse elimination effect on TVOC. Negative ion is cheaper than plasma, but its effect is better.

(3) Comparison of different function

Comparison of single air exchange and single ionization is showed in figure 11. The contrastive data is the average

of air exchange and average of ionization.

Figure 11 shows ionization function effects better than air exchange function on PM10, HCHO and ABC. but its purification effect on TVOC is worse. The air exchange function dilutes indoor pollute air and reduces concentration of TVOC.



5. CONCLUSIONS

It is compared and analyzed on purification effect of different air conditioner by experimental data; the following conclusions were arrived at:

- • • There is in positive correlation between purification effect of air conditioner and operation time. The effect of combined function is better than that of single function.
- 2• •• The air exchange function has rather good effect on TVOC, and there is in positive correlation between elimination effect and the air flow volume.
- S• •••The ionization function has better effect on PM10 (Particle with diameters of 10μm or less), HCHO (formaldehyde) and ABC than air exchange function. And negative ion is cheaper and better.
- 4• •• The elimination effect of ABC and PM10 maintains the consistent regular pattern. An air conditioner's elimination rate of ABC can be improved by improving that of PM10.
- 5• •••The oxygenation function improves the purification effects of air conditioners.

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