Smart Industrial Level Gas Leakage Detection System Using AI & IOT

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Abstract— The Intelligent Gas Leakage Detection System is an innovative system that combines artificial intelligence (AI) and the Internet of Things (IOT) technology to revolutionize industrial safety. This system utilizes gas, temperature, pressure, and humidity sensors, along with a PIC microcontroller, ESP32-CAM, relay, pipe valve, alarm, LCD, and IOT connectivity, to detect and monitor gas leaks in industrial environments. The AI algorithms within the system analyze sensor data in real-time and can accurately identify and locate potential gas leaks, providing advanced warning to prevent accidents. The system is also equipped with a powerful IOT platform that enables remote monitoring and control of the system, along with seamless integration with existing industrial infrastructure. The Intelligent gas leakage monitoring and detection offers a reliable, cost-effective, and efficient solution for gas leak detection, minimizing the risk of hazardous incidents and ensuring worker safety. With its cutting-edge technology and advanced features, this system is set to revolutionize the way industrial gas leaks are detected and managed.

Keywords— Portable IoT Module, Gas Sensor, Leakage, Camera,Alarm

I. INTRODUCTION

The Intelligent Gas Leakage Detection System is a revolutionary system powered by the latest advancements in artificial intelligence and Internet of Things technology, has transformed the landscape of gas leak detection in industrial settings. With its cutting-edge features and unparalleled accuracy, this device has undoubtedly set a new standard in ensuring safety and efficiency in the workplace. Gas leaks pose a significant threat to industries, with the potential to cause catastrophic accidents and significant financial losses. Traditional gas detection methods have been limited in their abilities to prevent these risks, mainly due to their reliance on manual monitoring and alarm systems.

However, with Intelligent Gas leakage detection system, industries now have access to a highly intelligent and automated gas detection system that continuously analyzes data and detects potential leaks in real-time In this introduction, we will explore the key features of Intelligent gas detection system, its impact on industrial gas leak detection, and the benefits it brings to various industries. We will also discuss how its innovative use of AI and IOT has transformed the way gas leaks are detected and prevented, making it an essential tool for ensuring safety and efficiency in the workplace. Installing gas leakage detecting equipment is one of the preventative methods to stop accidents caused by gas leakage, which is a serious problem in the industrial sector. Arduino now reads the output from the sensors. It is suggested that physical objects and the internet be connected through the Internet of Things (IOT), a futuristic technology. Safety comes first, thus the suggested gas detection system uses IOT to identify leaks and notify users so they can stop them. Since the gases are dangerous, it is necessary to keep an eye on them in order to spot any changes in their concentration and respond appropriately [1].

The disadvantage is that the system works slowly if more than one code is run at once because it can only execute one code at a time. There have been developed a number of gas leakage detecting technologies that perform notably better than conventional techniques. The PIC microcontroller was able to access the sensors output thanks to an integrated analogue to digital conversion. The PIC microcontroller reads the sensor's output once it has been converted to digital representation. The PIC microcontroller turns on the buzzer when the range exceeds the predetermined value. A gas sensor communicating with a PIC microcontroller is used to build the gas leakage detector and smart warning sign system used in this project. The LCD display displays the gas leakage percentage.

II. LITERATURE SURVEY

In Journal titled "Automation of LPG Cylinder Booking and Leakage Monitoring System," P. Bharath et al. [2] proposed an automated system for gas booking and leakage detection. The system automatically books the cylinder before the LPG supply is fully utilized and alerts the owner in case of a leakage. Continuous monitoring of the cylinder's weight is carried out using a weight sensor, and if the weight decreases below a preset amount, the technology automatically books the cylinder and notifies the owner via message.

In the research titled "Kernel Approach on Detection of Ethanol Connection Using ZnO Gas Sensor," L. Shaw et al.[3] examined the clustering of various ethanol gas concentration levels. It was demonstrated that kernel principal component analysis could be employed to cluster data in this scenario. Different gas concentrations were detected and displayed using the proposed technique on the LabView front panel.

The sensitivity of ZnO thick film resistors for sensing ethanol gas. It mentions that the sensor is a zinc oxide gas sensor with a thick film base. Additionally, it states that the sensor incorporates an inside heating coil capable of reaching temperatures between 75°C and 300°C. The essay notes that ZnO reacts promptly to even very low gas concentrations and demonstrates significant sensitivity, along with acceptable stability and responsiveness.

In a project proposal by V. Ramya et al.[4] the focus is on an embedded system designed for hazardous gas detection and warning. The project aims to modify the current safety paradigm used in industries and extend its applicability to homes and workplaces. The primary objective of the project is to design a hazardous gas detection and alerting system using a microcontroller. The system includes an LCD display that continuously monitors and displays dangerous gases such as LPG and propane. Additionally, if these gases exceed the normal levels, triggering an alarm, an alert message (SMS) is sent via GSM to the appropriate individual. The automatic detection and warning system offer advantages over the manual approach, including fast response times and precise detection.

In a project proposed by T. Kiran et al.[5] a "Gas Leakage Detection System" utilizing FPGA and GSM technology was introduced. The study suggested a system for detecting gas leaks, wherein the first response team would receive wireless notifications containing information about the leak. This enables prompt preventive measures to be taken, even in the absence of individuals. The detection system automatically places a warning call via GSM to identify the leakage using FPGA. LPG was utilized to test and develop a prototype of the gas leakage detection system. According to trial findings, the system can detect leaks in less than a minute.

The topic of a project offered by Luay Fraiwan et al. [6] was "A wireless gas leak detector for house safety." They proposed utilizing a wireless safety gadget to locate gas leaks, particularly in homes where the use of heaters and appliances powered by liquefied petroleum gas (LPG) and natural gas may raise safety concerns.

It was suggested that this device could also be applied to other natural gas and LPG-based industrial or plant processes. The system architecture comprises two main components: the detection and transmission module, and the reception module. The detecting and transmitting module utilize a special sensor circuit designed for this purpose to identify changes in gas concentration.

P.S. Murvay et al. [7] presented a research proposal concerning a survey on gas leak detection and localization methods. The primary objective of their study was to identify the most advanced leak detection and localization methods. Furthermore, they aimed to evaluate the capabilities of various techniques to ascertain the advantages and disadvantages of implementing each leak detection technique. Several organizations had conducted studies on the incidence of gas leak-related incidents and had generated statistics on the reported occurrences.

Fabien Chraim et al. [8] proposed the project titled "Wireless Gas Leak Detection and Localization." In their study, they suggested a method for locating and identifying wireless gas leaks. They utilized a monitoring system consisting of 20 wireless devices covering a 200-meter radius to track 60 propane releases. Following the application of the suggested detection and localization algorithms to the collected concentration data, they evaluated the methodology. They achieved a detection rate of 91% with seven false alarms over three days and an average detection latency of 108seconds. The localization results indicated a 5-meter accuracy. They recommended and discussed future designs for explosive gas sensors. Leaky compressors, valves, seals, and connectors were identified as the primary causes of most of these losses.

III. EXISTING METHOD

It was mentioned that the world has been evolving rapidly to embrace the latest technologies and interconnect everything. Various flammable gases such as carbon dioxide, ammonia, and others find applications in settings like hotels, canteens, and businesses. While the utilization of these gases has undoubtedly advanced technology, it also poses risks to human life and well-being. Consequently, safety emerges as a critical concern.

In the existing method, Arduino reads the output of the sensors. Considering the Internet of Things (IOT) as a futuristic technology, it is suggested that physical items be connected to the internet. Safety being of utmost importance, the suggested gas detection system utilizes IOT to detect leaks and alert users promptly to take necessary actions. Monitoring of these gases is essential due to their harmful nature, enabling the identification of any changes in their levels and facilitating appropriate actions to be taken. Overall, the project aims to mitigate the negative impacts of industrial pollution, create a safe working environment for employees, and reduce human intervention in monitoring pollution levels.

IV. PROPOSED METHODOLOGY

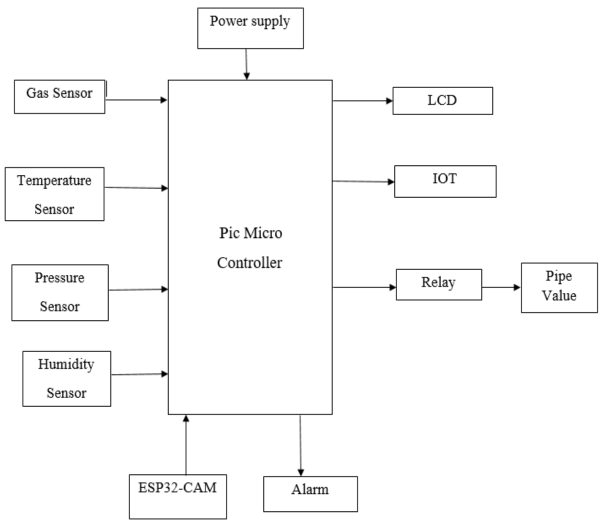

Fig.1 Block diagram

The block diagram for the proposed system was depicted in Fig. 1. It comprises the sensor unit, power supply unit, alarm unit, and display unit. A power supply of 230 V is provided to the transformer, which then converts AC to DC using a diode, capacitor, and 7805 IC regulator.

The regulator outputs 5V to all the sensors, including MQ2 (which detects smoke, LPG, and carbon monoxide) and MQ135 (which detects ammonia and CO_2), both of which are connected to the microcontroller [9]. Additionally, a vibration sensor detects panel vibrations in the industry, while a humidity sensor detects water content, especially if water is mixing with harmful gases. The data from all sensor units are displayed on an LCD, and IOT receives data by connecting to a mobile hotspot and setting the SSID and password. A Thingspeak server is loaded to display CO_2 level, O_2 level, vibration unit, and humidity unit. The current status is regularly updated.

Regarding alarm functionalities, when the vibration range and humidity level exceed preset values, an alarm is indicated. Conversely, when the levels decrease below preset values, the alarm automatically turns off. Similarly, if the CO_2 or O_2 levels exceed preset values, the alarm is triggered.The system's use of AI and IOT technology makes it a unique and innovative solution in the market for gas leak detection. With its advanced technology and features, this system efficiently detects and manages gas leaks, reducing the chances of accidents in industrial settings.

In the process of gas leakage detection system integrates various components and technologies to effectively monitor and manage gas leaks in industrial environments. Different types of sensors, including gas sensors, temperature sensors, pressure sensors, and humidity sensors, continuously gather data on gas levels, which is then transmitted to the PIC microcontroller for real-time analysis.

Acting as the system's central processing unit, the PIC microcontroller utilizes algorithms to detect potential gas leaks and control the relay, alarm, and LCD display. The ESP32-CAM facilitates wireless communication between the microcontroller and the IOT platform, enabling remote monitoring and control via the internet. Upon detection of a gas leak, the microcontroller triggers the relay, activating the pipe valve to halt the gas supply and prevent further spread of the leak. Simultaneously, the alarm sounds to alert workers, while the LCD display provides visual feedback on gas levels and system alerts. Data from the system is transmitted to the IO T platform, a web-based application that allows for remote monitoring, real-time analysis, and reporting. Additionally, the system is designed for seamless integration with existing industrial infrastructure, enhancing its cost-effectiveness and efficiency in gas leak detection and management within industrial settings.

V. HARDWARE SETUP

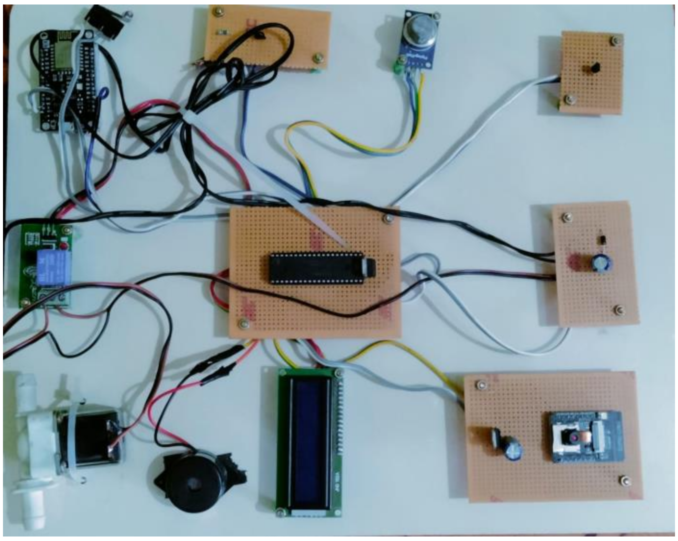

Fig.2 Hardware setup

The hardware setup includes four sensors: the MQ-2, MQ-135, humidity, and vibration sensor. A 12-0-12 5-amp center-tapped step-down transformer, mounted on a general-purpose chassis, is utilized. This transformer features a primary winding rated for 230V and a secondary winding with a central tap, without any ground wires. Its purpose is to convert 230V AC to 12V AC as a step-down transformation. The voltage regulator IC 7805, part of the 7805 series of voltage regulator integrated circuits, is employed. This regulator generates fixed linear voltages. It's used in circuits involving diodes and capable of handling up to 1A of current, necessitating the conversion of alternating current to direct current. The four sensors are interconnected to the PIC microcontroller.

The sensors utilized include the MQ-2, MQ-135, humidity, and vibration sensors. The MQ-2, classified as a MOS (Metal Oxide Semiconductor) sensor, is a prominent variant in the MQ sensor series.

It requires 5V DC to operate and can detect smoke, alcohol, propane, hydrogen, methane, and carbon monoxide concentrations ranging from 200 to 10,000 parts per million (ppm). Similarly, the MQ-135 gas sensor is capable of detecting smoke and hazardous gases such as ammonia (NH_3), sulphur (S), benzene (C_6H_6), and carbon dioxide (CO_2).

The MQ-135 is widely employed in devices for air quality management .Moreover, a humidity sensor is employed to gauge and report the relative humidity (RH) of the air, enabling the determination of water vapor content in pure gases or gas mixtures like air[10]. The PIC microcontroller gathers data from the MQ-2, MQ-135, humidity sensor, and vibration sensor. An IOT module, a small electronic device, is integrated into physical objects, machinery, and interconnected devices to transmit and receive data.

Through connection to a hotspot, configuring an SSID and password, and then linking to the ThingSpeak server, the IOT system acquires the data. The collected data is displayed on an LCD screen. In the event of a gas leak, the LCD displays the gas value, a red LED flashes, and a buzzer initiates a warning signal.

A. Gas Sensors : The project utilizes different types of sensors such as gas sensors, temperature sensors, pressure sensors, and humidity sensors to detect and monitor gas leaks in industrial environments. These sensors continuously collect data and send it to the microcontroller for analysis.

B. PIC Microcontroller : The PIC microcontroller serves as the brain of the system. It receives data from the sensors and uses algorithms to analyze it in real-time for detecting any potential gas leaks. The microcontroller also controls the overall functioning of the system, including the relay, alarm, and LCD.

C. ESP32-CAM : The ESP32-CAM is an integrated circuit that acts as a wireless communication interface between the microcontroller and the IoT platform. It enables the system to connect to the internet and send data to the cloud for remote monitoring and control.

D. Relay and Pipe Valve : In case a gas leak is detected, the micrTocontroller triggers the relay, which in turn activates the pipe valve to shut off the gas supply. This prevents the leak from spreading and causing any potential accidents.

E. Alarm: When a gas leak is detected, the alarm is activated, providing an audible warning to workers in the area. This enables them to evacuate the premises and take necessary safety measures.

F. LCD : The LCD display provides a visual representation of the gas levels detected by the sensors, along with any warnings or alerts from the system. It also serves as a user interface for controlling the system and viewing real-time data.

G. IoT Platform : The IoT platform is a web-based application that receives data from the system and presents it in a user-friendly interface. It allows remote monitoring and control of the system, along with real-time data analysis and reporting.

H. Artificial Intelligence : The AI algorithms within the system utilize machine learning and data analysis techniques to continuously improve the accuracy and reliability of gas leak detection. This makes the Intelligent GasGuard Pro a future-proof solution that can adapt to changing industrial needs.

VI. RESULT AND DISCUSSION

The objective was to utilize sensors for the detection and alerting of toxic gases in industries through IoT. Thanks to an internal analog-to-digital converter, the PIC microcontroller could access the sensors' output, which was subsequently converted into a digital format.

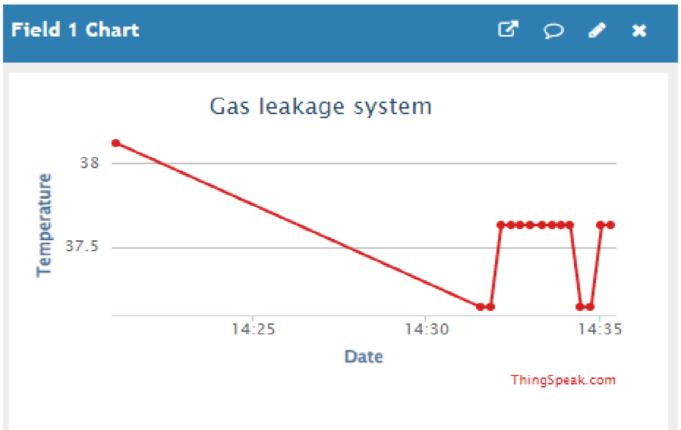

Fig.3 Temperature Detection

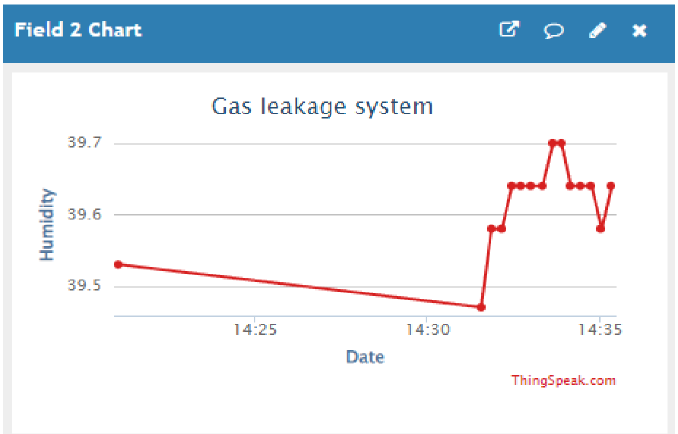

Fig.4 Humidity detection

The PIC microcontroller reads the output of the sensor, now in digital format. If the reading exceeds a predetermined value, the PIC microcontroller activates the buzzer.

In this project, a gas sensor interacts with a PIC microcontroller to create a gas leakage detector and smart warning sign system. The LCD display shows the percentage of gas leakage, along with notifications for O_2, CO_2, humidity and vibration.

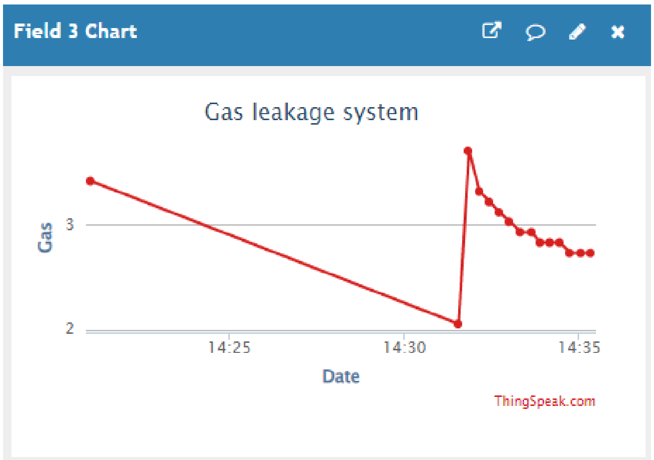

Fig.5 Humidity detection

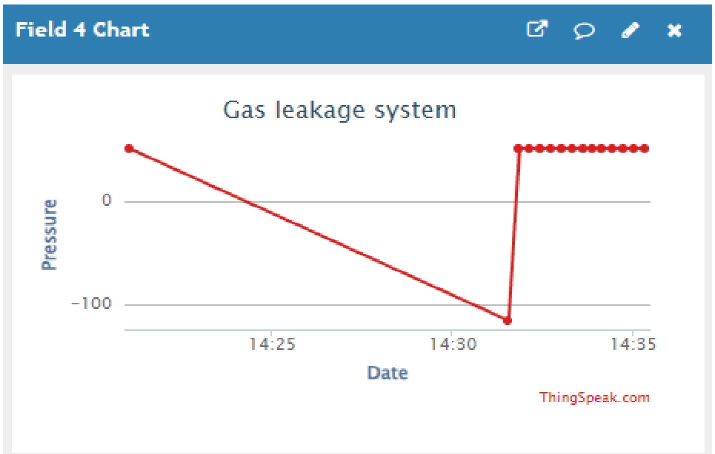

Fig.6 Pressure detection

The Intelligent gas leakage monitoring and detection system is a game-changing gas leak detection system that harnesses the power of AI and IOT technology to enhance safety in industrial settings. With its diverse set of sensors and advanced algorithm, the system can accurately detect and locate potential gas leaks in real-time, providing crucial warning to prevent accidents. Its remote monitoring and integration capabilities make it a convenient and efficient solution for industrial applications.

This innovative system is ready to transform the traditional approach of gas leak detection and revolutionize industrial safety standards. The ESP32 camera module integrates a camera sensor with the ESP32 microcontroller, enabling the capture and processing of images directly on the ESP32 platform.

This module is highly versatile, offering capabilities for image capture, processing, and transmission, making it ideal for various applications, including surveillance, IOT devices, and visual recognition systems. One of the key features of the ESP32 camera module is its ability to capture high-resolution images and video streams in real-time. The module supports different image resolutions and formats, allowing flexibility based on application requirements. Shown in Fig 6.3 Telegram Result

Fig 7 Telegram Result

Additionally, it offers features such as face detection, motion detection, and image filtering, enhancing its functionality for diverse use cases. Integrating the ESP32 camera module with a GPS module or utilizing Wi-Fi-based geolocation services enables the live transmission of both images and location data in a single application. By combining image capture with geolocation services, the application can provide real-time updates of the device's location along with the images captured by the camera.

To achieve this functionality, the ESP32 microcontroller can capture images using the camera module and then utilize Wi-Fi or other communication protocols to transmit both the images and the device's live location to a remote server or cloud platform. The application running on the ESP32 can periodically capture images and obtain the current GPS coordinates, sending this data to the designated server or platform.

On the server or cloud platform side, the received images and location data can be processed and stored accordingly. Depending on the application requirements, additional functionalities such as image analysis, data logging, or real-time monitoring can be implemented. Furthermore, integrating a user interface (UI) component into the application allows users to interact with the system, viewing captured images and live location updates.

This UI can be implemented using a web interface, mobile application, or other suitable platforms, providing a user-friendly experience for accessing the device's camera feed and location information. The ESP32 camera module offers a powerful solution for capturing and processing images, while integrating with geolocation services enables the transmission of both images and live location data in a unified application.

VII. CONCLUSION

In conclusion, the Intelligent Gas Leakage monitoring and detection system is a game-changing solution for gas leak detection in industrial settings. Its use of AI and IOT technology, along with its advanced sensors and remote monitoring capabilities, make it a highly efficient and effective system. With the potential to prevent accidents and increase worker safety, this system is sure to have a positive impact on the industrial sector. Its ability to integrate seamlessly with existing infrastructure makes it a cost-effective choice for businesses.

The Intelligent Gas Guard system is truly at the forefront of industrial safety and is set to revolutionize gas leak detection for years to come. It was mentioned that as per their aim, the drawbacks from previous methods had been addressed. The potential applications of the IOT concept were highlighted, particularly in industrial pollution monitoring, along with the presentation of a real-time IOT-based air pollution monitoring system. To facilitate real-time data access for users, GSM was connected via a level converter, and an IOT module was integrated. The system ensured continuous monitoring of air quality parameters, allowing for the tracking of data in a centralized location known as the cloud, thus aiding in pollution minimization based on the collected information.

The implementation costs were described as very low due to the affordability of sensors and microcontrollers. Additionally, the online database system offered improved flexibility by updating all current industry characteristics via a single server. Automated control actions could be generated in the absence of an authorized user. The simplicity of the gas leakage detector and its capability to issue warnings in the presence of dangerous gas leaks were highlighted as advantages. The GSM module was intended to send prompt messages to the appropriate personnel regarding gas leaks. Notably, the technique was designed to automatically turn off the cylinder's regulator knob upon the detection of a gas leak.

In the future, Integration with more advanced sensors for enhanced detection capabilities. Implementation in a wider range of industrial settings. Integration with other industrial safety systems for a comprehensive solution. Integration with AI-enabled robots for automated response to gas leaks. Further development of the IOT platform for advanced data analysis and visualization. Introduction of a mobile application for on the go monitoring and control.

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