Multi-functional bus station billboard

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Abstract: With the development of urbanization and the advancement of industrial processes in China, the energy consumption with fossil energy as the main energy source continues to increase, which will result in the increase of the pressure on prevention and control of air pollution. Relevant departments of the state, provinces, cities and regions attach great importance to the work related to the control of haze weather and the prevention and control of air pollution, and have taken a series of measures to deal with positively. In response to this situation, this product was designed to effectively utilize the idle resources of the billboards in the bus stations to automatically and efficiently purify the air polluted by the automobile exhaust and haze, by placing an air purifier on the inside of the billboard. Not only is it convenient for people to see the contents of the billboards and achieves good publicity, but also purifies the air and benefits human health, achieving two things at one stroke.

1. Project backgrounds

1.1 Project backgrounds

At present, the problem of air quality in the world is becoming more and more obvious. With regard to China's domestic situation, with the improvement of people's living standards in recent years and the deterioration of the environment, air quality has gradually attracted the attention of the people.

Haze not only causes reductions in atmospheric visibility and air quality, but also increases the incidence of diseases such as respiratory tract infections and asthma. Meanwhile, it has a serious impact on road transport, civil and military aviation, and navigational fields, posing a great threat to citizens' production, life and health.

Public transportation has a very important position in the urban transportation system, while the rapid promotion of automobiles as a convenient means of transportation has also caused serious air pollution problems. Especially during the rush hours, the crowd densities of bus stations are relatively large, and the waiting crowds inhale a large number of vehicle exhaust pollutants during the waiting process.

2. Project research objective, research contents and problems to be solved

According to the above contents, in this work, aiming at the existing problem of air pollution, the multi-functional billboard was designed, using the air purification module as the main body of the mechanism to realize related functions of the multi-functional billboard for purifying air.

The panoramic model of the multi-functional bus station billboard is shown in Figure 2.1.
2.1 Research objectives
An air purifier was installed in the cavity inside the bus station billboard, integrating the functions of absorption and purification of the polluted air and discharge of the clean air, effectively cleaning the air polluted by haze and the automobile exhaust around the bus station. It gives the public a fresh and comfortable waiting environment, and effectively inhibits the incidence of diseases such as respiratory tract infections and asthma.

2.2 Research contents
As shown in Figure 2.1 and Figure 2.2, a pull-out groove is installed in the inner cavity of the billboard, and lots of small cells are equipped in the pull-out groove. From left to right, there are a HEPA strainer, an electrostatic adsorption device, an atomization chamber, a condensation chamber, an activated carbon filter, and a negative ion generator in the small cell. These devices make up the internal structure of the air purifier.

At the meantime, two intake fans are installed at one outer end of the pull-out groove, and the air polluted by harmful substances such as automobile exhaust and haze is sucked into the pull-out groove to purify by fan blade rotation. The polluted air passes through the HEPA strainer to filter the impurities and then passes through the electrostatic adsorption device. The electrostatic adsorption device utilizes a high-voltage direct current electric field to ionize the gas molecules of the air, and uses high-strength...
voltage to capture the dust particles to achieve the effect of adsorption and dust removal. After electrostatic adsorption the air is introduced into the atomization chamber, and the atomization chamber utilizes the ultrasonic atomization sheet to atomize the ammonia water to generate ammonia water mist, so that the ammonia water mist is combined with small particles such as pm2.5 to achieve air purification. At the same time, it can absorb acid gases from the exhaust gas. The air then enters the condensation chamber, utilizing a semiconductor condensation device in the chamber to condensate and collect water mist combined with particulate matters in the air. Finally, the air odor is removed through the activated carbon filter, and the air enters the anion generator to generate air anions, which is discharged through the blinds.

3. Scheme of project research

3.1 HEPA strainer
Multi-functional composite filter paper can effectively filter out particles larger than 20 microns. The interior is made of very fine organic fiber colloids and has a strong ability to capture particles, with small pore size and large adsorption capacity, which makes the purification efficiency of the strainer greatly improved. It can effectively intercept the smoke in the air and large particle pollutants such as PM2.5 and PM0.5.

3.2 Electrostatic adsorption device
Electrostatic precipitation is a means to remove dust that the gas is ionized in an electrostatic field and then the ionized electrons meet the dust particles, making them charged and adsorbed on the dust collecting plate. The dust removal process includes ① gas ionization; ② dust charge; ③ dust deposition.

The device uses a double-layer power grid to generate a strong electrostatic field. The air is ionized into positive ions and free electrons in the strong electric field. After air ionization, the positive ions are immediately combined with the discharge electrode (negative electrode), and the free electrons are combined with the dust particles in the air, achieving dust charge. The charged dust reaches the surface of the dust collecting plate under Coulomb force, and then discharges its charge and deposits on the dust collecting plate.

3.3 Atomization chamber

3.3.1 Principle of ultrasonic atomization
Ultrasonic waves generated by electronic high-frequency oscillation, through the high-frequency resonance of the ceramic atomization sheet, break up the liquid water molecular structure to produce fine droplets with a diameter of only 1~50μm. The droplet dust is confined in the atomization chamber. According to the aerodynamic principle, when the dusty airflow bypasses the droplet, the dust particles will collide with the droplets due to the inertia deviating from the flow, so that the fine dust is condensed, making the dust settle down quickly and achieving dust removal from the air. The industrial ammonia water is used as the atomized liquid in the device, which can not only absorb the acid gas in the exhaust gas, but also can remove the small dust particles in the air.

3.4 Condensation room

3.4.1 Refrigeration cabinet design scheme
The semiconductor refrigerating sheet, using the "Peltier" effect, is selected as the refrigerating element, and the related design of the refrigeration cabinet of the condensing chamber is conducted.

As shown in Figure 3.4.1, the refrigeration cabinet is designed to isolate the cold and hot ends of the semiconductor refrigerating sheet with a thermal insulation material. The cool and hot ends are respectively equipped with a heat sink composed of aluminum fins and a fan, and the method of enhancing heat dissipation from the hot end is utilized to improve the performance of semiconductor
refrigeration systems. Due to the limited refrigerating capacity of the single-chip semiconductor refrigeration sheet, according to the different refrigeration space, several pairs of semiconductor refrigeration sheets need to be connected in series on the circuit to form a common refrigeration thermopile, to meet the refrigeration effect.

Openings of the semiconductor refrigeration system are set on the right wall of the cabinet for mounting two pieces of refrigeration sheets, the one at the cold end being placed in the refrigeration cabinet and the one at hot end being placed outside the cabinet.

![Internal structure of refrigeration cabinet](image)

**Figure 3.4.1 Internal structure of refrigeration cabinet**

### 3.4.2 Overall design of the condensation chamber

The condensation chamber consists of a refrigeration cabinet, a condenser tube, and a water pump. In order to achieve better cooling effect, the device adopts the method of water circulation, and uses the water pump to introduce cold water cooled by the refrigeration cabinet in the water tank into the condenser tubes of a certain interval. Finally, the water returns to the cooling water tank. The maximum refrigeration power of this module can reach 60W, which can reduce the overall temperature by 6 °C to 9 °C.

### 4. Feasibility analysis of the project

#### 4.1 HEPA strainer

The HEPA strainer can remove more than 99.97% of the particles with a diameter of 0.3 microns or less, effectively removing smoke, dust and bacteria from the air.

#### 4.2 Dust removal efficiency by ultrasonic atomization

When the water mist particles have a certain moving speed, the water mist particles remove dust by the combined action of the inertial collision mechanism, the mechanism of dust interception and collection, and Brownian diffusion mechanism. The dust removal efficiency by atomization is:

\[
\eta_I = R \eta
\]

According to the calculation formula for collision capture efficiency proposed by Calvert:

\[
\eta = \frac{S_I}{(S_I + 0.7)}
\]

It can be seen from the above two equations: the smaller the droplet diameter, the larger the Stokes number, the higher the capture efficiency of the inertial collision, the larger the density and particle size of the dust particles, the higher the relative velocity of gas and liquid.
Figure 4.2.1 Effect of steam-water ratio on dust removal efficiency

As can be seen in Figure 4.2.1, the ultrasonic atomization dust removal system has a dust removal efficiency of over 90% in a small range of steam-water ratio, 10 times of steam-water ratio smaller than the conventional spray, which indicates that less water is used by the ultrasonic atomization dust removal system.

5. Innovation of the project
(1) An air purifier was installed in the cavity of the billboard in the bus station to effectively utilize the idle resources of the billboard.
(2) Ammonia water atomization to condense the dust in the air and absorb the acid gas in the exhaust gas, achieves two things at one stroke.
(3) The design of the pull-out groove is convenient for the replacement and cleaning of the device.

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