The utility model relates to a system for absorbing, storing and reusing harmful gases in municipal sewer system

Xiaolong Tan¹, Mingxi Tu¹, Menglun Tao²*, Kuangxi Li³
¹Yujiatou Campus, Wuhan University of Technology, Wuhan, Hubei, China
²Yujiatou Campus, Wuhan University of Technology, Wuhan, Hubei, China
³Yujiatou Campus, Wuhan University of Technology, Wuhan, Hubei, China

*Corresponding author’s e-mail: taomenglun@whut.edu.cn

Abstract: With the acceleration of urbanization, the scale of urban sewage drainage systems is also getting larger and larger. The pipeline sewage carries a large amount of domestic garbage and sludge after being decomposed by microorganisms, which produces a large amount of toxic, harmful, flammable and explosive gases, such as methane (CH₄) and hydrogen sulfide (H₂S). When these gases are concentrated in the drainage pipe, it is a serious safety hazard. If these gases are directly discharged into the atmosphere, it will pollute the environment on the one hand, and waste resources on the other. In order to solve this important problem, this paper designs a system for the absorption, storage and reuse of harmful gases in urban sewage pipelines for hydrogen sulfide and methane. The hydrogen sulfide and methane gas are absorbed by the adsorption device, and then the gas is pumped out of the adsorption device by a solar driven pump and stored in the gas storage device.

1. Introduction:
Hydrogen sulfide belongs to asphyxiating gas, and is highly toxic. When the concentration of hydrogen sulfide in the air reaches more than 1000mg/m³, it can cause "electroshock like" death, which is mainly absorbed through the respiratory tract. Not only that, the greater harm of hydrogen sulfide to cities is that it can easily cause corrosion damage to the sewer structure.

The overflow of methane into the air will aggravate the greenhouse effect, and it will cause explosion hazards when accumulated in the sewers, which will seriously affect people's daily life and life and health. However, as important industrial raw materials, hydrogen sulfide and methane have a wide range of industrial and medical uses and can create important value in the lives of residents.

The prevention and control technology of hydrogen sulfide in the sewer mainly controls the removal of sulfide by adding oxygen, nitrate, iron salt, hydrogen peroxide, chlorine or nitrate and other traditional methods. At the same time, the way to deal with methane in urban sewers is to reduce its production or concentration. The practical of traditional management agent depends on the rate that get rid of, medicamentous price and dosage of medicamentous, existence management cost is tall, service life is short and easy run off wait for inadequacy.

This paper designs a system for absorbing, storing and reusing harmful gases in urban sewage pipeline. A gas collection device is placed under the sewage well head where the concentration of hydrogen sulfide and methane gas is high, and hydrogen sulfide gas flows to the gas collection device by utilizing the airflow pressure and altitude in the sewer. Hydrogen sulfide and methane gas are absorbed through different adsorbents, which are desorbed by solar energy driven pump under negative
pressure. Meanwhile, the exhaust gas is discharged, which is transported by pipeline and stored in the gas storage device. When hydrogen sulfide or methane is needed for production and processing in the plant, it can be taken directly from the gas storage device.

Figure 1 The system process

2. **Gas detection:**
The detection methods of hydrogen sulfide, such as gas chromatography, iodine quantity, titration, spectrophotometry and other methods, require a variety of drugs, high technical requirements for operators, time-consuming, not suitable for the high demand for the timeliness of this device. Therefore, this device uses sensors to detect hydrogen sulfide.

The main detection method of methane is sensor detection. Because the electrochemical sensor has fast response time, high linearity and less cross interference from other gases, it can be ignored when applied in this device. So these two gases can be detected by electrochemical hydrogen sulfide sensor and electrochemical methane sensor respectively.

When in use, after calibrating the sensor, the amplifier circuit is used to obtain the relationship between concentration and current, and then the least squares method is used for fitting. After the concentration of hydrogen sulfide detected by the sensor, the current signal is output, and the analog signal is output through the signal acquisition and signal processing circuit, AD is converted into digital quantity, and software filtering is performed to obtain the concentration value. By collecting concentration information, the location of the device in the sewer can be planned.

3. **Gas adsorption materials:**
Adopting the adsorption method to enrich gas has the advantages of high adsorption degree, high efficiency and environmental protection, simple operation and reusable adsorbent, and has good development prospects. The key to the adsorption method is to develop adsorbents with good selectivity, large adsorption capacity, stable performance and good regeneration.

The hydrogen sulfide gas adsorption material uses a mixture of zeolite molecular sieve and 4A molecular sieve. Zeolite molecular sieve has a large specific surface area and regular pore structure, high adsorption capacity, easy regeneration, and low energy consumption. In order to improve the adsorption capacity and selectivity of the adsorbent for hydrogen sulfide, the molecular sieve needs to be modified. The large vacancies in the zeolite structure when the modified molecular sieve is prepared by the ion exchange method provide conditions for the introduction of large ions. The synthesis conditions of 4A molecular sieve directly affect the removal rate of hydrogen sulfide. By adjusting the temperature, the pH value and the ratio of raw materials can theoretically obtain an adsorbent with a 100% removal rate of hydrogen sulfide.

The absorption material of methane is super activated carbon. With a large number of microporous structures, ANG technology has a better adsorption capacity for methane and a better cycling performance. Due to the characteristics of sewage gas, physical activation method is adopted in the preparation of super activated carbon. Physical activation method is a process in which carbonized carbon material reacts with activated gas to form pores. The activated gas is a mixture of water vapor and carbon dioxide gas.

4. **Float type gas collection device**
Because there will be intermittent water flow in the sewer pipe, in order to make the gas collection device float on the water, a floating device is designed, which can make the position of the gas collection
device change with the water level of the sewer, so as to ensure that the gas collection device is not soaked.

The float is composed of a floating body, a copper wire and a counterweight. The floating body provides buoyancy to ensure that the float can float on the water under a certain load; the counterweight provides plumb force and is fixed at the bottom of the sewer pipe. The float and the counterweight pass through the copper wire. The connection ensures that the floating body tilts without overturning under the action of external force, and when the external force disappears, the floating body can still return to its original equilibrium position. The greater the surface area of the float, the greater the horizontal resistance in the water, and the more uniform the distribution of stress points, the better the stability. When designing, we try to expand the surface area of the floating body as much as possible, and increase the plumb weight to increase the stability of the attached body. The floating body adopts foam material to provide buoyancy to the gas collection device and produce buffering and shock absorption effects.

![Figure 2 Floating device](image)

5. **Solar-powered gas transport and collection device:**

5.1 **Solar pump**

The solar air pump uses photovoltaic panels to convert the electrical energy from solar energy as energy. The pump is a miniature vacuum diaphragm pump, driven by a brushless DC motor, with low noise, small size and stable performance. Various required parameters can be adjusted through the winding of the stator and can be operated at a wide voltage. The controller controls and regulates the operation of the pump, and adjusts the output frequency in real time so that the output power is close to the maximum power of the photovoltaic cell array. At the same time, it is equipped with a battery pack to realize the function of continuous power supply during the day and night. The solar cell is used to drive the miniature vacuum diaphragm pump for desorption. The solar panel uses 18V, and the maximum working current of 300W is 15.5A. The battery is a 24V lithium battery. The solar panel charges the battery, and the battery powers the intermittently working micro pump. Since the power of the desorption gas required by the device is not large, the solar pump can reach a maximum negative pressure of 1MPa, a flow rate greater than 12L/min, and a maximum power of 18W, so it can meet the gas collection requirements.
5.2 Adsorption process
The gas collection device is composed of a baffle, a spring, an adsorption tube, a filter membrane and a metal shell. The baffle and the shell are connected by a spring. At the beginning, the air pressure is obtained through the sewer information, the spring preload is adjusted and the pressure inside the gas collection device is adjusted. The pressure is stronger than the sum of the air pressure inside the device and the pre-tightening force (0.06Mpa), the air inlet is opened, and the exhaust gas quickly enters the cavity of the gas collection device, causing the pressure in the device to rise rapidly and closing the air inlet of the device. The rear pump works to desorb the gas adsorbed on the adsorption device, and the gas passes through the valve and enters the gas collection device to store the gas. At this time, the pressure in the gas collection device is reduced to lower than the outside atmospheric pressure, the air inlet is opened again, and the circulation process works.

During the adsorption process of the adsorbent, the pump pumps the sewer gas into the cavity of the collection device, and the adsorbent fully absorbs methane and hydrogen sulfide. After a period of time, the sewer gas from which methane and hydrogen sulfide have been removed is discharged from the outlet. The outlet is equipped with Thiobacillus thiobacillus and Thiobacillus denitrificans, which can play a role in further sulfur fixation.

5.3 Desorption process
Hydrogen sulfide and methane are removed by differential pressure removal. When hydrogen sulfide is removed, the power of the solar pump is adjusted to the maximum level to create pressure difference, and the hydrogen sulfide is desulfurized by adsorption on modified activated carbon into the hydrogen sulfide collection device; The method of methane desorption is the same as that of hydrogen sulfide.
6. Economic Benefit Analysis of Energy Saving and Emission Reduction

In 2018, the total length of the drainage pipeline in Wuhan is 9350km. The drainage pipeline diameter is 700mm and the average H2S concentration is 15mg/m3. The daily output is about 100kg, and the annual output is about 900 tons. With the CH4 concentration of 0.2%, the daily output is 18000m3. About 650,000 cubic meters per year. If municipal treatment of hydrogen sulfide waste gas and methane waste gas, the cost of processing materials plus manpower will be millions or even tens of millions, and if it is discharged into the atmosphere, the impact on the environment is incalculable, which violates the principle of protecting the environment. If this device is used, not only can it save tens of millions of disposal and waste costs each year, but it can also convert the collected gas into industrial products to generate considerable economic value. The concept of coexistence of energy saving and emission reduction has been realized.

From January 1992 to December 2017, a total of 275 hydrogen sulfide poisoning accidents occurred nationwide, resulting in a total of 967 deaths and 3,228 injuries, with an annual accident rate of 10.57 per year and an annual death rate of 37.07 persons per year. On July 22, 2019, a poisoning suffocation accident occurred in Zhangjiakou city, Hebei Province, causing five deaths and four injuries and a direct economic loss of 6.960 million yuan. Every time the economic loss caused by sewage exhaust is huge, and the loss of life can not be measured by the economy. Therefore, the device in the treatment of sewage exhaust, to ensure the safety of nearby residents and dredging workers, improve the quality of atmospheric environment, has produced good social benefits.

7. Summary:

This article introduces a system for absorbing, storing and reusing harmful gases in urban sewage pipelines, which integrates the actual toxic and harmful gas conditions in sewers and separates valuable gases to achieve energy saving and emission reduction. It reduces toxic and harmful gas emissions in sewers and prevent excessive hydrogen sulfide and methane spill into the atmosphere to harm the environment, and at the same time provides important raw materials for factory production, realize the purpose of energy saving and green life.

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