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Evaluating MQ Sensors in Gas Leakage Detection Systems

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Abstract Gas leakage detection systems are crucial for ensuring safety and preventing accidents in both domestic and industrial environments. The effectiveness of these systems largely depend on the performance of the gas sensors used, which are responsible for detecting gas concentrations. This review evaluates the various MQ sensors employed in gas leakage detection systems, focusing on their capabilities, limitations, and applications. The survey shows that while MQ2 and MQ5 sensors are versatile for domestic environments, MQ4 and MQ6 sensors are more specialized for methane and LPG detection. Also, MQ9 provides high-resolution detection of carbon monoxide and methane, whereas MQ135 is optimal for broader air quality monitoring. By analyzing these MQ series sensors, we have provided insights into their suitability for various gas detection needs and highlighted the potential areas for future research and development.

Keywords: MQ2, MQ4, MQ5, MQ6, MQ9, MQ135

1. Introduction

Gas leakage detection is a critical aspect of safety management in environments where hazardous gases are used or produced. Effective detection systems can prevent accidents, protect human health, and mitigate environmental impacts. Gas sensors, which play a central role in these systems, are designed to detect specific gases and provide real-time measurements of their concentrations. The choice of sensor technology can significantly impact the reliability, accuracy, and overall performance of the detection system. This article reviews a range of studies and innovations related to using MQ gas sensors in leakage monitoring systems. This will be followed by providing an overview of the different MQ sensors used, discussing their capabilities and limitations, and exploring their applications in various detection systems.

2. Review of Research Works

This section presents in a tabular form, various gas leakage monitoring systems where MQ sensors are used. In a summary, MQ sensors used in the development of various gas leakage monitoring systems were found to include MQ2, MQ4, MQ5, MQ6, MQ9, and MQ135 sensors.

Table 1: Summary of Authors and MQ Sensors used in gas leakage detection systems

Authors	Gas Sensor Used
Adamu & Suleiman (2021)	MQ2
Alshammari and Chughtai (2020)	MQ5
Anusuya *et al*. (2019)	MQ2
Anusha *et al*. (2020)	MQ2
Siddika and Hossain (2020)	MQ135
Malipatil *et al*. (2019)	MQ6

Naik *et al*. (2016)	MQ4
Priya and Kowsalya (2021)	MQ2
Chandak *et al*. (2020)	MQ6
Madhivathana *et al*. (2020)	MQ6
Ranjithkumar *et al*. (2021)	MQ2
Nguyen and Nguyen (2020)	MQ2
Shiyana and Deepa (2017)	MQ9
Inamdar *et al*. (2021)	MQ5
Rohan *et al*. (2021)	MQ135
Shah *et al*. (2021)	MQ6
Anandhakrishnan *et a*l. (2017)	MQ2
Rahmalisa *et al*. (2021)	MQ6
Srivastava and Varshini (2021)	MQ4
Sudar *et al*. (2021)	MQ4
Subbarayudu *et al*. (2019)	MQ135
Soh *et al*. (2019)	MQ2
Tamizharasan *et al*. (2019)	MQ6
Suma *et al*. (2019)	MQ5
Amuthan and Zin (2021)	MQ5
Khan (2020)	MQ6
Medilla *et al*. (2018)	MQ4
Evalina *et al*. (2020)	MQ6
Hassan *et al*. (2022)	MQ135
Palandurkar *et al*. (2020)	MQ5
Johare *et al*. (2022)	MQ6
Marin (2013)	MQ2
Kapadnis *et al*. (2022)	MQ6
Ahmed *et al*. (2023)	MQ6
Sai *et al*. (2023)	MQ2
Naveen *et al*. (2023)	MQ6

3. MQ Gas Sensors Overview

Gas sensors form the cornerstone of any gas leakage detection system. These sensors work by detecting changes in resistance due to gas concentration in the air, which are then converted into voltage signals that can be processed by a microcontroller.

MQ2 Sensor

The MQ2 sensor consists of a SnO2 layer that reacts with target gases. When gas molecules come into contact with the sensor's surface, they alter the electrical resistance of the tin oxide layer Marin (2013). The sensor operates based on the principle of resistive change, where the resistance of the sensor's sensing element varies in response to the concentration of target gases. The sensor generates an analog voltage signal proportional to the gas concentration, which can be read by a microcontroller or an analog-to-digital converter (ADC). The MQ2 sensor is a popular gas sensor used in various applications for detecting the presence of gases like methane, propane, carbon monoxide, hydrogen, Alcohol and smoke (Priya and Kowsalya, 2021; Anandhakrishnan *et al*. 2017).

MQ4 Sensor

The MQ4 sensor uses a similar working principle as the MQ2, where the sensor's heating element warms up the sensing material, leading to a change in its electrical resistance in the presence of target gases (Naik et al. 2016). However, it is specifically tuned for detecting methane, propane and carbon monoxide. It features a micro-heat system that enhances sensitivity. Its high sensitivity to methane and carbon monoxide, makes it suitable for detecting gas leaks in industrial settings (Srivastava and Varshini, 2021; Medilla *et al*. 2018).

MQ5 Sensor

Like other MQ sensors discussed, MQ5 sensor operates by heating a semiconductor material, causing a change in resistance that corresponds to the concentration of the gases being detected. The MQ5 sensor is designed to detect multiple gases and smoke, making it a comprehensive option for gas leakage detection (Palandurkar *et al*. 2020; Alshammari and Chughtai, 2020). It has a good sensitivity range for detecting LPG, methane, alcohol and CO, making it versatile for both domestic and industrial uses (Amuthan and Zin, 2021).

MQ6 Sensor

Similar to other MQ family, the MQ6 uses a heated sensing material to measure gas concentration based on the resistance change. The MQ6 sensor is known for its high sensitivity to LPG Carbon monoxide, propane and methane (Pooja *et al*., 2020; Ekah *et al*. 2024). It is used in applications where precise detection of these gases is crucial.

MQ9 Sensor

This sensor utilizes a micro-heat system to detect changes in resistance caused by the presence of target gases. The MQ9 sensor provides high sensitivity to carbon monoxide, LPG and methane, making it suitable for environments where these gases are present in varying concentrations (Shiyana and Deepa, 2017).

MQ135 Sensor

The sensor uses a tin dioxide (SnO_2) sensing layer and heating element to detect gases based on resistance changes in the presence of target gases. The MQ135 sensor is versatile and capable of detecting a wide range of gases, making it suitable for comprehensive air quality monitoring. Such gases include ammonia, nitrogen oxides, smoke, alcohols, SO_2, benzene, and CO_2 (Hassan *et al*. 2022).

4. Comparative Analysis of MQ Sensors

The various MQ sensors offer a range of capabilities and sensitivities suited for different applications. While MQ2 and MQ5 are versatile for domestic environments, MQ4 and MQ6 are more specialized for methane and LPG detection. MQ9 provides high-resolution detection of carbon monoxide and methane, whereas MQ135 is optimal for broader air quality monitoring.

5. Comparative Analysis of MQ Sensors

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Limitations and Challenges

Despite their effectiveness, MQ sensors face limitations such as:

1. Sensitivity to Environmental Factors: Sensor performance can be affected by humidity, temperature, and other environmental conditions.
2. Cross-Sensitivity: Some sensors may respond to multiple gases, leading to potential false readings.
3. Calibration Needs: Regular calibration is required to maintain accuracy over time.

6. Future Directions

Advancements in sensor technology are focused on improving accuracy, reducing cross-sensitivity, and enhancing durability. Emerging technologies such as nanomaterials and advanced signal processing are expected to address some of the current limitations and offer more reliable gas detection solutions.

7. Conclusion

Gas sensors are vital components of gas leakage detection systems, providing crucial data for preventing hazardous situations. The choice of sensor depends on the specific gases to be detected, the required sensitivity, and the environmental conditions. While traditional sensors like the MQ series offer versatile solutions, newer technologies and improvements continue to enhance detection capabilities and reliability. Understanding the strengths and limitations of various gas sensors is essential for designing effective gas leakage monitoring systems and ensuring safety in both domestic and industrial environments.

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