The Design and Implementation of Gas Concentration Detection Terminal for Fumigation System

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Abstract. This automatic gain gas concentration terminal is designed for PH3 in circulating fumigation. The automatic isolation device is used to open the acquisition terminal, which can effectively prolong the life of the sensor. Combining with the construction characteristics and data business of the granary site, the wireless module is configured for the terminal, and the standard wireless interface is provided for the next step to build the complete data collection and network transmission system. The experimental results show that the system can save fumigation, prolong the replacement cycle of sensors, reduce the cost and improve safety, which will be the trend of technology improvement in grain storage industry.

1. Introduction
At present, the detection method of effective gas concentration in fumigation is mainly the timing extraction of gas pump. However, most grain stores use empirical formula to control the amount of dosage and the control is not accurate enough. In addition, the measured gas sensor was exposed to the real time environment, replacement cost is very high. There are few devices that can set indicators, automatically detect concentration, automatically control concentration and wireless networking [1].

This automatic terminal is designed for PH3 in circulating fumigation. The automatic isolation device can effectively prolong the life of the sensor. The wireless module is designed combining with the construction characteristics and data business of the granary site. This instrument can be used to reduce the amount of medicine, prolong the life of the sensor, improve the safety factor, and greatly reduce the cost of production and labor maintenance.

2. Hardware of the system
The structure of the measurement device is shown in figure 1. The detector is mainly composed of gas isolation module, self-gain concentration detection terminal, micro controller, wireless communication module, special enclosure and gas sensor.
MCU control the micro air pump, miniature solenoid valve reasonably, combined with effective isolation sensor and measured gas sealing technology environment, after receiving the effective command from the wireless module, the inhalation and shutoff state is controlled scientifically. The detection terminal adopts the micro-current collection technology to collect the effective current signal of the sensor and send to the MCU for data processing [4]. PH3/ c-2000 comes from the Swedish MEMBRAPOR company. The O2 sensor i-06 comes from Germany ITG company, the measuring range is 0 ~100%, 3 accuracy level, minimum accuracy+ 0.1%.

2.1. Auto-gain concentration detection module
Because the output value is unstable after the amplification unit, a primary follower is added at the output end. Then TLC2264 is used in a group of transports, with typical Ib= 1pA and Uos= 300 μV [2, 3]. CD4052 is analog switch, According to the input voltage value, the gain is tentatively fixed 4 levels: 10 ~240 mV, gain x 10; 2241 ~ 700 m V, gain x 3. 3.3701~ 1 100 m V, gain x 2.2; 41. 1 ~ 1.8v, gain x 1.

2.2. Communication module
CC2530 is the core wireless chip in the communication module, CC2530 has the function of RF wireless transceiver and micro-controller on the single chip. On the basis of the star network topology, once the coordinator receives the acquisition command sent by the upper computer, it sends the acquisition command to the terminal immediately, after the terminal acquisition is completed, the
location and concentration information of the tester are transmitted to the CC2530 module through the serial port of the controller. CC2530 sends the collected information to external coordinator through the wireless network, then the coordinator transmits the information to the PC, terminal enters standby state after each round of uploading, waiting for the next collection command, as shown in figure 3.

![Figure 3. The communication module](image)

3. Installation point and special enclosure

Due to the need of effective gas concentration detection, the distribution of test points and the shape of the test terminal were designed. At the time of installation, five gas sampling probes should be placed at the four corners and the middle part of the granary, with the depth of 1 m, 1.5 m, 2 m, 2.5 m and 3 m. In addition, considering the corrosive characteristics of PH3 gas to metal materials, the shell structure shown in figure 4 is designed.

![Figure 4. Schematic diagram of the shell structure](image)

The uniform air vent can ensure that the gas continuously enters the probe and has the minimum impact on the air volume and airway pressure. The length of the PH3 and O2 measuring head is 10cm and 20cm, which can be extended according to the grain depth.

In addition to the need to collect on demand, the equipment's air tightness, isolation device distribution, air inlet, and embedded tip are added. In particular, the device's explosion-proof function is realized mainly through the external explosive shell, which not only prevents the PH3 gas detonation and the corrosion of the circuit board, but also meet the requirements of the sensor's quick response and the need to collect and extend the life. After installation, the equipment should be calibrated before use.
4. Result
In the actual measurement, the circulation is fumigated under the film, and the circulation return air duct is laid on the grain surface, so that PH3 is evenly distributed in the grain pile, thus reducing the "dead Angle" phenomenon that is easy to appear in the whole circulation. After the effective gas reached the basic equilibrium, the lowest average concentration and the highest average concentration ratio were 0.82, and the concentration curves of each point in the grain pile were smooth and showed a steady downward trend. The data of PH3 concentration within one month after the installation of the 24 warehouse is shown in figure 5.

![Figure 5. Measured concentration of 24 warehouse.](image)

As can be seen from the data in figure 7, because of the sequence of circulation and the influence of wind direction, the concentration of test points at different locations in the cabin fluctuates regularly in the vicinity of 1 minute and 12 minutes, however, it can be guaranteed that the effective fumigation value can be fully satisfied within 3-10 minutes. In particular, the concentration of PH3 concentration in 5-6 minutes is basically stable, which can provide a meaningful reference value for the subsequent dosage calculation. Through the analysis of the regular fluctuation value, we can further optimize the opening sequence of the combined circulation device, and further expand the stable and effective fumigation range.

Measured data is compared with that of DST-01D gas detector, the correlation is more than 0.98. The result indicates that the test terminal is accurate and meets the system requirements.

5. Conclusion
The test terminal can provide accurate and reliable real-time test value, and can be extracted to valuable information. On the basis of the existing drug delivery device, system can implement control of Fumigation dose scientifically, effectively prolong the life of sensor, improve safety coefficient, greatly reduces the production cost and artificial cost.

The terminal has the advantages of simple network, low cost and flexible upgrade, which can greatly reduce the maintenance cost of the existing fumigation system, and it is very suitable for the grain detection system used in the grain depot.

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