Grenze International Journal of Engineering and Technology, June Issue

# Automatic Industrial Gas Leakage Detection and Control System

Teja Sai Ethesh[1], Dr. N. Swathi[2], M. Sai Vamsi Reddy[3], N. Anusha[4] and A. Yashwanth Krishna[5]
[1, 3-5]IV- B.Tech., Department of EIE, VR Siddhartha Engineering College, Vijayawada, India
Email: etheshinala2002@gmail.com, morasaivamsi5555@gmail.com, anushanalluri999@gmail.com, krishnayashwanth18@gmail.com
[2]Asst. Professor, Department of EIE, VR Siddhartha Engineering College, Vijayawada, India
Email: swathinadipineni@vrsiddhartha.ac.in

***Abstract*—This project's primary goal is to develop a successful functioning prototype that can detect the existence of gas leakage, which in this case is liquefied petroleum gas (LPG) and control the gas to prevent leaks in great amounts. The prototype should perform immediate data transfer and warning in addition to detection and control. This can be done by implementing an alerting system, such as an alarm via a buzzer, an application via a Wi-Fi module, and SMS via a GSM module. Here, the alerting system is in place to inform nearby residents and industry workers about the leakage. Once a leak has been discovered, the first step is to pinpoint its precise location. This can be done in two different ways. The first way is to check the pressure using a barometric pressure sensor in each region, if there is a difference between the pressure in one region and the previous which means a leak of gas has occurred; the higher the pressure drop, the bigger the leak. The second approach involves using an appropriate gas sensor, in this case MQ-6, to directly detect the gas concentration that is leaking. This is accomplished by comparing the error between the actual value and the predetermined value of the sensors. Here, we are combining both the approaches to increase redundancy. When this condition is met, an alert is triggered, and valves at the location of the gas leak are controlled using an Arduino Mega Controller. Further repair action will be performed at the damaged pipe line. This results in a shorter response time for damage restoration. As a conclusion, this project has offered students the chance to incorporate theories into solving issues relevant to the engineering scope of work.**

***Index Terms*— Arduino Mega Rev 3, GSM module, ESP8266 Wi-Fi module, Sensor, HX710B Atmospheric Pressure Sensor Module.**

## I. INTRODUCTION

Today's industrial accidents and worker fatalities are primarily caused by dangerous gas leakages. Consider the recent "VIZAG GAS LEAK" event that happened in LG Polymers on May 7, 2020, for a clearer understanding. This issue involved uncontrolled Styrene vapours coming from the boiler tanks. In the immediate aftermath of the tragedy, 12 individuals lost their lives, 585 people required hospital care, and cattle and vegetation were destroyed. This is one of the recent incidents to occur in our nation. In this decade, there have been a lot of other accidents.

Gas usage causes serious issues in both domestic and commercial settings. The gas that is used could be pricey

*Grenze ID: 01.GIJET.9.2.808*

or hazardous. Therefore, if the gas that leaked is toxic, it may have negative effects on the worker's and the surrounding community's health. And if gas is expensive, the industrial management suffers a loss. So, to avoid these in most of the industries, one of the key parts of any safety plan for reducing risks to personnel and plant is the use of early-warning and controlling devices with the help of gas detectors. These can assist in giving you additional time to take corrective or preventative action. They can also be utilised as a component of an industrial plant's comprehensive, integrated monitoring and safety system. Gas leakage accidents, which are extremely significant and deadly, are caused by the oil and gas industry's rapid expansion. Since gas leaks also result in a large financial loss, solutions must be found at least to reduce the effects of these accidents. The difficulties lie in creating a prototype of a gadget that can not only detect leaks but also react to them automatically when they happen.

## II. LITERATURE SURVEY

### *A. Previous Works and their Limitations*

In the past, many authors came up with ideas to prevent and detect gas leakage. One such idea is presented in *"IoT Based Industrial Plant Safety Gas Leakage Detection System,"* done by *R. K. Kodali, R. N. V. Greeshma, K. P. Nimmanapalli and Y. K. Y. Borra* [1], and the detection is also can be done through robotics, the authors *Meer Shadman Saeed* and *Nusrat Alim* done the work on "*Design and Implementation of a Dual Mode Autonomous Gas Leakage Detecting Robot*" in which they implemented a robot that detect the gas leakage in small tunnels, vents, pipelines where human can hardly make access to detect the leakage of gas [12]. Most of these studies deals with only detection and not on control action i.e., it cannot prevent the leakage of gas. After a time, some authors proposed some ideas which deals with detection as well as control. Here, the control action is primarily focused on shutting off the system if there is any leakage, which may be accomplished by installing a control valve at the inlet or by turning off the system's power [2,4]. Due this the gas accumulated in the pipes are released into the atmosphere creating damage and loss to the industry. Also, the whole process in the industry will be shut down until the damage is rectified. Some authors came with other ideas of having additional control system such as neutralizing gas system that will decrease the effect of toxic gas by releasing a neutralizing gas in fixed proportion based on amount of toxic gas detected that neutralizes the toxic gas leaked. Here also the gas is wasted until the damage is cured and the cost of installation of extra or additional system (neutralizing gas system) is not that much beneficial for any small and medium scale industry.

### *B. Proposed Model to Overcome the Limitations*

In order to get over these limitations, this study proposes an IoT-based automatic industrial gas leakage monitoring and control system. It can detect gas leakage from a variety of remote locations with continuous monitoring of leakage and is able to control gas leakage via control valves placed in the necessary positions in the pipe lines. It generates real-time leakage information that is accessible through the internet and SMS by working with a gas sensor, pressure sensors, microcontroller through Wi-Fi module and GSM module. This idea of prevention of gas can be also implemented in LPG gas cylinders to prevent gas leaks in households[11].

## III. PROPOSED SYSTEM

The primary functions of the proposed system are to detect gas leaks, monitor leakage data and control toxic gas leaks with ON/OFF switching of control valves. In this proposed system, a microcontroller Arduino Mega has been used, that is mainly connected with hardware components like gas sensors (MQ6), Pressure Sensors (Barometric pressure sensor), Wi-Fi and GSM modules and solenoid valves.

### *A. Methodology*

Figure 1 shows the block diagram of the proposed model, which is divided into three main sections, labelled (i) Inputs, (ii) Alert system, and (iii) Control system, presents the proposed prototype's overall system information. The Input section is composed of the sensor data which are pressure and Gas concentration that are given to the Micro Controller. The Alert system consists of some modules such as Wi-Fi module, GSM module and an LCD. Finally in Control section there will be an IC i.e., L293D which delivers the desired control signal to the desired control valves.

The system's fundamental concept is to employ solenoid valves to partition the pipe lines into segments or compartments. A pressure and gas sensor are placed at every segment. Having two sensors is intended to boost redundancy. Since any sensor could undergo damage, the others would continue to function. Various components of our suggested system are depicted in Figure 2. As shown in Figure 2, we have taken 3 segments

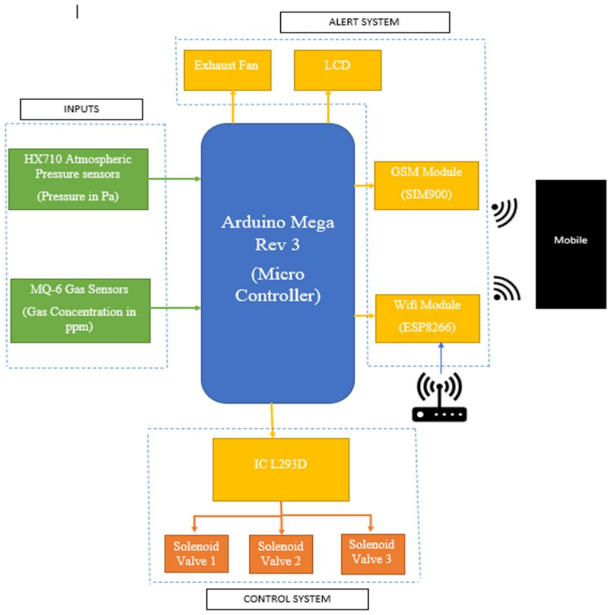



Figure 1. Block Diagram of the Proposed model

for our prototype. The primary objective of the system is to determine the location of the gas leak, or the precise segment where the gas leak occurred, by utilizing gas sensors (G1, G2, G3) and pressure sensors (P1, P2, P3). Opening any one of the hand valves (HV1, HV2, or HV3) in this prototype causes a leak at different positions. The attention shifts to controlling action once the damaged component has been located. Closing the control valves (Solenoid valves or air valves) at the beginning and end of the segment where the gas leak is occurring is the primary objective of the control action.

For a better understanding, if a gas leak occurred at segment 2, i.e., by opening of HV2, then there will be a change in pressure from segment 2, i.e., at P2, P3 respectively. We can also observe an exponential rise in the readings of the gas concentration in parts per million (ppm) with respect to the gas that is leaking at the gas sensor G2 only. The controller determines when to close the valves in relation to the intended set point by using these measurements of pressure change and gas concentration. Since we were using the MQ 6 sensor, whose range is 200 to 10,000 ppm, we had set the set point at 300 ppm. Whenever the concentration exceeds the predetermined level or whenever there is a significant shift in the pressure values from the previous segment., i.e., if the gas leak satisfied the aforementioned requirements, a signal from the Arduino controller is delivered to the solenoid valves, S2 and S3 which are located at the inlet and outlet of the segment 2 respectively. Additionally, a triggered signal is sent to the alarm system, which comprises of a GSM module that sends an SMS to factory workers informing them of the location of the gas leak and a Wi-Fi module that transmits continuous monitoring data from sensors to the ThingView application or ThingSpeak website over the internet [3]. In addition to these, we also have the most widely used equipment, such as an alarm (buzzer) to alert the industry that there is a leak and an exhaust fan to remove the gas leak into the atmosphere. Due to this segmentation and closing of control valves there will be a minor gas leak which will be released and breathed into the atmosphere where it does not significantly impact the health of the people in and around the industry premises. Therefore, since the desired position of the leakage at a specific section is known, less time is needed for damage restoration.

### *B. Hardware and software*

The hardware setup is shown in Figure 3. A brief description about the hardware used is given below.

*Arduino Mega 2560 Rev 3*

The ATmega2560 serves as the basis for a microcontroller board known as the Arduino Mega 2560. (datasheet). It includes 16 analogue inputs, 4 hardware serial ports (UARTs), a 16 MHz crystal oscillator, 54 digital input/output pins (14 of which can be utilized as PWM outputs), a USB connector, a power jack, an ICSP header, and a reset button. It is used to obtain sensor data and produces activation signals that operates the solenoid valves and sends alert signals.

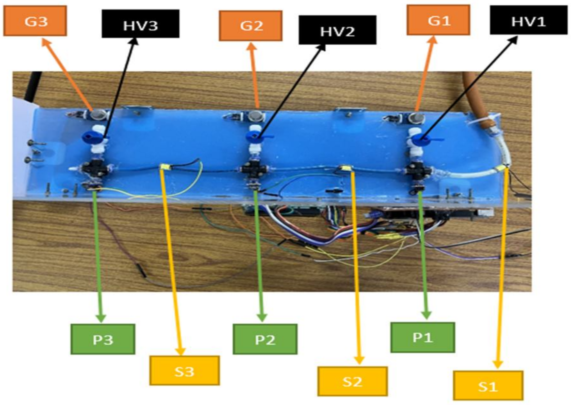



Figure 2. Top view of the proposed prototype

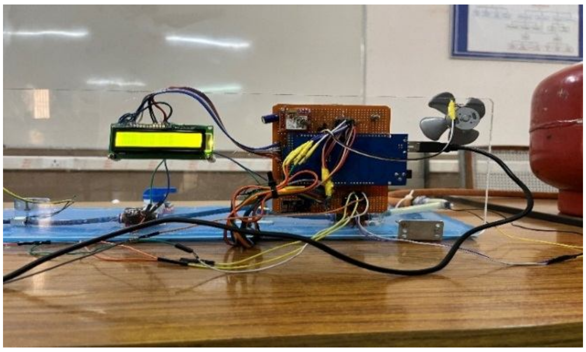


Figure 3. The hardware setup

*MQ-6 Sensor*
The MQ6 Gas Sensor is a Metal Oxide Semiconductor (MOS) type Gas Sensor that is primarily used to identify the presence of Butane and LPG in the air. The MQ 6 sensor has a range of 200 to 10,000 ppm [5].

*GSM Module*
SMS notifications are sent using a SIM900 GSM module when gas is detected. GSM is intended to be a tool for exchanging information [6].

*Piezo buzzer*
The buzzer's primary function is to transform the input signal, which is current (less than 15 mA), into sound.

*HX710B Atmospheric Pressure Sensor Module*
Atmospheric Pressure Sensor Module, HX710B, with an altitude resolution of 10 cm is used. This barometric pressure sensor is best used with altimeters and variometers. The sensor module can sense 0-40KPa air pressure. This sensor can be used to monitor water level and other air pressure [7].

*LCD*
LCD is employed for displaying the message indicating that "gas detected at zone" into the display, which is initially coded in program to display the danger.

*Wi-Fi Module*
A self-contained SOC with an integrated TCP/IP protocol stack, the ESP8266 Wi-Fi Module allows any microcontroller to access your Wi-Fi network. The ESP8266 is capable of offloading all Wi-Fi networking tasks from another application processor or hosting an application [8].

*Exhaust fan*
Exhaust fans are used for exhaling of toxic gases in industries.

*Solenoid Valves*
It is an electromechanical valve that is often used to control the flow of liquid or gas. There are many different kinds of solenoid valves, but the two most common varieties are direct acting and pilot driven [9].

*IC L293D*

L293D IC is a typical Motor Driver IC which allows the DC motor to drive on any direction. Here in this prototype, it is used for opening and closing of solenoid valves [10].

### *C. Proposed system design flow*

The flowchart diagram in Fig. 4 depicts the entire hardware connection process of the suggested system design. Following are some quick discussions of the process flow's steps:

- **Step 1:** Firstly, connect all the Modules and other components to the Arduino Mega Micro controller.
- **Step 2:** Get the sensor data from the respective sensors that are placed at respective locations.
- **Step 3:** Check whether the predetermined condition is satisfied or not, that is if the Gas concentration from the MQ-6 Gas sensor is greater than or equal to 300 ppm or if there is an exponential change in the Pressure values from Pressure sensor.
- **Step 4:** If the condition is not satisfied then go back to the second step.
- **Step 5:** If the condition met then Arduino finds the location where the leakage is occurred with the help of sensor data.
- **Step 6:** Now it sends a triggered signal to all the alert systems such as GSM module and Wi-Fi module and also share the sensor data with them.
- **Step 7:** It also sends the control signal (CO) to IC L293D to apply the desired control action at desired control valve.

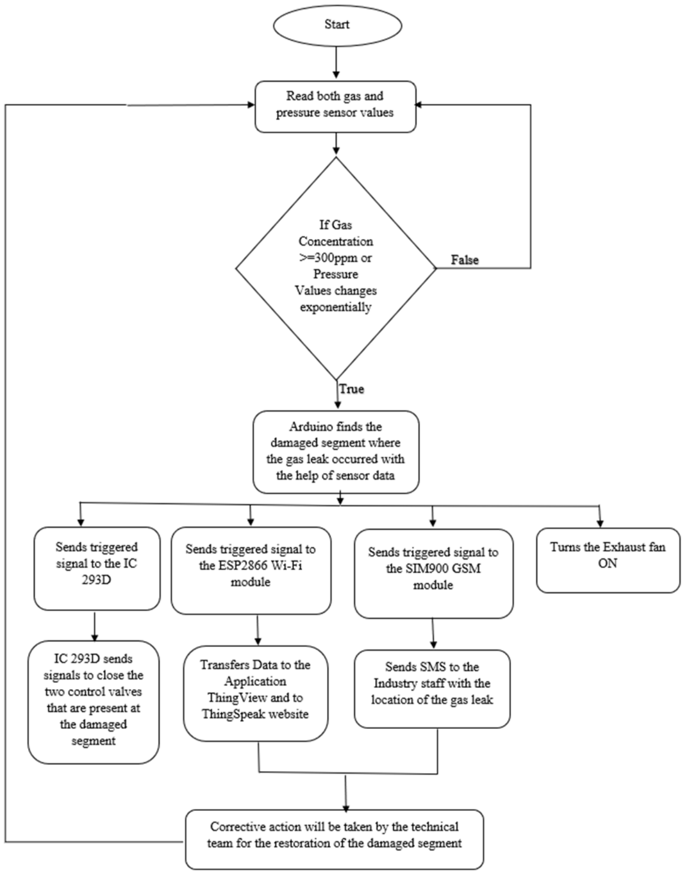



Figure 4. Flow chart of the proposed system

## IV. EXPERIMENTAL RESULTS

Figure 5 shows both the hardware and software setup circuit with Arduino Mega, pressure and MQ-6 sensors, control valves and a PC for detection, indication of position of gas leakage in the pipelines on LCD display and the control action taken.

As mentioned earlier in Methodology section, let us study the same example practically. That is if leakage is occurred at second segment which is done by opening second hand valve, then the sensor parameter changes are shown in Table 1.

Figure 6 shows the LCD display which displays the pressure and MQ- 6 sensor readings. Here in the display the first line shows the Pressure values and second line gives the gas concentration values. Here A, B, C indicates the segments 1, 2, 3 respectively. When the gas leakage occurs, then the LCD displays the location of gas leakage(Location 2) with respect to the pressure and MQ-6 sensor as shown in Figure 7.

TABLE I: OBSERVATIONS

| Parameters | Before opening the 2nd hand valve | After opening the 2nd hand valve |
|---|---|---|
| Pressure at position 1 (A) | 320 Pa | 215 Pa |
| Pressure at position 2 (B) | 315 Pa | 215 Pa |
| Pressure at position 3 (C) | 310 Pa | 220 Pa |
| Gas concentration at Position 1 (A) | 0 ppm | 0 ppm |
| Gas concentration at Position 2 (B) | 0 ppm | 431 ppm |
| Gas concentration at Position 3 (C) | 0 ppm | 0 ppm |

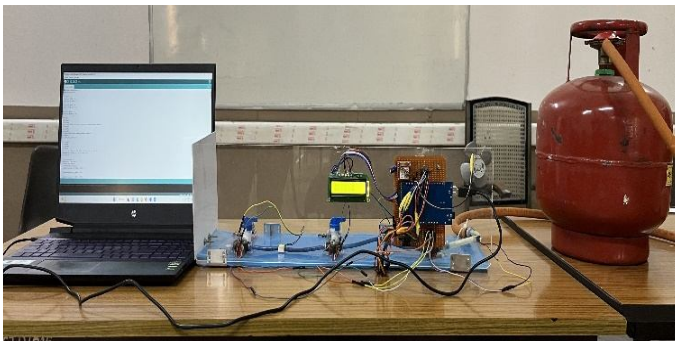


Figure 5. Proposed prototype model

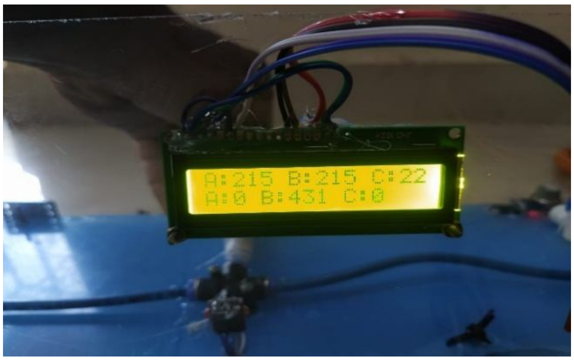



Figure 6. LCD display showing the gas and pressure sensors readings

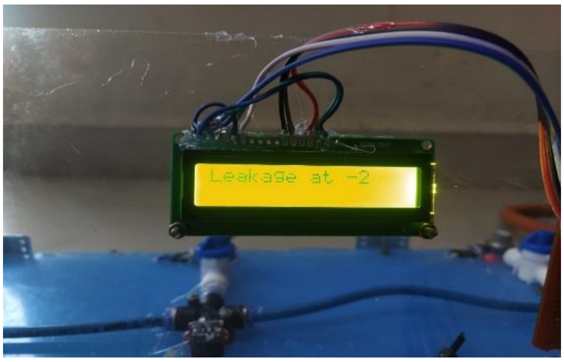
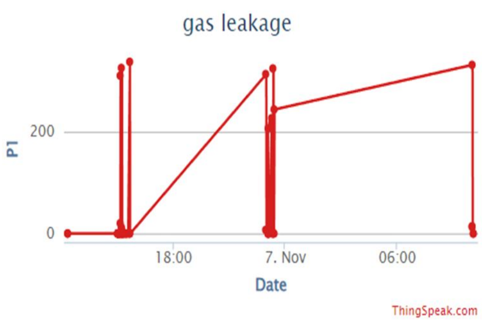



Figure 7. LCD display showing the position of leakage



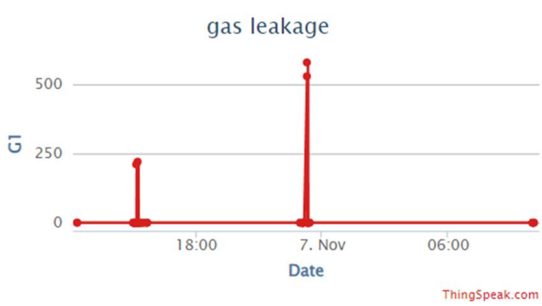




Figure 8. (a) Graphical Representation of pressure (Pa) values in ThingSpeak at segment 1, (b) Graphical Representation of Gas concentration (ppm) values in ThingSpeak at segment 1

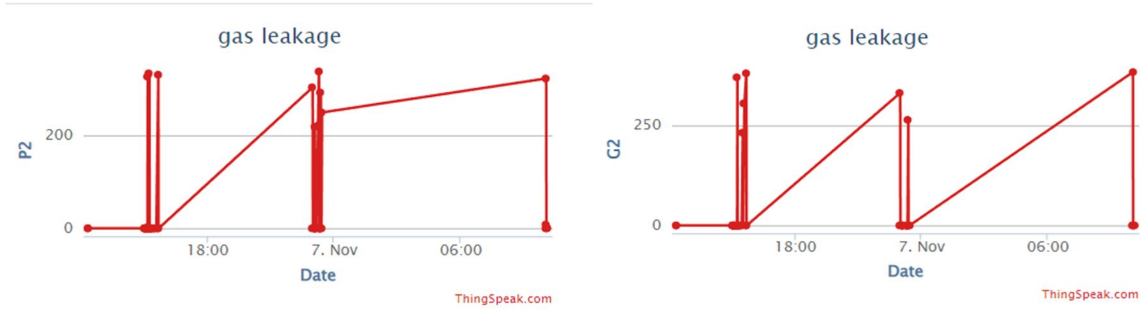



Figure 9. (a) Graphical Representation of pressure (Pa) values in ThingSpeak at segment 2, (b) Graphical Representation of Gas concentration (ppm) values in ThingSpeak at segment 2

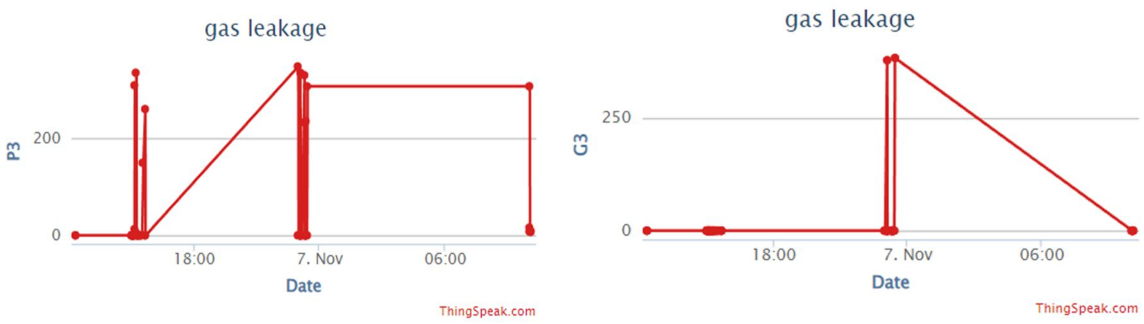



Figure 10. (a) Graphical Representation of pressure (Pa) values in ThingSpeak at segment 3, (b) Graphical Representation of Gas concentration (ppm) values in ThingSpeak at segment 3

Coming to the alerting system, the SMS and Graphical analysis data will be sent to the application or website. The Figures 8,9,10 gives the individual sensor data with respect to time which is sent to the ThingSpeak website through Wi-Fi module to get aware of the data in the form of graphs and a warning is sent when the gas leakage exceeds the limit. The same data can also be seen in mobile through ThingView application. For better understanding, visit the website through the link https://thingspeak.com/channels/243722.

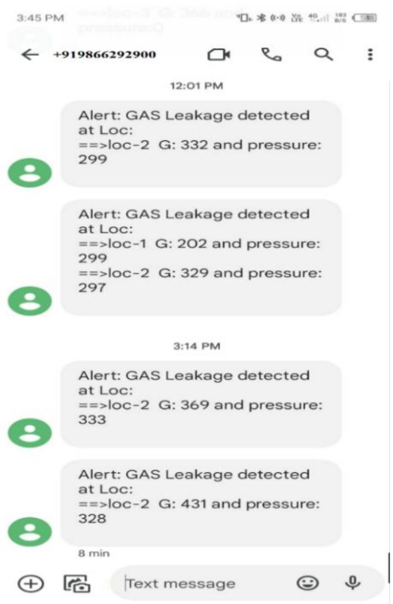



Figure 11. SMS sent to the registered mobile with sensor values

The Data is also sent to the mobile as SMS as shown in Figure 11 by using SIM900A Quad Band GSM/GPRS Module.

## V. CONCLUSION

In terms of the project's goals, the prototype has given adequate answers for preventing the toxic gas leaks in industries at low cost. The detection, alerting, and control systems make up the prototype's three core parts. The detection part is designed with a MQ-6 sensor and a HX710B atmospheric pressure sensor. The control system is constructed using solenoid valves, an Arduino Mega controller, an exhaust fan, and an IC L293D. The alert system is created using an LCD, an ESP8266 Wi-Fi Module, and a SIM900 GSM Module. This alert system is incorporated to increase public awareness of toxic gas leaks, which in turn lowers accidents brought on by toxic gas leaks. The integration of these three systems gives us accurate results. The prototype's design eliminates all the limitations of previous works and makes it simple for both small and large-scale companies to deploy without making significant changes to the existing system.

## FUTURE SCOPE

Other types of sensors, as well as other actuators, can be employed that may perform better than the traditional paradigm. It also enables flexibility because other modules may be introduced without affecting the existing modules for taking control actions and alerting system.

## REFERENCES


[1] R. K. Kodali, R. N. V. Greeshma, K. P. Nimmanapalli and Y. K. Y. Borra, "IOT Based Industrial Plant Safety Gas Leakage Detection System," 2018 4th International Conference on Computing Communication and Automation (ICCCA), 2018, pp. 1-5, doi: 10.1109/CCAA.2018.8777463.

[2] S. Z. Yahaya, M. N. Mohd Zailani, Z. H. Che Soh and K. A. Ahmad, "IoT Based System for Monitoring and Control of Gas Leaking," 2020 1st International Conference on Information Technology, Advanced Mechanical and Electrical Engineering (ICITAMEE), 2020, pp. 122-127, doi: 10.1109/ICITAMEE50454.2020.9398384.

[3] Yahaya, S. Z., Mohd Zailani, M. N., Che Soh, Z. H., & Ahmad, K. A. (2020). *IoT Based System for Monitoring and Control of Gas Leaking. 2020 1st International Conference on Information Technology, Advanced Mechanical and Electrical Engineering (ICITAMEE).* doi:10.1109/icitamee50454.2020.9398384

[4] H. Paul, M. K. Saifullah and M. M. Kabir, "A Smart Natural Gas Leakage Detection and Control System for Gas Distribution Companies of Bangladesh using IoT," 2021 2nd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), 2021, pp. 109-114, doi: 10.1109/ICREST51555.2021.9331226.

[5] Ba Thanh Nguyen and Anh Vu Nguyen, “IoT Application for Gas Leakages Monitoring,” International Research Journal of Advanced Engineering and Science, Volume 5, Issue 4, pp. 51-53, 2020.

[6] M. A. Subramanian, N. Selvam, S. Rajkumar, R. Mahalakshmi and J. Ramprabhakar, "Gas Leakage Detection System using IoT with integrated notifications using Pushbullet-A Review," Fourth International Conference on Inventive Systems and Control (ICISC), pp. 359-362, doi: 10.1109/ICISC47916.2020.9171093, 2020.

[7] A. Banik, B. Aich and S. Ghosh, "Microcontroller based low-cost gas leakage detector with SMS alert," 2018 Emerging Trends in Electronic Devices and Computational Techniques (EDCT), 2018, pp. 1-3, doi: 10.1109/EDCT.2018.8405094.

[8] R. K. Kodali, R. N. V. Greeshma, K. P. Nimmanapalli and Y. K. Y. Borra, "IOT Based Industrial Plant Safety Gas Leakage Detection System," 2018 4th International Conference on Computing Communication and Automation (ICCCA), 2018, pp. 1-5, doi: 10.1109/CCAA.2018.8777463

[9] A. Suryana et al., "Detection of Leak Position in Household LPG Distribution Pipes Using Gas Pressure Sensors and Continuity Equation,"6th International Conference on Computing Engineering and Design (ICCED), pp.15, doi10.1109/ICCED51276.2020 .9415775, 2019.

[10] R. S. Rosli, M. H. Habaebi and M. R. Islam, "Characteristic Analysis of Received Signal Strength Indicator from ESP8266 WiFi Transceiver Module," 7th International Conference on Computer and Communication Engineering (ICCCE), pp. 504-507, doi: 10.1109/ICCCE.2018.8539338, 2018.

[11] K. Gavaskar, D. Malathi, G. Ravivarma and A. Arulmurugan, "Development of LPG Leakage Detection Alert and Auto Exhaust System using IoT," 2021 7th International Conference on Electrical Energy Systems (ICEES), 2021, pp. 558-563, doi: 10.1109/ICEES51510.2021.9383633.

[12] M. S. Saeed and N. Alim, "Design and Implementation of a Dual Mode Autonomous Gas Leakage Detecting Robot," 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), 2019, pp. 79-84, doi: 10.1109/ICREST.2019.8644075.