

AN INTEGRATED METHOD TO ENSURING SAFETY IN GAS STORAGE FACILITIES

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ABSTRACT: This paper focuses on the safety of the gas industry. We discuss the overall safety management system designed to reduce risks to both the work environment and workers. There are important features of this system such as real-time updates on gas leakage, a gas level indicator displaying the gas level and constant monitoring and communication with a centralized location. The method presented in this study is an integrated system with Internet of Things (IoT) developed with a web application and emergency management system. As a result, this system gives quick responses without exceed 200 milliseconds. Additionally, the system utilizes the AWS EC2 cloud hosting platform for communication and storage purposes.

Keywords: gas leakage system, microcontroller and IoT cloud platform, valve control system

1. INTRODUCTION

The most recent accident due to a gas leak occurred on the 23rd of August at a factory in Gujarat, India. Today, various types of gases are used in the industry, and large quantities are stored to meet national requirements. However, there is a pressing need to reduce risks in the gas industry through proper monitoring and a centralized system. The gas industry faces critical challenges such as explosions, improper storage of gas, leakage of gas and lack of advanced monitoring systems resulting in environmental pollution, economic loss, and life threats to both society and workers.

However, current gas leakage detection systems are not advanced, and depend on manual reporting. This results in a lack of alert systems, leading to high-risk operations (Senthil et al., 2023). IoT technology helps overcome these issues to a certain extent through real-time monitoring, warning alerts and automation of systems (Paul et al., 2021). There are some systems for monitoring Liquefied Petroleum Gas (LPG) leakage integrated with IoT system. Other models emphasize LPG leakage detection and control systems that utilize Arduino, Global System for Mobile (GSM) modules, and Direct Current (DC) motors, incorporating Short Message Service (SMS)-based alert mechanisms (Jalel et al., 2023). One system proposes a Smart Natural Gas Leakage Detection and Control System (SNLDCS) specifically designed for gas distribution companies in Bangladesh. The SNLDCS is intended to detect gas leaks, monitor leakage information, and control gas supply to remote users (risers) through ON/OFF switching. This control is managed via an Android application over the internet (Li et al., 2020; Wang et al., 2021).

Another system utilizes an MQ-2 sensor to detect gas leaks and fire alarms, focusing on monitoring and management through an ESP32 processor. Additionally, a different IoT-based system has been proposed for detecting gas leaks, sending SMS alerts, and controlling the gas supply via an automated shutoff device (Zhang et al., 2020; Ren et al., 2015). The main contributions of the paper are:

- i. Design and develop a gas leakage system with a gas level indicator system.
- ii. Implement an IoT integrated system to control centrally.
- iii. Develop a user-friendly application for the web interface for monitoring and controlling systems.

As a future direction, this system can be designed with a Personal Protective Equipment (PPE) kit detection system to automatically recognize the safety clothing and equipment of workers, thereby helping to reduce the risk of accidents in a factory setting. This system is specifically designed for

industrial or large-scale natural gas distribution companies, allowing for remote monitoring and control of gas leaks from a central location.

2. METHODOLOGY

System design

The proposed system was designed to detect gas leaks in large gas terminals and control valves remotely using the IoT technology. It ensured quick response to potential hazards, preventing accidents and minimizing damage.

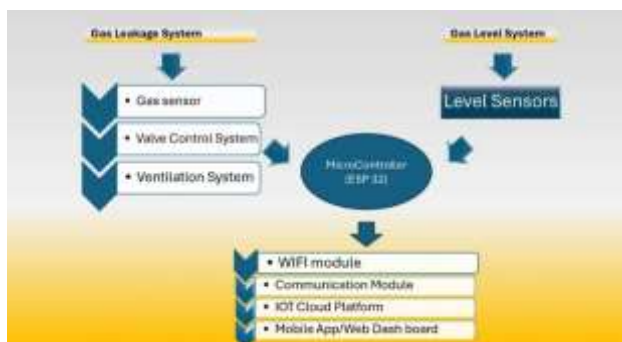


Fig. 1. Block diagram of Integrated Gas Leakage Detection System.

Fig. 1 shows the block diagram of the gas leakage detection system. This system comprises three subsystems such as gas leakage detection system, gas level indicator system, and communication system. All three subsystems can be centrally controlled. In a gas leakage detection system, gas sensors are strategically throughout the gas terminal, focusing on key areas that leak detection. Connect gas sensors to the ESP32 microcontroller and it has a dual- XSTensa® LX6 microprocessor it operates at 240MHz of clock speeds, which collects data from these sensors. The microcontroller processes the incoming sensor data and transmits it to a cloud platform. The cloud platform then analyses this data in real-time to detect any abnormal gas levels. If a gas leak is detected, the system generates an alert, which can be sent to designated personnel via email, SMS, or a custom notification system. Additionally, the proposed system includes a ventilation component alongside the gas leakage detection system. Operators can remotely access the valve control system through a user interface provided by the cloud platform. Upon receiving an alert, operators can activate actuators connected to valves to shut off the gas flow in the affected area.

Fig. 2 shows the Schematic diagram of the Smart gas leakage detection system which uses ESP32 to read both digital and analog data from the MQ2 sensor. MQ2 sensor measured in 200ppm-10,000ppm gas concentrations and response time is less than 10 milliseconds. Activate the Light Emitting Diode (LED) (green for safety, red for danger) trigger the buzzer if needed and use the Organic LED (OLED) display to show current gas levels, system status, and alerts. Fig. 3 shows the 3-D view of the gas leakage detection system.

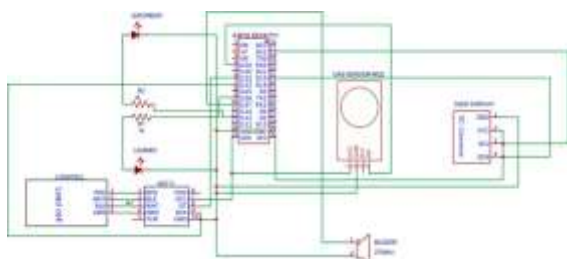


Fig. 2. Schematic diagram of Smart gas leakage detection system.

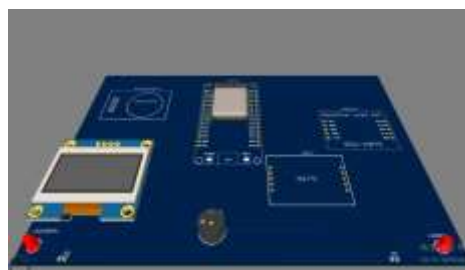


Fig. 3. 3-D view of gas leakage detection system.

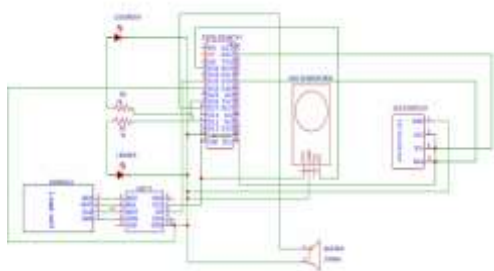


Fig. 4. Schematic diagram of gas level indicator system.

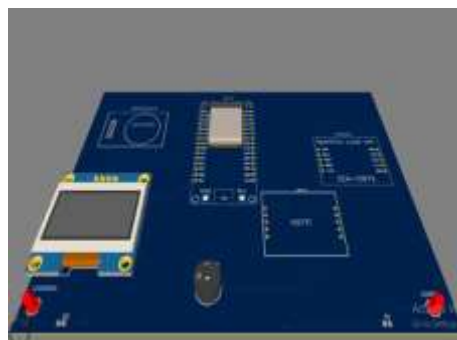


Fig. 5. 3-D view of gas level indicator system.

Fig. 4 shows the Schematic diagram of the gas level indicator system and uses a gas level detection system using a load cell, ESP32 microcontroller, HX711 amplifier, and a 16x2 Liquid Crystal Display (LCD) display. The system provides accurate and real-time monitoring of the gas level in a cylinder, ensuring timely refills and enhancing safety. Fig. 5 shows the 3-D view of the gas level indicator system. In the communication system, we use a cloud platform (AWS IoT Core/Azure IoT Hub) to connect the app and send the sensor reading to ESP32s.

3. RESULTS AND DISCUSSION

In this section, we present the implemented circuit and results of the gas detection centralized system. Fig. 6 shows the implemented circuit diagram of gas leakage and gas level indicator. Fig. 7 shows the gas leakage in the red button and the buzzer is activated. Fig. 8 shows the different gas levels in mobile applications. The importance of this system lies in its ability to centralize all data at a single point.



Fig. 6. Implemented circuit diagram of gas leakage detection and gas level indicator.



Fig. 7. Gas leakage detection results displayed in the mobile app



Fig. 8. Gas level detection display in the mobile app

4. CONCLUSION

This design integrates multiple gas leakage detection methods into an IoT solution. By utilizing microcontrollers, gas sensors, communication modules, cloud platforms, and mobile applications, this system is designed to detect gas leaks in real-time, generate alerts, and enable remote valve control. This integrated system gives quick responses without exceeding 200 milliseconds. These features collectively enhance safety measures and help prevent accidents, thereby improving overall safety and hazard management.

5. REFERENCES

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