Improving Property Operation and Maintenance Efficiency: Carbon Emission Sensors and their Lifecycle Management Practices

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Abstract. With global warming, extreme weather phenomena are becoming increasingly frequent. Carbon dioxide, as the greenhouse gas with the largest proportion of global emissions, has attracted widespread attention to its emission issues. How to monitor and measure carbon dioxide in the environment, and how to extend the lifecycle of carbon emission sensors, have become particularly important and urgent. This article aims to explore the concept, classification, principles, and maintenance methods of carbon emission sensors, making positive contributions to intelligent construction and providing technical support for achieving the "dual carbon" strategy.

Keywords: carbon emissions; Carbon emission sensor; carbon dioxide; life cycle

1 Introduction

Climate change is one of the great challenges facing the world today, and greenhouse gas emissions generated by human activities are its main driving force, making this problem even more serious.[1][2] According to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), human activities are expected to have caused global warming since the Industrial Revolution, which is 1.1 ℃ higher than pre industrial levels. If global carbon dioxide and other greenhouse gas emissions are not significantly reduced in the coming decades, global temperatures will rise by over 1.5 ℃ in the 21st century.[3] Against the backdrop of continuously increasing carbon dioxide emissions, improving energy efficiency and reducing carbon emissions have become particularly urgent. In response to the "double reduction" policy and to promote sustainable development, the correct use of carbon emission sensors has become particularly important. By monitoring and measuring carbon dioxide in the environment through sensors, we can detect the concentration of carbon dioxide in real time and accurately, and take effective measures to address climate change.

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Just as a good house requires careful maintenance, various electrical and mechanical equipment in a building also have their own lifecycle. The lifecycle of sensors is closely related to their own performance, usage conditions, and environmental factors. Under normal circumstances, the lifespan of sensors is 3-10 years. Only by ensuring the extension of the lifecycle of each device and maximizing its value can the lifespan of the entire room be extended. It is crucial to extend the service life of carbon emission sensors in order to improve their efficiency, reduce operating costs, and promote sustainable development throughout their entire lifecycle. Once the sensor exceeds its expected lifespan, it should be replaced regularly. To this end, this article provides a detailed introduction to the classification of carbon emission sensors, common faults and their handling methods, best practices for regular maintenance, precautions for maintenance at any time, and methods for determining replacement cycles, aiming to help maximize the performance and value of sensors.

2 Concept of Carbon Emission Sensors

In the early 1970s, sensor technology evolved from the initial structural sensors to solid-state sensors composed of magnetic materials and semiconductor components, giving rise to photosensitive sensors and thermocouple sensors. In the late 1970s, based on the development of microelectronics and integration technology, sensor technology entered the stage of low price and series development. In the 1980s, it developed into intelligent sensors with comprehensive capabilities such as automatic detection, automatic diagnosis, and adaptation. At the same time, with microprocessors as the development direction, it optimized the sensor signal regulation circuit and successfully integrated it with memory. In addition, with the integration of artificial intelligence technology, the application field of sensors was expanded and widely used in the industrial field.[4]

A carbon emission sensor is a professional monitoring device designed specifically to detect the amount of carbon dioxide (CO2) emissions in the environment. It works based on chemical sensing technology and electrochemical principles, and can achieve real-time and accurate monitoring of carbon dioxide concentration. Carbon emission sensors are widely used in smart homes, smart agriculture, industrial gas emission monitoring and other fields, providing important support for improving indoor air quality, promoting smart planting, reducing greenhouse gas emissions and other aspects. The sensor contains special chemical materials inside that can react with carbon dioxide and generate electrical signals. By accurately measuring the intensity of these signals, the concentration of carbon dioxide in the environment can be reflected. In addition, sensors also have functions such as temperature and humidity compensation to improve the accuracy and reliability of measurement results.

3 Classification of Carbon Emission Sensors

3.1 Classification Based on Measurement Principles

(1) Optical carbon emission sensor

Optical carbon emission sensors use the principle of absorbing and emitting infrared radiation to measure CO2 concentration, which typically includes an emitter and a receiver. This sensor has the characteristics of high precision and long-term stability, and is suitable for indoor air quality monitoring and industrial process control.

(2) Chemical carbon emission sensor

Chemical carbon emission sensors measure CO2 concentration based on the principle that CO2 reacts with chemicals (such as alkaline solutions) to produce ions. This type of sensor is typically equipped with an electrode immersed in a chemical substance and a reference electrode, which calculates the concentration of CO2 by measuring the potential difference between these electrodes. Chemical CO2 sensors have the characteristics of fast response speed and low cost, making them suitable for some cost sensitive applications that do not require overly complex monitoring.

(3) Capacity carbon emission sensor

Capacity carbon emission sensors measure the concentration of CO2 by monitoring the capacitance changes between CO2 and capacitive materials. This type of sensor typically includes a capacitive material and an electrode, and calculates the concentration of CO2 in the environment by measuring the capacitance change of the capacitive material. Capacity carbon emission sensors have the characteristics of high accuracy and low power consumption, and are suitable for some application scenarios that require high energy consumption.

3.2 Classification Based on Application Fields

(1) Indoor air quality monitoring carbon emission sensor

Indoor air quality monitoring carbon emission sensor is a device used to monitor indoor CO2 concentration. It is usually installed in offices, schools, hospitals and other places to evaluate and ensure the quality of indoor air, and can also assist in implementing corresponding control measures to optimize indoor environment. This type of sensor requires high precision and long-term stability to effectively ensure indoor air quality.

(2) Industrial process control carbon emission sensor

Industrial process control carbon emission sensors are devices used to monitor and control the concentration of CO2 in industrial processes. They are widely used in industrial scenarios such as petrochemicals, steel, and chemicals to ensure that CO2 emissions during production meet environmental requirements. This type of sensor needs to have the characteristics of high precision and fast response to ensure that the emission level always meets the prescribed environmental standards, which helps to achieve the green transformation and sustainable development of industrial production.

(3) Greenhouse gas emission control carbon emission sensor

Greenhouse gas emission control carbon emission sensor is a device used to monitor and control the concentration of CO2 in greenhouse gas emissions. It is usually installed in greenhouses, large livestock farms, and other places to monitor the emission of greenhouse gases in real time, and take corresponding measures to control the concentration of CO2 based on the monitoring results. This sensor has high accuracy and strong stability to ensure reliable measurement data under various environmental conditions to help control greenhouse gas emissions.

3.3 Classification Based on Signal Output

(1) Analog output carbon emission sensor

The simulated output carbon emission sensor reflects changes in CO2 concentration by adjusting the output voltage or current. This type of sensor typically requires connection to an analog input interface or analog measurement device for reading and processing.

(2) Digital output carbon emission sensor

Digital output carbon emission sensors convert CO2 concentration into digital signals, typically equipped with serial communication interfaces (such as UART, I2C) or digital output interfaces (such as PWM) for easy connection and communication with computers or other devices.

4 Working Principle

The core working principle of carbon emission sensors relies on non dispersive infrared (NDIR) technology, which detects carbon dioxide concentration by measuring the degree of absorption of specific wavelength infrared light by carbon dioxide. The sensor utilizes the selective absorption characteristics of different gas molecules towards specific wavelengths of infrared light, especially the significant absorption ability exhibited by carbon dioxide molecules in the near-infrared band. Specifically, the infrared carbon emission sensor includes an infrared light source emitting infrared light of a specific wavelength, which is captured by an infrared detector located on the other side after passing through a measurement chamber filled with sample gas. Due to the strong absorption of specific infrared bands by carbon dioxide molecules, the sensor can accurately calculate the concentration of carbon dioxide by comparing the intensity of infrared light emitted by the light source with the intensity received by the detector.

5 Common Faults and Their Solutions

The operation of carbon emission sensors relies on stable power supply, effective communication connections, sound hardware status, and accurate data processing. Here are some common problems and their solutions.[5]

(1) Power issue

Generally speaking, carbon emission sensors rely on battery power supply. If the battery life is too short or the circuit board malfunctions, it will cause them to malfunction. This situation requires replacing the battery or repairing the circuit board to solve the power problem.

(2) Communication malfunction

Communication interruption between sensors and monitoring devices may also lead to abnormal operation. At this point, it is necessary to check whether the connection of the communication cable is secure, whether the network cable is damaged, and whether the network settings are correct to ensure smooth data transmission between the sensor and the monitoring device.

(3) Hardware malfunction

Hardware issues with carbon emission sensors, such as damaged sensor components and product aging caused by prolonged use. At this point, it is necessary to replace the damaged components or replace the sensor with a new one.

(4) Data processing exception

The data collected by carbon emission sensors needs to be processed before they can be used, so if there are abnormalities or program failures in the data, it can also cause the sensor to malfunction. At this point, the data processing program should be checked, and sensors and monitoring devices should be restarted. If the problem still cannot be solved, it is advisable to seek the intervention of professional technicians for further diagnosis and repair.

6 Regular Maintenance Methods

To ensure the long-term stability and accuracy of carbon emission sensors, it is recommended to develop regular maintenance and upkeep plans.[6]

In mechatronics systems, sensor technology is at the core, especially with the continuous improvement of mechanical automation level, the application of this technology has become commonplace. In previous mechatronics systems, there was a failure to focus on controlling the efficiency of system operation, and management personnel were unable to grasp the real-time operation of the system. Only after a system failure occurred, could the analysis, judgment, and location of the problem be completed, and targeted maintenance and prevention be carried out.

(1) Carbon emission sensors should be regularly maintained to avoid any form of falling or impact. Meanwhile, ensure that the sensor does not inhale dust to avoid affecting its performance.

(2) When the carbon emission sensor is not used for a long time, the instrument power should be turned off, stored carefully, and protected from moisture and dust.

(3) During maintenance, the model, specifications, and parameters of components in the original circuit must not be changed, and the original packaging must not be altered. All repairs must be carried out by professionals on the well.

(4) If the alarm function of the sensor is silent or has poor contact, the overall condition of the solder joints, wire connections, and circuit should be checked.

7 Precautions for Maintenance at Any Time

The application of sensor technology is of great significance for production safety in various industries. For example, in the coal mining production process, the application of sensor technology can effectively reduce personnel casualties and improve the accuracy of coal mining excavation and processing. Therefore, sensors need to be regularly inspected to ensure their safety.

(1) Regularly test carbon emission sensors, such as calibration and impact testing.

(2) Stay away from dust and keep the environment around the carbon emission sensor clean.

(3) The ambient temperature should be moderate and not too high or too low to avoid affecting the accuracy of electronic components.

(4) Prohibit the use of high concentration irritating chemicals and cleaning agents to prevent damage to sensitive components of sensors.

(5) During the maintenance of carbon emission sensors, special attention should be paid to the possible detection interference between different sensors to ensure the independence and accuracy of measurement results.

(6) Use a soft cotton cloth dipped in a small amount of water to wipe the surface of the sensor, and dry it promptly after cleaning to prevent moisture from entering.

(7) Keep the surface of the carbon emission sensor dry and clean, away from moisture, rain, and corrosive liquids.

(8) Regularly inspect components such as the air pump diaphragm, sealing ring, condensate gas, and four-way valve for damage to prevent air leakage in the air circuit system.

(9) The detection hole of the carbon emission sensor should be wiped regularly to keep the hole tube unobstructed and prevent liquid from flowing into the detection hole. If liquid accidentally flows in, the sensor should be inverted to allow the liquid to flow out automatically.

(10) Check for any air leaks in the carbon emission detection gas system. Check whether the diaphragm of the sobbing pump is damaged, whether the sealing ring of the sampling probe is broken, whether the four-way valve and condensate are damaged, etc.

8 Regularly Change the Time Cycle

The maintenance and upkeep of carbon emission sensors should regularly calibrate and maintain the alarm, with a calibration cycle not exceeding 15 days. During normal use, the transmitter should undergo calibration checks at least once every 6 months or annually during the effective service life of the sensor., To ensure accurate and effective gas monitoring. If the sensor exceeds its effective service life or malfunctions, it must be replaced with a new sensor in a timely manner.

9 Conclusion

Carbon emission sensors are playing an increasingly important role in monitoring and controlling carbon dioxide emissions. This article delves into the lifecycle of property management, including concepts, classifications, working principles, and maintenance. This provides practical guidance for improving environmental management efficiency and achieving the "dual carbon" goal, and enhances the operational efficiency of property management. Accurate carbon emissions monitoring is crucial for reducing greenhouse gas emissions and improving energy efficiency. Regular maintenance, calibration, and replacement are key to ensuring sensor performance and environmental protection. With the advancement of technology, we look forward to the emergence of more efficient and accurate sensors. Call on all parties to work together and adopt advanced sensor technology to contribute to the protection of the Earth's environment.

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