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"Take the Wind as a Mirror and Know the Profit and Loss": Intelligent Air Purifier

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Abstract

In order to improve the situation that the air purifiers on the market lack the filter reminder device or the reminder device is not intelligent, this work designs a more intelligent and accurate reminder device that calculates the replacement time by monitoring the loss of the filter element, which is different from the traditional extensive type in the market. The countdown timer-type filter replacement reminder device is significantly different. The device includes an aerodynamic module, an air inlet and outlet module, an air purification module and an intelligent control module. The aerodynamic module is located inside the air outlet module, and uses the DC brushless motor to provide power to rotate the fan to generate air flow; the air inlet and outlet modules form a complete external structure of the air purifier, and together form a continuous air duct to ensure smooth air circulation, The air flows in from the two-way air inlet orifice of the inlet module, passes through the air purification module, enters the aerodynamic module in the air outlet module from the air collecting port, and is discharged from the spiral top air outlet, thus completing a complete air purification process. The air purification module is composed of a filter element. The air enters the air purifier through the inlet, and reaches the aerodynamic module after being purified by the filter element. The intelligent control module is composed of an analog gas pressure sensor and its related components. The differential pressure of the inlet and outlet air is directly obtained through programming, and the degree of filter element wear is divided into three grades: I, II, and III, which are displayed on the display screen respectively. Green, orange, red three colors, when the pressure difference at the outlet reaches the specified value, the display turns red. This device improves the service life of the air purifier and reduces secondary pollution by designing a new monitoring device for the loss of the filter material of the air purifier. It has broad application prospects for products used in filter media.

Keywords

Intelligent; Purifying Air; Reminder Device.

1. Research Background and Significance

As the country pays more and more attention to atmospheric problems, people also put forward higher requirements for the air quality of their living environment. Various air purifiers that can absorb inhalable particulate matter and volatile organic compounds have been launched on the market. The main component of the air purifier to filter and process the air is the filter element. Over time, the filter element will be gradually covered and blocked by impurities such as dust particles, resulting in poor filtering effect. Therefore, the air purifier needs to replace the filter element regularly. Existing air purifiers usually specify the recommended service life of their filter elements by the manufacturer, and the user replaces the filter element regularly. However, the air quality of the installation environment is different, and the actual service life of the filter element will also be different. Replacing the filter element according to the time

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given by the manufacturer may cause the effective filter element to be replaced, resulting in economic waste, or the filter element has failed but cannot be replaced in time. It does not have the effect of air filtration, and even causes secondary pollution.

How to effectively filter and purify the air and reduce the waste of resources caused by premature replacement of the filter element is a problem that needs to be focused on. The team proposed a new detection method to design a filter life detection device to reduce energy consumption while ensuring air quality.

2. Design

2.1. Design Ideas

At present, most of the air purifiers on the market have tended to be complete in terms of functions, but there is still a large technical gap on the issue of when to replace the filter material. Although some manufacturers have added the filter replacement reminder function to the air purifier, the actual experiment shows that the existing filter replacement reminder device on the market is just a countdown timer, regardless of whether it is turned on or not, it will count down, regardless of the use time and air pollution. The degree of influence is not intelligent, and it is an extensive product.

In response to the above problems, the team took into account the two concepts of "energy saving" and "emission reduction", considered the possible parameter changes before and after air purification, and finally chose the air pressure difference as the standard for detecting the degree of filter material loss. Based on the basic principle of Bernoulli equation, an air purifier that can intelligently detect the degree of wear and tear of filter material is designed. The air enters the air from the side holes, and the pressure P1 is collected here; after being purified by the filter material, the pressure P2 is collected at the air outlet; according to the variation range of the pressure difference in the experimental results, the corresponding relationship of the level of loss is set, and the level of loss is displayed on the LCD screen. level; when the loss level reaches the threshold, the reminder device sends out a prompt signal.

This method enables real-time monitoring of the air evolution device and makes it more intelligent. This work effectively solves the problems of energy consumption and secondary environmental pollution caused by premature or untimely replacement of filter materials caused by traditional air purifiers without a filter material replacement reminder device or relying on timing to remind.

2.2. Working Principle

1) Using the principle of aerodynamics, the air is sucked into the interior of the air purifier by forming a negative pressure;

2) Measure the pressure of the air inlet through the pressure sensor 1;

3) The air purified by the filter material is powered by the DC brushless motor to send the air out through the fan;

4) Measure the pressure of the air outlet through the pressure sensor 2;

5) Determine the loss level of the filter material according to the pressure difference on both sides and display it through the liquid crystal display;

6) When the threshold is reached (the filter material is completely unusable), the reminder device will issue a prompt signal.

3. Design Calculation

Assuming that the pressure at the side air inlet hole (Fig. 1) is, and the pressure at the air outlet side of the upper fan (section 2-2) is:

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$$Z_1+\frac{P_1}{\rho g}+\frac{V_1^2}{2g}=Z_2+\frac{P_2}{\rho g}+\frac{V_2^2}{2g}-P_e+\sum_{i=1}^{n}h_{wi}+h_{wl}$$

where is the height at the air inlet, is the height at the air outlet, is the pressure at the section a-b-c-d; is the pressure at the section 2-2; is the air density, assuming that the density is constant during the process; is the acceleration of gravity, ; is the section a-b-c-d Airflow speed; it is the airflow speed at the section 2-2'; it is the pressure head provided by the fan to the flowing air, because the fan power is stable, so it is a constant value; it is the sum of all local losses except the filter element in the process, and the specific value needs to be calculated It is determined by the test that it is the local loss caused by the filter element, and the air outlet pressure can be expressed as:

$$P_2=(Z_1-Z_2)\rho g+\frac{\rho(V_1^2-V_1^2)}{2}+P_1+\rho g P_e-\rho g(\sum_{i=1}^{n}h_{wi}+h_{wl})$$

With the increase in the use time of the air purifier, h_{wl} increases, The outlet pressure value decreases.

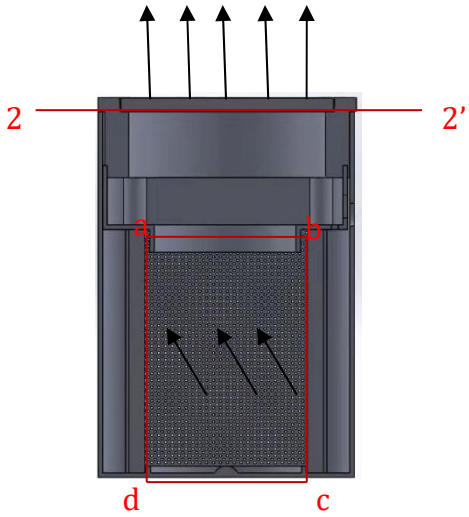

Fig 1. Schematic diagram of section a-b-c-d and section 2-2'

4. Experimental Test

4.1. Experimental Procedure

① Detect the pressure value of the air inlet. The air inlet pressure value is constant, and the air outlet pressure value reflects the pollution degree of the filter element.

② Set a blank control group without filter element, and measure the air outlet pressure at this time (as shown in Figure 2).

③ Put the clean filter element into the air purifier and measure the air outlet pressure at this time.

④ in order to speed up the experimental process, artificial sanding was used (as shown in Figure 3) to increase the pollution degree of the filter element. Weigh 0.5g of fine sand with an electronic balance, sprinkle it into the filter element, specify that the pollution level at this time is I, and measure the air outlet pressure at this time, continue to sprinkle the same mass of loose sand and increase the pollution level in turn, and measure the corresponding state. outlet pressure until the reading no longer changes.

⑤ Repeat the above steps three times to reduce errors and improve data accuracy.

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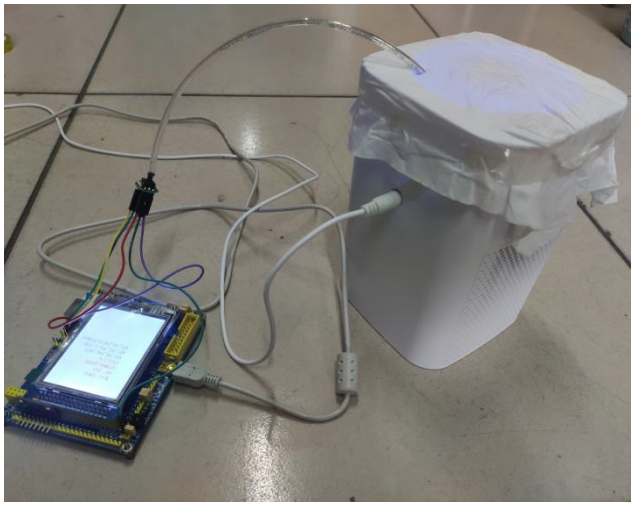
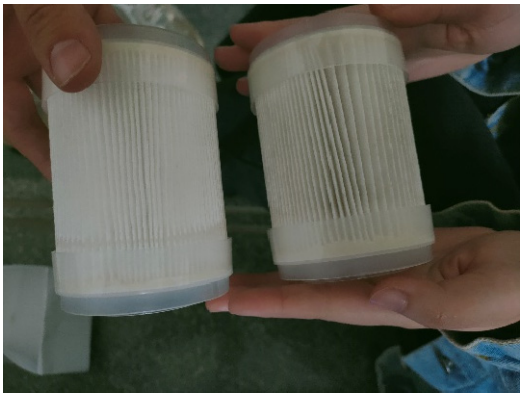


Fig 2. Air outlet pressure measurement

(a) fine sand weighing



(b) Comparison of filter element status before and after pollution

Fig 3. Artificial sanding increases the pollution degree of the filter element

4.2. Data Processing

Table 1. The outlet air pressure values under different filter element pollution levels

Experiment number	No filter element	Clean filter	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ
1	0.291	0.276	0.274	0.270	0.269	0.269	0.270
2	0.291	0.277	0.273	0.271	0.269	0.269	0.269
3	0.293	0.283	0.275	0.276	0.268	0.268	0.268
4	0.292	0.278	0.274	0.272	0.268	0.269	0.269

Note: The units not marked in the table are all kpa, and the inlet pressure is 0.267kpa

Organize the data and plot the trends as follows:

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The data obtained from the above experiments are listed in Table 1.

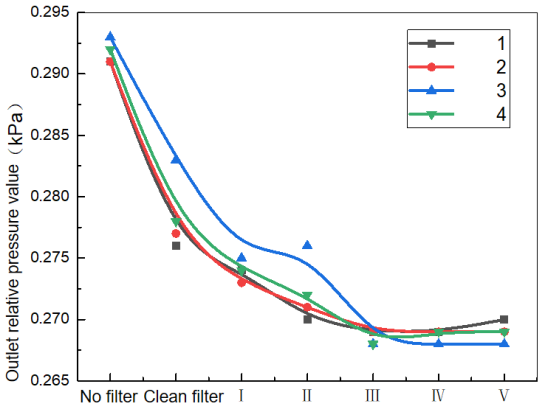

Fig 4. The curve of outlet pressure value changing with pollution degree

It can be seen from the above chart that the pressure value will drop significantly after the filter element is installed. The reason is that the local resistance increases after the filter element is added.

With the increase of the pollution level (that is, the increase of the amount of falling sand), the pressure value shows a trend of first slowly decreasing and then gradually stabilizing. When the value is further increased, when the filter element no longer has adsorption effect, the pressure value no longer changes significantly, which is consistent with the theory.

4.3. Achievement Display

After the threshold is determined through the above experiments, the pollution degree of the filter element is divided into three grades, which are divided into grade I, grade II and grade III, which are displayed in green, orange and red on the display screen respectively. Figure 5 and Figure 6 are clean filter elements. And the display of the completely contaminated filter element:

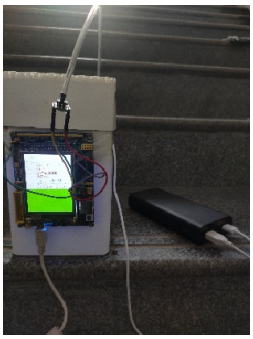

Fig 5. Display of clean filter element display

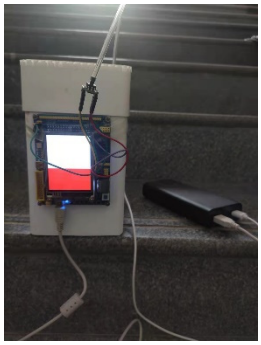

Fig 6. The display of the filter element after complete contamination

ISSN: 1813-4890

5. Conclusion

5.1. Innovations

1) The monitoring method is new: the loss degree of the air purifier filter material is reflected by measuring the pressure difference before and after the filter material, and then compared with the threshold value to finally judge the replacement time;

2) Real-time monitoring and intelligence: Compared with the rough filter replacement time provided by traditional manufacturers, this device can more accurately detect the degree of filter material loss according to the actual use of the user, so as to give a more accurate filter replacement time to avoid Unnecessary waste of energy and protection of user health and safety.

5.2. Application Prospects

As a time reminder device, this work can provide users with a more accurate filter replacement time and play a timely reminder role. In addition, the filter replacement reminder device made in this project can not only be used in air purifiers, but also in all products containing filters, such as filters in cars, air conditioner filters, etc. It is widely used and has high promotion value. Its design ideas are in line with the national concept of energy conservation, emission reduction and sustainable development, and have broad application prospects.

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