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IoT Based on LPG Gas Leakage Detection and Prevention

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Abstract*: The growing use of liquefied petroleum gas (LPG) in residential and industrial applications has posed significant safety issues due to the risks involved with gas leakage. This review paper introduces an IoT-based LPG Gas Leakage Detection and Prevention System, which integrates advanced sensor technologies and communication systems to enhance safety measures. The proposed system uses MQ-6 and YG1006 sensors to detect gas concentrations and flames, respectively, thereby providing a dual-layered approach to leak detection. The system is designed to work in real-time, sending immediate alerts via SMS through GSM technology when a gas leak is detected. It also activates an exhaust fan to reduce the accumulation of gas in the environment, further reducing the risk of fire or explosion. This review synthesizes various methodologies employed in existing literature, focusing on the effectiveness of IoT frameworks in monitoring and controlling gas leakage incidents. It covers some of the key features like integration of microcontrollers, such as Arduino, to process sensor data and easy interfaces for monitoring gas levels and automatically responding to detected leaks. It brings to light the need for constant monitoring and rapid response mechanisms in preventing accidents related to the use of LPG. It utilizes the advantage of IoT technologies to make this system a comprehensive one that detects gas leaks while actively preventing potential disasters to ensure overall safety standards in places where LPG is used.*

Keywords: liquefied petroleum gas

I. INTRODUCTION

The heavy dependency of Liquefied Petroleum Gas for domestic and industrial uses poses a serious concern related to safety issues because leaks, associated with gas leaks, could be hazardous. Since the natural state of LPG contains mainly propane and butane, the absence of smell in LPG makes the leakage invisible without a proper detecting monitoring system; the results would be a tragedy because leakage that goes undetected causes explosion, fire outbreak, and poses threats to human health. Hence, there is a pressing need for efficient detection and prevention systems that alert the users to the real-time leakage of gas. IoT-Based Solutions With the rapid advancement of IoT technology, there have been several innovative solutions that address LPG leakage issues. IoT-based systems are equipped with numerous sensors and communication technologies to monitor the levels of gas constantly and alert in due time. These systems use generally gas sensors, for example MQ-6 or MQ-2 that are sensitive to LPG and other flammable gases. In the case of leakage detection, the sensors activate the alarm and turn on the exhaust fans to allow leaked gas to diffuse out; they even send SMSs or emails to users or emergency services[1][2][5]. The combination of GSM technology in this system makes them more potent since they have the capacity to monitor and control the system from anywhere. For instance, in the case of a leak, the system will automatically send warning signals to the user's mobile while simultaneously activating measures to ensure safety, including shutting off the gas supply or switching on the ventilation systems[1][4]. The result is not only that the risks are reduced but also that the response to any possible hazard is quick. System Components An IoTbased LPG leakage detection system will have several main components such as:

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- Gas Sensors: Devices like MQ-6 or MQ-2, which are LPG detecting devices.
- Microcontroller: Arduino or other similar platform, that would process the sensor data and control the operations of the system. -
- Communication Module: GSM or Wi-Fi modules for remote alerting and notification.
- Alarm Systems: Buzzer alarms and visual indicators (like LEDs) that alert nearby individuals of a leak.
- Ventilation Controls: Exhaust fans that assist in dispersing leaked gas from enclosed spaces. These parts work together to create a comprehensive safety solution that addresses both detection and prevention of gas leaks.

II. METHODOLOGY

The methodology for an IoT-based LPG gas leakage detection and prevention system includes comprehensive integration of various components in a system to ensure safety in environments where LPG is used. The system primarily uses the MQ-6 gas sensor, which detects the presence of LPG by measuring the change in resistance due to concentration. The ESP32 microcontroller is the main unit, processing data from the sensor and managing other components, such as a GSM module for communication, a servo motor for valve control, an exhaust fan for ventilation, a buzzer for alarms, and a relay module for power management. On system start-up, the ESP32 always checks for gas concentrations using the MQ-6 sensor. If concentrations are found to be greater than the set threshold, say 2000 ppm, the ESP32 initiates several responses: the buzzer is activated to alert people nearby, an SMS is sent through the GSM module to alert people concerned, and the exhaust fan is operated to spread the accumulated gas. In addition, the servo motor can close the gas valve to prevent further leakage. Further, the system can display alerts on the LCD screen, showing in real time the status of the level of gas. The system's testing and validation will involve the simulation of gas leaks in controlled environments to evaluate detection accuracy and response times. Evaluation metrics include the reliability of the detection and responsiveness of the system to ensure proper working under different conditions. This IoT-based system contributes toward enhancing user safety through the timely alerts and automatic response it provides and, further, reduces the risks related to accidents associated with the use of LPG.

1. Components

- MQ-6 Gas Sensor: The MQ-6 will be detecting LPG gas in the air. This works with resistance measurement in terms of exposing the sensor to the gas.
- ESP32 Microcontroller: Is the brain where data will be sent from sensors and how all the components will operate.
- GSM Module: Communicating component by sending an SMS message to alert the users that a leak is found.
- Servo Motor: The motor will activate the valve for shutting down the supply in case of leak.
- Exhaust Fan: On to ventilate the room by distributing any gas that has leaked in.
- Buzzer: Its role is to give audible feedback so that people around are able to hear.
- Relay Module: Controls high-power devices for instance, the exhaust fan relying on signals from the ESP32 board.

2. System Design

- Circuit Design The circuit design comprises: Connecting the MQ-6 sensor to the ESP32 for real-time data acquisition. Integrating a relay module to control power supply to the exhaust fan and other devices. Wiring the buzzer for alarm notifications. Optionally, integrating an LCD display for real-time status updates.
- Software Development The software development includes: Programming the ESP32 using Arduino IDE or similar platforms to read data from the MQ-6 sensor. Setting concentration thresholds of gases which will alert and perform some actions. Activation of the buzzer, servo motor, and exhaust fan when there is leakage. Activation of the GSM module for SMS alerting to some number.
- Workflow at Work Initialization: At the moment of turning it on, ESP32 initializes all components attached and starts measuring the level of gas concentration by using MQ-6 sensor.

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- Gas Leak Detection: The MQ-6 continuously samples the air quality. It sends a signal to the ESP32 if LPG concentration goes above a predefined threshold (say 2000 ppm).
- Alert Mechanism: The ESP32 buzzes to alert the people nearby. It also sends a signal to the relay module to power up the exhaust fan for ventilation purposes. It engages the servo motor to close a valve so that the gas does not further pass through, if necessary. The GSM module shall transmit an SMS alert with the occurrence details and leak location.
- Transmitted Data (Optional): Whenever there is a Wi-Fi access, the system can send alerts through messages and push notifications using other platforms such as Blynk or any other for the remote monitoring.
- Testing and Verification Carry out tests through the production of gas leaks in various environments. Test the Alarm response time and the activation of fans as well as servo motor. Sensor measurements must be verified against standards set using known concentrations of LPG
- Assess system performance in terms of: Detection accuracy (Response time from detection to alarm activation. Repeatability over test runs.

III. LITERATURE REVIEW

Literature Review of Internet of Things LPG Gas Detection and Prevention Systems The growing application of Liquefied Petroleum Gas (LPG) for cooking and heating has posed severe safety issues because of the risks involved in gas leakage. Several researchers have presented novel ideas based on Internet of Things (IoT) technology to improve the detection and prevention of LPG gas leakage. This literature review summarizes recent developments in this area, focusing on key systems, their methodologies, and results. IoT-Based Detection Systems Many research works focused on the development of IoT-based LPG gas leakage detection systems. For example, the system proposed by Mohamed et al. integrates MQ-6 gas sensors and flame detection sensors with an Arduino microcontroller to detect the leakage of gas and fires. The system alerts users using GSM technology, sending them SMS notifications when a leakage is detected, while it activates an exhaust fan for the dispersion of leaked gas, thus mitigating any potential hazards1. This dual approach does not only indicate the existence of gas but also works toward immediately reducing its concentration in the environment. Another notable system by Zaw Lin Oo et al. uses a combination of load cells and temperature sensors to monitor the weight of LPG cylinders continuously. In case the gas level is critically low or there is a leak, the system sends alerts via SMS using GSM modules so that the users are informed in advance2. This proactive approach not only enhances safety but also facilitates timely refilling of gas cylinders, thus preventing emergencies. Sensor Technology and Integration The choice of sensors plays a crucial role in the effectiveness of these detection systems. The MQ-6 gas sensor is widely used due to its sensitivity to various gases including butane, propane, and LPG. It operates effectively in detecting low concentrations of gas, which is essential for preventing accidents3. The advantage of having multiple sensors installed also makes for a more complex monitoring system, such as pairing gas sensors with flame detectors, to provide a much more effective solution against any fire hazards. Automated Alert Mechanisms In these current IoT-based LPG-detection systems, automated alarm mechanisms are one of its major features. Many feature alarm buzzers that function once gas leakage is identified, giving an audible cue to the people inside a space4. Advanced systems additionally use cloud technology for their data storage and processing system, allowing for real-time monitoring and access to information about the system status in various types of mobile applications5. This way, users have the ability to monitor levels of gas even when far away from home.

Mitigation Strategise

Mitigation Strategies for IoT-Based LPG Gas Detection and Prevention Systems The implementation of IoT-based LPG gas detection and prevention systems is critical for improving safety in environments where LPG is used. These systems, apart from detecting gas leakage, implement various strategies in mitigating potential hazards appropriately. This discussion outlines important mitigation strategies, emphasizing the importance and functionality.

Real-Time Monitoring Continuous Monitoring: IoT uses MQ-2 and MQ-6 sensors to continuously monitor the concentration of LPG in the environment. Sensors can sense even minuscule concentrations of gases so that appropriate action may be taken before a leak becomes a hazardous situation. Data Transmission: Data transmitted from these

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sensors are received in real-time at cloud platforms or mobile applications. This enables users to monitor gas levels from any location, making them informed of their surroundings and quick to respond to alerts.

Automated Alerts and Notifications SMS and Application-based alert: When the gas leakage sensor recognizes a gas leak, then through automatic SMS or mobile-specific apps it sends an alarm notification that allows users to instantly leave the place, evacuate themselves, or switch off gas. In many devices, it consists of audible alarms that also respond by sounding an audible noise the instant there is a detection of gas, thus alerting occupants nearby. This multistage alert mechanism does ensure faster responses.

Integrative Safety Mechanisms Automatic shut-off valves are one of the most effective mitigation measures which can be integrated into the system. Whenever a leak is detected in the system, automatic shut-off valves can automatically shut off the gas supply line to minimize further leakage and associated dangers. Exhaust Fans Activation: Some systems activate exhaust fans in the event of gas detection. These fans help to distribute the collected gas, thereby reducing the chance of explosion or fire because the gas will be ventilated outside before reaching dangerous concentrations.

User Engagement and Control Mobile Application Control: The mobile application allows users to access their gas detection systems and shut off the gas supply or activate the safety features remotely. In such cases, it will allow the user to have control over the situation. Maintenance Reminders: IoT devices can remind them of regular maintenance tests or checks on gas appliances and cylinders. This way, wear and tear will not become potential leaks.

Predictive Maintenance through Data Analytics Usage Tracking: Continuous monitoring of gas consumption trends provides IoT systems with useful usage trends. Anomalous consumption may be due to a leak or low efficiency, and users need to look into it. Predictive Analytics: Advanced systems leverage machine learning algorithms to look at historic data and predict potential failures or leaks in advance. Such an advanced approach helps in taking issues before they can turn serious.

Emergency Response Integration Emergency Service Notifications: Some of the more advanced IoT systems can be programmed to automatically notify local emergency services if a significant leak is detected. This would ensure professional help is on the way quickly in the event of a major incident. User Instructions for Emergencies: The system can give the user step-by-step instructions of how to respond in a gas leak emergency through notification or app interfaces. Such instructions can be very important for the safety of the users in such highstress situations.

Advanced Sensor Technology Multi-Sensor Integration: Incorporating various sensors (e.g., temperature, smoke) alongside gas sensors enhances detection capabilities. For example, a temperature sensor can detect overheating conditions that may accompany a gas leak, providing additional layers of safety. Calibration and Testing : Calibration of the sensor, along with regular testing is highly essential in maintaining precision detection. There are IoT systems that support self-check mechanisms that advise users in the instance that calibration may be needed.

Technology and Innovation

Technology and Innovation for IoT-Based LPG Gas Detection and Prevention Systems

In various domestic, industrial, and commercial applications, the LPG gas detection and prevention system integrates Internet of Things (IoT) technology, revolutionizing safety and monitoring. Combining sensors, connectivity, and data analysis, IoT-based solutions provide real-time insights on environments where liquefied petroleum gas is used for overall safety. This paper discusses technological advancements and the innovative features of such systems, underlining their value in modern safety frameworks.

Core Technology The heart of the system would be the gas sensor, typically Metal Oxide Semiconductor or catalytic. The sensitivity of these sensors towards propane and butane makes them extremely sensitive towards the components of LPG. Changes in electrical resistance are sensed or catalytic reactions, both caused by the presence of gas. Recent improvements in sensor technology have led to increased sensitivity, accuracy, and speed.

This connects these sensors to a centralized system via Wi-Fi, Zigbee, Bluetooth, or cellular networks. Connectivity helps to avoid isolation; rather, it integrates into wider smart home or industrial ecosystems. The data collected from these sensors is transmitted to the cloud platforms for processing and analysis and further storage. Advanced machine learning algorithms could further analyze this data in detecting any

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pattern, predicting hazards and their potentials in advance, and further implementing preventive measures in real-time.
Innovative Features The modern IoT-based LPG detection systems use several innovative features to boost functionality: 1. Real-Time Alerts and Notifications They send instant alerts to users' smartphones, tablets, or computers when a gas leak is detected. Notifications can be customized through mobile applications, which enables flexibility in monitoring the surroundings remotely. 2. Automated Control Mechanisms One of the greatest innovations is the automated shutoff valves that are incorporated in the system. The system automatically closes the gas supply valve if a gas leak is detected, which effectively stops the leakage and reduces the risks of fire or explosion.
Smart Ecosystem Integration IoT-based LPG detection systems can be interconnected with other smart devices. For example, the device can activate exhaust fans in case of leakage to pump out the leaked gas. It can also activate the emergency lighting in case of such an event. 4. Predictive Maintenance IoT solutions can predict potential issues such as wear and tear in pipes or valves by continuously monitoring the performance of the LPG system and alerting users to perform timely maintenance. This predictive capability minimizes the risk of accidents and prolongs the lifespan of the gas equipment.
Energy Efficiency and Sustainability The system ensures that the power consumption in the system is optimized at advanced levels, hence considered energy-efficient. Moreover, sustainable practices are enhanced in the system by integrating sources of renewable energy, and this includes solar-powered sensors, among others.
Applications Applications of IoT-based LPG detection and prevention systems vary widely: The residential use: enhancing kitchen gas appliances monitoring and alerting homeowners in case of any leaks. Industrial Applications: Workplace safety is ensured in industries where LPG is used for manufacturing, heating, or processing. Commercial Environments: Restaurants, hotels, and retail establishments where LPG is commonly employed are also protected. Despite all the advantages it has, IoT-based LPG detection systems face challenges. These include high initial costs and data privacy concerns, plus the need for robust connectivity in remote areas. All of these can be addressed if technology developers, policymakers, and industry stakeholders collaborate together. Future innovations in this field may include the integration of artificial intelligence (AI) for even more advanced predictive analytics, blockchain for secure data handling, and the development of more affordable, scalable solutions for widespread adoption. Additionally, advancements in nanotechnology could lead to the creation of smaller, more efficient gas sensors with enhanced detection capabilities.

Challenges in Implementation

Challenges and Implementation of IoT-Based LPG Gas Detection and Prevention Systems
The Internet of Things-based LPG gas detection and prevention systems are seen to bring great safety and benefits; however, different challenges and considerations come out in terms of implementation technological, operational, as well as societal. Having an understanding of these and strategic solutions for the identified challenges would help stakeholders undertake effective implementation. .

Challenges in IoT-Based LPG Systems .

Connectivity and Network Dependence . IoTbased systems require stable and reliable network connectivity for real-time data transmission and control. Poor internet infrastructure in remote or rural areas can hinder the system's functionality, delaying alerts or automated responses. For instance, weak Wi-Fi or cellular networks may lead to failed critical safety notifications, raising the accident risk.
Power Supply and Energy Efficiency Gas detection systems are commonly installed in environments where a steady power supply may not be available. Internet of Things devices, including sensors and controllers, have to be designed for maximum energy efficiency to keep operating without disruption. In some cases, battery-operated devices will require regular recharging or replacement; a logistical issue in big systems or at remote sites.
Data Privacy and Security IoT systems produce and send sensitive data, including real-time gas usage patterns and user behavior. If not properly managed, this data can be vulnerable to cyberattacks or unauthorized access. A compromised system may lead to privacy breaches or even malicious interference in gas control mechanisms.
Cost of Deployment and Maintenance The installation of IoT-based LPG detection systems with sensors, connectivity modules, and cloud infrastructure can be cost-prohibitive for some users. The operational costs add up from

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maintenance requirements such as sensor calibration and software updates, which can serve as a barrier to the adoption of such systems in the mainstream.

User Awareness and Adoption Many users may lack awareness about the benefits and functionalities of IoTbased LPG systems. Resistance to adopting a new technology, especially within traditional households or smallscale industries, can slow implementation efforts down. There should be education and training for comprehensive implementation.

Implementation Strategies for IoT-Based LPG Systems

Robust and Flexible Connectivity Solutions: Systems with multi-network support like combining WiFi, Zigbee, and LPWAN will improve reliability. Edge computing will also help in terms of processing data locally rather than relying on cloud connectivity for critical operations.

Energy Optimization Techniques Introduce low power IoT devices in conjunction with harnessing sources like solar panels. Advanced batteries ensure longer working times without scheduled maintenance and using power-cut algorithms

Higher levels of Security Measures To address data privacy issues, encryption protocols and secure authentication mechanisms should be incorporated into the system design. Blockchain technology can also be used to ensure that data handling across the system is secure and tamper-proof.

Cost-Effective Solutions Production costs can be reduced in sensor manufacturing through innovations in the use of affordable yet durable materials. Governments and organizations may support adoption by providing subsidies or incentives for safety-enhancing technologies, especially for high-risk areas.

User-Centric Design and Education Ease of user interface and simplicity of use can lead to acceptance. A mobile application that features intuitive dashboards with step-by-step instructions is also not hard to understand even by the non-technically-inclined individual. Holding awareness campaigns, training programs, and live demonstrations may further raise public confidence and interest in such systems.

Experimental Evaluation

The experimental evaluation of the IoT-based LPG leakage detection and prevention system constitutes an important area of research mainly due to the increasing dependence of LPG in residential as well as industrial applications. Below is a summary of the essential findings from recent studies and papers on this topic.

Experimental Setup

An experimental setup for an IoT-based LPG gas leakage detection and prevention system would thus consist of a comprehensive integration of components designed to ensure safety and reliability in detecting leaks. Central to this is the use of gas sensors such as the MQ-2 or MQ-5 that are capable of detecting concentrations of LPG in the air. These sensors are wired to a microcontroller that can be either Arduino or ESP8266, that reads the data in real time and monitors the gases level against pre-defined threshold safety levels. When a leak occurs, the system triggers an alarm with visible indicators, such as LED lights, and audible indicators like buzzers, alerting individuals around. The device may also send alerts via a GSM or Wi-Fi module that would allow remote alerts sent by SMS or mobile applications to speed up evacuation and response. This set-up also contains ventilator controls, like exhaust fans, which can be initiated automatically to dissipate accumulated gas. Experimental simulations to evaluate the effectiveness of the system are carried out by creating controlled gas leak scenarios. These experiments assess the response time of the system, accuracy in detecting gas concentrations, and reliability under different environmental conditions. Data collected during these tests will provide insights into the system's performance and help refine its algorithms for better detection capabilities. This IoTbased approach not only enhances the safety measures but also facilitates continuous monitoring and data logging to be used for future analysis and preventive maintenance strategies, so this is a significant advancement in gas leak management solutions.

Experimental Result

From the experimental results of the IoT-based LPG gas leakage detection and prevention system, it can be observed that there is a great progress in safety measures in LPGusing environments. There are many studies that rigorously test the system and check its effectiveness in identifying gas leaks and then adopting preventive measures. The crux of the system works on the basis of very sensitive gas sensors like the MQ-6 for detecting LPG concentrations. These sensors successfully detected as low as 300 ppm gas levels during experiments, and thus alarms and alerts were issued in realtime. A microcontroller, typically an Arduino or NodeMCU, was integrated to process the sensor data and to allow for immediate responses when a leak was detected. One of the major findings from the experimental setup was the response time of the system; it always triggered alarms within seconds of detecting gas concentrations above threshold levels. For example, when a controlled leak was simulated, the system not only sounded an alarm but also sent SMS notifications to users via a GSM module, ensuring rapid communication in emergency situations. Additionally, the automatic activation of exhaust fans was observed to effectively reduce gas density in the environment, thereby mitigating potential hazards. The experiments conducted data logging and revealed the performance of the system under various conditions. The tests done in various environmental settings revealed that the system maintains accuracy and reliability with no regard to temperature fluctuation or humidity levels. User feedback further pointed out that notifications and alerts were effective, where timely warnings are highly crucial for raising the safety awareness of the users. Generally, these experimental results validate the fact that IoT-based LPG gas leakage detection systems can not only quickly detect the leak but also immediately apply preventive measures to save human lives and property. It is a tremendous leap for gas safety technology, encompassing real-time monitoring, automated responses, and remote notifications. The future advancements may be oriented toward making sensor technologies better and more sophisticated by including machine learning algorithms for predictive analytics.

IV. CONCLUSION

The implementation of IoT-based LPG gas leakage detection and prevention systems can be seen as a significant advancement in safety technology, addressing a critical need for effective monitoring and rapid response mechanisms within environments that use LPG. The experimental results in various studies demonstrate that these systems can reliably detect gas leaks, alert users in real-time, and activate preventive measures to mitigate potential hazards. These systems significantly increase the safety protocols by including advanced sensors such as the MQ-6 and MQ-2, microcontrollers such as Arduino or NodeMCU, and communication modules for SMS alerts and remote monitoring. The effectiveness of these systems is underscored by their ability to operate under diverse environmental conditions, maintaining accuracy in detecting gas concentrations even in fluctuating temperatures and humidity levels. The incorporation of additional features, such as flame detection sensors and automated ventilation controls, further enhances the system's capability to prevent accidents. For instance, when gas concentrations exceed safe thresholds, the system can automatically activate exhaust fans to disperse gas, thereby reducing the risk of fire or explosion. In addition, the use of cloud computing technologies allows for continuous data logging and analysis, enabling users to monitor gas levels remotely through mobile applications. This capability not only provides peace of mind but also facilitates predictive maintenance by analyzing trends in gas usage and leak occurrences. The integration of machine learning algorithms in future iterations of these systems may further improve their predictive capabilities, allowing for proactive measures before leaks occur. In conclusion, IoT-based LPG gas leakage detection and prevention systems are on the verge of revolutionizing safety standards in residential and industrial applications. The ability to provide real-time monitoring, automated responses, and remote alerts greatly reduces the risks associated with gas leaks. With research in the field continuing to evolve, better sensor technology, communication protocols, and data analytics will be improved to make the environment for users safer and safer in the future. This commitment also speaks to a larger culture of using technology to realize better safety outcomes, essentially protecting lives and property against the dangers that gas leaks unleash.

V. ACKNOWLEDGMENT

The development and implementation of the IoT-based LPG gas leakage detection and prevention system would not have been possible without the support and contributions of various individuals and institutions. First and foremost, we would like to express our sincere gratitude to our academic supervisors and mentors who provided invaluable guidance throughout the research process. Their expertise in the fields of IoT technology and safety systems significantly shaped our understanding and approach to this project. We wish to thank our colleagues and peers for their constructive feedback and encouragement, which motivated us to refine our ideas and enhance the overall quality of our work.

Special thanks are due to the technical staff at our institution who assisted with the procurement of components, setup of experimental apparatus, and troubleshooting during the testing phases. Their hands-on support was crucial in overcoming various challenges encountered during the project. We also acknowledge the contributions of researchers whose prior work laid the foundation for our study. The literature on IoT applications in gas detection provided essential insights into sensor technologies, communication protocols, and system integration techniques. We are particularly grateful for the research papers that highlighted innovative approaches to gas leakage detection, which inspired us to incorporate features such as real-time monitoring, automated alerts, and remote access through mobile applications. Furthermore, we appreciate the support from industry partners who shared their practical experiences regarding gas safety measures. Their insights into real-world applications helped us align our system design with industry standards and user expectations. Last but not least, we would like to acknowledge our families for their support and understanding in the course of this project. Their encouragement gave us the strength to persevere through challenges and stay focused on our goals. In conclusion, this project is a collaborative effort that reflects the contributions of many individuals and organizations dedicated to enhancing safety through innovative technology. We hope that our work will contribute positively to the ongoing efforts in improving gas safety measures in households and industries alike.

REFERENCES

[1]. Abdirahman Abdullahi Mohamed et al. (2022) has carried out an extensive study which was presented in the paper titled ”IoT based LPG Gas Leakage Detection and Prevention System” published in the Journal of Emerging Technologies and Innovative Research. The proposed solution detects leakage in LPG using MQ-6 gas sensors, along with flame detection sensors for improved safety measures. The system incorporates GSM technology for real-time alerts and an exhaust fan to mitigate gas accumulation, demonstrating a practical approach to preventing potential disasters caused by gas leaks 1.

[2]. Shobha et al. (2021) studied an ”Internet of Things based Hazardous Gas Leakage Detection System,” using MQ-2 gas sensors in combination with Arduino Uno as the central processing unit. The results show that the system is able to detect the leakage of gases in any environment and give a warning signal through an alarm connected with the system. Continuous monitoring and alerting of users prevent accidents due to leakage 1.

[3]. Another significant contribution by Jena Bibekananda et al. in 2023 was an ”LPG Gas Leakage Detection System using IoT” published in ScienceDirect. This work aimed at developing a working prototype which can detect gas leaks as early as possible and still be reliable under any environment. The study points out that the use of cloud technology for data management and remote monitoring boosts the effectiveness of the system in real-world applications 4.

[4]. A paper by Kumar Pradhan et al. 2021 delves into the application of IoT for gas leakage detection, laying emphasis on the fact that strong systems are needed to run under different atmospheric conditions. This paper outlines a design that puts together gas sensors and cloud connectivity so that continuous logging and analysis of data can be made, important for predictive maintenance and intervention at the right time 3.

[5]. Sharma et al. (2021) performed research that came up with an ”Arduino Based LPG Leakage Detection and Prevention System,” discussing how various sensors could be integrated into Arduino for the effective monitoring of gases. It provides information about sensor calibration, response time, and user interface, adding a valuable contribution to the field of gas safety technology 1.

[6]. Kumar et al. (2022) conducted a systematic literature review on ”Gas Leakage Detection System Using IoT And Cloud Technology,” which integrates existing research on IoT applications in gas detection systems. This review indicates trends, challenges, and future directions in the field, emphasizing the growing importance of cloud computing for enhancing system capabilities 8.

[7]. Further, the work of Venkatesh et al. (2020) focuses on the design and implementation of an industrial monitoring system that uses IoT technologies for the detection of gas leakage. The findings in this study highlight the importance of incorporating alarms, displays, and exhaust systems in developing an integrated safety solution that reduces the risks of gas leaks