Research and Analysis on Performance of Purified Air Conditioning

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Abstract: In order to study the performance of purified air conditioning, the author designed an air conditioning with purification function. On the basis of the original air conditioning, honeycomb activated carbon filter and precious metal room-temperature catalytic filter are added to the purified air conditioning. We have analysed the purification performance, refrigeration performance and power consumption of the conditioner, which provides references for the design and energy consumption analysis of purified air conditioner.

1 INTRODUCTION

Indoor environment refers to the small space made of natural or artificial materials, and it is a small environment which is relatively separated from the external environment. The architectural indoor environment is the most important and most common. A lot of chemical composite materials are used during the modern interior decoration, such as man-made sheet, wallpaper, paint, composite ceiling, furniture and interior soft decoration. These elements emit a large number of poisonous and harmful gaseous pollutants continuously, including formaldehyde, benzene, xylene and VOCs (Volatile Organic Compounds). With the development of economy and people's living standard, urban residents spend more than 80% of their time indoors. IAQ (Indoor Air Quality) affects not only the comfort and health of human body, but also the working efficiency of indoor personnel prominently. A study by Harvard University shows that air quality in office has a significant impact on work efficiency. Good air quality helps to improve the ability to thinking, understanding, memorizing, learning and decision-making. The study found that people in the office with a good ventilation condition and a low concentration of pollutants were 61 percent more efficient than in a traditional office. With the improvement of healthy and environmental awareness, the indoor air pollution has aroused great attention in China (GB/T 18801-2015, 2015).

Relevant information from the WHO (World Health Organization) showed that the number of deaths due to indoor environmental pollution was about 2.8 million per year all over the world (GB/T 18883-2002, 2002).

The American Cancer Society studies founds that indoor air pollution had an great direct link with urban residents' health, and that more than 4% diseases in the world had a direct relationship with indoor pollution. It also indicated that the number of deaths from asthma attacks caused by indoor air pollution was more than 300 thousand every year, 40% of which are children (Guo, 2012).

In such a grim situation of air pollution, people attach more and more importance to problems related to IAQ. China's environmental protection industry is also taking advantage of development. The indoor air purification device began to rise, comprising air purifier, purified household air conditioner, purified central air conditioner, fresh air unit and so on. At present, the main purification technology for treating gaseous pollutants on the market is activated carbon adsorption, which belongs to physical adsorption. This technology has low purification efficiency and short service life. It needs to be replaced after a period of use, increasing after-sales costs and maintenance costs.

In this study, the purified air conditioning unit has been developed independently. And the experimental research and performance comparison are carried out mainly aiming at air purification capacity, service life, and energy consumption.

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2 INTRODUCTION OF PURIFIED AIR CONDITIONING

The purified air conditioning unit adds air purification function section, compared with original air conditioning unit. The unit mainly includes the panel, air inlet, air outlet, initial effect nylon filter, modified honeycomb activated carbon filter, precious metal room-temperature catalytic filter, surface cooler, water tray, frequency conversion fan and so on. The design air volume is 2000m^3/h, the cooling capacity is 11.6kW, and the external pressure is 120Pa.The structure of the unit is shown in the following chart (Figure 1 and 2).

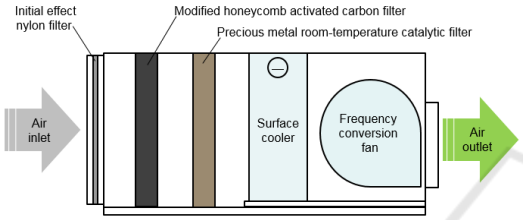

Figure 1: Structure diagram of purified air conditioning unit.

Figure 2: Appearance diagram of purified air conditioning unit.

2.1 Modified Honeycomb Activated Carbon Filter

Modified honeycomb activated carbon material uses honeycomb activated carbon composites as matrix, and its purification ability is improved by chemical modification. This material combines physical and chemical adsorption, with high purification efficiency and low desorption capacity. Compared with conventional activated carbon particle and activated carbon fabric, this material has the advantages of long purification life. The material is integrated, so its strength is greater and it is harder to break and leak powder. The material has through-hole structure, which makes the resistance very small. The modified honeycomb activated carbon material can effectively remove benzene and other TVOCs, abnormal flavor and odor.

2.2 Precious Metal Room-temperature Catalytic Filter

Precious metals generally refer to metals such as gold, silver, platinum, palladium, rhodium, iridium, osmium and ruthenium (JG/T 294-2010, 2012). Gold, platinum, palladium and other precious metals have good chemical stability and catalytic activity, and they have excellent performance for catalytic decomposing formaldehyde at room temperature.

Precious metals are not used as purifying materials directly, but as materials for purification by loading on carriers. There are two forms of carrier: one is the ceramic honeycomb, also called cordierite, the other is the metal honeycomb winding, like Fe-Cr-Al heat-resistant steel (Jin et al., 2007).

The precious metal room-temperature catalytic material is supported by ceramic honeycomb, whose surface is loaded with precious metal material. At room temperature, the material can decompose formaldehyde to CO_2 and H_2O under the action of precious metal catalysts, as shown in the Figure 3. The purification efficiency of precious metal room-temperature catalytic material is very high and thorough, without secondary pollution. Because the material plays the role of chemical catalysis, the purification effect of material is long-lasting and durable.

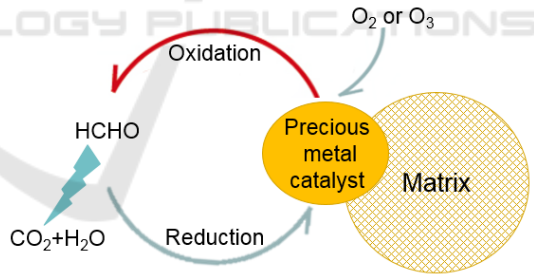

Figure 3: Principle diagram of precious metal room-temperature catalysis.

3 EXPERIMENTAL METHODS AND RESULTS

3.1 Primary Purification Efficiency

Primary purification efficiency is the ratio of the difference between the pollutant concentration of upstream and downstream to the pollutant concentration of windward, as shown equation below. In reference to *JG/T294-2010 Test of*

Pollutant Cleaning Performance of Air Cleaner (Shao et al, 2016), the test of primary purification efficiency is carried out at the air tunnel test system.

$$P = \frac{C_1 - C_2}{C_1} \times 100\% \quad (1)$$

P — the primary purification efficiency.

C_1 —the pollutant concentration of upstream

C_2 — the pollutant concentration of downstream.

The experimental conditions are that the ambient temperature is 23±2℃, the relative humidity is 50±10%, and the concentration of the upper air side is 3S±0.1S (S is the concentration limit specified in *GB/T 18883-2002 Indoor Air Quality Standard* (Zhang et al., 1999). The concentration limit of formaldehyde is 0.10mg/m^3 and that of TVOC is 0.60mg/m^3.). The primary purification efficiency of formaldehyde and TVOC are tested on the purification function section. The results are shown as Table 1.

Table 1: Results of the primary purification efficiency.

Project	Test Results	Standard Requirements
Primary purification efficiency of formaldehyde	76.6%	≥50%
Primary purification efficiency of TVOC	62.3%	≥50%

The primary purification efficiency of formaldehyde is 76.6% and that of TVOC is 62.3%.

According to *JG/T294-2010*, the primary purification efficiency should be more than 50%, and the above two items are much higher than the standard values.

3.2 CADR and CCM Values of Formaldehyde

The Clean Air Delivery Rate (CADR value) is a parameter of the purification capacity for the target pollutant, indicating the rate of air purifier to provide clean air.

The Cumulate Clean Mass (CCM value) is a parameter of cumulative purification capacity for the target pollutant. It indicates the total mass of the target pollutant when the CADR converges to 50% of the initial value. In reference to *GB/T18801-2015 Air Cleaner* (Zhu and Xiao, 2012), there are four levels of CCM value in Table 2.

Table 2: Evaluation of CCM value.

Grade	CCM value
F1	300 mg ≤ CCM < 600 mg
F2	600 mg ≤ CCM < 1000 mg
F3	1000 mg ≤ CCM < 1500 mg
F4	1500 mg ≤ CCM

The tests of CADR and CCM are carried out in the environment cabin test system under the same conditions as in the previous section. According to the gradual incremental injection method prescribed in *GB/T18801-2015*, the CADR values of formaldehyde were tested when the cumulative injection volume reached 300mg, 600mg, 1000mg, 1500mg, 2100mg, 2800mg, 3600mg, 4500mg, 5500mg……, respectively. Originally planned, the test would be finished when the CADR value of formaldehyde dropped to 50% of the initial value. However, the CADR value remained at a stable level during the test, because of the steady purification performance of the product. The test was carried out for 4 months, and the CADR value of the product was still not significantly reduced, so the test was terminated. The results are shown as Figure 4.

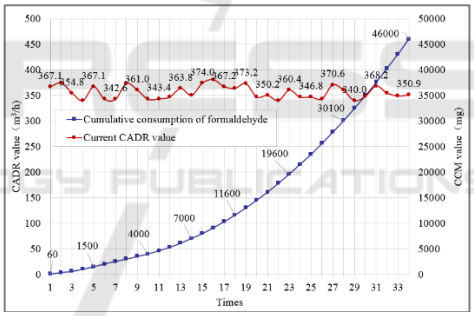

Figure 4: Test results of CADR and CCM values of formaldehyde.

The square points in the diagram represent the total amount of formaldehyde treated after each incremental injection, and the last value is the CCM value of formaldehyde. The round points represent the CADR values of formaldehyde tested after each incremental injection.

The initial CADR value of formaldehyde is 367.1 m^3/h and it is 350.9 m^3/h when the test ends. The final CADR value is 95.6% (much higher than 50%) of the initial value, without significant decline keeping between 340 and 380 m^3/h. During the whole lifetime test, the total formaldehyde is 46g, which is 30 times higher than that of the F4 level in *GB/T 18801-2015*. The corresponding CCM of F4 level is 1.5g.

3.3 Cooling Capacity and Energy Consumption

In order to study the effect of purification function on the performance of air conditioning units, we test the cooling capacity and power consumption of the units, through frequency conversion controlling the air volume at 2000 m^3/h and the external pressure at 120Pa. The experimental conditions are that the air dry-ball-temperature is 27℃, the air wet-ball-temperature is 19.5℃, the inlet-water-temperature is 7℃, and the temperature difference between the inlet and outlet water is 5℃. The results are shown as Table 3.

Table 3: Test results of cooling capacity and energy consumption.

Project	Unit without Purifying Filters	Unit Installed Purifying Filters
Air volume	1951 m^3/h	1970 m^3/h
External pressure	121 Pa	122 Pa
Cooling capacity	12154 W	12222 W
Input power	301 W	355 W

Under the same conditions of air volume and external pressure, after installed the purifying filters, the cooling capacity of the air conditioning unit is basically unchanged and the energy consumption is increased by 17.9%.

4 CONCLUSIONS

The purified air conditioning unit adds air purification function section to the original common air conditioning unit, including modified honeycomb carbon filter and precious metal room-temperature catalytic filter. It can purify formaldehyde, TVOC and other gaseous pollutants and provide comfortable, healthy, clean air. At the same time, there is a certain increase in resistance and energy consumption of the unit. The concrete results are as follows:

1) The air purification function section has high purification effect on formaldehyde and TVOC. The primary purification efficiency of formaldehyde is 76.6%, and that of TVOC is 62.3%. Both are higher than the standard values 50%.

2) The initial CADR value of formaldehyde is 367.1 m^3/h. The final CADR value is 367.1 m^3/h, which is much higher than 50% of the initial value.

3) The purification performance of the air purification functional section is stable, so it has long purification life, low replacement frequency and low running cost. During the whole lifetime test, the total formaldehyde is 46g, which is 30 times higher than that of the F4 level in *GB/T 18801-2015*. And the final CADR value is 95.6% (much higher than 50%) of the initial value, without significant decline keeping between 340 and 380 m^3/h. The CCM value of formaldehyde is far greater than 46g.

4) Compared with the common air conditioning unit, under the same conditions of air volume and external pressure, the cooling capacity of the air conditioning unit installed the purifying filters is basically unchanged and the energy consumption is increased by 17.9%

REFERENCES

GB/T 18801-2015 Air Cleaner [S]. Beijing: China Standard Press, 2015.

GB/T 18883-2002 Indoor Air Quality Standard [S]. Beijing: China Construction Industry Press, 2002.

Guo, S. B., 2012. Central Air Conditioning System Purification Technology [D]. Taiyuan: Taiyuan University of Technology.

JG/T 294-2010 Test of Pollutant Cleaning Performance of Air Cleaner [S]. Beijing: China Standard Press, 2012.

Jin, J. M., Bao, W. F., Wu, J. Q., Zhang, D. M., 2007. Supporter Materials and Noble Metal Catalyst [A]. Shanghai Powder Metallurgy Conference [C]. Shanghai, 2007:190-195.

Shao, Z. Y, Tang, X. C., Han, B. S., 2016. Research on Air Purification Technology of Central Air-conditioning [J]. Central Air-conditioning Market, 6(6): 68-70.

Zhang, G. Q., Shang, S. P., Xu, F., 1999. Indoor Air Quality [M]. Beijing: China Construction Industry Press.

Zhu, X. W., Xiao, G. M., 2012. The Research Progress of Precious Metal Catalysts [J]. Chemical Time Journal, 12 (26): 27-32.